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# The Canadian Engineer

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**The Canadian Engineer.**

ISSUED MONTHLY IN THE INTERESTS OF THE

CIVIL, MECHANICAL, ELECTRICAL, LOCOMOTIVE, STATIONARY, MARINE, MINING AND SANITARY ENGINEER, THE SURVEYOR, THE MANUFACTURER, THE CONTRACTOR AND THE MERCHANT IN THE METAL TRADES.

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## CANADIAN ENGINEERS ON THE G.T.P.

It was well that the Dominion Government appointed a well-qualified judge to determine the charges made from one end of the line to the other that the management of the Grand Trunk Pacific have loaded up the engineering corps of that road with men from the United States while the applications of well-qualified Canadians for positions on the staff have either been ignored or "placed on file." It was well that the Government appointed an impartial jurist to investigate these charges, but it would have been better had it taken a simple precaution that would have made these charges impossible. Before the agreement with the company was ratified by Parliament the Canadian Society of Civil Engineers conveyed to Government a resolution respectfully expressing the hope that Canadian engineers would be employed on this work. It was naturally to be expected that upon a work which was to receive such a valuable franchise and such signal favors from the Canadian Parliament and people every care would be taken to employ Canadian brains and labor; but in case this should not be sufficiently obvious to both parties concerned the society gave the reminder. Considerations of self respect probably restrained it from going further, and we find it taking no further action than to have the investigation watched by a legal gentleman. The relations of the society with the American Society of Civil Engineers have always been of the most cordial character, and it does not appear that the unfriendly alien labor law passed by Congress as a bad example for this country to follow ever had any general sympathy in that society. At all events, until alien labor legislation was put into force in the United States there was no jealousy towards Canadian engineers who sought employment there. In fact, many members of the Canadian society have profited by United States experience, and still more have attained to high positions on United States roads, and have remained permanently in that country. These facts, however, are in themselves a sufficient answer to the fears expressed by officers of the Grand Trunk Pacific as to whether Canadians of ability and experience could be found to do the work of surveying and locating. Mr. Hays, the general manager, may not share the view of many who contend that an enterprise of such a national character and so heavily subsidized should be a special training field for native Canadians; but few of his critics will credit him with such short-sighted partizanship in favor of his former fellow-citizens as appears to have been displayed by the chief of locating engineers he appointed. Mr. Hays is usually a correct judge of men, and the appointments he has made in the Grand Trunk—notably that of promoting Joseph Hobson, a Canadian, to the chief engineership—have shown a discernment that rarely errs. He knows also that a Canadian engineer built the Hoosac tunnel as well as the St. Clair tunnel, and knows that if Canadians could locate such difficult lines as the Intercolonial and Canadian Pacific they can locate this. Mr. Hays appears to have made one serious mistake in appointing a citizen of another country to the position of chief engineer of the G.T.P. It is true that he first offered the position to Mr. Lumsden, a Canadian, but that gentleman having declined it was given to Mr. Stephens, an American, at $7,500 a year, There were other Canadians besides Mr. Lumsden who were quite qualified for the place, and had it been given to any Canadian the subordinate appointments, whether given to Canadian, British or American engineers, would never have raised any serious question. But it appears from the evidence before Judge Winchester that Mr. Stephens and his appointees, such as Mr. Kyle in the West and Mr. Knowlton in the North Bay division, made it more or less a practice to allow applications from Canadians to remain unacknowledged, or to inform them that their offer would be put on file for "future consideration" (the future never seems to have had a period); and where appointments were made Canadians received $150 per month, while men from the United States were paid $175 for precisely the same work. Mr. Stephens appears also to have paid scant respect to the judge. He was expected to give evidence at Edmonton, but promised to appear at Winnipeg. He failed to appear before the judge when the court sat at Winnipeg, and promised again to appear at North Bay, but once more failed. One cannot anticipate the judge's findings, but Mr. Hays has probably seen enough already of the state of affairs in the engineering staff to realize that with a Canadian as chief the subordinate appointments will be accepted without undue criticism, and that until such appointment is made there will be just ground for dissatisfaction.

—The signs of the times appear to point to a general acceptance of the principle of municipal ownership of such utilities as water, gas and lighting and to the public or Government ownership of such franchises as the telephone, telegraph and railways. A single service well administered and on the cheapest terms consistent with good maintenance and a moderate return on the capital invested is manifestly the most satisfactory to the public, and when that moderate margin of profit is returned to the general public from whose needs it derives its existence the ideal has been reached. But the conditions for this ideal are farther away under private than municipal or public ownership. Where more than one company is in the field for a service in a city, for instance, the natural struggle to obtain complete control leads to the buying out of the opposition at a price many times beyond its earning power, and no sooner is the victorious company seated in its monopoly than rates are raised sufficient to pay a dividend on the inflated capital; in other words, on paper that represents no conceivable value, either in plant or good-will. The income from these non-existent values is transferred from the pockets of the citizens in general to the few of them who have been in the deal, while, on the other hand, the service, when the opposition has been removed, is usually poorer than before. Under municipal ownership the acquisition of the rights of existing companies is apt to be obtained upon terms that represent something like the actual value of the plant, and there is no danger of further watering of stock, since the people have no object in exploiting themselves. As for the quality of the service, it can be made just as efficient as the people desire, since the control is in their own hands. It is true that corruption gets into municipal politics too often and too deeply, but this again is capable of cure, and the evil will work itself out in time. The evil, on the whole, is probably not greater than the corruption and dishonesty that exists among the employees of private corporations owning large franchises. Municipal management in the cities of Canada has extended a great deal in the past ten years, as it has also in Great Britain and the United States, and with a few exceptions the change has been for the public advantage. In view of this tendency it is satisfactory to learn that the Dominion Government is considering the acquisition of both the telegraph and trunk line telephone systems of Canada. Sir William Mulock, into whose department the work would fall, has not only been capable of "thinking imperially," but of acting imperially in working out his postal problems; and if he takes control of the telephone and telegraph services he can count on having the support of the people who will be relieved from a situation already full of danger and irritation, and which is bound to grow worse as such monopolies as the Bell Telephone Co. extend their sway. There is very little prospect of relief from the formation of rival telephone companies, since sooner or later the Bell will buy them up, and the telephone-using public will be bled to pay for the deal. The only remedy for the telephone trouble is Government ownership of the trunk lines, with the extension of municipal ownership, if not Government ownership, of local exchanges.

## K. B. THORNTON.

K. B. Thornton, now president of the Canadian Electrical Association, is the youngest man (with the exception of Mr. Gossler), who has held this position. He has a good education, part of which was obtained in England. For a number of years he has been superintendent of the Construction Department of the Montreal Light, Heat and Power Co. Mr. Thornton was 1st vice-president of the Association last year, and held the 2nd vice-presidency the year previous.

## CANADIAN ASSOCIATION OF STATIONARY ENGINEERS.

Two branches of the above association have been organized recently, one at Chatham, on the 28th May, and one at St. John, N.B., on the 23rd June. The former started with ten charter members: Wm. Condon, Thos. Stephenson, John Buck, Albert Trott, Chas. Kelley, R. G. Brown, Edw. Grandbois, Wellington McGregor, Wm. Prout, and J. W. Montgomery. The St. John branch starts with 43 charter members and both organizations promise well.

## NEW CATALOGUES.

The following catalogues may be obtained by those interested, by referring to the Canadian Engineer:

"Metal-Working Machine Tools," Garvin Machine Co., Spring and Varick streets, New York.

"S.K.C. Generators," Bulletin 923, Canadian General Electric Company, Toronto.

"Compressed Air Appliances," The Canadian Rand Drill Co., Sherbrooke, Que.

—The Decimal Association of England is offering prizes of £20 and £10 for the two best essays on the advantages to be gained by the adoption of the Metric Weights and Measures throughout the British Empire, and on the best means of effecting the transition. Essays must be in by January 1st, 1905. The secretary is Edward Johnson, Oxford Court, Cannon St., London, E.C.

**A. A. WRIGHT, M.P.**

A. A. Wright, M.P., first vice-president of the Canadian Electrical Association, was born at Farmersville (now Athens), Ont., June 16th, 1840. He received his education at Athens Public and High Schools, and Toronto Normal School, after which he became head master of the Gananoque Public School. In 1865 he entered the Military School, at Montreal, obtaining a first-class military certificate. In 1870 he went into mercantile life at Renfrew, Ont., and in 1886 entered the electrical field by installing an arc plant in that town. This was later supplemented by an incandescent plant, and the business is now carried on by the Renfrew Electric Co, Limited, of which Mr Wright is president.

Mr. Wright was a charter member of the Canadian Electrical Association, and has been an active member since its organization. In 1899 he was elected member of the House of Commons, which position he still holds.

## LIGHT, HEAT, POWER, ETC.

The Niagara Falls Park Commission has approved the plans of the Ontario Power Co. for their power house at the foot of the Falls, and for the gate and screen houses at the intake.

Natural gas has been struck at Medicine Hat. N.W.T., at a depth of 1,010 feet. The flow is estimated at 1,500,000 cubic feet a day. The strike was made by the commissioners for the proposed municipal gas plant.

The Toronto and Niagara Falls Power Company has awarded a contract, which calls for six generators of 7,500 kilowatts capacity each, or 45,000 kilowatts in all. The Canadian General Electric Company secured the contract.

The plant of the Kingston Light, Heat and Power Co. is to be taken over by the city August 1st, the company to pay taxes to that date and costs of the appeal against the award, while the city agrees to continue to supply power to the Street Railway Company at $2 per car per day for six months.

The Canadian Westinghouse Company have closed a contract to furnish the Shawinigan Water and Power Company, Shawinigan Falls, with a 6,600 K.W., two-phase 2,200 volt, 3,600 alternations, 180 R.P.M., rotating field alternator, for direct connections with water wheel. Two 2,200 K.W. oil insulated water-cooled transformers, 2,200 volt primary, 50,000 volt secondary, are included in the contract.

At the annual meeting of the Ottawa Electric Co., last month, a net profit for the year of $47,734, was carried to credit of profit and loss; $25,000 was added to the rest account, and $25,000 laid aside for depreciation. There was added during the year 12,524 incandescent lights, 99 arc lights, 23 power motors, and 616 other customers. Thomas Ahearn was elected president; F. P. Brown, vice-president, and D. R. Street, sec.-treasurer.

The suit of the Minnesota Canal Power Co. vs. Koochiching Power Co. is about to be heard in Fort Frances. This suit is in connection with the expropriation of lands for the purpose of diverting the water of Rainy Lake and River into Birch Lake and St. Louis River, as explained in the Engineer last month. A strong protest has already been entered by residents and companies on both sides of Rainy River, and it is hoped the United States Government will nip the scheme in the bud.

The Western Electric Mfg. Co. is getting its new works in shape, at Berlin, Ont. Some machinery has been installed, and more will be added as business develops. The company is making switch and panel boards and fuses, and later on will make watt meters. It is also preparing to make for the Canadian market a new type of arc lamp, invented in Germany, and said to require less current than any yet devised. The president of the company is Peter Hyman, hardware dealer, and the manager John H. Messner.

The Mexican Light and Power Company, Limited, of Montreal, the $12,000,000 enterprise of which James Ross is president, has just placed the largest single order for copper cable ever let in the States. The order calls for 1,500 miles of cable, weighing upwards of 2,000 tons. The cable is to be built from the company's Necaxa power plant to Mexico City, and from there on to the El Oro mining district, a total distance of some 125 miles, and will be supported on steel towers in spans of 500 feet. The contract for the cable was let to the Ansonia Brass and Copper Company, of Ansonia, Conn. The Mexican Company's construction operations are among the most extensive ever initiated on this side of the Atlantic. The capacity of the Necaxa plant will in the first instance be 45,000-h.p. Eventually there will be installed additional machinery which will permit of the generating of 80,000-h.p. Fully $8,000,000, it is estimated, will be expended before the company begins to transmit the electric current.

**THE TARIFF CHANGES.**

On the 7th June, the Finance Minister announced a number of changes in the Canadian tariff. Among these it is provided that notwithstanding the preferential tariff, the minimum duty on woolen goods (excepting blankets, flannels and bed comforters), shall be 30 per cent., and on twines and cordage, 20 per cent. The duty on common window glass shall be 7½ per cent., and plate glass, not bended, in sheets or panes, not exceeding 7 sq. ft., shall be 10 per cent., and from 7 to 25 sq. ft., 25 per cent. Paraffine wax candles and paraffine wax are dutiable at 25 per cent.; coal oil costing more than thirty cents per gallon, 60 per cent.; lubricating oils, composed wholly or in part of petroleum, costing less than twenty-five cents per gallon, 2½ cents per gallon; crude petroleum, gas, oils (other than benzine and gasoline), above 40 Beaume gravity, at 60 degrees temperature, 1½ cents per gallon; oils, coal and kerosene, distilled, purified or refined, naphtha and petroleum, and products of petroleum, n.e.s., 2½ cents per gallon; lubricating oils, n.e.s., and axle greases, 20 per cent.; vaseline and all similar preparations of petroleum for toilet, medical or other purposes, 25 per cent.

Among the articles transferred to the free list are machinery and appliances, not made in Canada, for alluvial gold mining, machinery for the manufacture of linen; rotary printing presses of a kind not made in Canada; machinery of a kind not made in Canada for the manufacture of brass goods, such as are mentioned in item 492, schedule B; well-drilling machinery and apparatus of a class not made in Canada for drilling for water and oil (not to include motive power), artificial teeth, quassia juice, crude petroleum, fuel and gas oils, 40 Beaume gravity or less, at 60 degrees temperature (.8233) specific gravity; whole oil soap, hydro-fluo-silicic acid, and glass for dry plates for photographers; also scientific apparatus when imported by order of an educational or scientific institution for its own use and not for sale.

One pargaraph reads as follows: "The provisions respecting a special duty of customs shall apply to imported round rolled wire rods not over ⅜ of an inch in diameter, notwithstanding that such rods are on the customs free list. Provided, however, that the special duty of customs on such wire rods shall not exceed 15 per cent. ad valorem."

Provisions are also made intended to prevent the slaughtering of foreign goods on the Canadian market in competition with home manufacturers.

The term of the free entry of beet root sugar machinery is extended over one year.

The imperial standard gauge has been adopted to determine the classification of metal plates and wire, and will replace the Stubbs' gauge.

## INDUSTRIAL NOTES.

Palmerston, Ont., is installing a water supply and sewage system.

Creemore, Ont., is spending $20,000 in installing a gravitation water system.

Springhill, N.S., will put in a supply system by which water will be brought eight miles by gravitation.

The Guelph Foundry Co. have moved into their new four story addition. The foundry now stretches 171 feet.

The Enterprise Foundry Co., of Sackville, N.B., are installing a new plant for the manufacture of steel ranges.

Peter Lyall & Sons have begun work for the steel sheds which they have contracted to erect on the harbor front at Montreal.

Grimsby is raising $34,000 to put in a waterworks system, to consist of a filtering basin and pump house at the beach, and a reservoir on the mountain.

Oshawa, Ont., is granting a ten thousand dollar loan and ten years' exemption from taxation to the Canadian Saddlery and Harness Manufacturing Company, Toronto.

The Manitoba Construction Co. has the contract for the erection of the new gas tank and enlargement of the present works, in Winnipeg. The new tank will be one of the largest of its kind in Canada.

The Verity Plow Company, of Brantford, announce that they will erect large extensions to their factory. The capacity of the works will be doubled, and will employ 250 more men.

The Canadian Iron Co., of Ottawa, has been incorporated with a capital of $2,000,000. The provisional directors are: H. F. Gooderham, H. Barry, and Robert Weir, all of Toronto.

It is said that the Dominion Saw Works are contemplating the establishment of a manufacturing branch in Vancouver. James Robertson Co, Limited, of Montreal, are the proprietors.

The Department of Public Works is investigating the necessity of a bridge over the Saskatchewan, at Medicine Hat. The bridge, which would be cement and steel, would cost about $85,000.

The extensive planing mills of the St. Catharines Box and Lumber Company were totally destroyed by fire on June 25th. The loss will be between $45,000 and $50,000, with insurance of about $30,000.

Brampton has granted a loan of $25,000 to the Copeland-Chatterson Company, of Toronto, who contract to erect buildings to the value of $30,000, and to employ 125 hands, to whom they will pay annually not less than $40,000.

Representations are being made to the Minister of Railways and Canals with a view to the lengthening of Rideau Canal for the benefit of mining operations. Frontenac is rich in feldspar, but must have better transportation facilities.

The Rat Portage Lumber Co.'s factory was destroyed by fire on June 18th. The fire started by a boiler explosion, and spread to a number of adjacent residences. The loss is placed at $140,000. The company is rebuilding at once.

The Canadian Pipe and Foundry Company is the title of a new company recently started in Vancouver, and organized for the purpose of manufacturing wire-wound wooden pipes. J. R. Berry is the manager, and F. A. Shand assistant manager. The company report prospects for business very bright.

The city of St. John's, Nfld., is remodelling its waterworks system, under the supervision of John Galt, of Toronto. The water is to be brought by gravitation through a canal a mile long cut out of the solid rock, and is carried by a conduit for two miles further to a receiving basin from which it is distributed by two cast iron mains. The cost of the work will be about $125,000.

The Oshawa, Ont., Steam and Gas Fitting Co., manufacturers of steam and gas pipe fittings, are enlarging their plant by the addition of a two-story building, and a three-story building, with cement flooring, as machine and pattern shops, etc.

J. A. Jamieson, C.E., Montreal, has been instructed by the Minister of Railways to prepare plans for a two-million-bushel steel elevator at Port Colborne to be finished in the autumn of 1905. It is to be constructed to attract to the St. Lawrence route grain shipments that now go by way of Buffalo.

The Canada Iron Furnace Co., of Midland, has a daily output of about 120 tons, and the coke consumption is from 130 to 150 tons a day. The latter is brought by rail from Pennsylvania. The total amount of ore brought, chiefly from Lake Superior ports, is from 50,000 to 60,000 gross tons. The business has been running four years.

Fort Frances is looking forward to large industrial developments in the future. Work on the big dam will commence in a few weeks, followed by the erection of a 5,000 barrel flour mill, a paper mill, a pulp mill, and other industries. American capital is behind the enterprise. Privileges are being granted by the town to industries locating there.

F. H. Clergue, A. B. Wolvin, and W. F. Fitch will erect a coke plant in the Michigan Soo, which will roast not far from 750,000 tons, to supply the surrounding country with the fuel for commercial purposes. It will take 250,000 tons to supply the Algoma steel plant alone. The building of the plant will mean the reduction of $500 per day in the running expenses at once.

Consequent on the death of President Calloway, a meeting of the Locomotive and Machine Company of Canada was held at the company's new offices, Imperial Bank building, Montreal, when a new board was elected as follows: Albert J. Pitkin, Pliny Fisk, G. R. Sheldon, W. M. Barnum, K. E. Blackwell, Roger Miller and D. W. Morrow. The officers elected were: Albert J. Pitkin, president; J. E. Sague, vice-president; R. J. Gross, second vice-president; C. E. Patterson, comptroller; Leigh Best, secretary; G. B. Denny, treasurer. In addition to the improvements in the plant already decided upon and which will cost $300,000, it was decided to erect another addition to the big machine shop which will be 33 feet by 250 feet.

The strike at the works of the Dominion Iron and Steel Co., which practically began on the 7th June, has not yet been broken. The company claim that the wages paid are higher than any paid in New Brunswick or in Nova Scotia, outside of Cape Breton. The men refused the arbitration which was offered by the company, and demanded a return to the wage scale in force before November last. Now, it appears that the men are willing to arbitrate, and Mr. Plummer, president of the company, is about to submit an arbitration proposal to the other members of the board. In respect to membership in labor unions, the position of the company is said to be unchanged. On July 4th, an attempt was made to operate the plant, under the protection of the militia. Serious disturbance resulted, and more is anticipated. The men claim that if the Coal Company begin to supply fuel to the steel plant, the employees of the former company will strike in sympathy.

A long-drawn out case before the High Court, at Hamilton, is that of E. A. Wallberg, who formerly did business as a contracting agent in Toronto, but is now engaged in Ottawa and Montreal, against the Steel Storage Elevator and Construction Company, of Buffalo, for three items of commission for securing contracts for the defendant company. They were: $10,000 on a $600,000 contract for the construction of a steel grain elevator in Montreal; $1,431 on a $95,460 contract for a wharf in Montreal, and $4,500 on a contract for a steel elevator annex for the C.P.R. Company, costing $300,000. The defence was that the contracts had not been secured through the plaintiff, who also had failed to notify the defendants of the commission he expected on the contracts, so that the amount could be included in the deals. The defendants did not consider he was entitled to any commission, as the work was regarded as an advertisement for him. The court's jurisdiction was denied by the defendants. The case was transferred from Ottawa to Cornwall, and from the latter place to Hamilton, owing to the defence not being ready.

## CANADIAN ELECTRICAL ASSOCIATION.

The fourteenth annual convention of the Canadian Electrical Association was held in the Royal Hotel, Hamilton, on Wednesday, Thursday and Friday, June 15th, 16th and 17th, the president J. J. Wright, of Toronto, in the chair.

The following registered attendance: From Toronto: J. J. Wright, C. H. Mortimer, A. B. Smith, T. R. Price, J. M. Leamy, W. A. Bucke, R. G. Black, E. Irving, W. W. Bogart, E. B. Merrill, R. H. Fraser, K. L. Aitken, F. Rose, J. W. Campbell, W. V. Warren, E. D. McCormack, Acton Burrows, Frank T. Dryden, W. H. Dudley, John W. Watts, W. H. Fiske, W. D. Wilgar, P. E. Hart, H. O. Edwards, H. G. Nicholls, Walter Nicholls, E. B. Walker, Frederic Nicholls, G. W. Hill, D. H. McDougall, A. C. Larkin, A. E. Esling, F. C. Smallpiece, J. P. Thompson, A. M. Wickens, G. F. Perry, W. R. Scadding, J. Herbert Hall, C. H. Wright, R. T. MacKeen, H. J. Surtees, Roderick T. Parke, A. B. Lambe, W. M. McKay, W. McCaffery, J. F. H. Wipse, E. W. Davies, James Bannon. From Montreal: Henry D. Bayne, A. McLean, Edward F. Sise, A. E. Wilson, J. A. Fletcher, J. M. Wright, W. H. Reynolds, T. J. Mullen, L. Rousseau, G. C. Rough, R. A. Stinson, Paul Size, C. W. Henderson, T. R. Fulton, Cecil Doutre, Alfred Collyer, W. C. Brown, H. W. Weller, W. A. Duff, Fred Thompson, G. F. Olney, D. W. McLaren. From Hamilton: Gordon Henderson, C. K. Green, J. A. Kammerer, H. W. McPhie, Geo. Black, D. S. Henderson, W. C. Hawkins, N. S. Braden, John Patterson, John Knox, John Knox, Jr., H. M. Bostwick, H. P. Douglas, T. F. Niven. From Ottawa: John Murphy, J. Johnston, T. Hilliard, O. Higman, A. A. Dion. Also the following: B. F. Reesor, Lindsay; C. B. Hunt, London; John Yule, Guelph; H. O. Fisk, Peterboro'; R. J. Smith, Perth; W. E. Reesor, Lindsay; W. Williams, Sarnia; J. G. Archibald, Woodstock, Ont.; J. W. Crawford, Durham; C. H. Abbott, St. John, N.B.; H. N. Dignum, Bowmanville; C. B. Roulet, New York, N.Y.; T. H. Bibber, Boston, Mass.; K. Hadin, London, Eng.; T. D. Loneragan, Quebec; R. M. Saxby, Whitby; C. T. Starr, Halifax, N.S.; C. H. Clark, Boston, Mass.; A. F. McBean, St. Catharines; F. C. Whatmough, Stratford; F. Chowen, Stratford; W. H. Wiggs, Quebec; W. L. McFarlane, Cornwall; A. T. Duncan, R. R. Wiley, and R. B. Hamilton, St. Catharines; Louis W. Pratt, Brantford; R. B. Smith, Boston, Mass.; H. Webster, Norwich; W. J. Ingram, Kincardine; Arthur Doddridge, Quebec; L. R. Grimshaw, St. Catharines; A. H. Oesterreich and C. W. Schneidel, Waterloo, Ont.; Chas. L. Farrar. Lakefield, Ont.; Simon Plewes, Creemore, Ont.; J. A. Culverwell, Peterboro'; F. B. Utley and Jas. Buchanan, Galt; G. U. G. Holman, Levis, Que.; J. D. Lachapelle, Sorel, Que.; V. B. Coleman, Port Hope; F. W. Martin, St. Catharines; E. Craig, Niagara Falls, Ont.; T. Beecroft, W. A. Boys and T. H. Bennett, Barrie; J. W. Crosby, Halifax; J. M. Deagle, E. F. Terman, Cataract, Ont.; T. E. Gayfer, Ingersoll; Fred Deagle, Eugenia Falls; P. S. Coote, Chatham; P. M. Lincoln, Pittsburg, Pa.; L. B. Hastings, Pittsfield, Mass.; A. H. Skene, Bracebridge; S. T. Kelley, Barrie; A. Walker, Bracebridge; W. Langford, Quebec; W. R. Reynolds, Mitchell.

An address of welcome was delivered by Mayor Morden, in which he referred to Hamilton's growing importance as a manufacturing and electrical centre. "Once Hamilton was called the Ambitious City; but there is a difference now. It then had an ambition to be great among the cities of Canada; now it is ambitious to be the greatest of them all." He referred to the fact that there were now in operation in Hamilton more than three hundred important industries.

The president then delivered his annual address, in which he referred to the meeting of the Association in Hamilton twelve years ago. This period covered practically the entire development of long-distance transmission of electricity. Hamilton had in that time attained the distinction she now enjoyed as the Electric City, and one of the first cities to minister to the needs of its manufacturers by transmitting electric power from a natural reservoir. Among the important matters that should engage the attention of the convention would be the endorsation of the application to the Minister of Inland Revenue for the better utilization of the resources of the Inspection Bureau of the Government. The favorable hearing accorded a deputation a few weeks ago gave encouragement that a further application would secure increased facilities for protection, and also legislation that would still further protect the companies engaged in electrical enterprises. A committee had been appointed, he said, to confer with the underwriters as to protective devices to be used in the installation of electric appliances; "and it could do good work if it were to succeed in inducing the insurance companies to investigate thoroughly the cause of the many fires that are continually taking place." It had become the fashion now, he said, wherever there were wires in a building to blame all fires upon the electric wires where there was no other obvious reason. The chief of Hamilton Fire Department had estimated that 60 per cent. of all fires were incendiary, but the speaker thought this estimate too low. Gratification was expressed that the legislation requiring a municipality to purchase at a fair valuation the plant of a company with which it would otherwise go into competition still remained on the statute books. Municipal socialism was designated as a passing whim. Theoretically, a municipality should be equal to private enterprise, but practically it was impossible. In some isolated instances it had been accomplished in England with more or less success, but the difference in constitution of municipal bodies in England and in Canada was sufficient to account for the impossibility of such results here. The speaker expressed great satisfaction with the progress of the Association in the past twelve years, both in the matter of growth and in respect to accomplishments of the association as such.

The secretary-treasurer, C. H. Mortimer, then read his report, which announced the appointment of A. A. Dion as editor of the "Question Box," the first volume of which would be distributed at the present convention. A membership of 375 was reported, being an increase of 31 during the year.

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On assembling for the afternoon session E. B. Walker was called on to read his paper on "The Origin and Development of Storage Batteries." The paper was as follows:

## THE ORIGIN AND DEVELOPMENT OF STORAGE BATTERIES.

By E. B. Walker.

In 1801 Gauthert first observed that if two metals—platinum and silver—were immersed in an electrolyte and a current passed through them, a secondary current could be obtained in the opposite direction by joining the two metals by a conductor.

In 1842 Grove observed that if two gases of strong chemical affinity were connected by pieces of metal through an electrolyte, a current would pass until the two gases were exhausted. In his experiment he used two test tubes inverted over strips of platinum foil in a vessel containing dilute sulphuric acid. The two tubes contained two volumes of hydrogen and one volume of oxygen respectively. On joining the platinum strips with a wire a current passed until the gases in both tubes disappeared. On sending a current through the platinum and acid from a primary battery, the gases were formed again by electrolysis, thus storing a small supply of electricity, represented by the volumes of the gases. About 830 cubic centimeters of hydrogen at a temperature of O. degrees C. and 760 m.m. pressure, being equivalent to one ampere hour. Grove constructed a battery of fifty of these cells and managed to obtain a small arc light.

. The year 1859 opens the era of the first storage battery of any practical value. Gaston Plante discovered that if a current were passed through two plates of lead immersed in dilute sulphuric acid a small current could be obtained for a short time, in the opposite direction to the charge, by joining the two plates with a conductor. This was due to the formation of lead peroxide on one of the plates, causing a difference of potential.

He also observed that by a series of charges and discharges of this nature, and by reversing the direction of the charge each time, the quantity of lead peroxide on one plate was greatly increased, while a spongy surface of pure lead was formed on the other; as this increased the capacity of his battery, he was able to construct a cell that was of some practical value. His method was to roll together two sheets of roughened lead, which were kept from touching by sticks of paraffined wood, and to immerse the whole in dilute sulphuric acid. The cell was then charged, discharged, and charged again in the opposite direction, until the plates were "formed," i.e., a coating of lead peroxide was formed on one plate and of spongy lead on the other. This process occupied a month or two, but after several experiments Plante succeeded in reducing this time considerably by soaking the plates in a bath of nitric acid, previous to the formation process.

Plante carried on his research work until 1879, but he does not appear to have succeeded in sufficiently shortening the formation period of his battery, although he is said to have made some experiments with mechanically applied active material.

### FAURE SYSTEM.

As the long and tedious process of formation of the Plante element added much to the expense, it greatly checked the commercial growth of the storage battery.

In 1879, however, R. L. Metzger partially overcame this by mechanically applying to a lead plate active material in the form of a paste of lead oxide. This important improvement was not generally known, until Camille Faure obtained patents on a similar process, which is now known as the Faure system. Faure's first experiment was to cover an ordinary Plante plate with lead oxide but he subsequently improved this by using an antimonious lead grid, with a paste of red lead, and sulphuric acid for the positive and litharge and sulphuric acid for the negative. The advantage of the antimonious lead grid over pure lead will be dealt with later.

### COMPARISON OF PLANTE AND FAURE SYSTEMS.

We now have two methods of making a storage battery, both of which have striking advantages, and both, unfortunately, striking disadvantages. In the Plante system the time of formation is long and a large amount of electric power is consumed; the proportion of active material to the weight is small, as the lack of mechanical strength of the lead makes it necessary to have a thick plate to withstand any strain; the lead plate is continually undergoing a formation process from the repetition of charge and discharge, which reduces its strength. On the other hand, the conductivity of the Plante plate is excellent as the active material being formed directly on the surface is always in good contact with its supporting lead plate. The active material is not likely to be jarred off or forced off by the evolution of gases; rapid discharges of heavy currents may be maintained with little or no injury to the plates.

In the Faure system the advantages and disadvantages are almost diametrically opposed to those of the Plante. The formation is quick and may be accomplished in one continuous charge. The proportion of active material to the weight is large, therefore the capacity is increased. The antimonious lead grid has greater strength, and is more rigid than the lead plate. The antimonious lead grid is only very slightly subjected to the "forming" process, and therefore retains its strength.

Here it may not be amiss to explain the term antimonious lead grid. I have used it in a general way to represent those alloys of lead, antimony, arsenic and tin, which have been made with a view to obtaining increased strength and immunity from the electrolytic effects of the current on charge and discharge. Some of these are quite successful, but the manufacturers keep the exact composition secret.

On the other hand, the conductivity is lower than in the Plante, as it is difficult to maintain good contact between the active material and the grid. The expansion and contraction on charge and discharge is apt to loosen the active material and render it liable to fall out. Very heavy discharges are likely to force off the active material by forming gases inside of it.

Since this time the manufacturer has been endeavoring to produce a battery which will combine the advantages of both with none of the disadvantages. Needless to say, this battery has not yet been made, but nevertheless the improvements now existing are such that the storage battery holds an important place in modern engineering practice, and it is safe to say that few, if any, of the larger direct current plants could be considered up-to-date without such an auxiliary.

To enumerate the varieties of batteries which have been patented and manufactured would occupy the remainder of the evening, but it may not be out of place to mention those which present radical improvements or entire departure from standard practice.

### METHODS OF MANUFACTURE.

In order to increase the capacity per pound, many methods of increasing the active surface of the lead plate have been devised.

1. Lead plates are scored all over with a sharp tool, which raises fine leaves on the surface and increases the area, in some cases, to 17 times the superficial area.
2. Grooves are cut in a thick plate generally by sawing,
3. Plates are built up of alternate laminae of flat and corrugated lead, which are burned together at the ends.

In these three systems solid ribs are usually left at intervals in the plates, to increase the rigidity, which, however, never equals that obtained by the antimonious lead grid of the same weight.

The advantages of these systems in increasing the active surface are manifest, the drawbacks, however, are rather serious. In all three cases the chief support is pure lead, which, as was mentioned before, is subject continually to a formation process. Thus the thin leaves, ribs or laminae produced by these methods are apt to become formed right through and so break away. Too many ribs or laminae will not allow sufficient room for the formation of the lead peroxide, and buckling or forcing off some of the active material is sure to result.

Plates of this type expand and contract laterally across the surface and consequently are sure to buckle sooner or later, as it is manifestly impossible to keep this expansion and contraction the same for both sides of the plate.

The long formation process of Plante has been overcome to a great extent by the addition of lead dissolving acids or salts. The formation of peroxide or sponge lead is so hastened that the time taken is not much longer than that required for the Faure system. In some cases it has been reduced to fifty hours. Care must be taken, however, to free the plates thoroughly from such chemicals before putting them into use, as otherwise the formation process will continue until all the lead is worn away.

In these ways the Plante plate has been so improved that from a standpoint of capacity and fairly quick formation little is left to be desired, but it must be remembered that the former is only obtained by a sacrifice of mechanical strength.

These methods refer more particularly to positive plates. Negative plates for batteries of these types have been made in a similar manner, although there is not so great a necessity for strength, and consequently the number of ribs is usually less.

The Faure system has resulted in more varieties than the Plante. The chief improvements have been the shaping of the grids so as to retain more firmly the active material and the discovery of pastes which set more firmly than those originally used by Faure. Various attempts have been made to increase the porosity of the active material by the addition of powdered pumice, asbestos, etc. The exact composition of the pastes used in the leading batteries of this type are kept secret.

With all these improvements the initial disadvantages still existed, although to a less degree. The next step was to cast the grid about active material formed into pellets. In the original chloride accumulator, buttons of fused lead chloride and zinc were set in operation and an antimonious lead framework cast round them under pressure. The formation process removed the chlorine and zinc, reduced the buttons of one plate to sponge lead and oxidized those of the other, to lead peroxide.

This method forms a very serviceable element with the important advantage that the strain caused by the expansion of the active material acts along lines radiating from the buttons and edgewise to the plate, consequently buckling is reduced to a minimum. This type, however, has been abandoned for a more improved pattern.

From these statements it would appear that a plate with the advantages of the antimonious lead grid for strength and non-corrosibility, and of the Plante formation for durability of active material would be the most efficient combination. A few batteries of this type have been constructed, of which I shall mention two.

In one case a framework of antimonious lead is used on which are supported long narrow coils of lead ribbon, giving a large, active surface with a correspondingly large capacity. As the coils are free to expand and contract little chance is left for buckling. On the other hand the lead ribbon is weakened by the continual formation of lead peroxide, and consequently there is a likelihood of its being broken and the whole coil disintegrated.

The most prominent example of this class is made of a lead antimony plate cast under pressure with a series of round holes three-quarter inch in diameter throughout. Into these holes is pressed corrugated lead ribbon coiled into spiral buttons.

Such a plate combines many advantages, the antimonious lead alloy cast under pressure gives the requisite strength and non-corrosibility. The lead buttons are "formed" by an improved Plante method and the expansion due to the lead peroxide wedges them so firmly in the plate that good contact is assured, the strain of expansion acts in a similar way to that described previously in the chloride plate, reducing buckling to a minimum.

The negative plates of all types present fewer difficulties. The expansion and contraction is much less, and therefore the tendency to buckle and to shed active material is diminished. One of the difficulties seems to be a tendency to form lead trees, or fine branches of lead from the negative over to the positive, thus causing a short circuit, unless the growth is removed by probing from time to time. This difficulty and the chance of plates short circuiting, if they are slightly buckled, has caused a great deal of experiment with different kinds of separators and envelopes to protect the plates, various forms of parchment, celluloid, pyroxylin, hard rubber, asbestos-cloth, porous earthenware, and wood have been tried; of these only two are really successful, i.e., perforated hard rubber sheets, and wood. The cost of supplying perforated hard rubber sheets for a large battery is prohibitive, and besides there is always a possibility of short circuiting through the small holes. The wood separator, however, is a decided success. Difficulty was at first experienced by the formation of acetic acid, which is a solvent of lead, but this difficulty has been removed by chemical treatment, and the wood separator is now used by the leading manufacturers.

The manufacturers of the last battery referred to have lately developed a new negative plate, which practically does away with the branching towards the positive, and also the shedding of active material.

This plate is formed of a rigid frame of antimonious lead, with square boxes covered with perforated sheets of antimonious lead; in the boxes are placed square pellets of the active material. The perforated covering so protects this that the expansion and contraction takes place altogether inside and any tendency to form lead trees is thus checked.

### OTHER FORMS.

Many novel and ingenious methods have been invented to prevent buckling and the shedding of active material. Among them is the use of earthenware grids, which support the active material and prevent it from any possibility of short-circuiting. While this is interesting from an experimental standpoint, it is of little commercial value, as the plate has low conductivity and the porous earthenware greatly increases the internal resistance of the cell. Another form is a battery built up of trays laid horizontally, one on top of the other, the active material is held by trays and the whole forms a battery, somewhat like the voltaic pile. The high internal resistance and the difficulty of keeping the trays properly insulated makes this of little practical use.

Various experiments have been tried with active material without any grid. The material itself is a poor conductor, and on this account graphite has been mixed with it, and the whole compressed into flat plates on framework of thin sheet lead, used solely to obtain good contact. In a prominent example the active material was formed of litharge and ammonium sulphate pressed into a flat plate. By various chemical processes this plate was formed into lead peroxide and hardened. A framework of lead was used to support it and to give the necessary contact, making the whole look like a school slate. The capacity was very high, being about 16 ampere hours per pound.

These methods, however, while interesting from an experimental standpoint, are also of very little use, as the active material rapidly disintegrates.

Several batteries have been constructed, in which two different metals are used for the plates. The most notable of these are the lead-zinc battery and Edison's nickel-iron battery.

There is one inherent drawback in all batteries in which two different metals are used, and that is the probability of small particles of one of the metals being carried across to the other, thus forming a local cell. In the lead battery if a small particle of one plate were to be deposited on the other, a local cell would be formed, but action would only take place until the foreign particle was converted into the same material as the plate. This, of course, could never take place in a cell using two different metals.

As regards Edison's battery, very little reliable information can be obtained on certain points. However, most of those who have made tests seem to be agreed. Recent tests made in London show the ampere-hours per pound to be undoubtedly higher than in the lead battery, the average voltage per cell is about 1.2 as against 1.95 in the lead battery. This makes it necessary to use about 70 cells of Edison's battery against 44 cells of lead battery, making a proportion of 5 to 7 in weight for the same watt-hour capacity, in favor of the lead battery. The internal resistance is high, causing bad regulation. The efficiency has been rated as low as 60 per cent., whereas the lead battery is rated from 75 per cent. up. The chief point urged by its advocates is durability; of this quality, however, we have no authentic proof. The writer heard, not long ago, that Mr. Edison had withdrawn his battery from the market, as he is not yet satisfied with it.

In the lead-zinc battery a peroxide plate is used for the positive, and a pure zinc plate for the negative. The advantages are higher voltage (about 2.5 per cell), and about 57 per cent. more capacity per pound in watt-hours. The drawbacks are the difficulties in redepositing the zinc, and in preventing small particles of it from being deposited on the peroxide plate, thus causing local action.

Notwithstanding the numerous varieties of storage batteries which have been produced, we are still limited to the Plante and Faure systems for all commercial work. Each has found its place and to-day the Plante system is almost universally used for stationary work, and the Faure for vehicle work.

There is one particular feature about the Plante battery which renders it especially superior to the Faure type for heavy discharges of short duration, such as are required in the regulation of railway loads, and this is that the capacity of the Plante battery at the one hour rate is 55 per cent. of its capacity at the 8-hour rate, while that of the Faure is only 46 per cent. Among the prominent types of batteries used to-day, the Plante for stationary work has a capacity of about 2.3 to 4.1 ampere-hours per pound of element, and the Faure for vehicle work about 4.8 to 5.6 The Plante negative is little used, as the advantages of this system, which appear in the positive, are not manifest in the negative. A good negative will often outlast two sets of positive plates.

DISEASES AND THEIR REMEDIES.

(1) Shedding of active material and loss of capacity.

(2) Corrosion of plates.

(3) Buckling.

(4) Sulphatation.

(5) Formation of lead growths from negative to positive.

1. Shedding of active material and consequent loss of capacity is caused by too rapid discharges, forming gases which force out the active material. Loss of capacity is further caused by the formation of excessive lead sulphate, which often clogs the pores of the lead sponge and forms a layer between the grid and the active material. The shedding of active material is also due to the following causes:

(1) Imperfect application of paste.

(2) Overcrowding of active material in the formation of Plante plates.

(3) Discharging at too high rates.

2. Corrosion of plates is caused chiefly by the presence of lead dissolving chemicals in the electrolyte; on this account it is advisable, in replacing loss by evaporation, to use distilled water, unless very pure water is otherwise obtainable.

3. Buckling is due to heavy rates of discharge, which cause unequal expansion. It can also occur at low rates, if the active material is unequally applied.

4. Sulphatation; an excess of lead sulphate is formed when a battery is over-discharged. It can be removed by overcharging at a low rate, but if allowed to remain long after formation it hardens, and on account of its low conductivity cannot be reduced by its recharging.

5. The formation of lead trees, which we have already mentioned, has been overcome by the use of the box negative and wood separators previously referred to.

APPLICATIONS.

There are many more uses of the storage battery than would occur to the layman. The simplest and most apparent application is "straight" storage work, as used in connection with automobiles. The efficiency of this method is not very high, about 75 per cent. being a fair average. However, by intelligent handling much higher efficiency may be obtained, 85 per cent. being about the maximum.

The next example of "straight" storage work is the use of batteries for supplying lights at night, after the generators are shut down. This necessitates some method of controlling the voltage of the battery, which will drop from 2.1 volt per cell at the beginning of discharge to 1.75 at the end, with an average of 1.92 to 1.95. The three standard methods of regulating this discharge voltage are: (1) resistance; (2) end cells; (3) counter E.M.F. cells. The resistance method is the simplest, but it is very unsatisfactory except when lights are burned continually, as every time a light is turned on or off the rheostat handle must be adjusted.

End cells are the most efficient method by far, for on 110 volt circuit 52 cells will be needed at the beginning of the discharge, and 63 or 64 cells at the end. These extra cells are cut in and out by means of an end cell switch. During the greater part of discharge 56 or 57 cells will be in use, the remainder only coming into service at the end, and thus they are only slightly discharged.

There is one drawback in the end cell system, and it is that the different cells require different amounts of charge, necessitating great care on the part of the attendant to prevent overcharging. On this account the counter E.M.F. cell is preferable in small plants, where efficiency is of less importance and where skilled attention is more difficult to obtain.

These counter E.M.F. cells are black grids without active material, immersed in dilute sulphuric acid, and they offer an opposing E.M.F. to the passage of the current of 2.3 to 2.5 volts per cell. The system is no more efficient than the resistance, but the fact that the potential difference of the counter E.M.F. cell only varies between 2.3 and 2.5 volts from any load from one lamp to full load, makes the voltage regulation almost equal to that of the end cell.

Another feature of storage batteries for work of this kind is the necessity of higher charging voltage than the 'bus pressure. The maximum is 2.5 per cell, making a total of 160 volts for a 110 volt battery. Thus extra pressure must be obtained to the extent of 50 volts.

There are three standard ways of accomplishing this, one by cutting the battery into halves and charging in parallel, thus making the total necessary voltage 80, the remaining voltage is cut down through resistance. This of course is very inefficient, but is suitable for small plants where it would be too expensive to install a booster.

The second method is to use a specially wound generator of 160 volts maximum, which will operate successfully at 110 volts. The voltage is raised as the charge proceeds and the discharge voltage controlled by counter E.M.F. cells or by tapping off the battery at the necessary point by means of an end cell switch.

The third method is to use a small shunt generator of 50 volts' capacity termed a booster, connected in series with the battery and 'bus.

REGULATING BATTERIES.

Storage batteries are now very generally used in regulating the rapid fluctuations in railway and other power circuits. Here the battery charges and discharges with fluctuations in the station load and consequently does not have time to reach the higher portion of the charging voltage curve, nor the lower portion of the discharge curve, thus raising the efficiency of the battery as high as 92 to 95 per cent. For work of this nature the battery will require a line voltage which fluctuates more than the battery voltage, or some means of regulating the latter so that the battery may take its share of the load automatically. A highly fluctuating voltage is not usually permissible except out on a long railway feeder where it cannot be helped. A battery installed at such a point will reduce the fluctuations in voltage and by supplying a source of power at the point of application will lessen the copper drop, as loads between it and the power house will be fed both ways.

Where constant potential is required, as when a battery is installed at the power house, a booster with a compounded field or some other regulating device is necessary to regulate the battery voltage.

Many different devices have been patented in the way of regulating boosters. Most of them consist of some system of a series field opposing a shunt field by which the fluctuations of the external load are made to regulate the booster voltage, so that the battery will discharge and charge automatically with the rise and fall of the external load above and below the average, keeping the generator load constant.

It would occupy too much space to give a detailed description of the various styles of boosters, and for the same reason I have not alluded to many of the interesting characteristics of storage batteries.

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Mr. Dion in commenting on the paper asked for a statement from the author as to the use of chemically pure acid. "The commercial acid is much cheaper; may it be used?"

Mr. Walker replied that commercial sulphuric acid is often sufficiently pure for storage batteries, but it never ought to be used without previous analysis. "There are certain organic impurities that are harmless, but traces of iron, chlorine, nitric acid or arsenic are very injurious. The necessity of using chemically pure acid has been largely done away with by the greater purity of commercial acid." Mr. Walker stated that the battery companies supply their own electrolyte, which is very carefully tested; hence, in his paper, he had emphasized the necessity of purity of water more than that of acid, because the former is more in the hands of the user.

Frederic Nicholls, vice-president Toronto Railway Company, extended an invitation to the members of the association to visit the new storage battery house just erected by his company. "Although it has been in operation only a very short time," said he, "its advantages have so demonstrated themselves that we are sorry we did not install a battery at an earlier date."

W. L. McFarlane was then called on to read his paper on "A. C. vs. D. C. Arc Systems."

Mr. McFarlane's paper, and the discussion on it, will appear in next month's Engineer.

On Wednesday evening two papers of exceptional merit were read, one on "The Curtis Steam Turbine," by Frank C. Smallpiece, and the other on "The Niagara Power Development," by K. L. Aitken. Both papers were illustrated with stereopticon views. Mr. Smallpiece and Mr. Aitken were warmly complimented on all sides for the research shown in their papers, and the admirable way in which they were presented. Summaries of these papers will be found elsewhere.

Thursday morning was spent by the convention in visiting points of interest in Hamilton. The party was carried by special cars to the Victoria Avenue sub-station of the Cataract Power Co., where the first stop was made. After allowing some time for the visitors to look over all parts of the plant, the party was taken to the new buildings of the Canadian Westinghouse Co., now in course of erection. Surprise and delight was expressed on all sides at the appearance of the buildings and surroundings. The feature that attracted most attention was the extensive, and in fact almost exclusive use of cement in construction. From the Westinghouse grounds the party was carried to the Deering works, the plant of the International Harvester Co. Here the convention party wandered at will over the extensive grounds and became quite scattered, some going to the sub-station, where the company receives its power direct from DeCew Falls, and some investigating the machine shops or pattern shops or moulding rooms, or other departments of the institution, that will, it is said, employ 3,000 hands when complete. There was some difficulty in getting the crowd together again, but the closing of the works for noon seemed to be effective in this regard, and the two cars were soon full and on their way back to headquarters at the Royal Hotel.

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When the convention assembled on Thursday afternoon, Roderick J. Parke, E.E., was asked to read his paper on "Aluminum Wire as a Conductor," of which the following is a summary:

## ALUMINUM ELECTRICAL CONDUCTORS.

By Roderick J. Parke, E.E.

Aluminum is so far the only material which possesses the requisite properties to render practical its substitution for copper. Since 1898, when it was first placed upon the market in solid drawn conductors, the consumption has rapidly increased until 1902, when the world's product was estimated at 8,000 tons per annum. The corresponding production of copper is estimated at 497,000 tons per annum, for all purposes. The statistics available up to the present, however, show that the production and consumption of aluminum is rapidly increasing and that it has become a very strong competitor of copper for electrical conductors.

There are now nine plants in the world producing aluminum, of which three are in America, two in France, and one each in Great Britain, Germany, Switzerland, and Austria. The total power utilized in the production of the aluminum is from 36,000 to 40,000-h.p., practically all water power.

The following figures are for commercial aluminum and commercial copper of sizes commonly used in practice, the copper being hard drawn:

| | Aluminum. | Copper. |
|---|---|---|
| Specific gravity | 2.68 | 8.93 |
| Conductivity (Matthiessen standard) | 62. | 97. |
| Tensile strength (per sq. inch) | 28000 | 45000 |
| Co-efficient of linear expansion (per F°.) | .0000128 | .0000093 |
| Co-efficient of temperature resistance | .00114 | .00117 |
| Modulus of elasticity | 9,000.000 | 14,000,000 |

(Commercial aluminum is 99.5 per cent. pure.)

From the above figures we deduce the following:

| | Aluminum. | Copper. |
|---|---|---|
| Cross-section for equal resistance | 1.56 | 1 |
| Diameter for equal resistance | 1.25 | 1 |
| Weight for equal resistance | .47 | 1 |
| Tensile strength for equal resistance | .96 | 1 |
| Price for equal cost | 2.13 | 1 |
| Rate of temperature change (resistance) | 1. | 1 |

We see at once that the principal difference, from an engineering standpoint, is that aluminum possesses less than half the weight of copper for equivalent resistance. This is a marked advantage and results in benefit in three ways: 1st. The cost of transportation of aluminum is less than that of copper. 2nd. The cost of erection of the aluminum is less. 3rd. The durability of the line is greater and cost of maintenace is less on account of the smaller strains to which poles, cross-arms, pins and insulators are subjected, (assuming equal spans).

An additional advantage of aluminum is that it retains for years, some of the grease used in drawing, and this grease prevents any great amount of sleet from forming upon it, thus avoiding one of the serious causes of interruption to service over pole lines. This result is rather surprising, but the fact has been well established.

It does not follow that sleet will never gather on aluminum wire anywhere, because in the neighborhood of railroads and manufacturing plants, the wires are likely to become coated with smoke or some other foreign substance upon which the sleet will form. In general, however, it may be safely assumed that sleet does not form upon aluminum wires.

To balance the advantages cited there are the following disadvantages: 1st. Difficulty in making joints. 2nd. Greater sag, due to larger co-efficient of expansion. 3rd. Insufficient strength for conductors of the sizes used for telephone and telegraph wires.

### JOINTS.

The difficulty of soldering aluminum is well known. This difficulty arises from three causes: First, because solder does not alloy with aluminum at a low temperature. It will alloy with copper at approximately 460 deg. F., but the alloying temperature with aluminum is about 200 deg. F. higher. Secondly, because of the high thermal conductivity of aluminum, the metal conveys the heat away very rapidly from the solder and the soldering iron, making it difficult to maintain a soldering temperature. And, thirdly, when aluminum is exposed to the air a thin invisible coating of oxide of aluminum instantly forms upon the surface, which must be removed to permit of the formation of an alloy between the solder and the clean metal. With other metals than aluminum, the oxide coating can be dissolved by means of soldering salts, but no such salt or flux has been discovered for aluminum, hence the difficulty in soldering it.

For joining aluminum wires smaller than No. 0000 B. & S. gauge, the two ends are inserted into a piece of flattened tube and the tube given two and one-half twists by means of two pairs of ordinary wire connectors. This makes a perfectly satisfactory joint of low resistance and as strong as the wire joined.

Larger sizes are conveniently joined in any of three ways. 1st. By means of the ordinary dovetail cable splice. (The Niagara Falls-Buffalo line, consisting of 500,000 c.m. aluminum cable, is joined in this way and has been in use three years with perfect satisfaction). 2nd. By means of terminals compressed on the ends of the cables at the factory, these terminals being threaded and thus adapted to be united in the field by a threaded stud. 3rd. By inserting the ends to be joined into a cast sleeve and compressing the sleeves between dies in a small portable press.

Taps are made by means of aluminum clamps, one of which carries a lug into which the tap wire is either soldered or secured by set screws. Soldering into a lug is one of the pieces of aluminum soldering which can be readily accomplished.

It will be seen from the above that the difficulties of making aluminum joints have been reduced to an extent which leaves almost no disadvantage whatever.

### SAG.

The sag of aluminum conductors is somewhat greater than that of copper in hot weather and on the ordinary spans, because the co-efficient of expansion of aluminum is 38 per cent. greater than that of copper. The sag is not as much greater, as might be expected, however, because the lower modulus of elasticity of aluminum causes it to contract more as the strain is relieved from it, and because the weight of aluminum, for equal areas, is only 3-10 that of copper, while the strength of it is 2-3 that of copper. This causes aluminum to start with a smaller minimum sag than copper.

One curious result of this is that whereas aluminum will have a maximum sag of three or four inches more than copper in a 100-foot span, it will have actually a smaller maximum sag in a 1,000-foot span, for while the span moves further, or deflects more rapidly, than copper, for a given temperature change, it starts with so much smaller sag at low temperature, that it never overhauls the copper, when long spans are used. On this account, and that of its small weight, it would seem to be the best material for long span work.

The writer has prepared a set of tables showing the tension of the various sizes of aluminum stranded conductors from 1,000,000 circular mills to No. 2 B. & S. gauge, when erected on standard spans ranging from 80 to 400 feet. These tables are based upon the table of tensions and deflections, prepared by the Pittsburg Reduction Company, and presented by Dr. F. A. C. Perrine and F. G. Baum, in a paper which these authors read before the American Institute of Electrical Engineers, at Philadelphia, May 18th, 1900. The deflections are calculated on the formula for the catenary, and the permissible tensions and corresponding deflections specified in these tables are based upon a maximum strain of 15,000 lbs. per sq. inch on the aluminum at 20 deg. below O.*

For 100 Ft. Spans
of
ALUMINUM STRANDED CONDUCTORS

T = Temp. of Atmosphere in Deg. F.
D = Deflection of Conductor in inches at Centre of Span.
The numbers represent the Dynamometer readings in lbs of tension.

| Gauge (B&S) | T=-20° D=1⅛" | T=-10° D=7¼" | T=0° D=10¼" | T=10° D=12½" | T=20° D=14⅜" | T=30° D=16" | T=40° D=17¾" | T=50° D=19" | T=60° D=20⅝" | T=70° D=21½" | T=80° D=22¼" | T=90° D=23⅞" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000,000 | 11904 | 1916 | 1352 | 1106 | 959 | 853 | 799 | 707 | 676 | 639 | 605 | 578 |
| 750,000 | 8929 | 1437 | 1014 | 829 | 719 | 644 | 600 | 530 | 507 | 480 | 454 | 433 |
| 600,000 | 7142 | 1149 | 811 | 664 | 575 | 515 | 480 | 425 | 406 | 384 | 363 | 347 |
| 500,000 | 5952 | 958 | 676 | 553 | 479 | 429 | 400 | 353 | 338 | 320 | 303 | 289 |
| 400,000 | 4762 | 767 | 541 | 442 | 383 | 343 | 321 | 283 | 270 | 256 | 242 | 231 |
| 0000 | 2523 | 405 | 287 | 234 | 203 | 182 | 169 | 150 | 143 | 136 | 128 | 122 |
| 000 | 2006 | 323 | 228 | 186 | 162 | 145 | 135 | 119 | 114 | 108 | 104 | 97 |
| 00 | 1592 | 256 | 181 | 148 | 128 | 115 | 107 | 94 | 90 | 85 | 81 | 77 |
| 0 | 1255 | 202 | 143 | 117 | 101 | 90 | 84 | 74 | 71 | 67 | 63 | 61 |
| 1 | 996 | 160 | 102 | 93 | 80 | 72 | 67 | 59 | 57 | 54 | 51 | 48 |
| 2 | 789 | 127 | 90 | 73 | 64 | 60 | 53 | 47 | 45 | 42 | 40 | 38 |

The use of a reliable dynamometer for stringing aluminum wire is strongly recommended, as it is a difficult matter to obtain linemen experienced in handling aluminum wire or who can be depended upon to provide that proper sags shall be set when stringing the wire. The use of the dynamometer does not involve any greater expense for the stringing of aluminum conductors than its non-use when stringing copper conductors, because the material can be handled much more easily and quickly than the copper can, size for size. The third objection for aluminum applies only to telegraph and telephone and similar work. The smallest size of aluminum, which it would be advisable to use in pole line work, is No. 4 B. & S. gauge, which has a breaking strength of about 1,000 lbs. which is the minimum strength that should be allowed in any conductor on a pole line, if uninterrupted service must be given over it. The principal uses of aluminum conductors have been for railway feeders, high tension transmissions and bus bars. Its use in Canada has not been very extensive, due to the fact that the beginning of its manufacture here is of rather recent date. But there are very few places in the United States where it is not found in service. Railway feeders have absorbed nearly two-thirds of what has so far been used. This use, presents no problems with which engineers are not familiar. For power transmission, its use has become very extensive. The longest and largest transmissions in the world are now made over aluminum. The following list and data may be of interest:

| Locations. | No. Cables. | Miles per Cable. | C.M. Area of Each. |
|---|---|---|---|
| Niagara Falls to Buffalo.... | 3 | 20 | 500,000 |
| Shawinigan Falls to Montreal | 3 | 85 | 183,708 |
| Electra to Mission San Jose | 3 | 100 | 471,034 |
| Colgate to Oakland ......... | 3 | 144 | 211,000 |
| Farmington River to Hartford | 3 | 11 | 336,420 |
| Lewiston, Me. ............. | 3 | 3.5 | 144,688 |
| Ludlow, Mass. .............. | 6 | 4.5 | 135,257 |

In addition to the foregoing list, the lines of the Telluride Power Transmission Company, in Utah, Colorado, and Montana, use nearly 2,000 miles of wire, involving transmission distances of 130 miles. The Cataract Power Co. has now 34 miles of aluminum.

For 200 Ft. Spans
of
ALUMINUM STRANDED CONDUCTORS

T = Temp. of Atmosphere in Deg. F.
D = Deflection of Conductor in inches at Centre of Span.
The numbers represent the Dynamometer readings in lbs of tension.

| Gauge (B&S) | T=-20° D=4⅜" | T=-10° D=14¼" | T=0° D=20⅜" | T=10° D=24⅞" | T=20° D=28¼" | T=30° D=31⅛" | T=40° D=35¼" | T=50° D=38¼" | T=60° D=40¾" | T=70° D=43" | T=80° D=45½" | T=90° D=47¾" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1000,000 | 11905 | 3869 | 2711 | 2211 | 1917 | 1776 | 1538 | 1948 | 1355 | 1281 | 1211 | 1155 |
| 750,000 | 8928 | 2902 | 2033 | 1658 | 1438 | 1332 | 1153 | 1086 | 1016 | 961 | 908 | 866 |
| 600,000 | 7143 | 2321 | 1627 | 1327 | 1150 | 1066 | 923 | 869 | 813 | 769 | 727 | 693 |
| 500,000 | 5953 | 1934 | 1355 | 1105 | 958 | 888 | 769 | 724 | 677 | 640 | 605 | 577 |
| 400,000 | 4762 | 1548 | 1084 | 884 | 767 | 710 | 615 | 579 | 542 | 512 | 484 | 462 |
| 0000 | 2523 | 820 | 576 | 469 | 401 | 376 | 326 | 307 | 287 | 272 | 252 | 245 |
| 000 | 2006 | 652 | 457 | 372 | 323 | 299 | 259 | 244 | 228 | 216 | 204 | 195 |
| 00 | 1592 | 417 | 362 | 296 | 256 | 237 | 206 | 194 | 181 | 171 | 162 | 154 |
| 0 | 1255 | 408 | 286 | 233 | 197 | 187 | 162 | 158 | 143 | 135 | 128 | 122 |
| 1 | 996 | 324 | 227 | 185 | 160 | 149 | 129 | 121 | 113 | 107 | 101 | 97 |
| 2 | 789 | 257 | 180 | 147 | 127 | 118 | 102 | 96 | 90 | 85 | 80 | 77 |

The question of the durability of aluminum conductors has frequently been raised, but so far aluminum has thoroughly established itself as a conductor offering no disadvantages which are not, in other respects, proportionately found in copper or iron. Aluminum is not readily oxidizable (the thin film spoken of above acting as a protecting coat, and preventing further oxidation). The greater number of mineral acids seem to have no chemical effect upon it, but chlorine in any of its unstable combinations is more or less detrimental to it, particularly where the conductors are exposed to sea air or where they are installed within the vicinity of certain chemical works. On the other hand, copper also is liable to be detrimentally affected by atmospheres laden with acid fumes. The most common impurity of aluminum is sodium which forms a very unstable alloy, readily attacked and corroded in even slightly moist atmospheres, but this defect can be provided against by the manufacturers. The tensile strength of any given aluminum conductor is increased somewhat by building it up of several smaller strands wound together, and since this form has been adopted, the writer has not learned of any instances in which conductors, properly installed, have broken on account of deficient tensile strength.

In connection with the installation of the electrical lighting power distribution system along the Welland Canal, now in progress, the Government purchased a quantity of alum-

*Two of these tables, those for 100 and 200 foot spans, will be found on this page.

inum and copper conductors for the transmission, distributing and telephone circuits.

The writer's specifications called for Nos. 0, 2, 4, 6, and 10, B. & S. copper conductors, the No. 6 B. & S. (for arc lights), to be medium hard drawn, and the No. 10 (for telephones), to be hard drawn. Tenders were also taken as alternative, for the supply of aluminum conductors of conductivities equivalent to those of copper conductors specified, and on comparing tenders it was found that the Nos. 3/0, 0, and 2, B. & S. aluminum conductors offered as equivalents for the Nos. 0, 2, and 4 copper, would cost less than the copper, and the aluminum was purchased. The aluminum equivalent for No. 6 copper, considering the tensile strength specified for the medium hard drawn copper, was found to be more expensive than the copper, consequently copper was purchased for the No. 6 and No. 10 gauges. The gauge numbers just mentioned for the aluminum conductors do not represent the correct relative proportions, as compared with copper, but are the nearest gauge numbers corresponding to the area of the aluminum conductors representing the copper equivalent.

The writer tested a proportion of the aluminum conductors for cross-section, tensile strength, torsion and resistance, and found the results given in the table below:

| Approx. Gauge | No. of Strands | Approx. Gauge of Strands | Twists in 6 inches | Breaking Strains per sq. in. | Elongation in 6" per cent. | Res. per 1,000 ft. at 75° F. |
|---|---|---|---|---|---|---|
| 000 | 7 | 7 B & S. | 21 | 29,100 lbs. | 2 | .106 |
| 0 | 7 | 9 " | 22 | 33,000 " | 2-2/3 | .172 |
| 2 | 7 | 10 " | 30 | 35,500 " | 3-1/3 | .262 |

These results seem to show that the tensile strength increases somewhat with a reduction in area of the smaller strands composing the conductor.

Also it will be seen that the conductivity of the aluminum conductors, as compared with that of pure copper conductors of the equivalent smaller gauges specified, is approximately 99.3, 98.5, and 99 per cent., respectively, and the respective breaking strains of the aluminum, per square inch, exceed the breaking strain usually allowed for soft copper (pure), namely, 23,600 lbs.

The questions are often asked, with relation to alternating current work, as to the respective capacity, self-induction and skin effects of aluminum and copper.

As aluminum is ¼ greater in diameter than equivalent copper, it is evident that the self-induction of the line will be the same when the aluminum wires are separated 25 per cent. more than the copper wires. The static capacity of the aluminum will be approximately 5 per cent. greater than that of copper, with the same spacing. The skin effect will be exactly the same with either of the two metals, since the effect of the greater diameter of the aluminum is exactly offset by its greater specific resistance, in making the calculations for the per cent. increase of resistance.

All practical transmission lines possess sufficient excess of self-induction over capacity to cause a slight lag in alternating currents, and the power factor over an aluminum line would therefore be slightly better than that over a copper line, on account of the smaller self-induction and greater capacity. The difference is small, but what there is, it is in favor of aluminum.

The market prices of aluminum and copper have always been such, for the past five years, that from 5 to 15 per cent. can be saved by the purchase of aluminum. For instance, the present market price of copper is about 14c. An equivalent price of aluminum would be 29.8c., whereas aluminum can be had to-day for 27.5c., or the equivalent of 13c. copper.

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At the close of his paper, Mr. Parke read an extact from a paper by L. B. Stilwell, which stated that in the Niagara Falls-Buffalo transmission line, 500,000 c.m. aluminum and 350,000 c.m. copper cables are used, and that during a high windstorm the vibration on the pole of the copper circuit could be felt from the ground up, while on the aluminum line there was no vibration. Aluminum, says Mr. Stilwell, seems to keep a constant position relative to the wind, whereas copper introduces stresses and strains on the line.

Mr. Lincoln criticized Mr. Parke's tables of sag, as being merely theoretical. He said there were causes other than temperature that would produce deformation in a copper wire, consequently the tables would not be borne out in practice. He had been told that when a short circuit occurs on an aluminum conductor, several spans of the aluminum disappear. He did not vouch for this, but said it might occur, and would be an objection to aluminum. He suggested in regard to Mr. Stilwell's remark, that perhaps the copper line was equipped with six wires, while the aluminum line carried three, making the weight on the former three or four times that on the latter.

Mr. Parke explained that the Pittsburg Reduction Co. made some experiments two or three years ago, and deduced a formula from which they calculated deflections. "In the 1900 Transactions of the American Institute, in Dr. Perrine's paper, you will find table No. 2, which was calculated and partly observed by the Pittsburg Reduction Co. They made a theoretical table and also a practical table and found the results agreed very closely." Mr. Parke mentioned a new point, namely, that in tying aluminum wire it is essential that a soft aluminum wire should be used, not larger than No. 2. In making connections to an aluminum wire, the use of copper or any other metal should be avoided, as aluminum is highly electro-positive in regard to all the other commercial metals. The aluminum is rapidly corroded, except where the copper is well soldered in and covered with rubber.

George Johnson's paper on Statistics of Electrical Progress in Canada was taken as read. Mr. Johnson's paper will be published in the Engineer next month.

P. M. Lincoln was then called on for his paper on, "Heavy Electric Traction," the substance of which was as follows:

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## HEAVY ELECTRIC TRACTION BY ALTERNATING CURRENTS.

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By P. M. Lincoln.

Again and again the prophecy has been made that electricity will take the place of the steam locomotive in through service in trunk lines just as it has replaced the horse as a motive power for local service on urban and suburban lines. The writer recently looked up the records of one of the large electric manufacturing companies to find the extent in which electricity has been substituted for steam. He had in mind the B. & O. tunnel, in Baltimore, the New York elevated lines and the proposed electrification of Pennsylvania and New York Central systems in and around New York. He expected to find many other examples where electricity had displaced steam. It was surprising to find that these examples were practically the only ones where such substitution has been made or actively undertaken in the United States. Even in the cases cited, the change from steam to electricity can hardly be said to have been made voluntarily. The New York Central decided to make the change only after an appalling accident, due to the obscuring of signals by the smoke of locomotives. In the case of the Pennsylvania Railroad the use of long tunnels, which would be fouled by locomotive smoke and gases, forced the adoption of electricity. In the case of the Baltimore tunnel, it required an edict of the courts before the change to electricity was made.

There seem to be two reasons for this lack of progress in displacing the steam locomotive, one a technical and the other a psychological reason.

First, till recently the only thing that the electrical engineer had to offer for trunk line operation was the direct current motor with a maximum voltage of, say, 700, and the necessary rotary converter equipment. In spite of the objections to this system, there has been no time within the last five years when the electric companies would not have undertaken to equip any trunk line and guarantee to render at least the same service as is rendered by steam. As to relative cost, there comes in the question of the character and density of the traffic. In many instances, the trunk line traffic could be done more cheaply by electricity even when the D. C. system was used. With heavy trains at long intervals, the handicap against electric traction increased until the point where practically no saving could be shown. The advent of the alternating current motor changed all this.

As to the psychological reason, the author says the electrical engineer must not only develop a system capable of handling the traffic of a trunk line, but he must convince the trunk line managers that he can handle their traffic. It is not the trunk lines that are putting in the many high-speed and heavy service electric roads, but a new type transportation engineer not bound by the traditions of the steam railroads.

It is appreciated that there is reason why the trunk lines should hesitate to adopt at once so radical a change as that of electricity as a motive power. The steam locomotive is doing its work and doing it well. Electricity, therefore, is not a necessity, the manager reasons, only an improvement —and of that proposition he is by no means convinced, and apparently does not desire to be convinced. Briefly, the question is: Can trunk line traffic be handled economically by electricity? Since the advent of the single phase A. C. motor our answer is an emphatic yes.

The advantages of the alternating over the direct current systems are apparent. Those which pertain particularly to heavy traffic are:

1st—Elimination of the trolley voltage limit resulting in: (a) Reduction of the current to be collected by use of higher trolley voltages. (b) Ability to use overhead contact conductors rather than third rail. (c) Increased economy both in copper and power.

2nd—Elimination of the rotary converter.

It is in the elimination of the trolley voltage limit set by the maximum allowable voltage that can be put on a D. C. motor that the principal advantage accrues to the A. C. system. To do the work now done by the steam locomotive requires enormous power. To get this power at even maximum voltages allowable in D. C. work involves currents from 4,000 to 8,000 amperes for a single train. The delivery of this power from sub-station to train means both expensive conductors and large losses. But the expense and the loss are perhaps not the greatest problems. These currents must be taken into the trains through a moving contact. This in turn demands a working conductor with a large surface, and is a problem that demands the most careful consideration. The usual solution is the third rail. This furnishes a working conductor with both a large surface and large current carrying capacity. But the expediency of equipping trunk line railway systems with third rail is, to say the least, doubtful. An overhead conductor is preferable for many reasons. Raising the voltage of the working conductor cuts this Gordian knot at once. For trunk lines a trolley voltage of 3.000 might be a minimum, and 10,000 volts would be proposed without hesitation. This latter voltage has been successfully used abroad under circumstances much more trying than would obtain with a single phase system, in that all three conductors of a three-phase system with 10,000 volts between any two were used as working conductors. In the single phase system only a single overhead conductor need be used.

Since the cost of conductors to take power from substation to train is the greatest single item in the D. C. system, this raising of the trolley voltage is a large factor in cutting down the cost of the A. C. relative to the D. C. system.

The elimination of the rotary converter is probably the difference next in importance. Not only does the use of alternating current eliminate a large element of first cost, and an element of loss averaging probably 10 per cent., but by making available higher trolley voltages, it also makes the number of sub-stations smaller and eliminates the necessity of skilled attendance at the sub-stations that are used.

Considering electrically-driven trunk line traffic, we have two problems to discuss:

1st—Electricity vs. steam, and

2nd—Direct current vs. alternating current.

As to the latter question, there is no doubt. As to the first, the following points of advantage in electric drive may be offered:

1st—Reduced Weight of Locomotives—Forty-five per cent. of the weight of a steam locomotive and tender is about the average available for traction. In the electric locomotive every pound is available for traction. The weight of an electric locomotive, so far as tractive effort is concerned, may be cut down to at least half that required by steam, and as the weight of locomotive and tender constitutes 5 to 25 per cent. the weight of the train, electric traction can save from 2½ to 12½ per cent. of the power required under steam service. In other words, considering tractive effort alone, the live freight per train may be increased 2½ to 12½ per cent. with electric drive.

2nd—Uniform Torque.—Another condition that will serve to enhance the difference in weight is the uneven torque exerted by the steam locomotive within a single revolution of the drivers, as compared with the perfectly even torque exerted by the electric locomotives. A given weight on drivers is therefore more effective in the electric than in the steam locomotive.

3rd—Perfectly Balanced Drivers.—In this respect the electric locomotive is decidedly superior to the steam locomotive, where a perfect balance is an impossibility. At high speeds, therefore, the pounding of the steam locomotive on the track, one of the greatest elements in the deterioration of the permanent way, is entirely avoided by the use of electric drive.

4th—Fewer Repairs.—Electric railway motors have been known to make a mileage of as much as 450,000, requiring renewal of bearings only. Such a record with a steam engine and boiler under such conditions is unthinkable, as well as unreasonable to expect in view of the greater number of parts and the reciprocating motion. On account of this greater sturdiness of the electric locomotive, it follows that to render a given service fewer electric than steam locomotives will be required, because the proportionate number in the round-house will not be so great. The result is not only a smaller repair bill but also a smaller number of machines to provide, house and care for.

5th—Utilization of Water Power.—The use of electric traction gives an opportunity for the utilization of water power that is impossible with steam. This is of particular interest to Canadians, because of the scarcity of coal and the abundance of water power. This same consideration has caused the Swedish Government to determine to change all the railroads of Sweden from steam to electric drive, and the first active steps looking toward this change have already been taken.

6th—Multiple Control.—The electric drive lends itself easily to distant control. It is possible to subdivide the drive into relatively small units and place them at intervals through the train, still retaining control over the individual units at a central point. This avoids the necessity of concentration of weight at the front of the train, as well as the excessive draw-bar pulls, both of which problems are of no small dimensions in steam practice.

7th—Smoke and Cinders.—The abolition of the smoke and cinders of steam locomotives, though it does not add to the economy of the electric system, still is an advantage vastly appreciated by the travelling public.

8th—Economy.—All the points above mentioned are in the direction of increased economy. In addition, however, we have in case steam power is used, the vast difference between the economy that can be obtained from relatively large stationary engines operated with condensers on the one hand, as against the locomotive on the other, which must run non-condensing and in which the losses by radiation, relatively small grate area and changes in load are severe. The question of relative economy between steam and electric motive power on trunk lines was considered by Mr. A. H. Armstrong, in a paper read before the Canadian Society of Civil Engineers, November 19th, 1903. From his analysis and conclusions, it is safe to assert that nine-tenths of the trunk line traffic on this continent can be operated more economically by electricity than by steam. This showing is made, too, on the basis of using steam generated power. The showing is bound to be much better where water power is available, as is the case throughout the whole of Canada.

In reply to various questions, Mr. Lincoln gave the following additional information:

A single-phase system requires only two conductors, one of which may be the rail. With polyphase it is necessary to have at least two conductors beside the rail. The frequency first proposed was 16 2-3 cycles per second, but that has since been changed to 25, the standard for power purposes now. The motor is practically a D.C. motor—a series motor with laminated field, so designed as to work on A.C. If you raise your frequency, it still operates, but the power factor becomes lower. If the frequency is raised too far, sparking will be produced at the commutator. The maximum voltage at the motor is about 150, or for steam railway practice, as high as 500. The trolley voltage is limited only by the line insulation. The air-gap is very nearly the same as that in an equivalent D.C. motor—about ⅛ in a 100-h.p. motor. One feature in the A.C. motor, tends to limit bearing wear. If the armature gets out of centre, local currents are set up to make the magnetic side-pull practically nil.

An A.C. motor is also a D.C. motor, but it is not good practice to make the equipment so that it will operate on both. The capacity of a motor is greater as a D.C. motor.

Any method of regulating voltage will regulate speed. The rheostat method may be used as well as a number of other methods, such as bringing loops out of the transformer and attaching the motor to different loops. "We propose putting on each car an induction regulator connected between the motors and the transformer, so that by moving the primary of the regulator through an arc of 180 deg., its voltage may be added to or taken from the transformer."

This motor is just the type for work that demands a variable speed motor.

The single-phase system has not yet been put into actual service, except on what may be called an experimental line in East Pittsburg. The high voltage trolley is coming, but I do not think it wise to jump from 500 volts to 10,000 volts. I would recommend 1,000 or 2,000 volts at present. But on heavy railway lines higher voltage should be used. The trolley voltage for practically all the lines we have sold is 1,000 volts. Step-down stations are provided on the line at intervals of five or seven miles. There is no feeder on the lines, nothing but the trolley. One of these lines is at Indianapolis and Cincinnati, 53 miles. Another is the Fort Wayne and Springfield, Ind., 21 miles. Others are at San Francisco, Philadelphia, Atlanta, Cheboygan, Wis., and Jamestown, N.Y. None is less than 20 miles long. The first will be in operation this fall.

There will be no attendants at the sub-stations, as all apparatus will be automatic. The trolley is one that cannot get off the wire. The system, as a whole, costs at least 15 per cent. less than a D.C. system.

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An invitation for next year's convention was received from Peterboro, but as it was thought better that the Association should go east, it was decided to hold the convention in Montreal.

The election of officers resulted as follows: K. B. Thornton, Montreal, president; A. A. Wright, M.P., Renfrew, 1st vice-president; R. G. Black, Toronto, 2nd vice-president; C. H. Mortimer, Toronto, sec.-treas. Executive Committee, A. B. Smith, A. A. Dion, G. Henderson, B. F. Reesor, J. A. Kammerer, A. E. Evans, C. B. Hunt, John Murphy, Fred. Thompson, J. J. Wright.

C. B. Hunt reported for the Legislative Committee that no fighting had been necessary during the past year, but that it would still be necessary to watch the existing law which will sooner or later be attacked by a growing agitation for municipal ownership. It behooves existing companies to deal generously with the public and educate them to understand that electric light companies are not veritable gold mines, or otherwise robbers, which some agitators would lead them to believe.

The business sessions of the convention then adjourned.

In the evening the annual banquet was held.

Friday morning the convention was carried by special car on the Grand Trunk to St. Catharines, whence buses and carriages were provided to cover the four miles to the DeCew power-house. After spending a couple of hours in investigating the power house, penstocks, etc., and in doing justice to the ample luncheon provided by the Cataract Co., the party returned to the railway station and from there went by G.T.R. to Niagara Falls. The members then scattered over the ground occupied by the various power companies. The C.E.A. button was in evidence everywhere, and groups of men could be seen here and there earnestly discussing their surroundings, only to be interrupted by the sudden appearance of a construction train, or the unexpected movement of a derrick. The scattered electricians reassembled, however, in time for the five o'clock train to Hamilton, and with the return of the party to that city, the convention was over.

(Note.—The DeCew Falls and the Niagara Falls developments were described in the June number of the Canadian Engineer.)

## THE CURTIS STEAM TURBINE.*

By Frank C. Smallpiece.

The author, after sketching the early applications of the turbine principle, stated that the first announcement regarding the Curtis Steam Turbine was made in April, 1903. The design of this turbine is based upon the ideas of Chas. G. Curtis, of New York, which are the subjects of patents granted in 1896. Subsequently, machines of this type were built and tested at the Schenectady Works of the General Electric Company. The results of these extended investigations were so favorable that arrangements were made for the manufacture of the turbine.

Before undertaking commercial production, however, considerable time was spent in further development, under the direction of W. L. R. Emmet, of the General Electric Company. A number of features of the present machine were added during this period, the most important being the adoption of the vertical type of machine. Experience has demonstrated the reliability of the vertical turbine and all turbo-generator sets of 500 K.W. and upwards are now constructed in this form.

About a year ago the first Curtis turbine set built by the General Electric Co. for use outside its factories, was put into operation at Newport, R.I. Since its installation, two other machines have been placed in the same station. These turbines have carried the whole load of the station without interruption since installation. In Chicago, there have been installed three 5,000 K.W. units, two of which have been in regular service for some months. At the present time there are in regular operation Curtis turbines, aggregating 32,000 K.W. capacity in 28 units of 500 K.W. and upwards.

The action of the steam turbine involves the conversion of the heat energy of the steam into velocity by expansion. This rapidly moving steam is directed into buckets or vanes arranged upon the periphery of the revolving element where the kinetic energy of its particles is given up by impact. In its elementary form the steam turbine consists of one or more steam jets impinging upon the vanes of a single wheel, but the spouting velocity of steam is so enormous, that for most efficient action such an arrangement requires a wheel velocity much in excess of the safe working limit of the best materials. Further, unless a wheel of excessive diameter be employed, it is necessary to use gearing to reduce the speed for practical purposes. For this reason the efforts of inventors have been towards the design of a turbine which shall combine high efficiency with a speed permitting direct connection for electrical or marine purposes. In all turbines the expansion which takes place is so rapid that it necessarily follows the adiabatic line. The steam is directed upon the revolving buckets, either through stationary vanes, similar to the revolving buckets in form, but reversed in curvature, or by expanding nozzles which efficiently convert the energy of the expanding steam into velocity. In the latter case the conversion of the inherent energy of the steam into kinetic energy is carried out in the nozzle to any desired limit.

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* From a paper read before the Canadian Electrical Association.

Referring to Fig. 1, we have a sectional view of the expanding nozzle, such as is used in the Curtis Steam Turbine. Steam is admitted from the space above and converges towards the narrowest section known as the throat. At this point its pressure has fallen to .58 of the initial pressure and a corresponding portion of the heat energy of the steam has become active in expansion, thus performing work upon itself in giving velocity to its own particles. Beyond the throat, if it is desired to increase the velocity still further, the same energy transformation continues. To allow further expansion, however, it is necessary to increase the cross sectional area of the nozzle. This is evident when we consider that the work done by the expanding steam varies approximately in direct proportion to the number of expansions and also as the square of velocity. Hence the volume of the steam increases much more rapidly than the velocity, and it is necessary to provide for this increased velocity by enlarging the section of the stream.

It is difficult to appreciate the completeness of this energy transformation. Assume the case of a nozzle used to expand steam from 150 lbs. gauge pressure to an absolute pressure of 2 inches of mercury, or 28 inches vacuum. Entering the nozzle the steam is at 150 lbs. pressure, and its energy exists in the potential form. At exit from the nozzle, a few inches distant, the pressure has fallen to 28 inches vacuum, and the specific volume of the steam has increased some 125 fold. The same energy (neglecting slight friction losses), exists in the particles of steam which issue from the nozzle at about 4,000 feet per second. The energy of a moving body being proportional to the square of its velocity, one pound of steam under these conditions represents 250,000 foot lbs. of energy.

The writer then briefly described other leading commercial types of turbines, namely, the De Laval, the Parsons, the Rateau, and the Reidler-Stumpf, most of which were described in Prof. Jacquays' article in The Canadian Engineer for December, 1903.

The great advantage of the Curtis Steam Turbine, as compared with other types, is the low speed of rotation which it is possible to obtain without sacrifice of efficiency. In its present construction the expansion takes place in several stages or separate compartments, each stage being furnished on the admission side with suitable nozzles which direct the steam into the bucket wheels in that stage. In each stage are arranged bucket wheels carrying two or more rows of buckets, while between successive rows of moving buckets are the intermediates or stationary buckets reversed in direction. The steam from the nozzle strikes the first row of moving buckets, giving up some of its energy, shown in loss of velocity. Leaving the moving buckets, the steam is guided through the stationary vanes and impinges upon the second row of moving buckets, giving up another portion of its energy. Should there be more than two rows of buckets the same course is followed, rebounding from stationary to moving buckets, until almost brought to rest on leaving the last wheel. This process is known as fractional abstraction, and in this way high velocity steam is made to efficiently impart motion to a comparatively slowly moving element.

The arrangement of nozzles in the Curtis Turbine is clearly shown in Fig. No. 1. Instead of a number of separate streams, the flow is directed in a belt upon the buckets. The nozzles occupy only a small part of the circumference in the first stage, the breadth of the steam belt increasing in succeeding stages. In the last stage, where the volume of steam is very large, steam is generally admitted all round the wheels. As the steam admitted to the turbine is directed upon only a portion of the circumference, it is possible to obtain any desired speed of rotation within wide limits by using a wheel of suitable diameter. This is an advantage not presented by turbines in which steam is admitted all round the wheels.

Governing is accomplished without loss of pressure by throttling. The admission of steam to the sections of the first stage nozzles is controlled by separate valves, which operate consecutively. With a change of load the breadth of the active steam belt is varied automatically by the closing of one or more of the end sections. In this way the supply of steam is not dependent upon action of a single valve, and a failure of one of the sectional valves only serves to throw the work upon the next in order. In some of the first machines, this sectional governing was carried out simultaneously in all stages. However, as the economy is not materially improved by this arrangement, it is not employed. Hand operated valves, opening additional nozzles, are sometimes employed in the latter stages. These are set to give the best possible conditions under the average of load of the machine, but are not adjusted for fluctuations of short duration. For overload conditions automatic valves are occasionally used to limit the rise of pressure by opening additional nozzle sections in the next lower stage.

The governor itself is of the centrifugal type and is attached to the top of the generator shaft. The motion of the governor, by electrical or mechanical means, is made to operate small pilot valves, which in turn admit or exhaust live steam from the spaces behind the governing valves. In the case of electrically operated valves the governor actuates the fingers of a small controller, opening or closing the circuits of electro magnets, which in turn operate the pilot valves. The current for these magnets is taken from the exciter bus-bars, and the arrangement is such that, in case of failure of the current supply, the governing valves close, avoiding the possibility of a dangerous increase in speed. When the electrical control is not employed the pilot valves are actuated directly from a suitable cam cylinder, which is turned by the governor. For synchronizing purposes a device is used in conjunction with the governor whereby the speed of the turbine can be varied considerably while the machine is in operation. In large machines this synchronizing device is operated by a small motor, controlled from the switchboard.

As an additional safeguard against possible racing of the turbine, simple emergency tripping devices are arranged which act at a speed somewhat in excess of normal, and close a butterfly valve in the main steam pipe. At the same time a valve in the lower part of the machine is operated and breaks the vacuum.

A distinctive feature of the Curtis Turbine, as compared with other types, is its vertical form. The saving in weight and floor space is very considerable, the weight being from 15 to 25 per cent. and the floor space less than 10 per cent. that of a slow speed engine generator set of the same capacity. Fig. No. 2 shows a comparative view of a 500 K.W. 100 R.P.M. Hamilton Corliss Cross Compound Engine with generator and a 500 K.W. 1,800 R.P.M. Curtis Turbo-Generator unit. The engine unit occupies 750 square feet and weighs 277,000 lbs., as compared with 50 square feet and 38,000 lbs. for the turbine set. The adoption of the vertical form of machine called forth considerable criticism, but the satisfactory results obtained have exceeded the expectation of the designers. The step bearing consists of two cast iron plates, one of which is keyed to the foot of the shaft, the lower plate being stationary. Oil under pressure enters a central recess in the faces of the plates and is forced outwards to the circumference. Thus the whole weight of the moving element is carried upon a thin film of oil. The upper bearings serve only as guides for the shaft, and are not subjected to any load. The mechanical friction of this arrangement is almost nil. With the vertical type of machine there are none of the difficulties in vibration met with in the supporting of a heavy rotating element between horizontal bearings at a considerable distance apart. There is less tendency of the shaft to spring and cause rubbing, and as the whole weight is carried by the step bearing, the diameter of the shaft need not be reduced at the journals but may be made as large as desired. The compact arrangement of the wheels and casing makes the expansion very small, and furthermore, all expansion is upward and does not produce the distortion encountered in horizontal machines.

In a station comprising a number of vertical units, the oil is supplied from one or two steam-driven pumps, and as a precaution against failure, a dead weight accumulator may be employed, capable of supplying high pressure oil for a limited period. The worst that can happen in case of failure of the oil pressure is a grinding of the step bearing plates. These can either be faced off or easily and cheaply replaced by new blocks. When the forced supply of lubricant to a horizontal machine fails, it usually results in cutting the shaft as well as the bearing.

It is of interest to note that in the Curtis Turbine there is no end thrust due to the action of the steam on the buckets. The angles of entrance and of exit being the same in a moving bucket, the components of the force, exerted in a direction parallel to the shaft, are equal and opposite in sign. The pressure of the medium in any stage is the same at all points. The absence of end thrust is demonstrated in that there is no rise in the oil pressure on the step bearing of the machine when steam is turned on.

A very high degree of expansion is desirable, though not essential, for favorable results in the Curtis Turbine. Owing to the compact arrangement of the casing, the chances of air leakage are extremely small, and a high vacuum is easily maintained where a liberal supply of condensing water is available.

In general, the surface condenser is preferable for use with steam turbines. This type permits a higher vacuum and also allows the return of the condensed steam to the boiler. No oil comes in contact with the steam during its passage through the turbine. Consequently, the exhaust steam is free from impurities.

When the amount of cooling water is limited, the jet condenser may be found advisable, but the vacuum attainable with this type of condenser is not so good on account of the presence of entrained air in the injection water.

As to whether the somewhat higher initial cost warrants the installation of surface condensers is a matter to be decided by local conditions. The price of coal, the load factor, temperature and quantity of cooling water available, and other considerations may make it advisable to provide for a 27-inch vacuum or even a 26-inch vacuum in place of a 28-inch vacuum or higher. Nevertheless, in most cases the gain in economy, due to high vacuum, warrants the expense entailed. Accordingly, stations equipped with Curtis Turbines are almost, without exception, provided with condensing plants to secure a vacuum of at least 28 inches.

Machines known as the Condenser Base Turbines form a new type. Several of these are under construction, the condenser being contained in the turbine base. The simplicity of this arrangement, the short direct path of the steam to the condenser, and the saving in floor space are at once evident. Figure No. 3 shows a 2,000 K.W. set of this type.

The losses due to friction and windage in the Curtis Turbine remain in the form of heat, and are thus largely useful in re-evaporating the water of expansion. Drier steam is in this way supplied to the next stage. Unlike the reciprocating engine, the accidental carrying over of water from the boilers produces no ill effects in the turbine.

Superheated steam up to any temperature commercially available, may be used in the standard Curtis Turbines, the design of the apparatus allowing either dry or superheated steam to be used at will.

A limited series of tests indicates that in the Curtis Turbine the use of superheat decreases the steam consumption at the rate of about 1 per cent. for every 14 degrees F. Similar considerations as affect the choice of vacuum apply largely in the case of superheaters. The initial cost and maintenance, and cost of fuel have to be considered. Recent experiments indicate that at high temperatures the specific heat of superheated steam at constant pressure is considerably in excess of the value heretofore assumed (viz., 48). Hence the reduction in water rate due to highly superheated steam may be gained at the expense of too much fuel. However, as a general rule, a moderate amount of superheat is advisable.

It will be readily understood that the problem of generator design for steam turbines involves a great many features not encountered heretofore. The construction of the revolving element must be of great strength and rigidity. All parts must be balanced separately with the greatest care. In the case of revolving field machines, the field core is built up of steel plates rivetted together in sections of one-half to one inch thick, depending on the size. Each of these sections must be balanced accurately before assembling. The edgewise wound field coils are subjected to heavy pressure in baking, and are arranged so that shifting on the poles is impossible. The assembled field is given a balance under running conditions. This is done after the turbine is set up by the addition of suitable weights. Similar methods are employed in the balancing of direct current armatures, the commutator, armature heads, etc., being all balanced separately and the punchings balanced in sections.

Data regarding the performance of Curtis Turbines have up to the present been largely confined to results obtained in the factory, and few opportunities for official tests have been presented. The tests given below were made upon a 500 K.W., 60 Cycle, 2,300 V. set, operating at about 1,800 R.P.M., and installed in the Newport Station of the Massachusetts Electric Company. Current from this station is supplied for railway and lighting, the railway work being the most important part of the load. The tests were conducted by George H. Barrus, consulting engineer, representing the owners, and R. H. Rice, recently of Rice, Sargent & Company, and A. R. Dodge, acting for the General Electric Company.

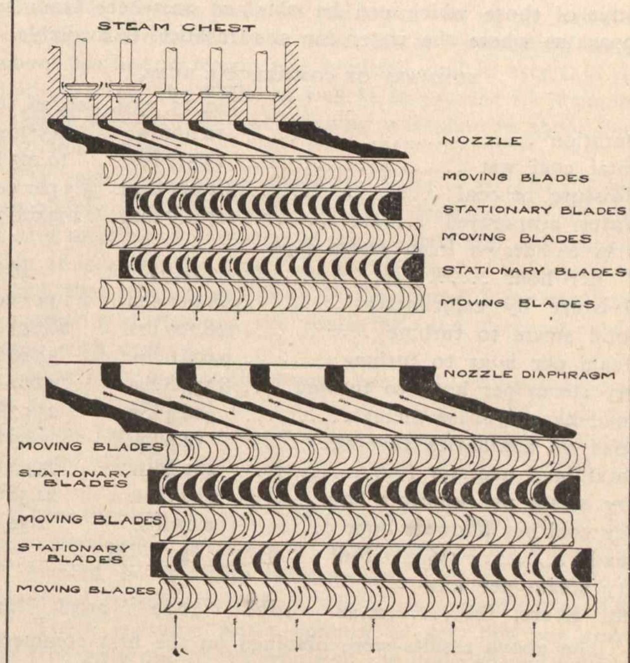



DIAGRAM OF NOZZLES & BUCKETS IN CURTIS STEAM TURBINE.

FIG. 1.

Tests were made and water rates measured with various conditions of fixed load, with and without superheat, as shown by the curves and tables. Tests were also made with such commercial loads as are daily experienced in this plant, and the steam consumption per kilowatt hour under working conditions was ascertained by careful determinations of the total water condensed, and of the load as measured by many instruments and as recorded by carefully checked recording wattmeters.

Attention is specially called to the records of operation under commercial load, since they illustrate the great practical advantage afforded by apparatus of this kind. The load during these tests fluctuated incessantly with an average sudden variation of about 100 kilowatts, and with an average load of 253 kilowatts in one case and 421 kilowatts in another. In the former case the average steam consumption per kilowatt hour was only 22.38 lbs. The best steam engines now used for such purposes in this country would consume at least 28 pounds of steam per kilowatt hour under such load conditions, and in most cases the consumption would be considerably larger. The consumption of 20.73 pounds per kilowatt hour with an average of 421 kilowatts for such variable load is also a very fine performance. During tests the steam pressure was about 145 pounds and the vacuum about 95 per cent. The speed regulation from no load to full load was 8-10 of 1 per cent. Momentum speed variations at full load did not exceed 1.6 per cent., and under the commercial load of the station showed a maximum of 2.1 per cent.

The liberal design of the generator is shown in the temperatures. After a run of eight hours at 660 K.W., the highest temperature rise was 38 degrees C.. and with a load of 764 K.W., or 53 per cent. overload for two hours, no further increase in temperature was noted.

In considering these practical results, it should be borne in mind that the plant which gives these results possesses many other practical advantages which conduce to economy. All the condensed water in this plant since it originally started has been returned directly to the boilers, and the boilers are consequently at the present time in a perfectly clean condition, although the natural water supply of Newport is bad. During all this time no oil has passed into the boilers nor has any been wasted. All the oil in use is simply circulated and used over and over again. The absence of air leakage in the turbine and the absence of air in the feed water greatly simplify the maintenance of good vacuum. which, of course, contributes to these excellent, practical results. The whole arrangement of this plant is compact, simple and easy of maintenance, and the results are representative of those which can be obtained anywhere from such apparatus where the water for condensation is available.

SUMMARY OF COMMERCIAL RUNS.

| | Jan. 15, 1904. | Jan. 26, 1904. |
|---|---|---|
| Duration | 12 hours. | 15 hours. |
| Total coal wet | 13,517 lbs. | 10,205 lbs. |
| Moisture in coal | 3.1 per cent. | 5.5 per cent. |
| Water evaporated | 127,267 lbs. | 104,026 lbs. |
| Drip withdrawn from steam pipe per hour | ...... | 46 lbs. |
| Moisture by calorimeter | 3.05 per cent. | 2.1 per cent. |
| Total steam to turbine | 108,100 lbs. | 86,833 lbs. |
| Steam per hour to turbine | 9,008.6 lbs. | 5,789 lbs. |
| Dry steam per hour to turbine | 8,733.8 lbs. | 5,667 lbs. |
| Load by polyphase meter | 406.4 kw. | 234.7 kw. |
| Load on auxiliaries (average) | 14.9 kw. | 18.5 kw. |
| Total load average | 421.3 kw. | 253.2 kw. |
| Dry steam per kilowatt hour | 20.73 lbs. | 22.38 lbs. |
| Dry coal per kilowatt hour | 2.67 lbs. | 2.54 lbs. |

| Load | 1½ | Full | ¾ | ½ | ¼ |
|---|---|---|---|---|---|
| Dry steam per kilowatt hours, lbs. | 20.22 | 19.78 | 20.69 | 21.38 | 27.85 |

The above results were obtained on the first commercial machine, and changes have since been made which greatly improve the economy. From incomplete tests upon a new 2,000 K.W. set, it would seem that the results obtained on the first machine can be improved by at least 15 per cent. Complete figures on these tests are not available at present.

## RECENT INCORPORATIONS.

Henry F. Gooderham, and others, have been incorporated as The Canadian Iron Co., Limited, with a capital of $2,000,000, to carry on mining, milling, reduction and development. The head office is at Ottawa. The provisional directors are: H. F. Gooderham, H. N. Barry, and R. Weir.

The Star Chrome Mining Co., Limited, has been incorporated at Montreal, with a capital of $450,000. Those incorporated are: F. Bayard, P. E. Beaudry, J. A. Brossard, P. Desforges and E. E. Gauthier, all of Montreal.

The Rio de Janeiro Light and Power Co., Limited, was recently incorporated at Toronto, with a capital of $25,000,000. The incorporators are: J. S. Lovell, W. Bain, R. Gowans, E. W. McNeill, M. Lash, and others.

W. M. Campbell, G. T. Merwin, and others, have been incorporated as the International Gas Appliance Co., Limited, with a capital of $49,000. Head office to be Toronto.

The B. C. Gazette announces the incorporation of the Chilliwack Power and Light Co., Limited, with capital of $500,000.

The following incorporations are announced in the Ontario Gazette:

The Richter Manufacturing Co., Limited, has been incorporated to manufacture and deal in burlaps, canvases, and other fabrics for interior decoration. The provisional directors are: P. C. J. Richter and F. H. Lancaster, of New Jersey, and R. W. Menzie, J. McK. Murray and R. E. Menzie, of Toronto. Capital, $50,000.

The Alvinston Power Co., Limited, to carry on business of an electric light company in all its branches. The provisional directors are: R. McLaughlin, A. S. Harkness, D. C. Munro, L. I. Hunt and T. A. G. Gordon. Capital, $40,000.

The Ronan Motor Co., Limited, has been incorporated in Toronto, with a capital of $100,000, to manufacture engines, motors, vehicles, etc. The directors are: J. S. Lovell, Wm. Bain, R. Gowans, E. M. McNeill, R. Richardson, M. Lash and W. Gow.

The Dominion Brass Works, Limited, has been incorporated in Port Colborne to manufacture and deal in all kinds of brass goods and hardware, and to acquire the Canadian patents for the manufacture of the Huxley Valve. Provisional directors: W. R. P. Parker, E. H. Bickford and W. A. Hare. Capital, $100,000.

The Canadian Adjustable Bearing Co., Limited, with a capital of $100,000, has been incorporated. The head office is to be at Windsor, and the provisional directors are: J. F. Harrigan, A. W. Atterbury, I. W. Durfee, F. H. McPherson, and A. F. Falls.

The Sovereign Oil Co., Limited, has been incorporated, with read office at Combe, Ont. The directors are: J. C. Winters, Wm. McIntosh and J. A. McIntosh. Capital, $50,000.

The following changes are announced by the Ontario Gazette:

The capital stock of the Elginfield Oil and Gas Developing Co., of Dutton, Limited, has been increased from $49,000 to $200,000.

The Guelph Axle Manufacturing Co., Limited, has changed its name to the Guelph Spring and Axle Co., Limited.

—On June 14th, His Lordship, Mr. Justice Lemieux, declared void the resolution of Sherbrooke City Council of 28th October last, which accepted the tender of R. W. Arkley, of $38,000, for building the dam at the Westbury Basin Water Power. A day's notice had not been given the councillors, hence the proceedings of the meeting were null and void.

## THE TORONTO AND NIAGARA POWER DEVELOPMENT.*

Toronto, as a manufacturing city, has recently experienced great development, due almost entirely to its location, and shipping facilities, and not because cheap power was obtainable. The geographical conditions which surround the city are ideal for expansion, and it is safe to assume that with cheap and unlimited power available, the growth of the city, as a manufacturing centre, would be simply enormous.

These facts have been patent for some time, and it is, therefore easily understood how the Niagara power scheme came into existence. Before any definite steps were taken, the matter received considerable attention, for there were many obstacles to be overcome. Almost all the points raised, however, have been cleared up, and we have to-day the Electrical Development Co., whose charter calls for the development of power at Niagara Falls, Ont., and the Toronto and Niagara Power Co., which will transmit and distribute the power generated.

On January 29th, 1903, an agreement was entered into between the Commissioners of the Niagara Falls Park and Messrs. Mackenzie, Pellatt and Nicholls, giving these gentlemen the right to take water from the Niagara river, at Tempest Point, for the purpose of generating electricity to the extent of 125,000 electrical horse power.

*From a paper read by K. L. Aitken, of Toronto, at the Canadian Electrical Association.

On February 18th, 1903, the Electrical Development Co. of Ontario was incorporated, and this company took over the agreement just mentioned. As soon as possible, plans were drawn up and contracts for various portions of the work let, so that no time has been lost in expediting operations since the formation of the company.

The low-water flow from Lake Erie is somewhere in the neighborhood of nine million cubic feet per minute, and it is estimated that a larger percentage of this (possibly 65 or 75 per cent.), is owned by the Canadian Government

The selection of the site of the power house was attended by a careful study of the conditions which have existed for the last six years in heavy water power installations, and particular attention was given to the plants in operation and under way, both on the American and on the Canadian sides of Niagara. Most of these installations have been made on a very large scale, and due consideration was given to the experiences of all the companies.

The construction of a deep, vertical wheel pit, and the discharge of water by the use of a low-level tunnel, having been demonstrated successful, and applicable to the geological conditions at Niagara, it was decided to lay out a power house using these principles. The point selected for the site seemed to lend itself particularly to this form of construction, as it was located sufficiently far from the edge of the Falls to remove it from the constant humidity at that point, and still not so far as to make the cost of the tail-race tunnel prohibitive. The site also provides an easy method of handling the ice which comes down the river, and this is one of the serious conditions which have to be dealt with at Niagara. There has been very little anchor ice noticed along the Canadian shore, although some difficulty has been experienced from this source on the other side.

Upon completion of the plans of the Electrical Development Co., the first step to be taken was the removal of the water which covered the site of the power house and wheel pit. At the time this work was commenced, it was recognized by all conversant with the plans, that the greatest difficulties that the company would have to encounter would be in the installation of the coffer dam, and the commencement of work on the main tail-race tunnel. It was considered by many that it would be impossible to carry out the work as outlined on the original plans, and it is certainly to the credit of the engineers that these difficulties have been overcome.

It was assumed in the original estimates that the depth of water would be about eight feet, as a maximum, on the line of the coffer dam. As the work proceeded, and it became possible to ascertain the depth of the river, it was found that in certain sections there was 26 feet of water, and not eight as originally figured upon; but in spite of this fact the dam was successfully placed in position. Besides the deep water, another difficulty encountered in the setting of the dam was the irregularity of the river bed. An immense number of boulders and fissures, of all shapes and sizes, was found, and upon this foundation the structure had to be built. Besides the actual setting there was the work of making the dam water-tight. When I visited the site recently, I found this matter in very good shape. In walking over the structure, I was impressed by its solidity, not the slightest vibration being noticeable.

When the dam had been run out into the river for a distance of about 600 feet, the depth of water increased to almost 24 feet, and as can be readily understood, the effect was decidedly severe, as the direction of the flow was at right angles to the end of the dam.

In order to break the force of the current, a fender was constructed of heavy timber, and placed against the upstream side of the cribwork, projecting beyond the last crib in place. This fender was held by three steel cables, passing along the outside face of the spur, where a winch was established to control the lines used in paying it out. The cribs were framed in the slack water below the dam and brought into place by means of stout tackle.

At a distance of 690 feet from the shore, the strain on the fender was so great, that the cables parted, and it was carried down the river, where it stranded about 150 feet from Tempest Point.

A new fender of heavier design was constructed, which served its purpose until the first cascade was reached. In attempting to move it over the cascade, it was broken to pieces by the force of the water, and carried over the Falls. At this point, however, the cribwork was running nearly parallel to the flow, and so no great difficulty was experienced in placing the cribs without its asistance.

As the site of the wheel pit was not entirely unwatered by the main dam, and as it was desirable to start work on the pit at the earliest possible moment, an inside dam was constructed. As the water in which this was set was practically still, no great difficulty was experienced in making it watertight.

The gathering dam will be constructed of cut stone and concrete, and from the upstream end down to a point about 150 feet from the power house, its top will be approximately level with the water. For the last 150 feet, the top of the dam will be about four feet below the water. Along the side of the power house will be built two rows of submerged ice arches, behind which will be located the screens. From this construction it will be seen that there will be a constant and heavy flow of water along the line of the arches, and that, therefore, any ice which is taken into the dam will be carried rapidly to the lower end, and discharged into the river.

In order to start work on the lower end of the tail-race tunnel, and drive back to the wheel pit, a construction tunnel of about 650 feet in length was required, and to ascertain the conditions under the Falls, as well as to provide for dumping the debris of excavation, an opening was planned about midway of this tunnel.

The rock encountered under the Falls is solid shale, and is absolutely dry. Mr. Value made a statement about this fact at a meeting of engineers at New York, and was laughed at, but it is absolutely true, and the dryness is evidenced by the fact, that when I was down in the tunnel, I put my hand up against a portion of the timbering, and drew it away covered with dust.

About 1,000 feet of the tunnel has been driven, and progress is being made at the rate of 50 feet a week. It is expected that work will commence at the upper end in the near future, and that the two will meet about October 1st of this year.

When the construction shaft had been sunk some distance, considerable trouble was experienced from water, the rock pierced being badly disintegrated. It was, therefore, necessary to concrete this shaft, which has proved fairly effective. There is some water coming in yet, but one small pump (the only one in the whole of the underground works), is sufficient to take care of it.

The shaft has a depth of 150 feet, and then turns and runs out under the river. At a distance of 385 feet from the shaft, the cross drift leading out under the Falls was begun.

Up to this time, the tunnel had been absolutely dry, but when the cross drift reached a point about 14 feet from the face of the cliff, a fissure in the roof developed, through which water came in considerable volume, flooding the tunnel, and causing a suspension of work. Pumps were installed and the water was lowered, but as preparations were being made for a blast, a portion of the roof collapsed, and a larger flow of water took place, again flooding the drift.

It was found that the water rose in the shaft to a height of 16 feet above the grade of the drift, before finding its level, thus indicating that the water came from the spray under the Falls, through fissures, whose openings were approximately at this level. This inference was completely borne out by subsequent examination.

A heavier pumping plant was installed, and the water lowered, thus allowing work to proceed. Holes were drilled in the face, varying in length from 18 to 22 feet, indicating a barrier of solid rock of about 12 feet in thickness, and beyond this a softer rock somewhat disintegrated, but of unknown thickness, none of the holes penetrating to the face of the cliff. As the flow into the drift was increasing in volume, and gaining on the pumps, it was decided to load the holes and blast away the barrier. In addition to the dynamite used in the holes, ten cases of the explosive were placed at the face of the cross drift, and the drift was allowed to flood before firing.

The blast broke down the solid rock barrier and opened a cut through the disintegrated rock and talus, out to the sheet of water, and down to an elevation about 12 inches below the drift roof.

The water fell to this level, and efforts were made to reach the opening by boat, in order to blast away the remaining barrier. A trip was made by three of the miners, and three cases of dynamite were placed in the most effective position, and fired. The blast tore a big hole in the rock, but did little or nothing towards removing the mass which prevented the water from escaping.

Failing in this attempt, two of the foremen successfully made the trip around behind the Falls, to the mouth of the drift. Starting from the Scenic Tunnel, these men, roped together, crept along the top of the talus, a distance of 450 feet, where they found the opening. A large amount of dynamite (in all, some 8,000 pounds), was carried out back of the Falls, and used in open blasts, making a large opening down to the level of the drift floor, and thus establishing complete drainage.

The wheel pit is designed for an installation of 11 turbines, and the tail-race tunnel comes up to a point 165 feet from its lower end, there branching into two lateral tunnels, which pass on either side of the pit. The intervening rock is pierced at intervals by draft tubes, which enter the tunnels through the invert, a water seal thus being preserved at all stages of operation. Single draft tubes are used, and each alternate wheel discharges into the same tunnel, six tubes entering the north tunnel, and five the south. Gates are provided for each side tunnel, so that it is possible by closing either gate, and shutting down the wheels discharging into this branch, to make an inspection while the other half of the station is in operaton.

The water which is taken in by the gathering dam, will be conveyed downward through steel tubes to the wheels at the bottom of the pit, and the difference of level is such, that, after deducting all losses due to friction, etc., there will remain an operating head of 143 feet. There will be two wheels on each shaft, the penstock entering between them. The old idea of having the top wheel somewhat larger than the bottom, having proved satisfactory, the same arrangement will be used, and the upward thrust thus produced will be just sufficient, at a predetermined gate opening, to balance the weight of the shaft and the revolving part of the generator above.

The wheel pit will be provided with a masonry lining, and the provision that the turbines and all of the machinery above them shall rest on solid rock foundations, instead of artificial supports, as has hitherto been the practice, is an element newly adopted for this construction, the value of which is evident.

The eleven generators will be installed on masonry foundations at the level of the power house floor, and the connections betwen them and the turbines will be made by use of hollow shafts, travelling in a vertical position, having a total length of approximately 115 feet, and supported at three intermediate points by solid masonry bearings. There will be one thrust bearing on each shaft, located just below the generator.

The placing of the labor of supporting the turbines, etc., upon solid rock foundations, and the provision of masonry intermediate supports for the shafting, are departures from previous practice, but have been adopted in order that the vibration in heavy revolving machinery may be reduced to a minimum.

The water, after passing through the turbines, will be discharged through steel draft tubes to the two branch tail race tunnels, connecting with the upper end of the main tunnel. This design is also a departure from previous practice, but has been adopted for two important reasons. First, it is not to be assumed that machinery can ever be installed without need of future repair, and second, by the use of two branch tail-race tunnels, it will be possible at any time to close down one-half of the station and make necessary repairs. In other words, the use of this double design makes in practice two stations out of one, each half being absolutely independent of the other. Another feature of the method of discharge is that the turbines themselves will always be accessible and not submerged at times, as in the case of some of the other plants.

In the first power house built on the American side, the turbines discharge at the bottom of the wheel pit into the open air, so that at all times the pit is very wet, owing to the spray. In the second power house draft tubes are used, and the general condition of things is better, but the scheme is such that the tail-race tunnel opens into the wheel pit, the draft tubes only preventing the throwing of water, and also giving an increase in operating head. In neither house is there any means of preventing the wheel pit from flooding, in case the water backs up in the tunnel. In the case of the Electrical Development Co. this is impossible with the construction used.

It has occurred in the Niagara River, below the Falls, that jams of ice have temporarily caused more than 50 feet of increase in the ordinary high water level below the Falls. If such a condition should exist when the Electrical Development Co.'s plant is in operation, the only result will be a reduction in the operating head during the temporary period, and not a filling up of the turbine chamber.

The water, after it is delivered to the branch tunnels, is by them delivered to the main tunnel, and is carried by means of this in a straight line and with a grade of five and a half feet per thousand to a point of discharge behind the main sheet of the Falls. This tunnel, in being straight, will be free from special erosion to its lining, due to a change in direction of rapidly-moving water, and the character of this lining will be such as to practically preclude the possibility of depreciation.

A point considered in the building of this lining is the fact that the Horseshoe Falls are constantly receding, and, for a distance of 300 feet from the lower end, the lining will be constructed in rings, six feet in length, so that, as the Falls recede, it will drop off in uniform sections, thus preventing cracking back of the portion shortened. The lining for the 300 feet mentioned, will consist of concrete, and for the balance of the distance two rings of hydraulic pressed brick will be used, backed solid to the rock with concrete.

A light steel observation gallery will be placed in the tunnel, running its entire length, by which it will be possible to make frequent examinations of the lining, etc.

The grade of the tunnel is sharper for the first three or four hundred feet. The water receives its initial velocity here, and the grade of the balance of the distance, namely, five and one-half per thousand, is sufficient to maintain this speed.

The total water required by the new power house, when under full load, will be in the neighborhood of 700,000 cubic feet per minute, or about 7.7 per cent. of the minimum flow.

Below are given a few figures in connection with the underground work: Depth of construction shaft, 150 feet; length of construction tunnel, 670 feet; length of main tail race tunnel, 1,935 feet; length of each branch tail race tunnel, 550 feet; from power house floor to bottom of wheel pit, 158 feet; length of wheel pit, 416 feet; width of wheel pit, 22 feet. The dimensions of the power house will be: Length, 500 feet; depth, 70 feet; height, 40 feet. Generally speaking, the structure will be built of light granite.

As to the electrical end of the development, very little information is ready for publication as yet, and, therefore, my remarks, under this heading, will be limited.

In the power house there will be eleven generators, each of 12,500 horse power capacity.

The machines are wound 25 cycle, three-phase, 12,000 volt current, and having 12 poles, will revolve at a speed of 250 revolutions per minute. Some figures in connection with them are given herewith:

Outside diameter, 18 feet 4 inches; height, 12 feet; diameter of revolving field, 12 feet 4½ inches; airgap, ¾-inch; weight of revolving element, 141,000 pounds; weight of complete machine, 400,000 pounds; diameter of shaft, 15 inches, with 8-inch hole.

I have no data on the exciters, but presume that these will be wound for 125 volts, and that some will be water wheel driven and some motor driven. The power house switchboard will be simple in principle, the only apparatus needed being that to control and synchronize the generators, and handle the exciters.

From the power house, underground ducts will be laid to the transformer house about 900 feet away, where the current will be stepped up to 60,000 volts and transmitted to Toronto.

The route of the transmission line has been laid out, and a right of way with a minimum width of 80 feet has been acquired, the total distance being 75½ miles.

The location of the line has been selected with a view not only to electric power transmission, but to railway purposes also, and it may be noted that the country traversed does not present serious engineering difficulties. There will be very few curves, and the sharpest will have a radius of not less than 1,600 feet.

I understand that current will be distributed in Toronto by underground cables, at a potential of 13,200, to a number of sub-stations, where, for local distribution, it will be reduced again or changed to direct current by means of rotary converters or motor-generator sets.

Little or nothing is known about the transmission line itself, except that it will follow generally the design used by the Mexican Light and Power Company, which was one of the first concerns on this continent to adopt long spans.

In the Toronto-Niagara line two rows of steel towers will be used, each pole supporting two three-phase circuits. The towers will be about 50 feet high, and will set about 400 feet apart. Each cable will be made up of six No. 6 wires, stranded together around a hemp core. This construction gives a wire that is very flexible, considering its area, and also gives the form of a hollow conductor. The cables will be arranged in the shape of an equilateral triangle, a distance of from five to six feet separating the wires of each circuit. The practice in America is to set the triangles so that one side in horizontal. In almost all European lines, one side of the triangle is set perpendicular, which seems a much better arrangement as it reduces to a minimum the danger of the wires swinging together, and this, I should think, is a point requiring much consideration, in long span work. I do not know which method will be used on the line under consideration.

This insulator is made of brown glazed porcelain and weighs about 22 pounds. The greatest width is 15 inches, and the overall height is 14 inches. The distance of surface leakage from the tie wire to the pin is about 40 inches; the striking distance being approximately 21 inches.

The Electrical Development Company has secured a property of 530 acres, in the vicinity of the Falls—to be rented or sold for manufacturing or other purposes. The land has a frontage on the Welland River of over one and one-half miles, and is located about three miles from the mouth of the river, and about two miles from the town of Niagara Falls. It is expected that this land will be taken up by manufacturers using electro-chemical processes, or other large power-using businesses.

## GRAIN PRESSURE IN DEEP BINS.*

By J. A. Jamieson, C.E., Montreal.

(Concluded.)

To obtain the relative vertical and lateral pressure produced by the grain, we divide the pressure per square inch on the bottom of the bin by the pressure per square inch on the side of the bin, both having been obtained by means of the hydraulic diaphragm and gauge. In every case, when wheat was being used for testing, we found the lateral pressure to be approximately equal to 60 per cent. of the vertical pressure, or the vertical pressure to be equal to 1.67 per cent. of the lateral pressure. This agrees exactly with the angle of repose of 28 degrees for wheat which was obtained by means of the apparatus shown.

To obtain the relative pressures due to the increased depth or diameter of bin, tests were made in bins 6-in. square, with a depth equal to thirteen times the breadth; and in 12-in. square, and a depth equal to 6.5 times the breadth; also in round bins 6-in. diameter, and a depth equal to thirteen times the diameter; and one 12-inch diameter, depth 6.5 times the diameter. It was found in each case that the pressures per square inch, both vertical and lateral in the larger bins, were approximately twice as great as in the smaller bins, and that the weight resting on the bottom of the larger bins was approximately eight times as great as in the smaller bins, or twice as great as the sum of

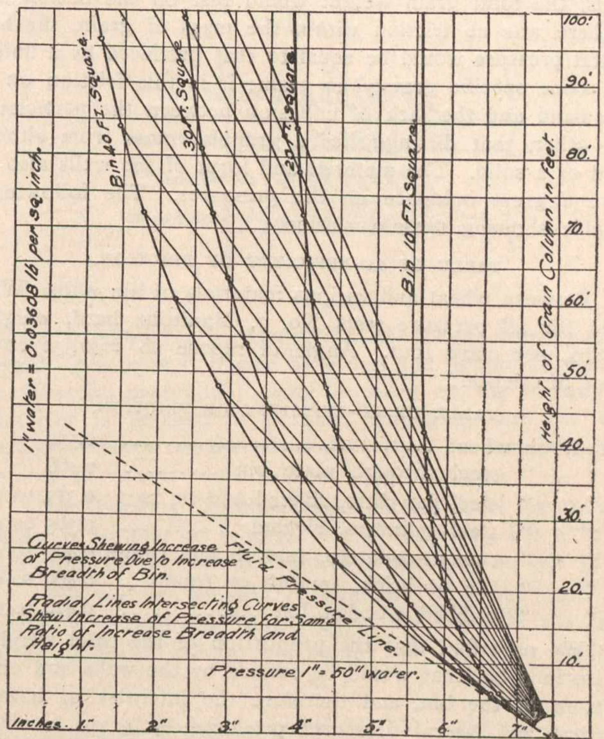


Diagram Illustrating the Ratio of Increase of Pressure with Increased Breadth and Depth of Bin.

the weight for four 6-in. bins. The proportion of the grain weight carried by the sides is dependent upon the ratio of horizontal area or the weight of the grain column, to the area of the bin walls, and if we increase the breadth and maintain the same ratio of breadth to depth, the pressure will increase directly as the breadth. As, however, the maximum pressures are reached at a depth of 3.5 times to 4 times the breadth, it may be stated that approximately both the vertical and lateral pressure will increase directly as the breadth.

Taking wheat weighing 50 pounds per cubic ft. as a standard, we find that corn weighing 45 pounds per cub. ft. will give approximately the same pressure per square inch as wheat; this being due to the slightly lower co-efficient of friction between the corn and the bin walls. Peas, weighing 50 lbs. per cub. ft., give a vertical and lateral pressure of about 20 per cent. more than wheat; while flax-seed, weighing 45 lbs. per cub. ft. will give a lateral pressure 10 per cent. greater and a vertical pressure 12 per cent. greater than wheat, this being due to its lower angle of repose, and lower co-efficient of friction. A bin designed with a proper factor of safety for wheat, will, however, be quite safe for the storage of peas or flax-seed. Taking a trough plate bin filled with wheat as a standard, and with a depth of bin equal to the breadth, we find that 57.1 per cent. of the grain load is carried on the bottom and 42.9 per cent. carried by the walls. At a depth equal to twice the breadth, 38.9 per cent. is carried on the bottom, and 61.1 per cent. by the sides. Depth equal to four times the breadth, 21.9 per cent. on the bottom and 78.1 per cent. by the sides. Depth equal to five times the breadth, 17.6 carried on the bottom and 84.9 per cent. on the sides. Depth equal to six times breadth, 15.1 per cent. carried on the bottom and 84.9 per cent. on the sides. Depth equal to 6.5 times the breadth, 13.9 per cent. carried on the bottom, and 86.1 per cent. by the sides. The above is for the weight of grain in the prism of the bin only, and if the bin is provided wth a hopper bottom, the full weight

*From a paper read before the Canadian Society of Civil Engineers.

of the contents of the hopper bottom must be added to the bottom load, since the walls cannot carry any part of this weight.

Dealing with the question theoretically, it is well known that if we pour grain upon a level floor, it will assume the form of a cone with sides at a considerable angle from the horizontal, and if we endeavor to run grain through a spout, the spout must have a considerable angle before the grain will run, thus clearly indicating a considerable friction, both of grain on grain and between grain and the spout or bin wall. If there was no friction between the grain and the bin walls, the total grain weight would rest on the bottom, and if there was no friction within the mass of grain, the horizontal pressure would be equal to that produced by a fluid of the same specific gravity as grain; it is this friction on the one hand and the lack of cohesion between the particles on the other, that distinguishes a granular mass from either a fluid or a solid. The material and form of the walls also will have a great influence on the pressures. The following is a table showing these variations:

TABLE OF CO-EFFICIENT OF FRICTION.

Between wheat and various materials of bin walls. Wheat used for all pressure tests No. 1, Manitoba hard, weighing 50 lbs. per cubic foot. Angle of repose 28° = 0.532 co-efficient of friction:

TABLE OF CO-EFFICIENT OF FRICTION.

| | |
|---|---|
| Wheat on wheat ............................... | 0.532 |
| " " steel through plate bin ......... | 0.468 |
| " " steel flat plate, riveted and tie bars | 0.375 to 0.400 |
| " " steel cylinders, riveted ........... | 0.365 to 0.375 |
| " " cement-concrete, smooth and rough | 0.400 to 0.425 |
| " " tile or brick, smooth or rough... | 0.400 to 0.425 |
| " " cribbed wooden bin ............. | 0.420 to 0.450 |

We now find that the proportion of the total weight of grain in a bin that would be carried by the walls and on the bottom of the bin, and therefore the intensity of both the vertical and lateral pressures produced by grain is entirely dependent upon the following factors:

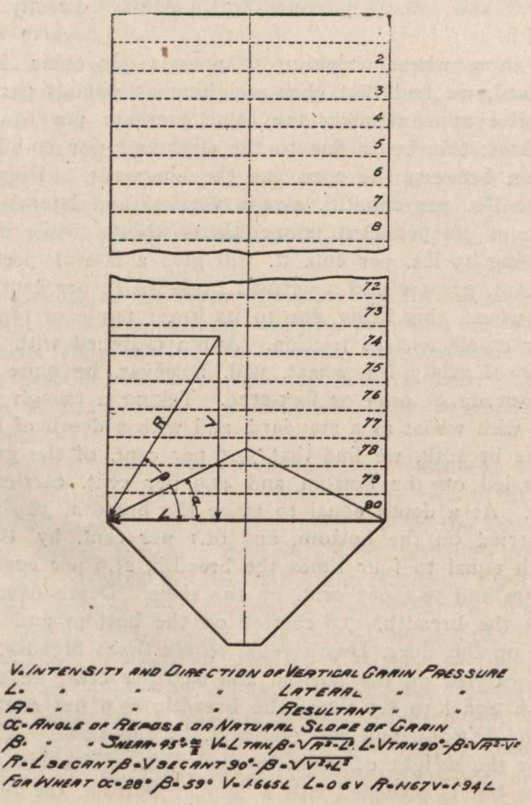
(1) The co-efficient of friction between grain and the bin walls.

(2) The ratio of the breadth or diameter of the bin to the depth.

(3) The ratio of the horizontal area or weight of the grain column to the area of bin walls.

(4) The angle of repose of grain, or the ratio of the lateral to the vertical pressure.

The latter is fully shown by the diagram.




Having established the factors and their values which govern the pressures, it is easy to determine the vertical and lateral pressures and the proportion of the weight of the contents of a bin of any given breadth and depth, or construction of walls, that will be carried by the walls and on the bin bottom.

To illustrate, we will assume a bin 10 ft. square, 100 sq. ft. horizontal area, filled with wheat weighing 50 pounds per cubic foot, each layer one foot thick will contain 100 cubic feet weighing 5,000 lbs. and the area of the four walls for one foot in depth of bin, will be 40 square feet. Starting with the top layer, we find that the lateral pressure, and therefore the friction between the grain and the walls, is very slight and may be neglected, and assume that the full weight of the first layer is resting on top of the second layer.

We therefore have:

$$\frac{5.000 \times 40 \text{ sq. ft.}}{100 \text{ sq. ft.}} \times 0.6 \times 0.41667 = 500 \text{ lbs. carried by the walls.}$$

This 500 lbs. deducted from the weight of the second layer will leave 4,500 lbs. (which we will call the remaining weight), plus the full weight of the first layer, making 9,500 lbs. which will rest on top of the third layer, and will produce lateral pressure in the third layer sufficient to support 950 lbs., which, deducted from the weight of the third layer, will give a remaining weight of 4,050 lbs. This remaining weight of the third layer plus the remaining weight of the second layer, and the full weight of the first layer, will produce pressure on top of the fourth layer, and so on for all succeeding layers. As the weight on top of each layer increases, the lateral pressure will be correspondingly increased, and the greater the pressure against the walls, the greater proportion of each layer that will be supported by the walls. The total weight on the bottom of a bin containing any number of layers of grain will be equal to the sum of the weight of the top layer plus the remaining weights of all succeeding layers, and the weight carried by friction on the bin walls will be the difference between the weight on the bottom and the weight of the total amount of grain in the prism of the bin.

Also Proportion of Grain Load Carried by Bin Walls and on Bin Bottom.—Calculated by Step Process.

Bin 20 ft. square, 80 ft. deep. Wheat = 50 lbs. per cub. ft. Weight, 1 ft. depth = 20,000 lbs. Horizontal area of bin 400 sq. ft. = 57,600 sq. inches. Area of four walls for 1 ft. depth = 80 sq. ft. = 11,520 inches. Co-efficient of friction between grain and bin sides = 0.41667.

$$\frac{20{,}000 \times 400}{0.41667 \times 80 \times 0.6}$$

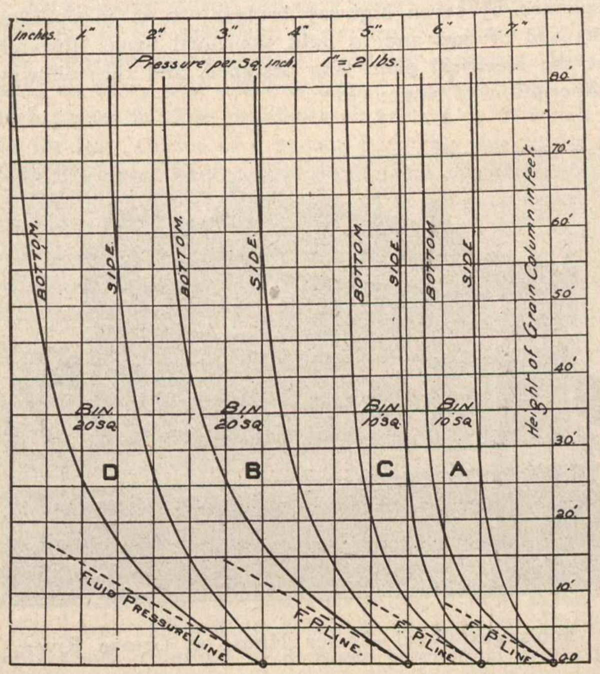
Angle of Repose of Wheat 28*

L = 0.6 V.

| Height of Grain Ft. | Weight in Bin. Lbs. | Car. by Sides per ft. Lbs. | Car. by Sides Totals. Lbs. | Car. on Bottom per ft. Lbs. | Car. on Bottom Totals. Lbs. | Pressure per sq. in. lbs By Step Process Lat. | Pressure per sq. in. lbs By Step Process Vrt'l | Pressure per sq. in. lbs By Pressure Factors. Lat. | Pressure per sq. in. lbs By Pressure Factors. Vrt'l |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 20000 | 000 | 000 | 20000 | 20000 | 0.00 | 0.34 | 0.00 | 0.00 |
| 2 | 40000 | 1000 | 1000 | 19000 | 39000 | 0.21 | 0.66 | 0.00 | 0.62 |
| 3 | 60000 | 1950 | 2950 | 18050 | 57050 | | | | |
| 4 | 80000 | 2853 | 5803 | 17147 | 74197 | | | | |
| 5 | 100000 | 3710 | 9513 | 16290 | 90487 | 0.77 | 1.54 | 0.56 | 1.59 |
| 6 | 120000 | 4524 | 14037 | 15476 | 105963 | | | | |
| 7 | 140000 | 5298 | 19335 | 14702 | 120665 | | | | |
| 8 | 160000 | 6033 | 25368 | 13967 | 134632 | | | | |
| 9 | 180000 | 6732 | 32100 | 13268 | 147900 | | | | |
| 10 | 200000 | 7395 | 39495 | 12605 | 160505 | 1.54 | 2.73 | 1.34 | 2.76 |
| 15 | 300000 | 10247 | 85317 | 9753 | 214683 | 2.14 | 3.65 | 2.02 | 3.67 |
| 20 | 400000 | 12453 | 143395 | 7547 | 256605 | 2.59 | 4.36 | 2.51 | 4.33 |
| 25 | 500000 | 14160 | 210955 | 5840 | 289045 | 2.95 | 4.91 | 2.91 | 4.90 |
| 30 | 600000 | 15481 | 285955 | 4519 | 314145 | 3.23 | 5.34 | 3.21 | 5.34 |
| 35 | 700000 | 16504 | 366434 | 3496 | 333566 | 3.44 | 5.67 | 3.46 | 5.64 |
| 40 | 800000 | 17295 | 451405 | 2705 | 348595 | 3.60 | 5.93 | 3.63 | 5.89 |
| 45 | 900000 | 17907 | 539779 | 2093 | 360221 | 3.73 | 6.12 | 3.75 | 6.10 |
| 50 | 1000000 | 18380 | 630780 | 1620 | 369220 | 3.83 | 6.28 | 3.87 | 6.28 |
| 55 | 1100000 | 18747 | 723818 | 1253 | 376182 | 3.91 | 6.40 | 3.96 | 6.43 |
| 60 | 1200000 | 19030 | 818430 | 970 | 381570 | 3.97 | 6.49 | 4.02 | 6.55 |
| 65 | 1300000 | 19250 | 914262 | 750 | 385738 | 4.01 | 6.56 | 4.08 | 6.67 |
| 70 | 1400000 | 19319 | 1011041 | 581 | 388959 | 4.05 | 6.61 | 4.14 | 6.76 |
| 75 | 1500000 | 19551 | 1108544 | 449 | 391456 | 4.07 | 6.66 | 4.18 | 6.82 |
| 80 | 1600000 | 19652 | 1206612 | 348 | 393388 | 4.09 | 6.69 | 4.20 | 6.88 |
| Maximum | | 20000 | | 0 | 400000 | 4.17 | 6.94 | | |

The co-efficient of friction of 0.41667 was chosen to reduce the amount of work required in calculating this table, 0.41667 × 0.6 being 0.25.

The discussion on Mr. Jamieson's paper extended over three meetings of the society, Dr. Bovey, John Kennedy,




Comparative Curves—Bins 10 ft. and 20 ft. square, 80 ft. deep. A. and B. derived from theoretical calculation. C. and D. derived from tests. Wheat = 50 lbs. per cub. ft. Angle of repose 28°. Co-efficient of friction between grain and bin sides = 0.41567.

Phelps Johnson, Max Toltz, H. E. Vautelet, and others, taking part. The discussion ran largely into controversial matters arising out of the report of engineers of the Public Works Department, appointed to examine Mr. Jamieson's plans for the Montreal harbor elevator.

Mr. Toltz gave from memory, the results of tests he made at West Superior in a bin 14 ft. square and 65 ft. deep, with a view to obtaining data by which to design the West Superior elevator. The tests were made in a bin of a wooden elevator, but the bin was lined with sheet iron, to imitate the steel bin which they proposed to build. He stated that they found the horizontal pressure did not exceed three pounds per square inch. This agrees with the present author's tests and also those made by Dr. Bovey, when he used the co-efficient of friction for steel instead of wood. Mr. Toltz stated that if he had had this information at the time of designing the Great Northern Elevator, at Buffalo, he could have saved from $75,000 to $100,000.

Mr. Johnson said he had watched a number of tests which Mr. Jamieson made in the model bins. He was satisfied that the results obtained were accurate and that the appliances used were suitable, and he illustrated by wooden bin construction that the pressures could not very much exceed the pressures obtained from these tests, without seriously endangering the wooden elevator bins, which have stood successfully for many years.

Dr. Bovey said he was satisfied that the results obtained by Mr. Kennedy and himself were very near absolute accuracy. These diaphragms were calibrated in direct hydraulic pressure, and also with test weights both before and after the experiments, and were found to give absolutely correct results. It was true that there must be a slight depression of the rubber diaphragm when the pressure is applied, but this depression is so very slight compared with the rise of the mercury in the gauge as to have no effect on the results.

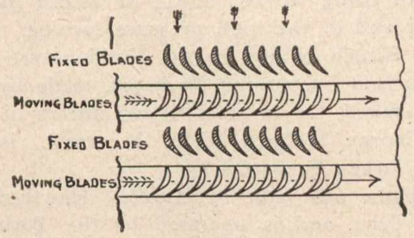
Mr. Kennedy said that anyone who had worked with these diaphragms for half an hour would question them. Every train that passed through the yard, causing a vibration, had its effect on the diaphragm and the gauges showed it instantly.

## THE TURBINIA.

The new turbine steamer, Turbinia, for passenger service between Hamilton and Toronto, has arrived from England, and is beginning her regular trips as we go to press.

The steamer is 260 feet in length, 33 feet in breadth, and 20 feet 9 inches in depth, and will carry between 1,500 and 2,000 passengers. The promenade deck, as will be seen from the accompanying photo, has a fine reach of clear space forward and aft. The hurricane deck is also available as a promenade deck, being clear from end to end, except for the

Fig. 1.



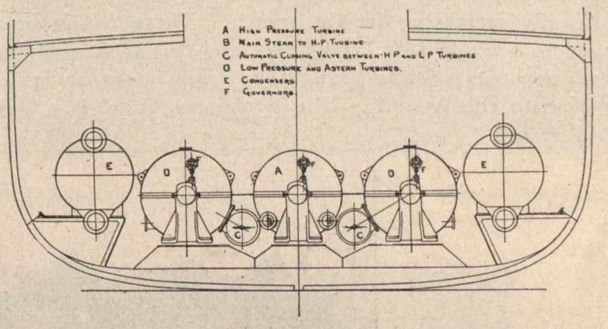

Blades

space required for life-boats, etc., and for the wheel-house forward. The boat is heated by steam and lighted by electricity, a powerful searchlight being installed on the bridge. The interior is finished in polished mahogany and the seating accommodation in the spacious saloon is tastefully upholstered in velvet.

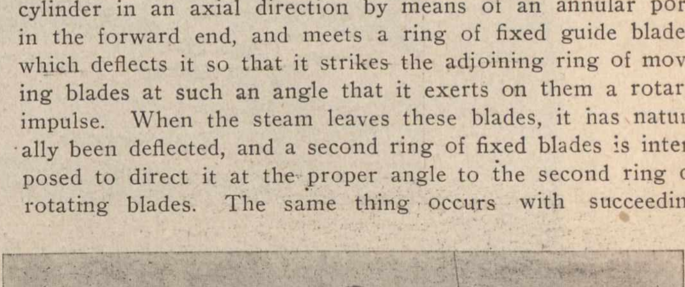
The Parsons Turbine, which is the novel feature of this boat, is familiar to readers of the Engineer, but a brief description of the salient features might not be out of place.

The turbine consists of a fixed cylindrical case within which is a revolving shaft. Upon the inside of the case are fixed blades or guides, and on the shaft also are blades pro-

Fig. 2




jecting outwardly. As the diameter of the shaft is less than that of the case, an annular space is left between the two, which is occupied by the fixed and moving blades, and through which the steam passes. The steam enters the cylinder in an axial direction by means of an annular port in the forward end, and meets a ring of fixed guide blades which deflects it so that it strikes the adjoining ring of moving blades at such an angle that it exerts on them a rotary impulse. When the steam leaves these blades, it has naturally been deflected, and a second ring of fixed blades is interposed to direct it at the proper angle to the second ring of rotating blades. The same thing occurs with succeeding



Turbinia.

rings or guides and moving blades until the steam escapes at the exhaust passage. Fig. 1 shows the arrangement of blades, the short arrows indicating the axial direction of the cylinder and the direction of flow of steam, and the long arrows the direction of rotation. Fig. 2 is a cross-section showing the arrangement of turbine machinery. There are three turbines, one high pressure in the centre of the ship, and two low pressure, one on each side of ship. Each turbine drives a separate shaft, with one propeller on each shaft. Inside the exhaust casing of each of the low pressure cylinders, a reversing turbine is fitted. In ordinary forward motion the steam is admitted to the high pressure turbine, and after expanding about five-fold, it passes to each of the low pressure turbines in parallel, and is again expanded by them about 25-fold, when it passes to the condensers. The total expansion ratio is thus 125-fold.

When manoeuvring in or out of a harbor, the outer shafts only are used, and the port and starboard engines are capable of being worked ahead or astern independently of each other and of the high pressure turbine.

The two Scotch boilers in the Turbinia are each fitted with four Morison Suspension Furnaces, made by the Leeds Forge Co., Limited, the original manufacturers of corrugated furnaces. George Holland, C.E., Montreal, is Canadian agent for the Leeds Forge Co.

The Turbinia was built by Leslie, Hawthorn & Co., Newcastle-on-Tyne, and is operated by the Turbine Steamship Co., Limited, of Hamilton. She is the first turbine steamship on fresh water, and the first mercantile turbine steamer to cross the Atlantic.

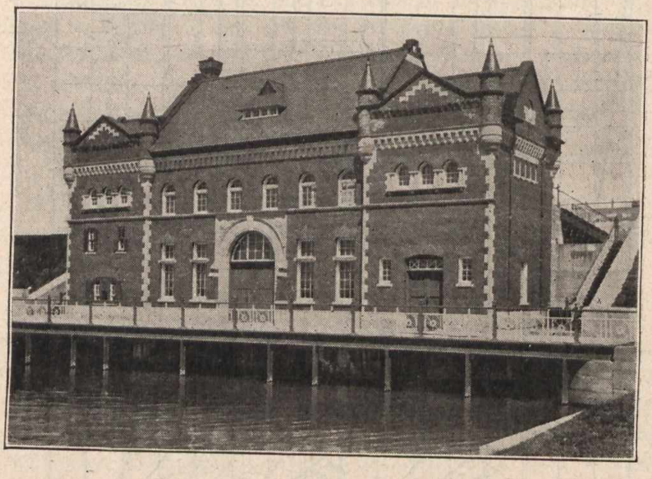
## THE POWER AND LIGHTING EQUIPMENT OF SOULANGES CANAL.

The following is an synopsis of an instructive description of this work given by J. Kynoch, chief engineer of the Canadian General Electric Company, before the Canadian branch of the American Institute of Electrical Engineers.

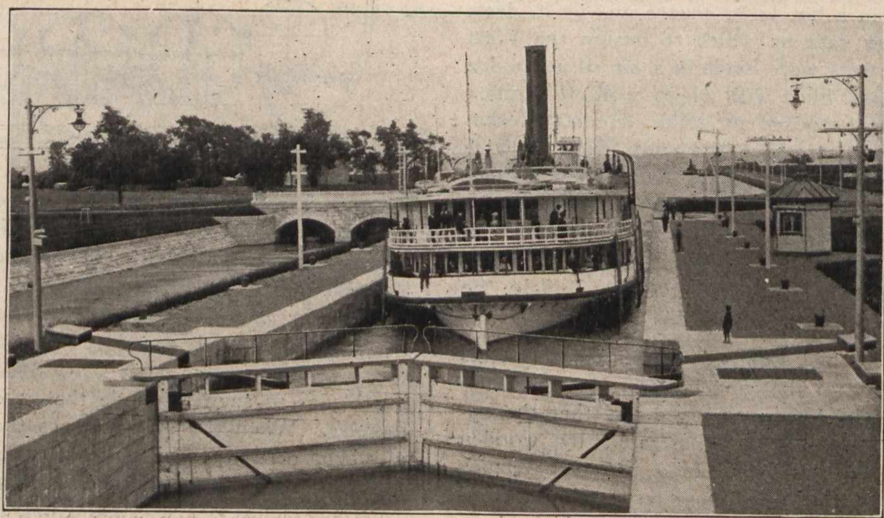
The extensive series of rapids on the St. Lawrence river route, between Prescott and Montreal, have necessitated a chain of canals being built to accommodate the large and continually increasing freight traffic. These canals are arranged to provide 14-ft. navigation, and this is the only route by which boats of this draught can now pass from Lake Superior to the Atlantic. The Soulanges Canal is a link in this chain. It is about fourteen miles long and couples Lake St. Francis with Lake St. Louis, and it replaces the old Beauharnois Canal, which was built for vessels of 9-ft. draught only.

The design of locks, location of same, and superintendence of construction was entirely in the hands of the late Thomas Monro, past president of the Canadian Society of Civil Engineers. It is generally conceded that this canal represents a piece of hydraulic engineering second to none on this continent.

The canal starts at Coteau Landing, on Lake St. Francis, and ends at Cascades Point on Lake St. Louis. The level of water at Coteau Landing is, on the average, 82.5 feet above level at Cascades Point. This difference in level is taken care of in five locks, each 280 feet long by 46 feet wide. These locks are numbered 1 to 5, starting at lowest water, viz., Cascades Point. Locks 1, 2, and 3 are designed for a lift of 23.5 feet each; lock 4 for a lift of 12 feet, and lock 5, which is the guard lock, has a lift of about 2 feet. The canal is spanned by seven highway bridges. It is to operate the locks and bridges and to light the canal banks throughout, that the electrical plant was designed, and the following is a description of same:



Soulanges Canal—Power House at Grease River.



Lock No. 5, Soulanges Canal.

Power House.—This is a neat and tastefully designed building of red brick, and is situated about five miles from the upper or Coteau Landing entrance to the canal. At this point the Grease river crosses the canal, being led under the canal in a 10-ft. culvert, and empties into the St. Lawrence. Advantage of this was taken to make the river a tail race, the supply of water for the turbines being taken from the canal, which provides a 20-foot head. The hydraulic portion of the plant consists of two-wheel chambers, in each of which are two pairs of Victor turbines on one shaft, which passes through the usual stuffing box into the generator room. To each of these shafts is direct connected a 2,400-volt, 3-phase, 264-K.W., 60 cycle Canadian General Electric revolving field type generator, operating at 225-R.P.M. The two exciters, which are four pole, 13½-K.W., 125 volt machines, are belted to the water wheel shafts. The switchboard consists of two generator panels, two feeder panels, and one exciter panel, fitted with the usual instruments; provision is made to run generators and exciters separately or in parallel.

Pole Line.—From the four feeder switches on the feeder panels are led four 3-conductor lead covered cables, which pass under the canal to a lightning arrester cabin on the opposite bank of the canal. In this cabin each conductor is connected to a fuse block and a C.G.E. Wirt lightning arrester, and from thence it passes to the pole line.

There are four three-phase circuits leading from the cabin, two to the upper entrance of the canal, each of No. 6 B. & S., one for power and the other for arc lights, and two circuits to the lower entrance of canal, one of No. 2 B. & S. for arc lights, and the other of No. 4 B. & S. for power. All wires are bare copper.

As lightning storms are very severe in the locality of the canal, and as the continuity of service of a plant of this kind is of immense importance, a lightning arrester has been placed on every wire which is tapped from the main line, and which passes in close proximity to ground or in which there was the least chance of a ground occurring due to lightning. There has never been a shut down from this cause.

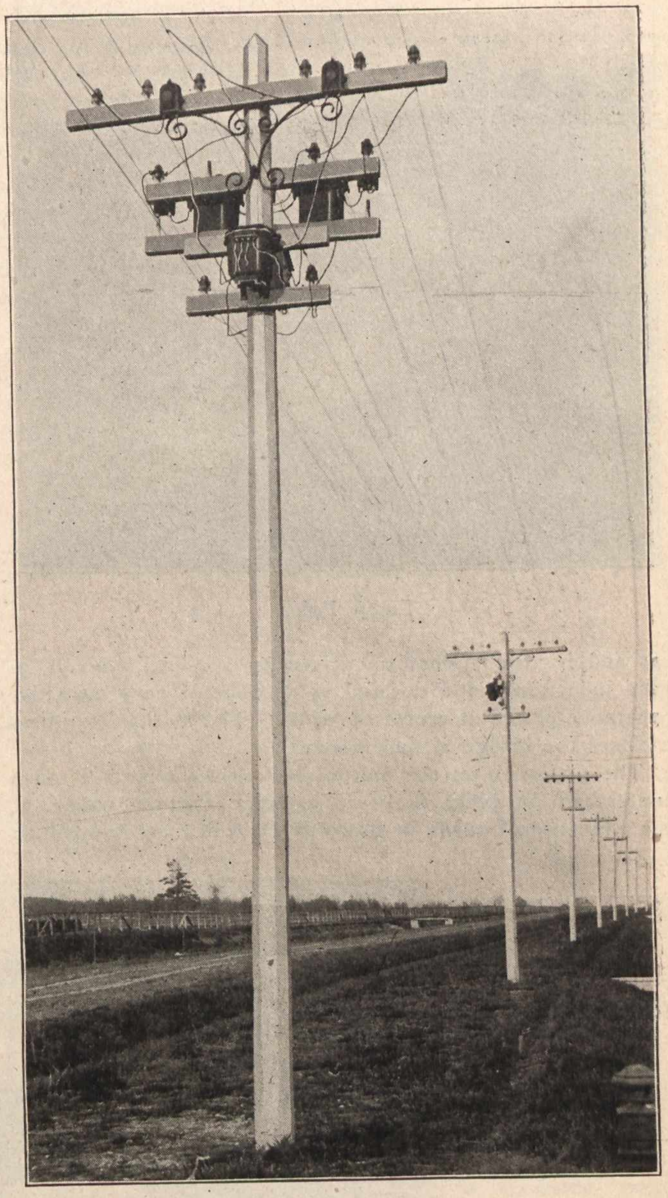
The poles, which are 30 and 35 ft. long of cedar, sawn octagonal, and set 6 feet in the ground and 120 feet apart, were brought from British Columbia; the cross arms, which are of red pine, are supported by an ornamental cross arm brace making a very artistic-looking line.

Arc Lamp.—The general lighting of the canal consists of 7½ amperes, alternating, multiple, enclosed arc lamps placed 480 feet apart on one side of the canal. Each lamp is supplied with current from a 1,000 watt, 2,080/115 volt, C.G.E. type H. transformer. Before deciding on the system of lighting to be adopted, the various merits and demerits of series and multiple systems was thoroughly discussed, and at that time the decision was given in favor of the multiple system. For canal lighting at night, the continuity of service is of immense importance, for the reason that if light failed, when a vessel was approaching a bridge or a lock, a collision might ensue, resulting in damages amounting to thousands of dollars, and it was thought at that time that as a short circuit across the line was a very remote contingency, the point for comparison was the breaking of a lead to a lamp; in the case of multiple lamps, only one lamp would be out, while in the series system all the lamps on that circuit would be out, which would mean every second or third lamp.

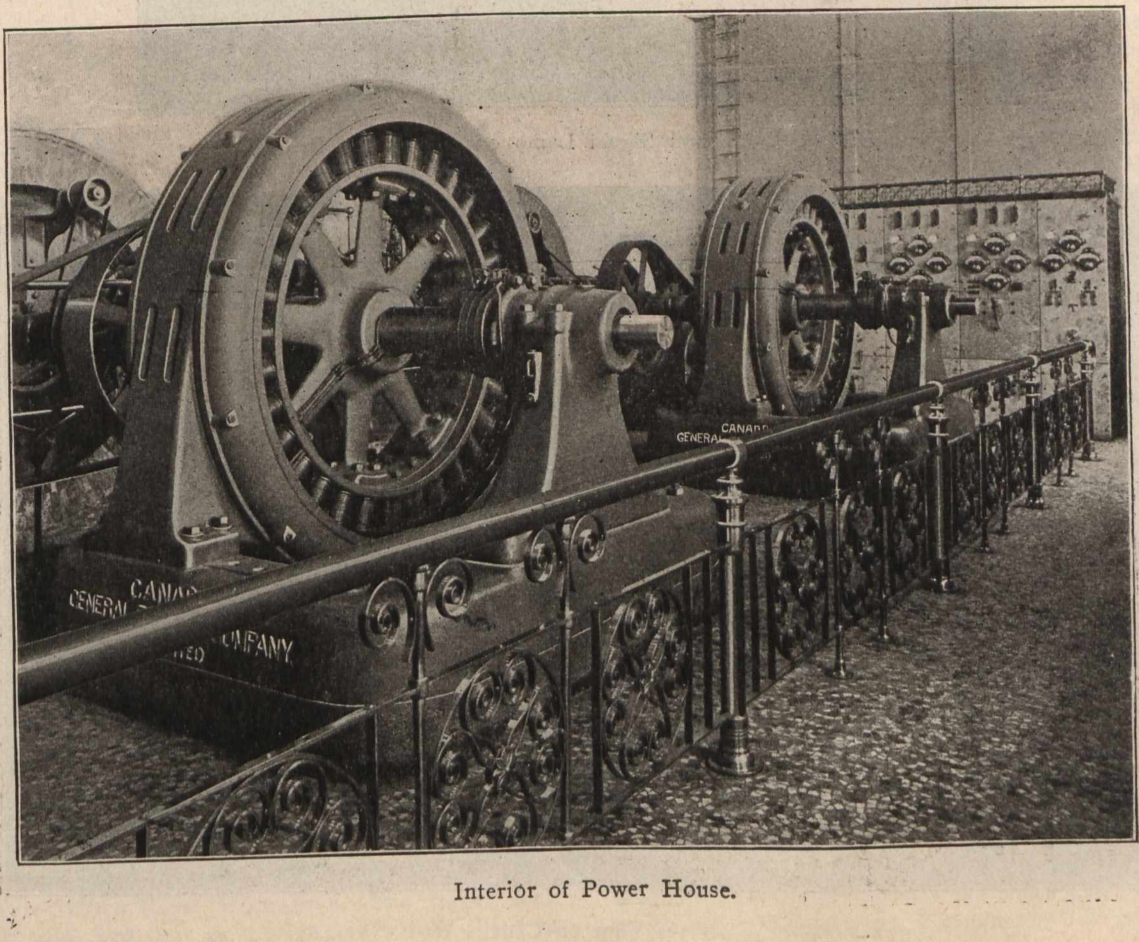
At the locks and bridges, the lamps are spaced closer, and are on both sides of the canal. The same arrangement also exists at upper and lower entrance to canal.

The arc lamp brackets are of neat design and artistic appearance, the supporting cable, which is of steel passes through the centre of bracket pipe, through pole, and over a pulley and down to a windlass, which is locked to prevent unauthorized persons tampering with the lamps.

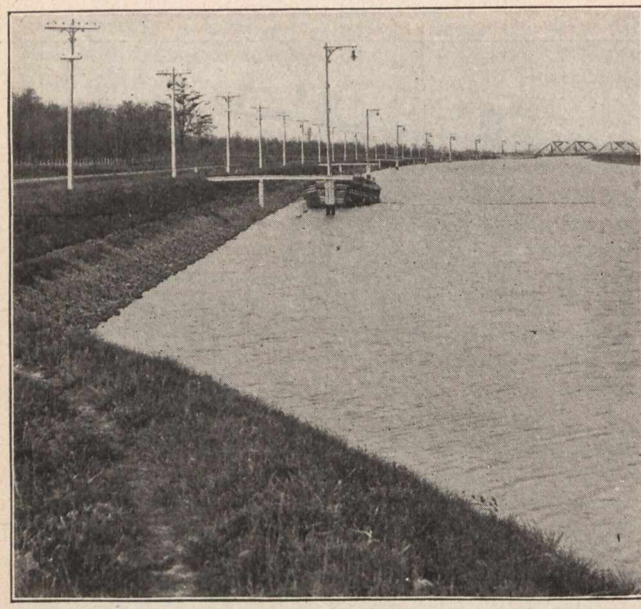
Highway Bridges.—These are of 180 feet span and weigh about 100 tons; the operating apparatus consists of a



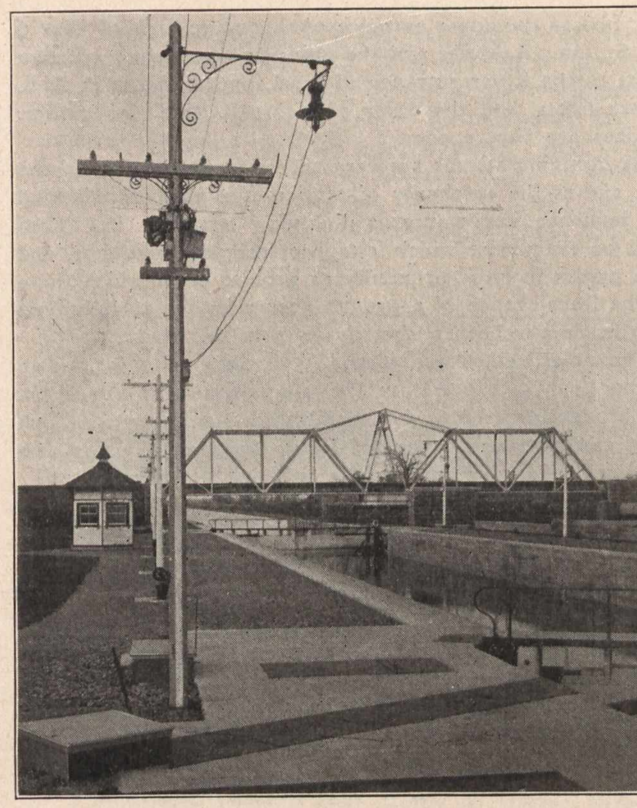
Transmission Line—Pole with Bridge Motor Transformers in Foreground.



Interior of Power House.



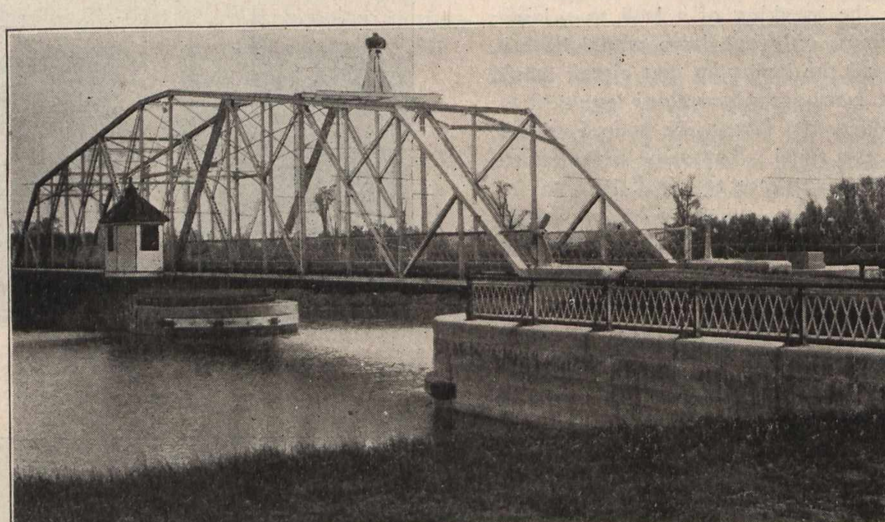
Lamp Poles.



View of Lock, Showing Location of Motor Boxes, Lamp Poles, and Switch Cabin.

gear and friction mechanism driven by a 2-h.p., 220-volt, 3-phase induction motor located in a cabin of very attractive appearance placed in centre of bridge. The mechanism opens or closes the bridge in two minutes.

The pinion A on the motor shaft drives a gear B on a countershaft on which is keyed a paper friction pulley C, This countershaft turns in bearings D, which are located on



Operating Cabin and Signal Lamp on a Highway Bridge.

Night View on Canal.

the ends of two arms or links; the other ends E of these links are held by studs which are axially on a line with centre of motor shaft. The bearings in which the countershaft turns are also connected by means of links to cams on another shaft F, on which is secured a lever G.

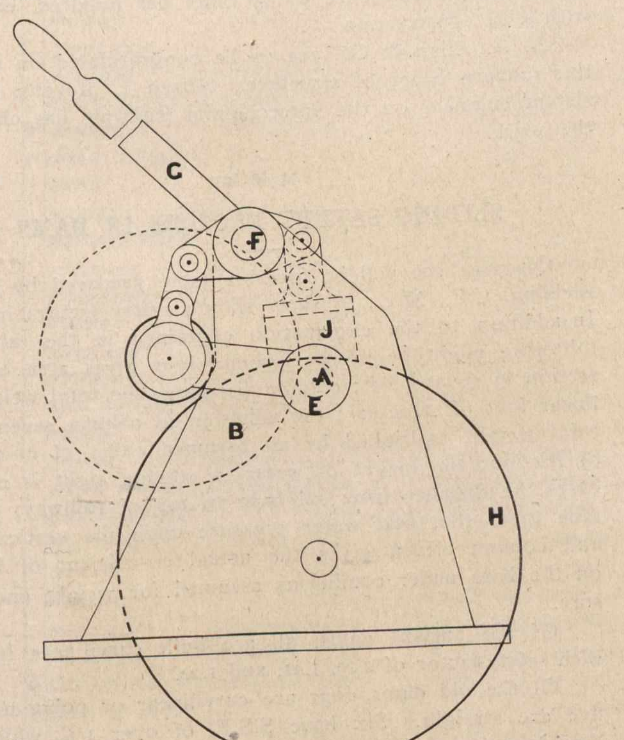
By moving the above mentioned lever in one direction, the paper friction pulley is brought into contact with a cast iron friction pulley H, which is keyed to the main shaft, which operates the bridge mechanism through a bevel pinion and gear.

On the above mentioned lever shaft F is located another cam, which is attached by means of a link to a brake shoe J; this shoe is brought into contact with the cast iron friction pulley by moving the lever in a direction opposite to that above referred to.

It will be noted from the above that by a simple movement of the lever in one direction the bridge can be started in motion, and by moving lever in the opposite direction the motion can be retarded or stopped. The direction of motion of the apparatus is reversed by a reversing switch in the motor circuit.

In the design of the above mechanism, two important points have been taken care of, viz.: (1) The paper friction pulley is brought into and taken out of contact with iron friction pulley without the motor pinion and gear getting out of true mesh with each other. (2) The brake cannot be put into operation unless the friction pulleys are thrown out of contact with each other.

In starting up this apparatus, the motor is started practically without load, the load being only the friction of motor and countershaft bearings, and the small motor pinion and gear, thus the motor reaches full speed in three or four

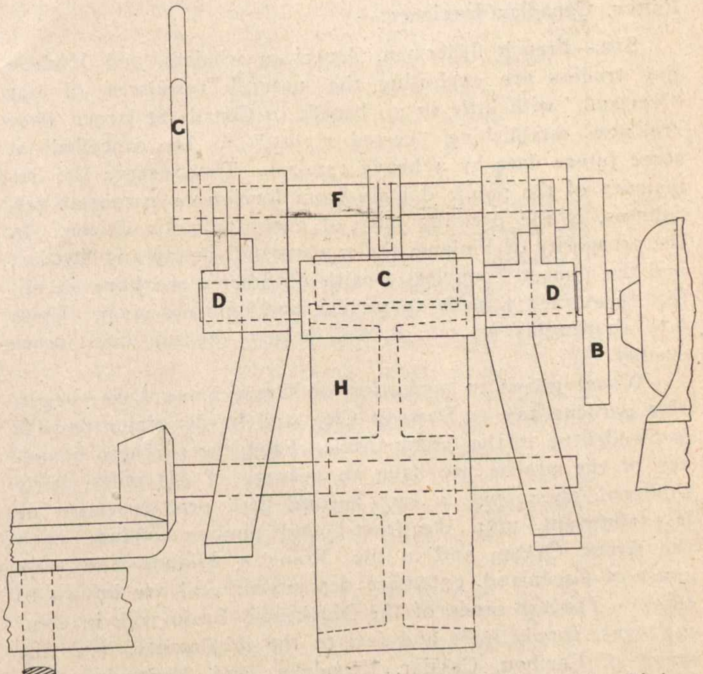



Mechanism for Opening and Closing Bridge. CC, Paper Friction Pulley. D, Bearings. B. Gear.

seconds, and the load is gradually applied by means of the lever and friction pulleys. The load being thus applied very gradually overcomes the jerking and whipping action, which is always incident to long, narrow bridges of light construction, such as those crossing this canal.

Each bridge is equipped with a large electric signal lantern which is placed on a line passing through the centre of the canal prism or navigable channel. This lantern shows, at night, a red light when bridge is closed, and a green light when bridge is open. The lights inside lantern, which consist of groups of incandescent lamps, behind which are placed metal reflectors, are controlled by a switch inside motor cabin.

Lock and Sluice Gate Mechanism.—The larger lock gate is 28 ft. wide and over 40 ft. high and weighs about 70 tons. Each gate turns in a hollow quoin, cut out of the stone walls of lock, its heel rests upon a pivot casting and it is held by a gudgeon and collar at the top. It is thus suspended on a hinge and hangs free in air, which is unlike any other lock gates in Canada. It is closed or opened by means of a strut, at the end of which is a rack and pinion mechanism, which in turn is operated by a friction mechanism involving the same principles as that described previously for operating bridges, and which is driven by a 3-h.p. 220 V-3-phase motor. This mechanism is enclosed in a cast iron box which

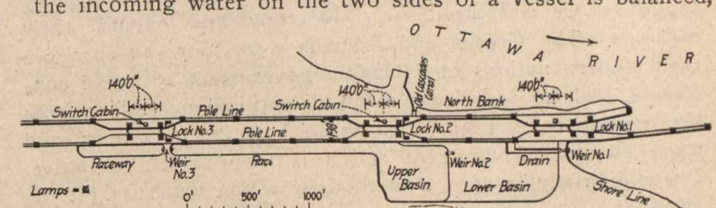



Mechanism for Opening and Closing Bridge. A, Pinions. B. Gear. E, End of Link. F, Shaft. G, Lever. H, Cast Iron Friction Pulley. J, Brake Shoe.

projects about 15 inches above coping of lock. These motor boxes have on the outside an indicator which shows just when gate is full open or closed. The gate is opened or closed in one minute. The handle of a reversing switch passes through the side of box.

The method of filling or emptying the lock was first used in Canada on this canal, and is taken care of as follows: Through each lock wall there is a longitudinal tunnel 6 ft. by 6 ft.; these tunnels are connected to the lock chamber through a number of openings. The upper and lower ends of the tunnels are closed by "Stoney" sluice gates, 6 ft. by 6 ft., which are operated by chains and counterweights through vertical wells 8 ft. by 4 ft. in the masonry, extending from lock floor to coping.

To fill the lock the lower sluice gates are closed, and the upper ones opened allowing the water to pass through the tunnel and opening into the lock, as these openings are equally divided between both sides of lock, the pressure of the incoming water on the two sides of a vessel is balanced,




Plan of Locks 2 and 3.

and so vessels do not surge about when lock is being filled or emptied. The lock can be filled in three minutes.

The chains and counterweights, which suspend the sluice gates, are hung on a horizontal shaft which passes into a cast iron box containing a 1-h.p., 220-volt, 3-phase motor and friction mechanism, as described for bridges, and operated by a lever in the same way. These boxes project above lock coping about fifteen inches and also have an indicator which shows when gate is closed or full open. A small lever, fastened to a spindle passing through side of box, operates a reversing switch. The sluice gates can be opened or closed in three-quarters of a minute.

SWITCH CABINS.—At each lock there is a switch cabin, which contains two transformers for stepping down from 2,200 to 220 volts for the motors. One main switch controls all the motors at the lock. From this switch, through Noark fuses, pass cables leading to each motor.

The plant, as above described, has been in operation for two years without a single breakdown.

## AN ARCTIC EMPIRE.

Editor, Canadian Engineer:—

SIR,—French fishermen, American whalers, and Hudson Bay traders are exploiting the natural resources of our "Norland," with little or no benefit to Canada at large. They are now establishing "vested rights," to be cancelled at some future date by a heavy ransom. To conserve the remainder of the public domain from foreign or corporate selfishness, is the pressing duty of every patriotic citizen. In the prosperity of Finland, the exports of Norway and Sweden, and the almost boundless wealth of Siberia, we have an object lesson for Canada to ponder and improve upon. Upon how thoroughly we con it will largely depend our future destiny.

Wheat grows to perfection on Great Slave Lake; vegetable gardens pay at Dawson City, and hardy grains flourish in Sweden up to the Arctic Circle. From the northern boundary of the prairie, we have an average of 300 miles, fairly timbered, abounding in fur; beyond that, peat is more or less abundant, until the frost-bound tundras impinge upon the Arctic Ocean, and in the Franklin Islands and west coast of Greenland, extensive deposits of coal are known to exist. The tar sands of the Mackenzie Basin will, in coming ages, supply light and fuel to the inhabitants; and the mines of Caribou, Cassiar, Klondyke, and Porcupine, may reasonably be expected running N 60° E, as in other mineral countries. The Cape Nome sands are worked southwest to Lake Baikal, and why may they not be also continuous across our territory?

The multiplicity of lakes and streams, from the 52nd to 68th parallels of latitude, gives a belt of over eleven hundred miles, suitable for the greatest fur preserve on the globe; while Alaska seals may be tried in Hudson Bay, and may possibly discount the value of the Pribilof Islands in the fur markets.

Briefly, our wheat belt (capable of a billion bushels per annum), with phosphates enough to ensure permanent fertility; our timber and water power, for pulp, etc., beyond; our peat, coal, and petroleum resources; our fur, game, and fishing capacity; our mineral wealth, and the hardy, active, honest men, such employment must breed, will make the model Northmen of earth's history.

The Jews had to be quarantined forty years in Midian to wipe out the stain of Egyptian slavery before entering on the conquest of Palestine; and the Hudson's Bay Co. spent two centuries in making the most perfect single object corporation on earth, and to cover the varied fields of industry suggested we will need only to copy and extend their methods. The Greeks and Romans were more co-operative than modern nations in extending government to social conditions, and we may learn much of national possibility from the present conflict in China as to how much cheaper and more effective government action is than private initiative. I would briefly suggest a method by which much might be effected:

1. By enlisting strong, healthy, young men of fair education, total abstainers, and each trained to some handicraft required, for seven years, with chances of re-enlistment and promotion till 21 years; and those having unstained record to receive medal and half-pay pension (as in the army), or Government employment while competent in Older Canada, pension to revert when they retired.

2. Men preferring to remain in Norland to receive free land, transport at cost, a triennial excursion to Old Canada free, and a bonus for any mines, water powers, or other public utility rendered practicable by them, as well as the usual medal and pension. With a population of educated abstainers and no need to hustle each other, save for honors, the cost of justice need be very small, and charitable institutions unnecessary. A good roads system of traction carriages would bring the benefits of civilization to the verge of eternal ice and make life tolerable if not enjoyable farther north than we suspect, and be promotive of longevity.

3. In dealing with the reckless, improvident, or criminal in our older country, we could set apart an island for each class, where useful employment and fair living would conduce to comfort, and mental improvement be given due encouragement, the genus tramp be eliminated, and the majority returned to their homes as renovated citizens.

THOS. FROOD.

Little Current, Ont.

## A CONCRETE BUILDING OF INTEREST.

A concrete building of interest to Canadian engineers and architects is to be erected on Bay street, Toronto, for A. A. Allan & Co., for warehouse purposes. It is designed to be seven stories high, six of which will now be built. The walls will be of brick and the entire structural portion, including footings, columns, beams, girders, lintels, floors and roof will be of concrete reinforced with Kahn solid steel bars. The columns in the front and rear walls will be of concrete veneered with stone and brick. Structural steel is entirely eliminated.

This building is designed to carry a safe load of 225 pounds per square foot. The load on the lower columns is 350 tons. With structural steel columns and this immense load, a small fire would soon soften the steel and a serious failure result. The insurance companies, recognizing this fact, grant a preference of 35 cents per hundred, compared with steel construction.

A. A. Allan & Co. are to be congratulated on erecting this modern fireproof structure. Alfred J. Stevens, late assistant engineer on the Intercolonial Railway, has charge of the work.

## SLIDING SAFETY FACTORS IN DAMS.

On page 209 will be found a table prepared by Jno. S. Fielding, C.E., M.E., to show sliding safety factors in dams. In addition to the explanation contained in the table, the following might be noted: Column four gives area of cross section in square feet; column six gives the total weight per linear foot of structure; the adhesion in column seven is the total weight multiplied by an assumed value of co-efficient of friction; the height of water in column eight is in most cases the distance from sub-base to top of spillway; column nine gives the total water pressure upon the vertical face; and column eleven gives the actual co-efficient of friction on the base under conditions assumed for weight and pressure.

Of the ancient dams, all are built curvilinear in plan with safety-factor of 2.29, 1.41, and 1.24.

Of the old dams, four are curvilinear or polygonal, and five are straight. Six have S.S.F. of over 1½, while four have less than 1½.

Of the 34 dams of late construction (from 1852 to 1892), two are dependent upon the arch plan; 15 are curvilinear, and 17 are straight. Five have a S.S.F. of over 1½, the remaining 29 having 1½ or less.

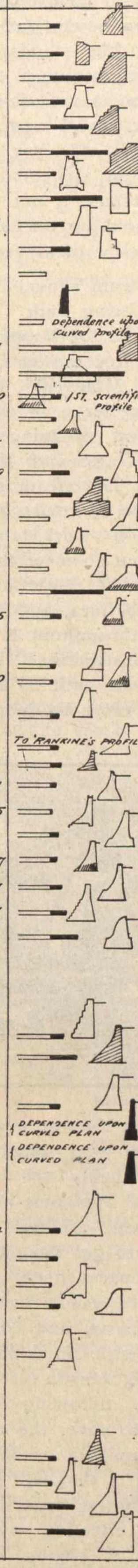
This table has been prepared to show how the S.S.F. has been greatly reduced since the introduction of the French scientific theoretical profiles and formulæ in 1852.

The above information, taken in conjunction with the fact that failures of masonry dams are of constant occurrence, and that many of them, such as the Austin, Columbus, Chambley, etc., actually slid out of their assigned positions, shows that the scientific profiles with their pretty exposition of the line of stress in a dam has lulled engineers into a sense of security that the actual condition of the safety-factor secured will not warrant.

(Mr. Fielding's paper on Dams, as read before the Engineers' Club, of Toronto, will appear in a subsequent number of the Engineer).

## ~ SLIDING SAFETY FACTORS &c. ~

| | NAME OF DAM | LOCATION | DATE MATERIAL PLAN | AREA | WT PER C FT. | TOTAL WEIGHT | ADHESION = T.WT. x by ·65 COEF. | HEIGHT OF WATER | WATER PRESSURE | SLIDING SAFETY FACTORS S.S.F. | COEF. OF FRICTION | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ALMANZA | SPAIN | AMT | 1496 | 150 | 224.400 | 145.860 | 61·3 | 117.562 | 145860/117562 = 1·24 | ·5238 | |
| | ELCHE | " | AMT | 2615 | 150 | 392.250 | 254.963 | 76·12 | 180.500 | 254963/180500 = 1·412 | ·4601 | |
| | ALICANTE | " | AMT | 11839 | 150 | 1.775.850 | 1.154.302 | 127·0 | 504.000 | 1154302/504000 = 2·29 | 2830 | |
| | LAMPY | FRANCE | OM- | 1229 | 150 | 184.350 | 119.828 | 51·35 | 82400 | 119828/82400 = 1·454 | ·4448 | |
| ø | PUENTES | SPAIN | OMP | 16349 | 150 | 2.452.350 | 1.594.027 | 153·5 | 740000 | 1.594.027/740000 = 2·154 | 3075 | |
| | VAL DE INFIERNO | " | OMP | 11668 | 150 | 1.750.200 | 1.137.630 | 116·4 | 420.500 | 1.137.630/420.500 = 2·705 | ·2402 | |
| ¤ | GROS-BOIS | FRANCE | OMS | 2503 | 150 | 375.450 | 244.040 | 83·0 | 215280 | 244040/215280 = 1·133 | 5733 | |
| | VIOREAU | " | OMS | 872 | 150 | 130.800 | 85.020 | 32·8 | 33620 | 85020/33620 = 2·529 | ·2570 | |
| | BOSMELEA | " | OMS | 987 | 150 | 148.050 | 96.232 | 46·9 | 68900 | 96232/68900 = 1·396 | ·4653 | |
| | GLOMEL | " | OMS | 774 | 150 | 116.100 | 75.465 | 39·0 | 47530 | 75465/47530 = 1·587 | ·4093 | |
| | TILLOT | " | -M- | 1173 | 150 | 175.950 | 114.367 | 65·6 | 134560 | 114367/134560 = ·8491 | 7648 | |
| | CHAZILLY | " | -M- | | | ~ THEOR.l PROFILE ~ SEE THEOR.l PROFILE SHEET ~ | | | | | | |
| | ZOLA | " | OMT | 3645 | 150 | 546.750 | 355.387 | 119·7 | 447750 | 355387/447750 = ·7937 | 8189 | dependence upon curved profile |
| | NIJAR | SPAIN | OMT | 5386 | 150 | 807.900 | 525.135 | 82.0 | 210.125 | 525135/210125 = 2·499 | ·2601 | |
| | LOZOYA | " | OMS | 9052 | 150 | 1.357.800 | 882.570 | 94·0 | 276125 | 882570/276125 = 3.196 | .2033 | |
| | FURENS | FRANCE | LMR | 10712 | 150 | 1.606.800 | 1.044.420 | 164·0 | 840500 | 1044420/840500 = 1·242 | ·5230 | 1ST. scientific profile |
| | TERNAY | " | LMR | 4355 | 147 | 640.185 | 416.120 | 112·7 | 396.915 | 416120/396.915 = 1.048 | ·620 | |
| ✦ | HABRA | ALGIERS | LMS | 5584 | 134 | 748.256 | 486.366 | 116·8 | 427.000 | 486366/427000 = 1·139 | ·5706 | |
| | CAGLIARI | ITALY | LM- | 2430 | 150 | 364.500 | 236.925 | 70·5 | 155.300 | 236925/155300 = 1·525 | ·4260 | |
| | VERDON | FRANCE | LMT | 863 | 150 | 129.450 | 84.142 | 41·17 | 53000 | 84142/53000 = 1·587 | ·4097 | |
| | BOYD'S CORNER | UNITED ST.s | LCS | 2039 | 140 | 285.460 | 185.550 | 78·0 | 190.125 | 185550/190125 = ·9759 | ·6660 | |
| | BAN | FRANCE | LMR | 6780 | 150 | 1.017.000 | 661.050 | 137·9 | 595.000 | 661050/595000 = 1.111 | ·5855 | |
| | TLELAT | ALGIERS | LMS | 1560 | 150 | 234.000 | 152.100 | 68·9 | 153.000 | 152100/153000 = ·9900 | ·6538 | |
| | GILEPPE | BELGIUM | LMR | 18708 | 143·5 | 2.684.598 | 1.744.990 | 147·6 | 684.500 | 1.744.990/684.500 = 2·549 | ·2549 | |
| | VILLAR | SPAIN | LMR | 11596 | 143. | 1.658.228 | 1.077.848 | 162·3 | 820.125 | 1077848/820125 = 1·3143 | ·4945 | |
| | PAS DU RIOT | FRANCE | LMR | | | PROFILE BASED UPON FUREN'S | | | | | | |
| | DJIDIONIA | ALGIERS | LMS | 2600 | 150 | 390.000 | 253500 | 83·67 | 218750 | 253500/218750 = 1·158 | ·5609 | |
| | GEELONG | AUSTRALIA | LCR | 1214 | 143. | 173.600 | 112 840 | 60·0 | 112.500 | 112.840/112500 = 1·003 | ·6480 | |
| | POONA | INDIA | -M- | 3725 | 150. | 558.750 | 363188 | 97·0 | 294.000 | 363188/294000 = 1·235 | 5261 | |
| | TOOLSEE | " | - - | 2527 | 150. | 389.050 | 250.680 | 79·0 | 195.000 | 250680/195000 = 1·285 | 5063 | TO RANKINE'S PROFILE |
| | HIJAR | SPAIN | LMT | 8454 | 150 | 1.268.100 | 824.265 | 141·0 | 621.280 | 824265/621280 = 1·326 | ·4900 | |
| | GORZENTE | ITALY | LM- | 5657 | 150 | 848.550 | 551.560 | 121·4 | 460.560 | 551.560/460560 = 1·197 | ·5427 | |
| ✦ | BOUZEY | FRANCE | LMS | 1961 | 150 | 294.150 | 191.200 | 75·4 | 180.786 | 191.200/180.786 = 1.057 | ·6145 | |
| ø | GRAN CHEURFAS | ALGIERS | LMS | 6775 | 150 | 1.015.250 | 659.912 | 131·0 | 536.280 | 659912/536280 = 1·23 | ·5262 | |
| | PONT | FRANCE | LMR | 2755 | 150 | 413.250 | 268.612 | 85·3 | 227.600 | 268612/227600 = 1·180 | ·5507 | |
| | HAMIZ | ALGIERS | LMS | 5629 | 150 | 844.350 | 548.828 | 114·8 | 411.800 | 548.828/411.800 = 1·33 | ·4877 | |
| | BRIDGEPORT | UNITED ST.s | LMS | 765 | 150 | 114.750 | 74590 | 40.0 | 50.000 | 74590/50.000 = 1·49 | ·4357 | |
| | VYRNWY | ENGLAND | LMS | 8972 | 160·8 | 1.441.700 | 937105 | 129·0 | 520 031 | 937105/520031 = 1·802 | ·3607 | |
| | VINGEANNE | FRANCE | LM- | | | Information | Lacking | | | | | |
| | TACHE | " | LMR | | | " | " | | | | | |
| | COTATAV | " | LM- | | | " | " | | | | | |
| | TYTAM | CHINA | LC- | 3978 | 150 | 596.700 | 387.855 | 95.0 | 282.030 | 387.855/282.030 = 1·375 | ·4726 | |
| | SAN MATEO | UNITED ST.s | LCT | 16660 | 150 | 2.499.000 | 1.624.350 | 170.0 | 903.125 | 1624.350/903125 = 1·79 | ·3614 | |
| | SODOM | " | LMS | | | Information | Lacking | | | | | |
| | TANSA | INDIA | LM- | 5790 | 150 | 868.500 | 564.525 | 118·0 | 435.125 | 564525/435125 = 1·29 | ·5010 | |
| | BEAR VALLEY | UNITED ST.s | LMT | 537 | 166·7 | 89.520 | 58.190 | 64·0 | 128.000 | 58190/128000 = ·454 | 1·429 | DEPENDENCE UPON CURVED PLAN |
| | SWEATWATER | " " | LMT | 2347 | 164. | 150.208 | 97.635 | 90·0 | 253125 | 97635/253125 = ·3857 | 1·685 | DEPENDENCE UPON CURVED PLAN |
| | BHATGUR | INDIA | LM- | | | Information | Lacking | | | | | |
| | BETWA | " | LMR | | | Information | Lacking | | | | | |
| | PERIAR | " | LMS | 10772 | 140. | 1.508.080 | 980.252 | 153·0 | 731.531 | 980.252/731.531 = 1·341 | ·4844 | |
| | BEETALOO | S. AUSTRALIA | LCR | 4810 | 150 | 721.500 | 468.975 | 110·0 | 378.125 | 468975/378125 = 1·24 | ·5240 | |
| | MOUCHE | FRANCE | LMS | 3300 | 134. | 442.200 | 287.430 | 95·0 | 282.030 | 287430/282030 = 1·02 | ·6423 | |
| ✦ | COLORADO | UNITED ST.s | LMS | 2300 | — | 322.000 | 209.300 | 70·0 | 153.125 | 209.300/153.125 = 1·366 | ·4755 | |
| | BUTTE CITY | " " | LCT | | | Profile | Lacking | | | | | |
| | TITICUS | " " | LMS | 5209 | 150 | 781.350 | 507.880 | 135·0 | 569.530 | 507880/569530 = ·891 | ·7288 | |
| | REMSCHEID | GERMANY | LMT | | | Profile | Lacking | | | | | |
| | LAGRANGE | UNITED ST.s | LMT | | | " | " | | | | | |
| | EINSIEDEL | GERMANY | LMR | | | " | " | | | | | |
| | HEMMET | UNITED ST.s | LMT | 7500 | 150 | 1.125.000 | 731.250 | 135·5 | 583.765 | 731250/583765 = 1·25 | ·5197 | |
| | WIGWAM | " " | LMS | 2870 | 150 | 430500 | 279825 | 90 | 253125 | 279825/253125 = 1·10 | ·5877 | |
| | NEW CROTON | " " | LMS | 28400 | 150 | 4.260.000 | 2.769.000 | 224 | 1.568.000 | 2.769.000/1.568.000 = 1·76 | ·3680 | |
| | ASSUAN | EGYPT | LMS | 3826 | 150 | 573.900 | 373.000 | 75·5 | 178.140 | 373.000/178.140 = 2·09 | ·3104 | |



### ~ EXPLANATION OF SYMBOLS USED ABOVE ~

A = Ancient or previous date to 1600
O = old " " " 1852
L = modern " since " of 1852

S = straight on Plan
P = Polygonal " "
R = curved " " to large radius
T = " " " " small "

M = Masonry
C = Concrete

✦ = Failed
¤ = " in part
ø = shewed weakness

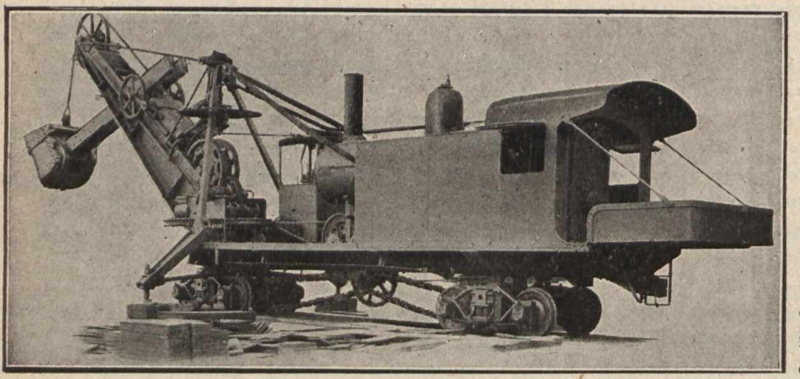
THE MARGIN of SAFETY is shown graphically in col. under Remarks.
The total length of the bar equals the safety-factor (S.S.F.)
The Light portion " " " " pressure
The Heavy " " " " " margin of safety, i.e. the excess strength over and above the pressure

IN LAST COL.n ARE ALSO GIVEN SECTIONS OF DAMS
THOSE IN BLACK ARE DEPENDENT UPON ARCHED PLAN
" HATCHED " CURVILINEAR TO SHORT RADIUS I.E. T
" SLIGHTLY " " " LARGE " " R
THOSE NOT HATCHED AT ALL ARE STRAIGHT ON PLAN - S

## THE ROBINSON WIRE ROPE STEAM SHOVEL.

The great expansion that has taken place in power and capacity of locomotives and rolling stock of railways now finds its counterpart in the necessity for corresponding increase in power and capacity of the steam shovel. Ten years ago the standard railway shovel weighed 35 tons and carried a dipper of 1½ cubic yards' capacity; now shovels are in use which weigh 90 tons and carry a dipper of 5 cubic yards' capacity. Mere weight and size, however, do not give efficiency in service. Great weight, which is necessary in a locomotive, is a disadvantage in a steam shovel, because it not only makes it cumbersome and difficult to hold up on temporary rails and soft ground, but makes it slow of movement.

The steam shovel illustrated herewith is a new machine which is being built in Canada by the Locomotive and Machine Co., of Montreal, and in the United States by the American Locomotive Co. from the designs of A. W. Robinson, C.E., Montreal. This machine is the result of many years' experience in the design and operation of steam shovels and dredging machines, and it includes all the desirable features of the best modern practice in shovel-building. The steam shovel has become an indispensable machine to railroad companies and contractors engaged in construction work, and the present machine has been brought out to meet the demand for a high-class shovel of greater speed, power and capacity. This shovel is built on locomotive lines, and the quality of the design and workmanship throughout is fully up to the best class of locomotive construction. This has not been the case hitherto with shovels built by manufacturing companies, whose aim has been more to keep the cost down to the lowest pos-



sible notch than to produce the best machine that can be built. The work which the steam shovel is called upon to do is probably the most severe and exacting of any mechanical appliance and as a rule it is handled by a class of men who are not careful engineers, and whose only object is to get the most work out of the machine regardless of consequences. A good shovel must be quick in its movements, easily handled, and very strong in all its working parts, and constructed so that it cannot get out of order with any kind of handling.

The Robinson wire-rope shovel has been designed to fulfil the following requirements, which are primarily intended to cover the conditions of modern railway work:

1. Simplicity of design with direct strain, and few and strong parts that will not break or easily get out of order. 2. The highest possible speed and power consistent with safe and effective working. 3. Avoidance of wear and breakage of chains and sheaves. 4. Moderate weight. 5. Better and more efficient boiler for easy steaming and economy of fuel. 6. The employment throughout of the highest quality of design, materials and workmanship, and fully equal to the best locomotive practice.

These and many other points will commend themselves to practical men. The shovel illustrated is one in use by the New York Central and Hudson River Railroad. It is a Class 38-16-2½ machine. This means a shovel having a pull upon the dipper of 38,000 pounds, a clear height of lift of 16 feet, and a capacity of dipper of 2½ cubic yards. This system of numbering expresses at once any combination of these three elements in a shovel, and is more systematic than the use of arbitrary numbers or letters of the alphabet commonly employed, which do not mean anything.

The distinguishing feature of this shovel is the direct wire-rope hoist. In an ordinary machine a chain is used for hoisting which passes over six sheaves. Few persons appreciate the great loss in wear and tear to heavy chain used in high-speed hoisting. This loss amounts to at least 40 per cent, whereas the loss in the case of direct wire rope hoist does not exceed 10 per cent. In the Robinson shovel there is but a single sheave used for hoisting, and this of very large size. This single sheave, besides reducing friction, has the very important advantage of increasing the angle of lead to the bucket. This is a most important feature, as it determines the digging efficiency of the machine. It is of but little use to exert a heavy pull upon the dipper by means of the hoisting chains if the angle formed by these chains on the dipper handle is so acute as to produce but little effect. In this shovel this angle is increased to such an extent that the digging effect is practically doubled. In other words, the same work can be done at higher speed and greater power and with a smaller expenditure of steam and less strain upon the machine.

The construction of this shovel is such that about four to six feet more height of lift can be obtained with the same length of boom as compared with other shovels, and it is possible to construct machines with a clear height of lift of twenty feet which will work at fully as high speed as the lower lift machines of the old type. This is a valuable feature in the reconstruction of existing railroads, of which so much is being done at the present time to reduce the grades.

Referring to the illustration, it will be seen that the hoisting engines are incorporated in the base of the boom, so that the whole hoisting machinery revolves together. This leaves more room on the car for the boiler, which is made unusually long and of first-class locomotive construction. The weak point of most shovels is in the boiler, which is too small and too cheap for the work. The boiler on these shovels is 21 feet long, and built for a working pressure of 150 lbs. per square inch. For ordinary purposes the shovel is not enclosed by the usual box-car construction. This looks well when new, but in a few weeks becomes dilapidated owing to the severe work. In the Robinson shovel ample protection for the men is afforded, and everything is covered that needs to be covered and the rest is left off. There is no woodwork whatever about the machine; therefore it is practically indestructible. The speed of the machine is such that six dipper loads per minute can be made and maintained by the operator without difficulty or fatigue.

The Canadian Locomotive and Machine Co., Montreal, are building four of these shovels at their works at Longue Pointe, and intend to make up a number for stock.

## MARINE NEWS.

The foundry building at the yard of the Collingwood Ship Building Co., Collingwood, Ont., is to be completed at once.

The Dominion Government is preparing to have a new steamer constructed for the quarantine service at Halifax, N.S.

The Allan Line officials have made arrangements with a New York wrecking company to attempt to float the steamer Hibernian, stranded near Codroy, N.F.

The three-masted schooner, Ida Oleson, recently lying at Alpena, Mich., has been bought by Capt. George Dunn, of Owen Sound, Ont., for the lumber trade on Georgian Bay.

A new steamer, named the Annie, for towing and general service on the Newfoundland coast, has been launched at Fogo, N.F. She is fitted with two sets of compound engines, 7½-in. and 13-in. cylinders, by 12-in. stroke, and will make 11 knots an hour.

The City of Windsor will be commanded by Capt. P. M. Campbell, and A. B. Pratt, lately with the Northern Navigation Co., will be purser. The steamer will run from Collingwood to Sault Ste. Marie, Ont.

Owing to the frequent delays of steamers at the western gap at Toronto, by reason of an inefficient foghorn service, the Dominion Government has decided to put up a more modern and more powerful horn.

The Dominion Parliament has under consideration a bill providing for the inspection of the machinery and equipment of boats propelled by gas, fluid, naphtha, electricity or any other mechanical or chemical power.

The steamer Urania, formerly run by the Lake Erie & Detroit River Railway Co., between Rondeau and Port Stanley, Ont., and Cleveland, O., has been sold to Windsor, Ont., parties, who propose to replace her on her old route.

The new steel dredge built at Lilloet, to meet the requirements of gold dredging on a swiftly flowing river, will soon begin operating on the Fraser river bars. This dredge is the largest of its kind in Canada, and was constructed at a cost of $87,000.

The Union Steamship Co. has just received a tug 81 ft. 6 in. in length, 18 ft. beam, fitted with compound engines, 13 and 26-in. cylinders by 18-in. stroke, built at the Cates yard, False Creek, Vancouver, B.C. The engines were imported from Scotland.

A company has been given a Dominion charter to purchase the steamer Richard and other vessels, and to engage in a general navigation business. The capital is $40,000, and the offices are at North Sydney, N.S. W. Hackett, North Sydney, is one of the promoters.

The new wharf under construction at Victoria, B.C., for the Canadian Pacific Railway, will be 430 ft. long by 90 ft. wide, and will have accommodation for six steamers alongside. There will be a shed 255 ft. by 60 ft. wide on the wharf for freight and passenger accommodations.

The Canadian Pacific Railway Co.'s steamer Princess May has been fined $2,600 for carrying thirteen passengers from Ketchikan, Alaska, to Vancouver, B.C., they being destined for Seattle, Wash., to which point they were subsequently ticketed by the C.P.R. by its steamer from Victoria or by rail.

The proposal of the Dominion Government to place the harbors at Port Arthur and Fort William, Ont., under the control of the harbor commission, is being opposed by the Dominion Marine Association, on the ground that the rates which the commissions will be empowered to charge will handicap the development of the trade.

The Department of Marine is conducting some experiments near Sorel, Que., with an electrical device for guiding steamers in narrow channels. Parallel lines of cables have been laid in the river, but not in the ship channel, for a length of two miles, in connection with the project. A report will be submitted to the department on the experiments.

Capt. McLaughlin, an old-time mariner, died in Toronto recently, aged eighty years. He was master, among others, of the Perseverance, Enterprise, Elizabeth, Victory, Mary Caroline, Mary Taylor, Odd Fellow, Alice Grover, J. A. Torrance and Lacoucier, whose names and routes old mariners will recall.

A bill providing for harmonizing the rules of navigation with those of the United States has been passed by the Dominion Parliament. The Act authorizes the Governor-in-Council to proclaim the new regulations as soon as they have been examined by the authorities. This question was one brought under the notice of the Government by the Dominion Marine Association.

A charter has been granted by the Dominion Government to Revallion Bros. (Limited), to take over the trading business of Revallion Freres, of Paris, London, and elsewhere. The company has trading stations at Quebec, Edmonton, on the shores of Hudson's Bay, etc., and its property includes a couple of steamers. The capital is fixed at $5,404,000, and P. D'Anigeaux, of Quebec, is named as the agent of the company in Canada.

The St. John, N.B., Dock Co. is negotiating with a contractor for the construction of the dry dock at that port, and expects to have the details all completed early in July.

The C.P.R. is considering plans for a new passenger steamer for its service on Kootenay Lake, B.C. It has just completed a new 15-car freight barge for Kootenay Lake.

The Richelieu & Ontario Navigation Co. have decided to raise the wreck of the Canada, and reconstruct it at its shops, Sorel, Que., at an estimated cost of $80,000.

The Quebec Steamship Company intend to inaugurate a new steamship line between St. Lawrence ports and North Sydney. The steamer St. Lawrence will be placed at once on this route.

The Arctic exploration steamer, Gauss, recently purchased by the Dominion Government from Germany, arrived in Quebec, June 13th, under Capt. Bernier, after a thirty-six days' trip from Bremerhaven.

The Dominion Government has under construction, at Selkirk, Man., the hull of a new steamer to replace the Victoria on Lake Winnipeg. The machinery from the old steamer will be placed in the new hull.

In reply to a question in the Senate, information was given that the Government intend building two ice-breaker vessels for use on the St. Lawrence. One is to be ready by September 1st. Canadian tenders were not received, as the firms could not have the vessels ready in time. Ice-breakers for the Great Lakes will be built in Canada.

The B. C. Foundry and Engineering Works, Limited, is erecting at Esquimalt a foundry specially adapted for marine work. The main building is about 90 feet by 50 feet. The plant is to be run by electricity, the power being obtained from Goldstream. Stevens & Hawkins are supplying the electrical plant for the works. The foundry equipment is being supplied through the Seabrook Machine Works.

The Dominion Government, by a special Act, has authorized the importation into Canada of the patented marine turbine machinery of the steamer Turbinia, as well as in kindred vessels up to the end of the year 1905, so as not to affect the validity of the Parsons steam turbine patents. Ridout & Maybee, of Toronto, were the patent solicitors employed in procuring the passage of the Act.

It is probable that a steel shipbuilding plant will be established at Dartmouth, on Halifax harbor. Halifax, Dartmouth, and the Nova Scotia Government have offered subsidies and bonuses amounting to to $300,000. The promoters recently asked the Federal Government for a bonus on the amount of tonnage built at Halifax. Ald. W. S. Rogers, J. E. de Wolfe, president of the Board of Trade; James Hall, representative of the Furness-Withy Line, and B. F. Pearson, M.P.P., all of Halifax, are interested.

The Richelieu & Ontario Navigation Co.'s steamer Canada was sunk in the St. Lawrence river, off Sorel, June 12th, after having been in collision with the Dominion Coal Co.'s steamer, Cape Breton. Five lives were lost. The Canada was a side-wheel steamer, built at Sorel, Que., 248 ft. long, 31.2 ft. beam and 10.8 depth of hold. She was 1,768 tons gross, and 962 tons register, and was licensed to carry 600 passengers. The Canada was formerly employed on the Quebec-Saguenay, but for the last year or two has been running between Montreal and Quebec. Her value is placed at $190,000, but she was uninsured.

In the absence of any big grain shipments from the West, the Canadian Pacific Railway Atlantic Steamship Co. have just closed an important contract, the first of its kind ever made in Canada, which calls for the shipment of 15,000 tons of lead ore from the Kootenay district of British Columbia to England. The company, in this way, will be able to fill up a great deal of space occupied in other seasons by grain, and will be able to bring the tonnage well up to the same level as last year. The C.P.R. have also made contracts for the shipment of large quantities of copper ore from the Sudbury districts.

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Richardson Bros., of Kingston, are building at Picton, Ont., the largest canning factory in Canada. It is to be ready for the fruit and vegetable season this year.

## NEW ONTARIO NOTES.

The Webbwood gold mine, in Shakespeare township, is being developed.

The Massey Station copper mine is installing an Elmore oil concentration plant for treating their ore.

Two water powers are being improved in the neighborhood of Sudbury for the purpose of supplying that town with electricity.

The mines now being operated in the nickel field are Creighton and Copper Cliff, belonging to the Canadian Copper Co., and the North Star, operated by the Mond Nickel Co. The west smelter, belonging to the Copper Co., was burned down a few days ago, but the new smelting works are nearing completion. This plant is thoroughly modern and on a large scale.

The Soo industries are at present running, as they have been for four or five months past, under the expiring company, that is, the pulp mill, veneer mill, sawmill, ferries, street railway, etc., are in continuous operation. The Lake Superior Corporation are making arrangements to open the steel works and other industries, and it is expected that all the works will be in operation in a very short time.

The Ontario Government has the following parties exploring New Ontario this summer: Under J. G. McMillan, a party is examining the geology and resources north and northwest of Lake Abitibi; a party, under J. M. Bell, is exploring the Michipicoten iron range; Dr. A. P. Coleman, with assistants, is examining the Sudbury nickel range; and Prof. W. G. Miller, Provincial Geologist, is examining discoveries of cobalt, nickel, and silver, in the neighborhood of Haileybury. Mr Bell reports having left the C.P.R. at Missinibie Station, whence he followed the chain of lakes to the Magpie river, and that he was able to make an excellent section through an entirely unexplored country. He is now at a point east of the Pacaswa river, and so far has encountered and examined three areas of iron-bearing rocks. One of these is at McDougall's claim, fourteen miles north of the mouth of the Pacaswa, where there is a wide band of magnetite in hornblende schists. The ore body is about 200 feet by 350 feet in side, and appears to be a valuable property. The second area is two miles north of the Pacaswa and extends for over a quarter of a mile, but it does not seem to be of great value. The third area is on the same river and resembles in many ways that first described. Mr. Bell says he has encountered a number of quartz veins, of which he has taken samples for subsequent analysis.

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## NEWFOUNDLAND'S MINERAL RESOURCES.

We have before us the report of the Newfoundland Geological Survey for the calendar year 1903. The report is made by James P. Howley, F.G.S., and while confined within short compass, it contains a comprehensive review of the mining industries of the Island colony.

The total value of raw mineral substances raised in the island in 1903 was $1,269,805, an increase of $52,119 over 1902, and this in the face of severe depression in the iron industry, which resulted in a great falling off in the shipments of iron ore from Bell Island last year. The amount of iron ore raised last year was 588,795 tons. The copper production was good, reaching 87,790 tons, an excess of 13,182 over last year.

Pyrites, for the manufacture of sulphuric acid, shows a production of 42,000 tons, an increase of 16,000 tons over 1902. A large deposit of pyrite at Rowsell's Harbor, held under option by the Dominion Iron Co., has not yet been exploited, but it is expected that it will be producing this season.

Barite is becoming important, showing a production last year of 4,300 tons.

$63,000 was the value of the roofing slate produced in the island in 1903. New machinery for the more economic treatment of slate has been installed, and this industry is one rapidly growing in importance. Several new deposits of slate are being exploited, and will probably become producers in a short time. A Welsh slate expert declares Newfoundland slate to be of superior excellence, and, as there are many slate deposits in various parts of the island, the outlook is very bright.

The brick industry showed a slight decrease, owing to unfavorable weather, and the destruction of an important plant by fire. The quality, however, is much improved, and the demand for the local product is on the increase, so Newfoundland is looking forward to the time when the importation of brick will be unnecessary.

Gold mining commenced during 1903. Gold exists, not only in the baser metals, but in quartz-leads, in free state, and at least in one instance, in the form of placer deposit. About $3,000 was the value of the total production last year.

Operations in the petroleum industry have not yet reached the productive stage, but the results are not at all discouraging, and it is now considered that the establishment of a refinery is fully warranted.

The chromite deposits have not been developed, but a mining company, at Benoit Brook, will start operations as soon as they complete a tramway now under construction for ore transportation.

Considerable attention was given last year to talc deposits, but the work of development has been retarded owing to litigation.

As nearly as can be ascertained, the total number of persons employed in mining operations is 2,067, over 800 of these being engaged in iron mining, and more than 600 in copper mining.

The mineral output of the colony, when reduced to commercial products, is worth, approximately, $8,000,000, while the raising and exporting of the crude minerals brings in a modicum probably not exceeding $350,000. Hence Mr. Howley strongly urges the Government to encourage the establishment of smelters and refineries in order to be able to export finished products.

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## RAILWAY NOTES.

A by-law to give $20,000 bonus to the Ontario Electric Railway was defeated in Clark township.

The Grand Trunk Railway has under consideration a project to enlarge its car and motive works at Point St. Charles.

The first through train for Victoria Falls over the Cape-to-Cairo Railroad, left Cape Town on June 22nd, amid enthusiastic demonstrations.

The G.T.R. shops, at Stratford, are to be enlarged at a cost of between $100,000 and $200,000. A boiler shop will be erected, 169 by 120 feet, a tender shop, 326 by 102 feet, a carpenter shop, 100 by 63 feet, and a brass foundry, 75 by 40 feet. The blacksmith department will also be enlarged, and an addition 175 feet long made to the erecting shop.

Arrangements have been completed whereby the investment of between a quarter and a half million dollars for a big tourist hotel in Victoria by the C.P.R. will be supplemented by the expenditure of another hundred thousand to complete an entire square. By the new arrangement the city cedes to the C.P.R. the whole of the reclaimed James' Bay flats and the esplanade fronting on the harbor.

The telegrophone is being installed on the C.P.R. system around Ottawa. A car on each train will be equipped with the telegrophone, and when it is desired to communicate from a point where there is no telegraph instrument all that is necessary is to make a connection with the telegraph wire and use it to transmit emergent telephone messages. The uses of the wire for 'phone and telegraph do not conflict.

St. Catharines has granted $20,000 aid to the Niagara, Queenston & St. Catharines Electric Railway. The company, which is incorporated under an Act of the Dominion Parliament, will begin construction early in the fall. The line extends from St. Catharines through the fruit districts of the Townships of Grantham and Niagara, to Niagara-on-the-Lake, thence along the bank of the Niagara river to Queenston, and from there to St. Catharines, forming a belt line of thirty miles. Among those interested in the railway are: R. S. D. Hartrick, of Pittsburg, and J. N. McKendry, W. B. Rogers, and Herbert L. Dunn, of Toronto.

The Guelph Street Railway has installed a 150-h.p. storage battery, which is giving great satisfaction.

The Edmonton Street Railway Co. is obtaining a charter which gives it power to deal in electricity and engage in coal mining.

The Dominion Government intends to purchase the Canada Eastern Railway, New Brunswick, for $800,000, to be operated as part of the Intercolonial system.

According to the St. John Sun, the Shore Line will change their terminus from Carleton to St. John, and intend doing a through business from that city to United States points. This will necessitate a bridge across the St. Croix river.

It is stated that the Canadian Pacific is preparing to erect the largest and most complete grain elevator in the world at Fort William, to double the capacity of its coal docks, and to enlarge its freight sheds at that point within the next eighteen months. Construction on some of these improvements will be begun this year.

The Ontario Government has passed an order-in-council preparatory to guaranteeing the bonds of the James' Bay Railway Company to the extent of $20,000 per mile from Toronto to Sudbury. The provincial guarantee will date from the completion of the road, and will run for a period not exceeding thirty years, at the rate of 3½ per cent. per annum.

It is said the Gand Trunk Railway Company have acquired an option on a controlling interest in the Hamilton, Grimsby and Beamsville Electric Railway, and that the electric railway may be turned over to the G.T.R. Company in the course of a month. The proposition is to run the electric line as an adjunct of the steam railway. For several years the H., G. & B. have been doing a big business in the fruit line in connection with the C.P.R. and the Dominion Express Company, and it is understood that all this fruit business will be diverted to the G.T.R. and Canadian Express Company. The report is that the G.T.R. Company are to pay $200 a share for the capital stock, which was recently raised from $200,000 to $300,000, the extra $100,000 being taken up at par. When the Vineland extension was built the bonded indebtedness was increased from $85,000 to $150,000. Hamilton gave the H., G. & B. Company a bonus of $25,000 on the understanding that at any time the present company or its successors failed to operate the line as a passenger line the bonus was to be returned.

## NOTES OF THE CONVENTION.

The Canadian Westinghouse Co. had a fine exhibit in a cafe on the ground floor of the Royal Hotel. Switches, transformers, lamps, controllers, etc., made an interesting display, while a side table was loaded with an abundance of information in the shape of catalogues and circulars.

Prominent in the main corridor were the exhibits of clay conduits from the Field-Foulks Co., of New York, and of insulators from C. S. Knowles, Boston.

Allis-Chalmers-Bullock, Limited, of Montreal, issued a neat and very convenient register of delegates, which made identification easy. In order to keep up to date, three or four editions of the register were issued during the convention.

Mr. Culverwell, of Peterboro, did considerable advertising for the Trent Valley Canal, "the only grain route whose competition is feared in the United States."

The generosity of the Cataract Co., in honoring the convention buttons, as passes on the Hamilton street cars, was much appreciated by the Association.

The Sunbeam Incandescent Lamp Co., of Canada, Limited, distributed a neat souvenir in the form of a perpetual pencil made by the American Lead Pencil Company. Mr. Edwin Irving, general manager in Canada for the Sunbeam Co., will be pleased to mail a pencil to any central station manager or other interested party, on application to him at the McKinnon Building, Toronto.

The registration at the convention was 156, twenty-two more than at any previous convention.

Regret was expressed at the absence of K. B. Thornton, and A. A. Wright, M.P., the former through illness, and the latter on account of parliamentary duties.

Frederic Nicholls was present at the convention, on Wednesday, returning to Toronto that evening on his new yacht, The Tranquilo, which is said to be one of the best on the lake.

A parlor in the hotel was devoted to a display by the Canadian General Electric Co. Tastefully arranged on a large table were samples of artistic electrical apparatus, such as lamps, brackets, push buttons, heaters, etc., etc. Literature descriptive of C.G.E. products was at hand, and an obliging attendant distributed souvenirs to visitors.

## CANADIAN SOCIETY OF CIVIL ENGINEERS.

About two hundred members of the Institution of Civil Engineers of Great Britain propose to visit Canada and the States during the coming autumn. During their stay of a week in Canada, they will be entertained by the Canadian Society of Civil Engineers. The visitors are expected to arrive in Montreal about September 20th. The 20th will be devoted to a drive in and around Montreal, the 21st to a trip to the Soulanges Canal, the 22nd to a trip to Ottawa, 23rd trip to Quebec, 24th to Toronto, and on Monday, 26th, the visitors will be taken to Niagara Falls. From here they will go to Chicago and then on to the World's Fair at St. Louis. These are the main features of the Canadian programme, the details of which are now being arranged by a committee of the society.

## INSTITUTE OF ELECTRICAL ENGINEERS.

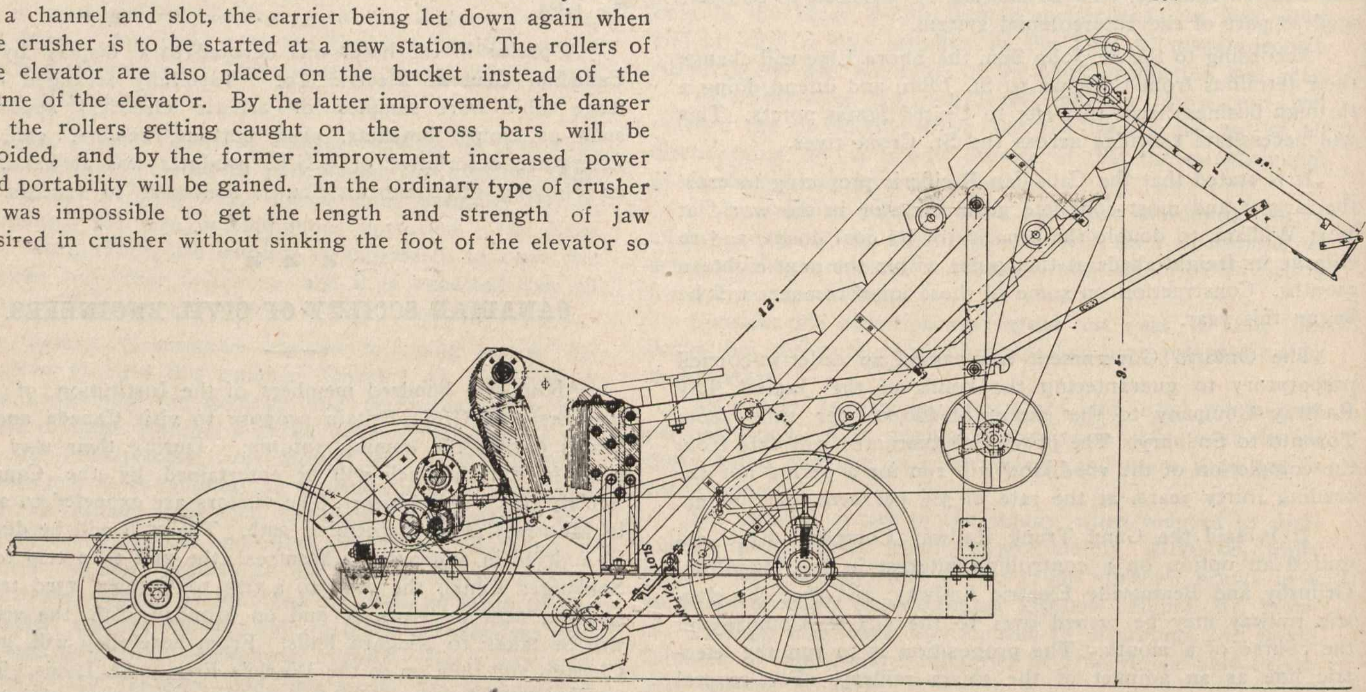
Under the presidency of J. A. Kammerer, the Canadian branch of the American Institute of Electrical Engineers has made healthy progress. The parent organization came into existence in 1884 with a membership of 100. It now has 3,000 members, among whom are many of the world's foremost electricians. The object of this institution is to advance electricity as a science, and in pursuing this high aim it has given to the world a mass of valuable technical literature. Its meetings and conventions have been free from the influence of the supply man and others, who are "out for business."

The Canadian branch has the benefit of copies of papers read before the parent institution with reports of discussions; but apart from this, some instructive papers have been presented at the meetings in Toronto during the past session. Among these papers may be mentioned one on "Transformers," by Prof. Rosebrugh, of the School of Practical Science, Toronto; one on the "Storage Battery," by E. B. Walker; one on the Toronto and Niagara Power Co.'s works at Niagara Falls, by K. L. Aitken, of Toronto, the two last named being repeated before the Canadian Electrical Association. Another paper on the Soulanges Canal electrical equipment, by J. Kynoch, chief engineer of the Canadian General Electric Co., appears in another part of this issue. The last meeting of the session was held on the 10th June in the rooms of the Engineers' Club, of Toronto, when Mr. Aitken's paper was read and illustrated by lantern slides. The meeting, which was well attended, was concluded by a supper, presided over by Mr. Kammerer. The following officers have been elected for the ensuing year: Chairman, Prof. T. R. Rosebrugh; vice-chairman, H. A. Moore; secretary, R. T. Mackeen (re-elected); executive committee, R. G. Black, J. A. Kammerer, and K. L. Aitken.

The meetings of the branch will be resumed at the rooms of the Engineers' Club, on the evening of October 7th. Information relating to membership may be obtained by addressing the secretary, R. T. Mackeen, electrical engineer, Canadian General Electric Co., Toronto.

## IMPROVED ROCK CRUSHER.

The cut below shows an improved rock crusher, placed on the market by the Good Roads Machinery Co, of Hamilton. When the crusher is to be moved from its working station, the carrier is lifted quite clear of the road by means of a channel and slot, the carrier being let down again when the crusher is to be started at a new station. The rollers of the elevator are also placed on the bucket instead of the frame of the elevator. By the latter improvement, the danger of the rollers getting caught on the cross bars will be avoided, and by the former improvement increased power and portability will be gained. In the ordinary type of crusher it was impossible to get the length and strength of jaw desired in crusher without sinking the foot of the elevator so low as to risk damaging the machine when moving it from place to place. By this simple shifting device, the jaws can be made long and strong enough for any service, and yet permit the elevator to be raised clear of the road when travelling. This improvement is the subject of a patent.



# PERSONAL.

Mr. John Coom, chief engineer of the Government Railways of New Zealand, spent a couple of days in Toronto recently, on his way home to the Old Country. He will not return to New Zealand until December.

Among the King's Birthday honors, distributed on June 24th, A. Gobeil, deputy Minister of Public Works, and David Pottinger, general manager, Government Railways, were made Companions of the Imperial Service Order.

Arthur W. Holmes has been appointed by the Ontario Government to the vacancy caused by the retirement of Jas. R. Brown, thus completing the staff of factory inspectors. Mr. Holmes has been a member of the executive of the International Machinists' Union for some years.

Lieut. Gordon Tyndale Jennings, Reserve of Engineer officers, who graduated at the Royal Military College of Canada, in 1902, and subsequently obtained the degree of B.Sc. in Civil Engineering at McGill University, has returned to Toronto, and is engaged in his profession, with his father, W. T. Jennings, M.I.C.E.

T. S. Rubidge, chief engineer of the St. Lawrence canals, died at his residence, Mountain Place, Cornwall, aged about 84 years. The deceased gentleman was a native of England, but spent most of his life in Canada, being in the employ of the Government since 1844. He was engaged on the construction of the Iroquois Canal, a section of the Intercolonial, and other public works.

The Nova Scotia Government recently appointed C. R. Coutlee, of Aylmer, Que., good roads instructor. Mr. Coutlee is a member of the Canadian Society of Civil Engineers, and is under forty years of age. He was educated at the Royal Military College, Kingston, graduating fifteen years ago. Since then he has been employed on important works from Montreal to Vancouver, and is now carrying on a general engineering practice at Vancouver. He is regarded as an expert on highway construction.

Fred. B. Fetherstonhaugh, head of the firm of Fetherstonhaugh & Co., patent barristers, Toronto, has associated with him in charge of the Montreal office, Albert F. Nathan, late examiner in the United States Patent Office, Washington. Mr. Nathan is a member of the Bar of the Supreme Court and of the Court of Appeals, D.C., and holds degrees from the Massachusetts Institute of Technology, National University, and Columbian University, besides having had practical experience in electrical, mechanical, and chemical industries.

Geo. A. Mountain, chief engineer of the Canada Atlantic, has, by an order-in-council, been appointed engineer to the Railway Commission, created by the Dominion Parliament last session, and of which Hon. A. G. Blair is chairman. Mr. Mountain was born at Quebec in 1860, and began his professional career in the office of the City Engineer. He was engaged on surveys for the Newfoundland Railway and the Quebec and Lake St. John Railway. As assistant engineer on the Canada Atlantic, he superintended the construction of the Ottawa, Arnprior and Parry Sound division, and he became chief engineer of the system in 1890. Mr. Mountain is an active member of the council of the Canadian Society of Civil Engineers. In his new position he will be expert adviser to the Railway Commission.

The suit of Peter Lyall against the Glen Falls Portland Cement Co., for $38,000 damages for failure to supply cement of the quality contracted for, has been settled by jury trial in Montreal. The verdict is in favor of plaintiff for $10,393.86. The trial lasted three weeks. The cement in question was for the Chambly dam, the failure of which was described in the Engineer at the time.

—The problem of obtaining nitrogen from the atmosphere for fertilizing the land appears to have been solved, at least from a scientific point of view, by Doctor Erlwein, a German experimenter. His method is first to separate the nitrogen from oxygen by passing an air-current over red-hot copper, when the oxygen combines with the metal, leaving the nitrogen free. Then the nitrogen is caused to combine in an electric furnace with a mixture of powdered charcoal and lime. The product is a black substance suitable to be spread on the land, and possessing the fertilizing properties of Chile saltpeter and potassium nitrate. It remains to be demonstrated that the new ferilizer can be produced on an extensive scale and at an economical cost.