

The Author. power. He thought the future was much brighter than Mr. Lawson had suggested. In conclusion, he could only say he was proud as a Canadian member to have visited the Institution, and much gratified to have been received with such great courtesy.

Correspondence.

Mr. Bell. Mr. W. REID BELL observed that, having been connected with the preparation of the plans for the report on Montreal Harbour made in 1877 by Messrs. Bell, Newton, and Fleming, he was keenly interested in the Author's description of the progress made in the great Canadian port. It might be useful to recall some of the conditions and the views held at the time of the 1875-7 Report. The Harbour Commissioners, in their memorandum to the Reporting Commission, stated that they would

"draw . . . attention to the rapidly-increasing trade of this continent, especially of Western Canada and the Western United States. The rapidity of this increase in the last twenty-five years has made the then constructed canals in the United States and Canada utterly incompetent to meet the wants of even the present trade, hence their enlargement now, both in the United States and Canada, has become a necessity. In 1838, only 78 bushels of grain were shipped from Chicago and Lake Michigan; while in last year [1874], from that lake alone, the exports of cereal (without taking in provisions), were 123,000,000 bushels. In 1846 the value of the imports and exports to and from Montreal was \$10,099,180, while last year they amounted to \$65,808,448."

The memorandum gave the following figures :—

Tonnage arriving from sea in 1854	Tons 72,305
" " " 1874	" 423,423
" " from local ports but not from sea in 1861	" 523,224
" " " " " 1874	" 956,837
Revenues from Harbour dues 1854	\$64,000
" " " " 1874	\$280,021

and stated that

"The St. Lawrence is . . . the natural outlet for the western and south-western United States, and the Port of Montreal is 120 miles nearer to ports on the upper lakes, than any of the sea ports on this continent. The distance from Chicago or from any other lake port to Liverpool is 480 miles less *via* Montreal than *via* the Port of New York."

Again, the Report of the Commission of Engineers said :—

Mr. Bell.

“The introduction of steam totally changed the commercial character of Montreal. Previously, the supremacy of Quebec was assured; the delays in ascending the river were serious impediments. . . . Possibly it was only the introduction of steam which interfered to prevent Hochelaga being the site of the Harbour.”

It was instructive to follow the evolution of the harbour from the plans of 1877, and to note the departures made. The construction of the embankment, now called the Mackay Pier, northward from the Victoria Bridge, recommended in the 1877 Report, appeared to have effectually altered the conditions of the harbour-front, and, instead of the low-level trunk piers and breastworks, had allowed of the construction of high-level wharves throughout; whereas in the 1877 plans it was only contemplated to make a high-level harbour served with locks between the Lachine Canal and the embankment, leaving the rest of the wharves and piers at low level. The Author had not dwelt upon the early difficulties of the winter inundations and the ice-thrusts, but it would be of interest if he would give an account of the present-day winter phenomena on the river in front of Montreal, showing how the ice piers and breakwaters now acted, and comparing the present state of affairs with the graphic account given by Mr. (afterwards Sir) William Logan in 1842.¹ Mr. Bell demurred to the suggestion that Canadian methods of construction were not of interest to members of The Institution. Both in Britain and in the Colonies much was heard of “American methods,” but in engineering practice there were no water-tight compartments. The principles of construction were the same everywhere, and his experience was that under similar conditions engineers of all countries used in the end structures of similar types, whether it was cribwork in Canada, pin-connected bridges in the far west, plate girders in New York and London, earthworks in India, or timber trusses in New Zealand. Therefore all details of such evolution as had taken place at Montreal were of living interest, and were of the greatest use to engineers engaged in design. The Author's views as to the lengths and widths of the piers and water-spaces were borne out by experience elsewhere, and Mr. Bell had advocated for some years the necessity in modern deep-water harbours of utilizing to the full the costly wharves and piers by providing, in the case of wharves,

¹ Description of Winter Phenomena in the St. Lawrence, contributed to the Geological Society of London, 15th June, 1842, by the Provincial Geologist, W. E. Logan.

Mr. Bell. plenty of land alongside, and in the case of piers, sheds of two or more stories. In 1910, in a Paper¹ "On the Improvement of the Port of Melbourne," he stated :—

"It will not be sufficient to make the wharves wide, they must be backed by a deep strip of ground, running back from the water, whereon the merchants can have their permanent warehouses served by railway and water carriage . . . If the whole of these wharves were provided with high-level warehouses and transit sheds, worked with cranes on the quay side, and with road and railway below the sheds, each berth could be made to serve a very large increase of shipping, and such an equipment would obviate the construction of additional length of wharfage, while concentrating the shipping near the centre of the town."

And as to the works at Port Melbourne (formerly Sandridge):—

"The wharves must be laid out, not as 100 feet or 150 feet piers, choked up with railway lines, but must be deep-water quays, with 3, 4, or 500 feet in depth of solid ground opposite the berths, upon which permanent transit or storage warehouses can be erected by the authorities or their lessees. The railways, roads and sheds must be kept back from the ships, the quayage being occupied by passenger gangways and by whips and cranes, delivering the goods on overhead tram lines, whence they can be delivered on waggon, truck, or in store in any direction. The outward cargo should pass into transit sheds, whence, as soon as the ship is ready to load, it can be smartly brought forward to the cranes."

And, generally, owing to the great depth required and the consequent cost of modern quays, it was necessary to make them as short as possible, and to work them at the highest possible pressure. This could only be done by extending in depth the land attached to the quay, to give room for a proper equipment of cranes, transit sheds, and warehouses, and road and railway accommodation. The subject had been further dealt with in a recent Paper² by Mr. H. Ollendorff. These conditions were largely met by the typical pier shown in Fig. 1, Plate 4, but the full utilization of the water-space on a river-front was a difficult matter: piers did not afford the accommodation provided by quays, as they required double handling of goods, whereas quays backed by warehouses did not, unless the piers could be made as wide as those at Montreal, where the cribwork construction with filling favoured the adoption of wide piers. In other cases it might be necessary to build the piers as open structures, say, in timber piling or reinforced concrete; but it must be remembered that the cost of a timber or concrete structure per

¹ Proceedings Victorian Institute of Engineers, vol. xi (1911), p. 40.

² "The Utilization of Ground adjoining Harbours and Railway Stations by the aid of Mechanical Conveyers," Proc. Inst. Engineers and Shipbuilders in Scotland, vol. lvii.

square foot of wharf-space might be five or ten times the cost of Mr. Bell. reclamation, so that reclamation offered notable economy where it was practicable. Montreal Harbour was fortunate in the durability of timber work in the fresh waters of the St. Lawrence, and the crib-work made a good showing. The details of construction given by the Author would be of much value to engineers, and the high-pressure working-season was a welcome contrast to the present labour-conditions in Australia. The question of cranes and transporters in wharf-service was a difficult one in ports with established usages, and the double-story sheds with team hoists practically doubled the area of the quays at comparatively small expense. In connection with the vibration experiments on concrete, doubtless the amount of air imprisoned in concrete during the process of mixing was very considerable, and at present vibration seemed to be the most practical means of assisting the air to escape and allowing the concrete to consolidate.

Mr. R. D. BROWN regretted that the Author had not elaborated Mr. Brown. more the question of routes. The details of the development of Montreal Harbour were extremely interesting and valuable, but the Paper would have been still more valuable had the Author dealt at equal length with the transportation problem in Canada. At present this question was prominently before the public in that Dominion. A Royal Commission had just been appointed to inquire into the commercial feasibility of one of the routes mentioned, namely, the Georgian Bay Canal. This canal (not shown on Plate 3) would follow a chain of natural lakes and rivers almost in a straight line from Georgian Bay to Montreal, where it joined the present deep-water channel. The engineering possibilities and the cost had already been considered very carefully in reports to the Government, but the commercial necessity of the canal did not seem to have been settled satisfactorily. It must be obvious to anyone looking at the map that transportation in Canada would be completely revolutionized by successful construction and working of the canal. The points for and against the project might be briefly summarized thus:—The grain arrived at Port Arthur or Fort William by rail and was transhipped to lake vessels. That portion of it which was to pass through Montreal travelled south through the Great Lakes, via the Sault Ste. Marie and Welland canals and the Upper St. Lawrence river. Considerable variations from this route, such as re-shipment at Kingston, occurred; but a captain bound eastward from Fort William with grain would have the following alternatives to consider, if the Georgian Bay canal were open to him: (1) by going through the Georgian Bay

Mr. Brown. canal he would save 282 miles steaming; (2) by going through the Lakes, however, he would be able to travel at full speed with plenty of sea-room. In the canal he would be hampered by fogs, which it was alleged were frequent on that route; but he would be travelling entirely in Canadian territory. Among other arguments put forward, the power question had been given prominence. The promoters of the canal proposed to develop 1,000,000 HP., to bring in a revenue of £1,000,000 per annum. Their opponents maintained that there would be no market for the power developed. These points—and many others—were under heated discussion in Canada to-day.

Mr. Cochrane. Mr. M. FARRER COCHRANE observed that in Canada the transportation problem was of the greatest importance to the people, living as they did in a comparatively narrow belt across the whole width of the continent, a distance of more than 3,600 miles, and it afforded large opportunities for the civil engineer. In analysing the different routes described by which grain might be shipped from the prairie provinces to Great Britain, the advantage on paper would undoubtedly appear to be with the St. Lawrence all-water route, and this advantage was clearly shown in the following extracts from an address given by Mr. G. W. Stephens, formerly President of the Board of Harbour Commissioners of Montreal, before the Canadian Club of Ottawa in 1909:—

“From the head of ocean navigation at Montreal, westward, exist 1,600 miles of interior waterway, 500 miles of which is 14 feet deep, and the balance available for ships drawing 19 feet, and the entire 1,600 miles of inland waterway is made available by the system of Canadian canals, in all 65 miles long. On the other hand, the American water route from Buffalo to New York, in a distance of 430 miles, comprises altogether 306 miles of canal. A short comparison of the two great water outlets from the Great Lakes to the sea—one Canadian and one American—will show what an overwhelming position the Canadian waterway occupies: From Buffalo to New York is 430 miles; from Buffalo to Montreal is 320 miles. Between Buffalo and New York are 306 miles of canal, with a maximum draught of 6 feet. Between Buffalo and Montreal are 65 miles of canal, with a maximum draught of 14 feet. From Buffalo to New York maximum cargo is 8,000 bushels of wheat in one boat; from Buffalo to Montreal maximum cargo is 80,000 bushels. Now as the season of navigation is identical in both cases, and as it takes 40 hours more to carry grain by water from Buffalo to New York than it does from Buffalo to Montreal, it is possible for the same boat to make twenty-one more trips during the season of navigation from Buffalo to Montreal than it is for the same boat to do the same work from Buffalo to New York. In the twenty-seven trips made by the largest possible boat over the American waterway from Buffalo to New York, 216,000 bushels of wheat can be carried; whereas in the forty-eight trips made from Buffalo to Montreal 3,760,000 bushels can be taken. If the St. Lawrence water route therefore, to

Montreal is 110 miles shorter, has 240 miles less of canal with 8 feet more draught, upon which one boat can carry as much as it takes ten boats to carry by the American route, and is 40 hours shorter each trip, how is it, in the face of these overwhelming advantages, possible to ship grain by way of New York instead of by way of Montreal? On its merits, the Erie Canal as a competitor with the Canadian canals is dead. It is due, therefore, to the enterprise of the railways, who have erected at Buffalo sufficient terminal elevator capacity to accommodate all the grain brought from the western lake ports for export, whereas on the Canadian side elevator storage capacity to any extent has not existed at the terminals. When Canadians create sufficient storage capacity so that the grain business will not be a hand-to-mouth one, so that ships can be sure of their cargoes, then will the true advantages of this water route be made available. There is another reason, and that is the return cargoes which grain boats receive in going from New York to Buffalo. When this same class of business in return cargoes is developed from Montreal westward it will double the income of the lake freighters, and put Canadian vessels into a position where their grain-carrying rate will command, not only the Canadian grain business, but the export grain business of the United States."

The new Welland ship-canal between Lake Erie and Lake Ontario, which was now being constructed at an estimated cost of \$50,000,000, was expected to benefit the St. Lawrence route still more by allowing grain to be shipped in bulk to Kingston or Prescott, thus allowing about 200 miles of additional deep water navigation. This canal was one of the largest works of its kind ever undertaken, and it was designed with 30 feet of water over the lock-sills. Estimates had been made of the cost of deepening the St. Lawrence route to 22 feet over its whole length from Kingston to Montreal, but it would be very great, and the difficulties to be overcome still greater, as the St. Lawrence was partly an international river. An alternative to this was the proposed Georgian Bay ship-canal, for which preliminary surveys had been made by the Dominion Government. The results of these surveys, including plans and estimates, and the reports of the engineers engaged on the work, were published in 1908. The advantages of this canal were so great that it was probably only a matter of time before the work would be undertaken by the Government. The estimated cost was about \$120,000,000 (£24,000,000). The advantage in distance was as follows:—

	Miles.
Port Arthur, head of Lake Superior, to Montreal, via } Georgian Bay canal }	934
Port Arthur, head of Lake Superior, to Montreal, via } Welland and St. Lawrence canals }	1,226
Port Arthur, head of Lake Superior, to Liverpool, } via Georgian Bay canal }	4,120
Port Arthur, head of Lake Superior, to Liverpool, } via New York }	4,930

Mr. Cochrane. The advantage in the probable rates was also striking :—

	Per bushel of wheat. Cents.
Port Arthur to New York, via Great Lakes and rail } from Buffalo }	6·5
Port Arthur to Montreal, via Great Lakes and rail from } Georgian Bay }	8·0
Port Arthur to Montreal, via Great Lakes and St. } Lawrence canals }	7·0
Port Arthur, to Montreal via Great Lakes and Georgian } Bay canal }	2·0

This last rate for wheat was given as an estimate by Mr. Norcross, now Managing Director of the Canada Interlake lines, in the Dominion Government Report of 1908. The St. Lawrence canals suffered considerably on account of the one-sided nature of the traffic, as the eastbound tonnage was about ten times as much as the westbound tonnage. On the Great Lakes the eastbound traffic was about five times the amount of the westbound. The Georgian Bay canal would equalize the traffic to a large extent by offering markets in the west for two of Canada's most valuable products, the lumber of Ontario and Quebec and the coal of Nova Scotia. With regard to lumber, it would give the most extensive forest areas and the largest mills manufacturing forest products in Canada direct access to Chicago and the middle-western United States. The coal-traffic was more doubtful, but the following figures would show that there was at least a possibility of its extensive development. At present Nova Scotia coal could not compete successfully in Canada with Pennsylvania coal farther west than Montreal; but with a direct water route from the mines to the Great Lakes, and vessels carrying 10,000 tons, there was reason to believe that Canadian coal could be used profitably as far west as Port Arthur. The present freight-rates on Pennsylvania coal were approximately—

	Cents per Ton.
Mines to lake port at, say, Cleveland	80
Cleveland to upper lake ports	35
Duty	45
Total	\$1·60

The estimated rate from Sidney to Port Arthur via the Georgian Bay canal was \$1·10, with the advantage of non-transshipment. The large lake freighters described were at present used almost exclusively for the local coal and iron-ore traffic; but as the Georgian Bay canal was designed for a depth of 22 feet of water throughout, they would doubtless be used to carry grain to Montreal, taking more than 400,000

bushels each voyage. The round trip from Port Arthur to Montreal Mr. Cochrane. and back would take about 15 days, or nearly the same time as the present St. Lawrence canals route. It was probable that with Canada's unrivalled water routes, the United States railways from the Great Lakes to the eastern seaports would not continue much longer to have any large share of the Canadian export traffic. But the railways running north into the prairie provinces would year by year take more grain for home consumption. According to Mr. J. J. Hill, President of the Great Northern Railway, in 40 years the United States would have a population of 200,000,000, and would not only have ceased to export wheat but would by that time take every bushel of wheat which Canada could export. This aspect of the problem required serious consideration. The traffic on the Great Lakes was extremely interesting, and deserved the attention of every student of transportation : 80 per cent. of the total freight carried consisted of iron ore and coal, the iron ore being carried from Lake Superior to Lake Erie, and the coal forming the return cargo. The remaining 20 per cent. consisted principally of grain and lumber. The iron-ore and coal traffic had become highly specialized and of enormous proportions. The tonnage carried in 7 months was five times that passing through the Suez Canal in a year. It was to deal with this that the large "freighters" had been devised, to carry more than 12,000 tons of pay freight. The result had been to reduce the rates to the minimum, and the freight was handled more rapidly than any other in the world. Boats had loaded 11,000 tons and got under way in 3 hours, and the same quantity had been unloaded in 7 hours. Montreal undoubtedly occupied a very favourable position for a terminal port, as was well shown in the Paper. The absence of silting sands in the channel, and freedom from the disturbing influence of tides, were great advantages, the latter especially, as it allowed an open pier development, with all piers accessible to all ships at any hour, and this more than offset the disadvantage of the port being closed for 5 months in winter. The appliances for handling freight were also excellent, as could be judged from the fact that 13,000 tons had been loaded and unloaded in 3 days, from one steamer. Perhaps the most important advantage was the Government ownership of 16 miles of water frontage on each side of the river, giving absolute freedom from vested interests of all kinds, and enabling a comprehensive scheme to be developed in which docks, railway-termini, and industrial sites could be placed in their proper

Mr. Cochrane. relationship, to the best advantage of each, so that the most efficient sea terminus in North America could be created with the smallest capital investment.

Dr. Corthell. Dr. E. L. CORTHELL wished to commend the Paper especially for its complete details relating to Montreal Harbour. With regard to the commercial aspect, he had dealt with the general subject exhaustively in 1891 in a Paper¹ written after personal examination of the general routes between Chicago and as far east as the Chignecto ship-railway. As a member of the Advisory Board of Consulting Engineers, 1903-5, for the new barge-canal of New York State, and previously as consulting engineer for several years of the Hurontario ship-railway between Georgian Bay and Toronto, in association with the late Mr. Kivas Tully, he had had opportunities to form his ideas on some of the questions dealt with in Mr. Cowie's Paper. In the first place, it was necessary to appreciate the great drawback involved by 4 to 5 months of ice-bound navigation to any water route and any harbour in Canada or the northern United States. Suppose the climate of Great Britain were to change so that all its navigable rivers and ports, except, say, Southampton, were ice-bound one third of the year; how long would it take to divert to Southampton most of the traffic from Aberdeen, Glasgow, Leith, the Tyne ports, Sunderland, Liverpool, and London? Would the fact that Liverpool or Glasgow might be a few miles nearer than Southampton was to Montreal or to Boston and New York exert any measurable influence in holding back commerce from going to the open port of Southampton? By the Author's figures Montreal was a few miles nearer to Liverpool than Boston and New York were, but it was closed to commerce for 4 to 5 months in every year. He was not sure that the distance by sea was practically any shorter, for Mr. Robert E. Barrett, designing engineer of the port of Boston, had stated² that Boston harbour was about 110 nautical miles nearer than Montreal to Liverpool, and, according to him, Montreal was only 84 nautical miles nearer than New York. These ports were open all the year, and so were Portland, Philadelphia, and Baltimore. Boston and Portland had direct connection with the Canadian railway systems, so that they received the Canadian traffic over Canadian lines into adequate and well-equipped ocean terminals

¹ "An Enlarged Water-way between the Great Lakes and the Atlantic Seaboard." Trans. Canadian Soc. C.E., vol. v. (1891), p. 32.

² "The Development of the Port of Boston," *Engineering News*, vol. 71 (1914), p. 709.

during the 4 or 5 months that all water channels to Montreal Dr. Cortbell. were closed by ice. The Author referred to the immense tide of emigration from the United States to the new provinces, but he omitted to observe the same immense tide flowing back from the new provinces to the United States. The United States farmers, numbering about 600,000, who had had the Canadian fever, remained there only 2 or 3 years, when more than 500,000 of them returned. The Author also said that the north and south routes through the United States were principally by rail or by the Erie Canal from Buffalo to American Atlantic ports; from which it might be inferred that the Erie Canal had been and was a considerable factor in the transportation of western products to the Atlantic seaboard. The facts were, that the entire volume east and west carried on the Erie Canal, was not, and had not been for many years, more than $2\frac{1}{2}$ to 3 million tons, while the railways carried more than 50 million tons. The Author referred to the new Erie Canal. By this he must mean the new barge-canals of New York State, embracing not only the Erie Canal proper, which lay between Albany and Buffalo, but also the Oswego Canal to Lake Ontario and the Champlain Canal up the Hudson river and valley to Lake Champlain, the estimate of expected traffic being 10 million tons over the whole system. The cost of this work was given by the Author as \$150,000,000, including harbours and damages. It would probably be \$101,000,000, for the work originally contemplated, \$7,000,000 for the Seneca and other "finger-lakes" canal subsequently provided for, and \$19,000,000 for canal harbours and terminals at New York City, say, \$127,000,000 all told for works, and to cover excess damages a grand total of \$130,000,000.

Mr. W. H. HAMER observed that in the course of a tour of the Mr. Hamer. ports of the world for the purpose of comparison of methods, in connection with harbour-works and waterways in Northern New Zealand, he had had the opportunity of studying on the spot the question dealt with in this Paper, and the further advantage of the courtesy of the Author's guidance when in Montreal. To those unfamiliar with a continent of such vast distances it had possibly never occurred that about 2,200 miles inland from the ocean—or 1,200 miles west of Montreal—one might see 10,000-ton vessels taking their burdens at the great grain-silos of Port Arthur on Lake Superior; and only by means of such convincing figures as those given by the Author could it be conceived that the enormous sums expended by paternal Governments on improving waterways in Canada had been warranted. Early faith in the future of the rich lands of

Mr. Hamer. the west had been well founded, and the colossal increase of production during recent years, with the opening-up and development of new areas, would appear fully to justify the improvement of existing means of transportation and the development of the more direct route by the proposed Georgian Bay Canal, which, by avoiding the long detour of lakes Huron, Erie and Ontario, and the sphere of inducements offered by the United States ports, should ensure to Canadians retention of the full advantage of the enormous traffic within their own Dominion, instead of allowing a considerable portion to be diverted through American channels, all of which were making feverish efforts to obtain as much as possible of it. The story of the growth of means of transportation in Canada was equally the story of all new lands. Countless instances proved that population and manufactures quickly followed where easy transport facilities were provided. Agricultural districts had been transformed into busy hives of industry by the construction of canals; land-values had been enhanced; cheap water-power had been obtained; mineral resources had been opened up. Coal-traffic, that hitherto had been blocked by foreign competition, had been developed by cheap transport; and the Georgian Bay proposal offered real promise in this direction. It was impressive to see big vessels so far inland as Montreal—1,000 miles from the sea—and it would be the happy realization of a great dream to find it possible to take them through the heart of the continent to the head of Lake Superior without breaking bulk—a present impossibility by reason of the limited depths in the canals and rivers connecting the chain of lakes. The need had produced the method, and the vast work of deepening the channel from Montreal seaward to Lake St. Peter by dredging and removal of submarine rock, had caused the development of an exceedingly fine plant, the inspection of which had enabled him to improve his system on large dredging-operations with which he was connected in New Zealand. He had also the opportunity of inspecting the complete system of lighting the channels, and had since partially adopted the Canadian principle. Naturally, the question of handling bulk cargoes of grain—the thing that mattered most at Montreal—had led to methods of great capacity and economy, and the Author deserved congratulation on their successful accomplishment. The increase of shipping and trade at the port of Montreal, and the promise of the future, would seem to demand considerable increase in berthage accommodation. The economy of big ships was acknowledged. The frenzied rate at which vessels were increasing, particularly with regard to draught, was providing a big problem for engineers and

imposing a heavy burden upon port-authorities. It was satisfactory, however, to find the position accepted, and to note the enormous port-developments proceeding throughout the world. The conclusions arrived at by the Author in his study of the desirable lengths and widths of piers and basins at Montreal and Halifax were of exceptional interest, particularly because of the handling of large vessels at berths placed as they were with respect to a stream of such a velocity as 5 knots; and they closely confirmed Mr. Hamer's decision in the design of piers 1,200 feet long and 280 feet wide, with basins of 350 feet, in works recently constructed at Auckland, N.Z., where the tidal range reached 12 feet, and the velocity of the current was about $1\frac{1}{2}$ mile per hour. Vessels were there conveniently berthed at piers almost similar to those at Montreal, sometimes under their own steam and sometimes by the aid of a single tug. It would be of considerable assistance if the Author would describe the method of handling and berthing large craft at the Montreal wharves. At New York, Boston, and San Francisco piers were somewhat similarly disposed along the waterfront, and the largest vessels were very skilfully handled in narrower basins congested by small craft, in varying currents without any sheltering protection. In the proposed development of the waterfront of Chicago, which, of course, was tideless, it was interesting to note piers 2,500 feet long and 292 feet wide, and basins only 300 feet in width. Engineers unaccustomed to ice-bound ports would find a number of unfamiliar conditions at Montreal; for instance, the great height of quay-level above the water-line, and the sinking of mooring-posts and bollards below quay-level, each to avoid inconvenience and damage by ice. With regard to types of construction, the Author was not alone in his discovery of the two special principles he enumerated, namely, that the Colonies had found it necessary:—(1) To build for the present; (2) to accept any makeshift as satisfactory. These had been essential factors in all young, developing and unfinanced lands. With the passing of time and the establishment of great cities and ports, however, wealth and prosperity had made it possible to construct more permanent works, which, though initially more costly, were finally more economical. This was now rapidly becoming the approved policy in both Australia and New Zealand. Wooden cribwork, which was so prominent a feature of all American marine structures, had no equivalent in the South seas, though as timber-growing countries Australia and New Zealand had up to about 12 years ago, used practically nothing but timber in piers and quays. In Auckland, however, marine boring pests had done so much

Mr. Hamer. damage, and timber lasted such a comparatively short time and was becoming so increasingly difficult and costly to obtain, that concrete—either plain or reinforced—was being adopted, and latterly all structures had been entirely of that material, either as plain gravity walls, concrete caissons, or reinforced-concrete piles and decking. These countries, however, had no frost difficulties to contend with. Questions of dry docks, powerful floating cranes, and other special equipment, had been dealt with similarly to Montreal in the growing ports of the southern hemisphere. The wealth of Canada was developing at an extraordinary rate. The new world was finding food for the old, and this was being rushed eastward in ceaseless procession. Transportation in Canada—already based on a magnificent foundation—would need energetic expansion and the untiring watchfulness of its industrious people. It was a problem whose solution would pay.

Mr. Heathcote. Mr. C. HAROLD HEATHCOTE asked why such a large and presumably expensive system of conveyers was necessary for the handling of grain, as he understood that at all the lake ports steamers were loaded directly at the elevator; also, whether it was correct that the traffic in Montreal Harbour had more than kept pace with the development of the harbour, and that all the available steamer-berths were assigned by the year to individual steamship-companies? If this was so, what arrangements were there for the loading of tramp steamers? He would like to know whether No. 2 Elevator was in fact the largest reinforced-concrete building erected so far, and whether the structure was satisfactory from an engineering standpoint?

Mr. Humphreys. Mr. G. W. HUMPHREYS observed, with regard to the deepening of the channel and the dredging generally, and more particularly the means employed in those operations, that although the Author did not treat the matter in any great detail, the work might fairly be said to be illustrative of American practice in contradistinction to what might be said to be English practice. The characteristic feature of the plant employed was that all the floating plant was furnished with means for standing upon the bottom; that was, it rested upon spuds fitted with suitable suspending gear. This applied not only to the boring-machinery but also to the dredgers and to the cranes employed for putting the spoil ashore, as well as to the crane employed for construction work. In Mr. Humphreys's opinion there was no question but that, where circumstances permitted the use of plant of this nature, which, while possessing the mobility of floating plant, could readily be converted into a stable platform, great benefits accrued, tending to rapid and successful execution of

work. The principle had not, so far as he was aware, been applied to any extent in England, the reason being, he thought, that Canada and the United States possessing the large water area of the great lakes and the adjoining rivers, not subject to tidal range, a field was open there for the successful evolution of such plant; and, as was always the case, opportunity for its use had led to its production. The Author had been fortunate in having natural conditions so favourable to the use of what was really a very efficient contrivance for readily creating a stable platform in a waterway. Mr. Humphreys thought, however, that in any tidal water, unless with a very small range of tide, great difficulties would arise from the use of plant of this character. Occasionally the want of a suitable platform in a waterway subject to much oscillation, such as a site exposed to any ocean swell, as opposed to any small amount of wind wash, was felt severely; and some time ago the contractors for some dredging work at Peterhead, Scotland, had under consideration the means for boring holes on an open shore exposed to heavy seas and subject to a considerable rise and fall of tide—in fact, bare at low water. After repeated attempts, the use of floating craft proved to be impracticable, and ultimately the work was accomplished by means of a stage standing on legs. Instead, however, of the legs forming a part of any pontoon or floating plant, a special arrangement was devised. A small square stage or platform was constructed with a telescopic leg at each corner. Outside this square a larger square, also having a telescopic leg at each corner, was provided. The arrangement was such that, if the telescopic legs of the outer stage or framework were placed on the ground, the legs of the small internal staging could be lifted, and, by means of girders, its weight could be transferred to the outer framework. The girders formed a traveller, so that the inner stage could be moved to any point desired within the outer. By alternately placing the weight upon the set of legs of the outer and inner stages, and by moving one upon the other, progression was possible in the same manner as rooks could move upon a chessboard. The level of the staging was of course permanently above high-water mark, out of reach of disturbance by swell or breaking seas. Consequently, the telescopic legs had not to be interfered with, as would have been the case had a floating pontoon been employed, necessitating movement of the suspension-gear to counteract rise or fall of the tide. This machine worked very efficiently, withstood the heaviest seas, and had lately been applied successfully on a larger scale for constructing the new outer piers for the harbour at Whitby, Yorkshire, the stage being large

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enough to span the whole section of the pier; and, in spite of the severe weather often experienced on that coast, it had resisted the heaviest seas without any auxiliary moorings or anchorages. The method of drilling adopted was not clearly described by the Author; but it would appear from the photographs exhibited by him that steam percussive drills were used. The number of holes drilled during a season was not, however, very large, apparently fourteen or fifteen a day. The details of this class of drilling-plant had, it was known, been considerably developed in the United States of America generally; and the claim was made that with this system no time was lost, inasmuch as drilling from one portion of the boat or stage proceeded while blasting or charging a hole was being effected at another. It was plain that this method saved much time as compared with that of drilling a hole, removing the barge, firing, and returning the barge to a new position. While this might appear to be the case, Mr. Humphreys was struck with the small number of holes that an expensive piece of machinery such as the drill-boat in question, had dealt with over a period of time; and even assuming that the conditions did not preclude the use of a boring-stage standing upon the bottom, he was inclined to think that great advantages accrued from utilizing to the full the deck-space of a boring-barge by placing thereon as many drills as possible and working them all at one time, even if it entailed loss of the time necessary for displacing the barge during the operation of firing and returning to a new position. Some time ago he constructed a drilling-boat which was capable of drilling twenty holes simultaneously, and the capital cost of the boat and its drill equipment, which was manipulated by hand, amounted to £4,000. This boat could bore eighty holes in a day of 24 hours, working in a strong tidal current. The daily capacity of the boat would have been higher but for the fact that the current was such that it was only possible at times of slack water to displace the boat, the strength of the current being sufficient to dislodge charges from the bore-holes, owing to the resistance offered to the current by the electric discharge wires. The capacity of a drilling-boat of this description was considerably in excess of that of the boat described in the Paper; but before deciding upon the boat to install, he thought the whole of the circumstances would have to be considered. Speaking generally, he was of opinion that the percussive method of drilling possessed great advantages over other methods, and that no really efficient rotary drill for holes of small diameter, except that furnished with a diamond crown, had yet been devised for working under water. At the works undertaken between 1895 and 1900 for the

deepening of the approaches to Devonport dockyard in the Hamoaze, in addition to the percussive-drill barges, three barges, each furnished with thirty diamond drills, were installed, and did very efficient work. The price of black diamonds, however, entirely governed the continuance of their employment; and owing to the large number required, and partly, it was alleged, to extensive boring-operations on the Rand, where also they were used, the price rose steadily until it reached such a level that the diamond drills had to be abandoned for ordinary steel "jumper" drills. The material dealt with by the Author—shale with frequent insertions of igneous or "trap" rock—was precisely similar to that composing one of the shoals removed in the Hamoaze, and formed one of the most difficult combinations of material to be dealt with. He was struck with the large extent to which the Author had found it desirable to drill below the intended level, namely, 4 feet. It was, of course, necessary to drill deeper than the proposed finished bottom, but 4 feet appeared to be excessive. The difficulty of forming the bottom to an approximately level plane was recognized in the works in the Hamoaze, and a barge was constructed having a caisson about 16 feet in diameter slung in the centre, which could be entered by means of a tube and air-lock, standing always above high water. Inside the caisson several Ingersoll-Sergeant drills were fitted. The apparatus proved very efficient, especially so in searching for and blasting away the dikes of igneous rock. In this case the blasting became independent of the tide, and was governed only by the time necessary to bore the holes and remove the caisson—say, 2 to 3 hours. The work became independent of weather conditions, tide, current, and daylight, and practically no time was lost. The caisson itself was of considerable weight, so as to be stable in a very strong current. With regard to the dredging, the "dipper" dredger was undoubtedly a very efficient tool, subject to the same reservations as to its capabilities in a situation where there was a rise and fall of tide. It occurred to him that in the working of the dipper dredger a possible explanation might be found of the great depth beyond the finished surface to which drilling was necessary at Montreal, namely, that it was not capable of producing quite such an even bottom as the bucket dredger. Not having had any personal experience of working a dipper dredger, however, he was unable to speak definitely upon that point. The extreme ingenuity displayed, and the enormous size and strength of the component parts of the machinery of a dipper dredger, were striking. The machine was an evolution from the steam-shovel, and comparing the standard steam-shovel of America with the steam-navvy of England, he could not help thinking

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Mr. Humphreys. that if the constructor of the latter tool were to study the details of working the racking arm by power, a great improvement in its usefulness would be effected. The facility with which the bucket of the American steam-shovel could be worked and manipulated needed to be seen to be thoroughly appreciated. With regard to the cost of dredging and of rock removal, he considered the Author was to be congratulated upon the results he had obtained, especially having regard to the labour-rates prevailing in Montreal. It must be remembered that, according to the Author's description, the material to be blasted and dredged was of the most uncompromising and difficult kind, and a unit cost of 14 to 30 cents per cubic yard could not be held to be excessive for dredging work. With regard to the dredging, 2 dollars per cubic yard, measured in situ by the methods stated by the Author, was also a very favourable price, and Mr. Humphreys was of opinion that the work had been done for this amount only because the material to be removed must have contained a certain proportion of stuff that the dredgers had been able to get by themselves. In estimating the cost of work of this nature under water, one could not generalize. So many factors had to be taken into account that it was impossible to state in any general terms the cost of removing a shoal or obstruction. The difference between the cost of taking away material that could be removed by a dredger alone, and rock requiring the use of explosives or other disintegrating machinery to remove it, was so large, that the unit price depended entirely upon the relative quantities of material which could be removed by dredging alone and by dredging assisted by blasting. The average price resulting from these two factors might vary considerably, and he would not have been surprised if for a really solid rock requiring the use of explosives, the cost had been as high as 3 to 4 dollars per cubic yard.

Prof. Luigi. Professor LUIGI LUIGI observed that the Author had done a great service to European engineers in explaining so clearly the most important problem of Canada, namely, the transportation of the products of that promising land and their shipment to the European markets. In Europe it was customary to build railways between towns or villages already existing. In Canada, and in most new countries, railways were built across almost desert regions, which could not be cultivated with profit unless proper economical means of transportation were built before the settlers arrived. In fact, the prices of the products of the land were fixed by the European markets where these products were consumed. The greater the expenses of transport to these markets, the less the profit of the farmer, until a limit was reached at which farming

ceased to be profitable. Beyond this limit the land remained practically useless, or nearly so, and certainly not favoured by immigrants. As the expenses of transportation and shipment were reduced, however, more land was brought under cultivation, more immigrants were attracted, and the more Canada progressed. Thus the apparently simple problem of transportation, became in Canada—as in all thinly-populated countries—a very important one, upon which depended the future progress of the country and its people. This explained why the Government and the Canadians were doing their best to bring ocean-going steamers as far inland as possible. They had already done a great deal for navigation by making the port of Montreal accessible to large ships, at least for 7 or 8 months in the year, but that was not sufficient. They were aiming, very wisely, at bringing ocean-going steamers as near as possible to the centres of agricultural production, by improving their waterways up to the Great Lakes. He had travelled on a steamer belonging to that patriotic and progressive undertaking, the Canadian Pacific Railway, which brought him from the Great Lakes to Port MacNicol, and then the ship, drawing about 18 feet after it had been partly discharged, proceeded along the inland waterways to the St. Lawrence, and eventually to Glasgow. The present waterways would certainly be deepened and improved, to receive much larger ships than at present, but already the problem had been partly solved in the proper way. It was a matter of time and money to solve it more completely. In the meantime large ships would come from the Great Lakes to some deep-water harbour near Montreal, where goods would be transhipped on to the railway and sent on to Montreal, where large ocean-going steamers would receive them and bring them to Europe. And as the trade was very large and increasing steadily, so the harbour-works in Montreal must be on a large scale, and planned in such a way as to be susceptible of extension in proportion to the increase of cultivation in Canada. He had had the good fortune to visit the harbour-works of Montreal—and in fact many engineering works in Canada—in the company of Colonel W. P. Anderson, M. Inst. C.E., of the Royal Canadian Engineers and many of his colleagues, and had been very much impressed by the importance of the works carried out and the modest expenditure involved. In Canada, very wisely, engineers did not aim at carrying out works remarkable for their magnitude, solidity, and durability; they built for themselves, future generations might have different needs and would be better able to provide for them. This principle was a very practical one, and should be kept well in mind by engineers who designed works for new countries. The new harbour-works of Montreal formed a very

Prof. Luiggi. typical and praiseworthy example of it. A visit to Canada, in the company of some of its clever and wide-awake engineers, would be a profitable lesson to many European engineers, who sometimes in attempting to do better than their brethren, forgot that the cleverest engineer was he who achieved the same results with one dollar as his colleague with two dollars. The harbour-works of Montreal had been planned and carried out in the right spirit of progressive engineering.

Mr. Money. Mr. R. J. MONEY observed that one question worthy of careful consideration was the effect which the opening of the Panama Canal would have on the transportation problem. Winnipeg, which was approximately midway between Montreal and Vancouver, lay on the eastern boundary of the great north-western grain-field, while the Rocky Mountain range bounded its western border, and the town of Saskatoon was situated midway between the two. As the Rockies were approached from the east, the influence of the warm Chinook winds from the Pacific made itself felt, with the result that the northern limit of grain-growing extended to a much higher latitude than farther east (how high was still undetermined). The centre of this grain-field was therefore not Saskatoon, but some point farther west. For the purpose of argument, however, he would assume it to be Saskatoon. From the following Table of distances by rail to various Pacific, Hudson Bay, and Atlantic ports—

DISTANCES.		Miles.	
Saskatoon to Montreal		1,885	} Atlantic coast ports
„ Quebec		2,057	
„ St. John (N.B.)		2,366	
„ Halifax		2,643	} Hudson Bay ports
„ Port Nelson		754	
„ Fort Churchill		834	
„ Vancouver		1,120	} Pacific coast ports
„ Prince Rupert		1,288	

it appeared that there were the following savings of railway carriage over the ports of Montreal and Halifax:—

Port.	Saving as compared with	
	Montreal.	Halifax.
Shipment via Port Nelson	Miles. 1,131	Miles. 1,887
„ „ Vancouver	765	1,523
„ „ Prince Rupert	597	1,355

Of the grain (wheat, oats, and barley) grown in the Dominion of Mr. Money. Canada in 1911, 75 per cent. was raised in the north-western provinces of Alberta, Manitoba, and Saskatchewan. The total area of these provinces was 728,000 square miles, of which there were under cultivation 5,450 square miles in 1901, and 22,850 square miles in 1911. The grain-crop in these provinces in 1911 was ten times that of 1901, as shown by the following Table:—

GRAIN-CROPS.

	1891	1901	1911
<i>Area under cultivation—</i>			
All Canada. . . . Square miles	11,760	16,350	32,809
North-west provinces ¹ „	..	5,450	22,850
<i>Grain ² grown—</i>			
All Canada Tons	2,803,000	4,330,000	12,121,000
North-west provinces ¹ . . „	..	959,000	9,071,000

¹ Alberta, Manitoba, Saskatchewan.

² Wheat, oats, barley.

The Author stated that the transportation routes in Canada almost all led to Montreal. The effect of the opening of the Panama Canal, however, would be to divert a portion of the north-west grain-crop to Pacific ports, where Prince Rupert, although 170 miles farther from Saskatoon than Vancouver was, should take the lead, owing to the superior physical advantages of the railway route, as indicated by the following tabular comparison:—

Railway.	Summit Altitude.	Maximum Gradient per Mile.	
		West-bound.	East-bound.
	Feet.	Feet.	Feet.
Northern Pacific (U.S.A.) (three summits)	5,569	116 (1 in 45½)	116
	5,532		
	2,849		
Great Northern (U.S.A.) (three summits)	5,202	116	116
	4,146		
	3,375		
Canadian Pacific—to Vancouver (two summits)	5,321	116	118 (1 in 44·8)
	4,351		
Grand Trunk Pacific to Prince Rupert (one summit)	3,720	26 (1 in 203)	21 (1 in 250)

Mr. Money. The Author also indicated that the policy of harbour-construction in Canada was to build for to-day and leave the future to take care of itself. If the area under grain increased at anything like the rate at which it had done during the decade 1901-11, in 1936 the north-west would produce 30,000,000 tons instead of the present 9,000,000 tons; and to deal with this tonnage would keep not only Montreal fully occupied, but also Fort Churchill and Port Nelson on Hudson Bay, and Prince Rupert and Vancouver on the Pacific.

Mr. Mowat. Mr. MAGNUS MOWAT considered that, with regard to the produce of the Dominion, it would be of value to know what proportion of Canadian grain reached the British Isles as compared with the imports of other countries. From the current number of the *London Corn Circular* he had extracted the following particulars. For the periods 1st September to 31st March, the ratio of the Canadian grain to the total imports was:—

	Per Cent.
1911-1912	10·88
1912-1913	10·08
1913-1914	12·99

At the Millwall docks, with which he was associated, about one-third of the grain-imports of London were discharged, and he found that during the past year, 19 per cent. of Canadian grain was handled there, as compared with 81 per cent. from other countries, though in the case of wheat alone 54 per cent. was from Canada and 46 per cent. from foreign ports. It appeared that Canada had very favourable local conditions with regard to rapid and cheap dispatch of grain, as compared with the customs and practices which ruled the grain-trade in London. Primarily (and he could not lay too much stress on this) came the question of grading. In Canada, where grain was sent to the ports in large quantities, it was graded by accredited officers after it left the farmer's hands, and it was turned into grain-elevators in quantity, irrespective of ownership, so that the elevators were filled from top to bottom. Further, under this system of classification sales were effected by "grade," and grains of like quality were transferable. It was not so in London, where grain was purchased to sample and split up into small quantities, each owner insisting on having his lot kept separately. Mr. Gaskell in his letter (Appendix IV, p. 149) stated that some of the cargoes discharged at the Surrey Commercial Docks consisted of as many as ten to a dozen parcels. Mr. Mowat could instance cases at Millwall where forty-seven separations had been effected on a ship of mode-

rate size. It was impossible to use bucket elevators—which Mr. Mowat. were the most economical for grain in bulk—with a system of “retail” importation such as this, the only alternative to the costly hand methods being the use of the suction grain-elevators, which owed their inception¹ in 1893 to his former chief and predecessor, Mr. F. E. Duckham, M.Inst.C.E. Even with these elevators, which could draw up the grain from below the coamings and difficult corners with nicety, the loss of time in effecting separation of parcels—by removing mats in the ship’s hold, manœuvring barges to suit customers, arranging for landing to different granary-floors, and there further dividing by bulking-boards—was considerable. Mr. Mowat had kept careful records of these delays, and had found that they were responsible for a loss of 25 to 50 per cent. of the gross capacity of the machines. The “Rapid” elevator at the Surrey Commercial Docks was cited in the Paper as an example of an “improved pneumatic” installation which “gave excellent comparative results.” From the statistics of working of the Port of London Authority’s elevators obtained for the past year, however, this machine gave the least satisfactory results of any of the machines in the Authority’s flotilla in the matter of cost, notwithstanding the fact that it was the most recently constructed of the suction elevators. The engine-room charges, maintenance, interest, and depreciation on capital outlay amounted in the case of the “Rapid” to 9·15*d.* per ton of grain elevated, as compared with 5·79*d.* per ton for the “Mark Lane II,” and 6·73*d.* per ton for the “Dolphin” elevator, which had been taken over by the Authority from the late Millwall Dock Company. In making this comparison, it should also be observed that the “Dolphin” elevator had 12 feet more lift than the “Rapid,” to enable the apparatus of which it formed part to take the grain direct into the granary without intermediate barging. This could not be accomplished by any of the other machines. Mr. Mowat considered that the general lay-out of the grain-plant described by the Author was highly satisfactory, and congratulated him particularly on the successful manner in which he had brought the grain from the elevators to the adjacent berths, thus enabling general cargoes to be loaded at the same time, without moving the ship, which was a great convenience. The economic results obtained (covered by a tariff charge of 0·8 to 0·9 cent. per bushel) were also highly flattering to the Author, but Mr. Mowat concluded that in addition to such tariff the Commis-

¹ Minutes of Proceedings Inst. C.E., vol. cxxv, p. 296.

Mr. Mowat. sioners of the harbour levied a general rate on goods, as well as dues on the registered net tonnage on vessels entering the port. If so, he would be glad if the Author would state what those rates were, as in making comparison with other ports, the gross cost to the shipper and merchant should be considered. With regard to the cost of construction of the elevators, there appeared to be a striking analogy between the cost of the work at Montreal and in London. In 1909 he contributed a Paper¹ to The Institution, dealing with a granary and elevators at the Millwall docks. The cost of this work amounted to £1 per quarter of grain storage-capacity afforded. The Author gave the cost of the plant he had constructed at Montreal (without the conveyer facilities, which were an extra item) as 60 to 70 cents per bushel, or practically the same as the cost at Millwall. Another point of close analogy related to the belts, which the Author stated gave a friction load, running light, of about 75 per cent. of the total load. Tests had recently been made by Mr. Mowat at the Central Granary with the conveyers, and the figure obtained there was precisely that given by the Author. With regard to weighing (another very important matter), it was stated that the receiving legs discharged through a 120,000-lb. (53-ton) hopper scale and the grain shipped out passed through 5,000-lb. (2½-ton) automatics. It appeared to him that the "draftage" thereby occasioned was considerable, and he would be glad if the Author could state how apparent shortage in weight was met. At Millwall, deliveries from store had to be weighed out to merchants in 4-bushel lots. If the grain was weighed in by 1-ton automatic scale the draftage (occasioned by the turn of the scale on the smaller machines) was between 2 and 4 lbs. per ton, and rather than meet the difference, the late dock-company had reluctantly removed the automatic machines (which in other respects operated very successfully) and replaced them with 4-bushel or "sack" machines, in order to satisfy their customers. The bin or silo system of storage rather lent itself to uneven distribution of the grain with regard to quality, as it often happened that the lighter grain and dust was held up in the top of the silo. By taking advantage, however, of the fact that the pressure on the sides of the bins was greater than at the bottom, wooden shoots with openings or louvers at the sides could be introduced, enabling the grain to be drawn evenly from top and bottom, thus thoroughly mixing it. Had the Author experienced any difficulty

¹ Minutes of Proceedings Inst. C.E., vol. clxxvii, p. 58.

in mixing the grain in the bins, and if so, what method had he adopted for even distribution? Mr. Mowat would be glad if further particulars could be furnished regarding the wagons or cars—were these owned by the railway-companies or by the Commissioners? Was the grain received in them in sack or in bulk? If in bulk, was it discharged in the boot of the elevators by gravity slides or tipped? At Millwall the Authority owned a large number of travelling box bins¹ which conveyed the grain, from berths having no other direct-housing facilities, from the quay to any of the granaries, where they discharged their contents through sliding doors into the intake hoppers of the grain-stores. In former years these bins had also been largely used for the storage of grain, and were located in central depots, where they could discharge into truck, van, or barge.

Mr. J. V. NIMMO observed that the Paper left the impression that the Author attributed the shipment of 100 million bushels of wheat through Buffalo to lack of transportation facilities in Canada. Mr. Nimmo would suggest that the fundamental reason for this grain going by United States ports, rather than by Canadian ports, was the uneven balance of trade. Although the value of exports from Canada was a little more than one-half the value of the imports, yet, owing to the fact that only 12 per cent. of the exports as against 65 per cent. of the imports were manufactured goods, the weight of the exports was greater than the weight of the imports. On the other hand, the values of imports and exports into and from the principal ports in the United States, excluding the ports from which raw cotton was shipped, were more nearly equal. But the greater part of the imports into the United States were raw materials, the manufactured goods forming only about 16 per cent. of the whole; whereas, in the exports, the percentage of manufactured goods was approximately 30. From the above considerations it would seem that whereas the exports from Canada had greater weight than the imports, the reverse was true of the United States, especially of the North Atlantic ports. This being so, it seemed inevitable that the surplus grain exported from Canada must go via the United States ports until the balance in trade became more even; and no building of ship-canals, increasing of harbour-capacity, or construction of new railways could affect the situation. The natural outlets for the produce of the prairie provinces of Canada, which were destined to become the largest producers of the Dominion, were, namely: (1) the St. Lawrence river or

¹ Minutes of Proceedings Inst. C.E., vol. cxxv, p. 296.

Mr. Nimmo. Atlantic ports; (2) the Pacific ports; and (3) the Hudson Bay ports. With regard to the last, there seemed to be considerable doubt in the minds of experts whether the revenue from the railway to Port Nelson would equal the cost of working, and whether the insurance-rates would not be so high as to make the shipping-rates prohibitive, owing to the dangers to navigation from ice and snow-storms. But altogether apart from these considerations, the fact that for a long while to come the traffic from Port Nelson to Europe would be far greater than that in the opposite direction, raised the question whether the shipping-rates from Port Nelson to Europe must not necessarily be so high as to handicap this route in competition with the Atlantic and Pacific. With regard to the development of trade to and from the Pacific ports, the principal of which were Vancouver and Prince Rupert, he believed that a certain portion of the prairie, possibly the whole of Alberta, would be economically tributary to these ports when the Panama Canal was opened for navigation. Here again, however, the considerations outlined above must be of great importance. The distance from Vancouver to Liverpool via the Panama Canal was approximately 8,836 miles as against 2,760 from Montreal to Liverpool. If the freight-rate on grain from Montreal to Liverpool were taken as 8 cents per bushel, that from Vancouver via the Panama Canal must be in the neighbourhood of at least 20 cents; and this on the assumption that the ships could find an outward cargo to some port close to the Puget Sound. The distance from Edmonton to Vancouver via the Canadian Northern Railway was 774 miles, from Edmonton to Fort William 1,262 miles, and from Saskatoon to Fort William 926 miles. If the rate from Saskatoon to Fort William were 3 cents, then allowing as low a charge as 3 cents from Edmonton to Vancouver, as against, say, 4 cents from Edmonton to Fort William, it was obvious that the economic advantage possessed by Vancouver over Montreal for grain shipped from northern Alberta, all other things being equal, could not be great. The Pacific ports might indeed be able to compete with the Atlantic in winter shipments of prairie produce, but in any event the shipments via Vancouver or Prince Rupert could not grow more rapidly than the imports via these ports. At the present moment the trade through Vancouver was almost entirely with the rest of British Columbia, as very little was shipped to or from Alberta; and, as the imports by weight were greater than the exports, there would be room in the outward-bound vessels for about 10,000,000 bushels of wheat if there were facilities for handling the grain, and the Canadian Pacific Railway were wishful

to do the business. But this difference between imports and ex-ports was owing to the rather backward state of British Columbian farming, so that at the present moment most of the food of the province was imported. This state of affairs could only be temporary, and, in fact, was being changed rapidly; and if the balance of trade through eastern ports close to the larger centres of population was still so uneven as to force a considerable portion of the exports via the United States ports, it did not seem probable that the conditions in the west of Canada could develop on very different lines. If this reasoning were correct, it might be assumed that for a long time to come the products of the prairie would be shipped almost entirely by eastern ports during the summer, and very largely by United States ports. Mr. Nimmo considered there that was only one remedy for this state of affairs, namely, Canadian ports and railways should secure a large share of United States import business by offering such facilities as would attract that traffic. The St. Lawrence was the natural water route to the North American continent, but it would have to be supported by railway systems connecting with all the principal cities in the northern States—truly an heroic remedy. Canada had now reached a period in her economic development when her ship and railway terminal facilities must be given even more consideration than the internal transportation. The problem was not solved by giving adequate accommodation for ships unless railways had commodious accommodation at, and efficient access to, the shipping-berths. There could be no question that the organization of the port of Montreal was on the right lines, the railway and shipping terminal facilities being all in the hands of the same authority. Unfortunately, this was not the case with the Pacific ports. Perhaps in no engineering work did the need for provision for future development make itself more felt than in this question of railway approach to docks; because if schemes were not drawn out with ample provision for future extension, the cost of making such extension, when the pressure of business became too great, became almost prohibitive, owing to the enhanced land-values and the heavy expense in re-arranging structures. In the case of the principal Pacific port, Vancouver, a large part of the available water-front on one side of the harbour was owned by the Canadian Pacific Railway Company, and their approach to Vancouver along the south shore of Burrard Inlet, prevented the advantageous use of the rest; while the right of way for another railway had already been granted along the northern shore of the Inlet. Under present conditions the only way to obtain adequate advantage of the fine

Mr. Nimmo.

Mr. Nimmo. natural situation, both for railways and for ships, would be for the Harbour Commission to control the terminal facilities for both, as was done in Montreal. It was incredible that Prince Rupert would never be entered by any railway other than the Grand Trunk Pacific, and, owing to the fact that the harbour there had been granted to the Grand Trunk Pacific Railway Company as their private property, a situation must develop there too similar to that now existing in Vancouver. Perhaps two of the best-arranged ports from the point of view of the intercommunication between railway and ship, were Portland, Maine, and Tilbury, near London, as they gave the greatest efficiency in the arrangement of the yards for the economic sorting of cars after their arrival into the receiving yard, so that they could be arranged ready to be placed directly at the right berths, and provided smaller yards close to the berths, where, if necessary, any re-arranging for the proper hatches could be carried out. It would be interesting to know what had been done in this respect in Montreal. With regard to the details of design, Mr. Nimmo would like to raise the question whether the provision of a space for railway-tracks between the edge of the wharf and the shed could be economically justified unless the proportion of shipments from car to hold was very high. In New York most of the sheds were built so that there were only a few feet between the edge of the wharf and the shed. This was done in Manchester also, where cranes were placed on the roof. It meant the saving of very valuable space, namely 32 feet in each pier, besides rendering the work of transporting between hold and shed appreciably easier.

Mr. Ommanney.

Mr. G. G. OMMANNEY observed that the Paper was of the greatest interest at the present time, when the question of increased and improved port facilities for the handling of ocean steamships was receiving particular attention in Canada, and large works were in progress or in contemplation at almost all the principal harbours, with these ends in view. The Canadian Pacific Railway Company, as owning and operating the largest transportation organization in the Dominion, was vitally concerned with the entire operation of all these ports, from both the steamship and the railway point of view. In this connection it had been Mr. Ommanney's duty to make a close study of modern steamship terminal requirements, and he had had the opportunity to familiarize himself with the latest developments, both in the United States, and, very recently, at some of the principal European ports. The views of a Canadian port official of the Author's eminence were naturally of the first importance to all interested in Canadian transportation problems,

and Mr. Ommanney hoped that the comments which followed might commend themselves for his consideration. Dealing with the widths of piers and slips as adapted to Montreal requirements, the Author dismissed this important question by laying down an empirical width of 340 feet for both piers and slips, apparently irrespective of the size of the vessels or the business to be handled. He prescribed one front track and two tracks at the back of the shed, with a shed width of 100 feet and a drive-way of 30 feet—and this to accommodate vessels discharging 8,000 tons and loading 10,000 tons. At Montreal the imported cargo would be general freight, and 50 per cent. of the export cargo would be grain. The shed was 1,000 feet long, evidently providing two berths, so that each vessel would have available 100,000 square feet of floor-area (including both floors), and 1,000 lineal feet of track, since, with present methods of handling to and from vessels, the use of the frontal track was limited to discharging a few special car-loads of structural steel or machinery, and loading a few cars of lumber, the presence of side shoots and gang-planks preventing any extensive use of this track. The ship was to be turned round in 1 week—not, by the way, a very ambitious programme for a progressive port—so that it had about 50 hours in which to discharge 8,000 tons. The number of cars that could be loaded per berth in a fair day's work of 10 hours was twenty-five—containing about 500 tons; and about 100 tons would be moved by teams; so that, at the end of each day, there would be an accumulation on the floor of the shed of 1,000 tons—or 5,000 tons by the time the ship was completely discharged. A ton of miscellaneous package freight occupied about 80 cubic feet in the shed, on the average of large tonnage: 5,000 tons tiered 5 feet high would therefore require 80,000 square feet. The available shed-space was 100,000 square feet, of which the proper allowance for teamways and trucking-space was 30 per cent., or 30,000 square feet, so that clearly, with the shed-dimensions stated by the Author as standard for Montreal, the shed would be congested before a single ton of export freight had been received, and also no allowance had been made for office-space, gear-stores, or lavatories. The vessel could, of course, move to another berth to load, but this had been found very undesirable. The shed and the tracks should be so proportioned, and the facilities should be such, that the entire operation of discharging, loading, coaling, etc., could be accomplished without moving the vessel. Even with less to discharge, it would be impossible, with only two tracks, to begin the accumulation of export cargo until some hours after discharging had been completed, on account of the neces-

Mr. Ommanney.

Mr. Omman-
ney.

sity of holding cars for consolidated loads; which meant that both tracks would certainly be required for import cars until all of the import cargo had been sorted and loaded. The provision of at least one additional track would permit of cars of exports being sent in as soon as the vessel was ready to start loading; but, of course, such provision was useless unless the floor of the shed were properly proportioned. Clearly, for the particular business mentioned by the Author, a shed was required providing space for 5,000 tons of import cargo and about 1,000 tons of exports at the same time, which for a berth 500 feet long and a two-story shed necessitated a floor-width of 135 to 140 feet. The practice of elevating teams one and two at a time to the upper story of the shed seemed to be analogous to bringing the mountain to Mohammed. If the upper floor of the shed were extended over the tracks, all the import freight (for which the upper floors were exclusively reserved) could readily be loaded direct into teams in the drive-way by means of underhung-jib travelling electric cranes which, whilst they could traverse the entire length of the shed and command every foot of floor-area, were able, by means of the underhung jib, to deliver their loads through the continuous doors to teams below. This arrangement, besides obviating the slow and cumbersome process of elevating the teams, with the attendant expense of lifting cargo by hand labour from the floor to team level, would also secure an increase of valuable floor-space by an amount equal to the area of upper floor extended over the track plus the considerable area no longer required for circulation of teams, and would thus permit the theoretical ground-floor width of 135 feet mentioned above to be limited to 110 feet. In dealing with the question of handling appliances on the wharves, the Author cited the result of a trial of two electric transporters as indicating that wharf-cranes were not regarded favourably by Canadian shipping men. Wharf-crane installations, such as were found in all the leading ports of the world, had never been attempted in Montreal. The installation of two units would in no case be considered a satisfactory trial, since the success of wharf-crane methods depended on the completeness of the installation, whereby the use of ship's winches was entirely obviated or was limited to handling between hatch and deck, thus dispensing with all side shoots and skids and attendant costs and delays of rigging them, leaving front tracks available at all times for the movement of cars, which in itself encouraged more direct handling between vessels and cars. The two transporters installed in Montreal had very few of these advantages, and being fixed in

position had none of the flexibility of the modern wharf-crane, ^{Mr. Ommanney.} which permitted it to be used in any position, as many as two or three cranes often working at one hatch. It would be interesting to learn under what conditions the Montreal transporters handled 750 tons per day of 10 hours. Such a performance could hardly be the result of ordinary service conditions. These transporters apparently required more men to work them than were used when working with ship's gear, whereas modern wharf-crane installations economized labour. The working-cost of \$7.50 per day for the transporters compared unfavourably with wharf-cranes, for which it might be estimated that, allowing for fixed charges, maintenance, repairs, power- and working-costs, and profit on investment, a charge of 50 cents per hour for the use of the crane should be reasonable, based on handling large annual tonnage as at Montreal. Perhaps the Author would state the local reasons which made crane installations unsuitable. In actual practice the adoption of wharf-cranes, both in Montreal Harbour and at other Canadian ports, would have many advantages, and in planning future extensions of these ports this question was worth the most careful consideration of Harbour Commissioners and others responsible for the design of such works.

Mr. PAUL SEUROT considered that great credit was due to the ^{Mr. Seurot.} Author for what had been accomplished in the way of improvements during the last few years in the harbour of Montreal: improvements in deepening and lighting the channel, in providing better docking facilities, better handling of cargoes, and better storage and distribution of grain. All these improvements had had to be executed under difficulties, owing to the severe climatic conditions, and carried on simultaneously from April to November of each year when the harbour was crowded and worked to its maximum capacity. The improvements, as the Author pointed out, were all parts of a systematic and comprehensive programme, the aim of which was to retain for Montreal the rank of metropolis of Canada, and ultimately to keep for Canada, on Canadian railways, and in Canadian or British bottoms, the bulk of transportation and of shipments which, for lack of proper facilities, might be diverted via Buffalo and New York. When the problem was considered along these lines, it was evident that any improvements in the condition of the harbour of Montreal and in its transportation facilities, had a direct influence on the welfare of the entire Dominion. It was evident, also, that, in order to provide for future requirements, such improvements, whenever possible, should be made in advance of the expansion or growth of the country or of the city. The population of Montreal

Mr. Seurot, and of that surrounding territory which was geographically and practically, if not politically, an integral part of Montreal, had increased at an average rate of 7 per cent. for several years past, taking in years of prosperity and years of financial depression. The increase from 1909 to 1912 was 9·3 per cent.; it was 9 per cent. from 1910 to 1912, the mean of the foregoing averages being 8·4 per cent., which corresponded almost exactly with the increase (8·31 per cent.) of 1913 over 1912, according to official returns. Upon these data and upon the experience obtained in other cities, Mr. Seurot calculated that after the period of maximum increase—500,000 to 1,400,000—the increase would drop to a normal and uniform rate, varying between 2 and 3 per cent. until the “point of saturation” had been reached. And of course this growth of population was only taken here as the outward expression of the future wealth, strength, and resources of the city, when the new canals and the new railways converging to Montreal, planned or actually under construction, would have made her the great manufacturing and distributing centre of Eastern Canada. The question which arose then was: “Will the harbour as planned now answer these future requirements?” In spite of the Author's assurance, that in the new scheme of extensions permanence was the paramount feature, one felt, involuntarily, the spell of this first principle emanating from the unstable conditions in Canada and in the United States: “We shall build for ourselves; future generations may know better what they want, and will be able to take care of themselves.” The Harbour Commissioners and the Author had undoubtedly given a great deal of thought to the various solutions, and must have had good reasons for deciding to dam the river as shown in Plate 4 and condemn all that part of the harbour between St. Helen's Island and the Victoria Bridge, with $1\frac{1}{2}$ mile of river-frontage on the right shore and 1 mile on the left shore, just when new factories, large plants, and workshops crowded out of Montreal proper were establishing themselves on the south side of the river, as well as for condemning nearly a mile up-stream from the Victoria Bridge. The fall from this bridge to the end of the guard-pier, and the troublesome St. Mary's current from the guard-pier down, were serious arguments which certainly had been the subject of careful studies and discussions. And yet to those who had not the necessary data at hand and could merely conjecture what might have been done, it seemed that a dam—if one were necessary—might have been built at the extreme boundary line of the harbour, 4,000 feet up-stream from the Victoria Bridge. This, with the remodelling of one or two spans of the bridge and

probably the construction of a training-wall, would have eliminated Mr. Seurot. or controlled the St. Mary's current and reclaimed an area of about 2,000 acres which rightly belonged to the harbour of Montreal and which would now become useless. The solid barrier which was to be built between the guard-pier and St. Helen's Island would effectively deflect the strong current due to the drop in elevation between the Victoria Bridge and the island. This current would probably follow the shore of St. Helen's Island and rush into the new channel to be dredged, making it rather hard at that point for any craft to negotiate the openings left between the piers of the proposed bridge to the south shore. What would be the effects of the new channel, once clear of St. Helen's Island? Would it expand itself in the river, or would it not more likely continue on its course until it met the main ship-channel south of the Laurier pier, just where the river narrowed and where the convex shore was being crowded with new structures and brought towards the channel instead of being pushed inland? Was not this contrary to a principle of river hydraulics, that the width at the point of inflexion should increase from up-stream downward, and that the convex shore should have a development notably greater than the concave shore? Certainly the bed of the St. Lawrence was such that little trouble might be expected from these conditions, the only possible result being the creation of new eddies, currents, and counter-currents; the problem would be much more serious if the bed were silty and movable. The foregoing remarks were not intended to be criticisms of a very interesting Paper presented in the ablest manner. They were merely questions which had been thought worth propounding and the solutions of which the Author had doubtless worked out.

Mr. W. A. TAIT, having lately revisited Quebec and Montreal, Mr. Tait wished to congratulate the Author upon both his Paper and his life's work in successfully opening up such a magnificent waterway as now existed between the two towns. The ordinary traveller might perhaps agree with the dictum of the writer in the *Queen's Quarterly* that, "the ocean vessel is too expensive for the lakes, and the lake vessel is too slightly built for the ocean"; but that, after all, was hardly sufficient reason for not carrying the waterway much farther inland than Montreal. It must be kept in view that even large ships at present took only about 12 hours or so to get from Quebec to Montreal. Transshipment was thus avoided for anything sent from or consigned to Montreal warehouses or railways. The Author had brought out some very interesting facts as to the formation of the first ice of

Mr. Tait. the season at different places. Probably the best use was made at present of both the lake ships and the ocean-going ships by arranging that transshipment should be at Montreal, and that the last ocean-going ship should leave Montreal in time to get out before the ice formed in Lake St. Peter. No detailed description was given as to the formation of the ice. Probably, however, the deep channel through the lake would be the last place to freeze. Some really good and inexpensive method for delaying the formation of the ice in the channel was very desirable. In this connection the Author might perhaps clear up a matter to which he referred as "the average current in Lake St. Peter." Did this average of 3 miles per hour apply only to the deep-water channel, or was it suggested—although it seemed rather unlikely—that there was this movement towards the sea throughout the whole extent of the lake? The actual work of deepening the channel appeared to have been performed at very reasonable rates, but this was no doubt due partly to the fact that the material in the bed was capable of standing at a fairly steep slope, with the result that further deepenings as years went on did not necessitate any widening of the slopes of the channel. It would be interesting, however, if the Author would state approximately the cost of dredging the last 5 feet or so of depth of the present channel for any given length. This figure would no doubt be easily ascertained, as the work had been carried on by administration. It was interesting to learn that timber always under water was practically permanent as far as Canadian records showed, and this was another justification for the expenditure required to make Montreal an inland port. Probably the floating dock "Duke of Connaught" had not been long enough in place to enable any statement of its work to be made. Having regard, however, to the fact that this floating dock was to take the place of a graving-dock estimated to cost about half a million sterling, it would be interesting to learn its exact cost. Probably one of the most striking features in Montreal Harbour at present was the elaborate provision of sheds. From a national point of view it seemed to be very important that grain stored in steel or concrete bins might, if looked after well, remain in store without harm for several years.

Mr. Wragge. Mr. EDMUND WRAGGE had read with interest the account of the progress of Montreal Harbour, but he was rather disappointed that the "transportation problem" was touched upon superficially and almost altogether from the point of view of Montreal. The conditions under which traffic from the north-west of Canada had to be

moved to the seaboard were of the first importance to the question. Mr. Wragge. The wheat-crop in the district which the Author regarded as centering at Saskatoon was not harvested until late in August, or the early part of September, and only a small portion of it reached tidal water in the latter month, leaving 6 or 7 weeks afterwards for it to be got away before Montreal Harbour was closed for the winter. There was, therefore, a very large surplus which had to seek the seaboard, if intended for shipment to Great Britain, by other routes, and from other ports than Montreal, such as Portland, St. John, N.B., Halifax, or Boston, which were reached by Canadian, or chiefly Canadian, railways, as well as by the route through the United States, via Buffalo to New York, mentioned by the Author. Nearly every farmer wished to turn his crop into money as soon as he could do so advantageously, and the shipment of much must necessarily be lost to the port of Montreal, owing to its winter conditions. The map (Plate 3) was somewhat incomplete, which rendered it difficult for anyone not well acquainted with the country and its various routes to follow them out. The route of the proposed Georgian Bay canal, down the Ottawa river, was not marked. The routes of the Grand Trunk and Canadian Pacific railways from the south end of Georgian Bay at Tiffin and Port McNicoll respectively, through which the bulk of the north-west produce passed to reach Montreal, were not indicated in any way; neither was the Welland Canal shown, though all these routes were very important to the understanding of the question. It would be interesting, in connection with the subject of transportation, to know what proportion of the 60,000,000 bushels of wheat shipped from Montreal in 1913 arrived by water through the Welland and St. Lawrence River canals from the north-west, and what by railway from Georgian Bay. Might it be assumed that of that quantity 16,000,000 bushels were passed through the Grand Trunk elevator, and the 44,000,000 bushels, to which the Author referred, were handled by the Harbour Commissioners? The returns issued at Ottawa with reference to the crops for 1913 in Canada showed that the total wheat-production of all provinces was 231,717,000 bushels, that 97 per cent., or 224,810,000 bushels, were merchantable, and that of this quantity 38,353,000, or 16·5 per cent., were still in the hands of the farmers on the 31st March, 1914, which left a total of 186,457,000 bushels of the crop of 1913 as having been moved up to that date. It was understood that the provinces of Ontario and Quebec between them required about 30,000,000 to 40,000,000 bushels per annum more than they produced; the wheat

Mr. Wragge. grown in Ontario averaged about 20,000,000 bushels, that in Quebec being rather less than 2,000,000 bushels. There had never been so small a percentage of the wheat grown left in the farmers' hands by the spring as in 1914; and in addition to this it might be mentioned that 40 per cent. of 404,669,000 bushels, the total crop of oats, were also still in the farmers' hands. Most Canadians were aware that a very small portion of the north-west crop reached Montreal at present by an all-water route from Port Arthur, and its movement, coming so late in the season of navigation, could hardly ever be expected to take that route so far as the bulk of the crop was concerned. Not only was the lateness of the season against it, but also the loss of time occasioned by the extra distance of 900 miles by water as against 365 miles by rail from the Georgian Bay, and also by vessels having to be locked down through the Welland and St. Lawrence canals from the level of Lake Erie 572 feet above sea-level to that of Montreal, 29 feet above sea-level. Therefore it would doubtless be many years before the depth of water in these canals would be made sufficient to permit large cargo-vessels to go direct from Fort William to Montreal. If the rates of freight on wheat from, say, Winnipeg to Liverpool were as stated in the Paper, the mileage cost was:—

Per bushel, by rail from 73 to 140 miles	1 cent.
„ „ „ lake for 500 miles	1 „
„ „ „ sea for 311 sea miles	1 „

On the face of these figures they did not appear to be quite accurate, but if they were, it would not seem vain to hope for an all-rail rate of 10 to 12 cents from Winnipeg to Portland, equivalent to 140 to 170 miles for 1 cent; and this, with the same ocean rate as from Montreal, would mean what the Author stated as the present rate. The all-rail route through the United States to New York had been referred to, but it seemed doubtful if much wheat went by that route at present; a considerable quantity left the Canadian north-west in that direction, but went to Lake Superior at Duluth, or to millers at Minneapolis, St. Paul, or elsewhere. The all-rail distance from Winnipeg to New York, via Chicago and Buffalo, was 1,873 miles, to Buffalo and New York via the Canadian Pacific Railway, 1,780 miles, and to Portland via the Canadian Pacific and Grand Trunk railways, 1,711 miles. It might be assumed, therefore, that if, as the Author stated, 100,000,000 bushels travelled via Buffalo and New York, they went chiefly by water to Buffalo from either Duluth or Port Arthur. With regard to the channel of the St. Lawrence between Montreal and Quebec, the Author was to be

congratulated upon the large share he had had in carrying out this Mr. Wragge-very successful work. Mr. Wragge remembered the day when the steamers of the Allan Line, all having a tonnage of less than 5,000 tons, had to lay over at Quebec either to unload cargo when arriving, or take in coal when leaving, so as to enable them to run between Quebec and Montreal. The work of deepening the channel must still proceed, for the two largest boats owned by the Canadian Pacific Railway, each of 14,600 tons, still had to berth at Quebec, and the Allan Line had now declared that their last new boats, "Alsatian" and "Calgarian," would not be able to get up to Montreal, and would stop at Quebec this season [1914]. It seemed quite probable, therefore, that instead of spending large sums of money upon the St. Lawrence canals, or upon the Georgian Bay canal in order to enable large freighters to ply between Port Arthur and Montreal, it might be wiser to look for relief in moving the rapidly-increasing crop by facilitating its movement by rail to the seaboard (as far as possible through Canada), not only while navigation was open at Montreal, but also during those months when the St. Lawrence was closed by ice. Much had been done, and was being done, by reducing gradients, doubling tracks, increasing the number and capacity of the locomotives and wagons on the railways, and in other ways, to reduce the cost of railway transportation, and no doubt this work would be continued.

* * The Author's reply to the Correspondence, which has been unavoidably delayed, will be printed in the next volume of Proceedings.—SEC. INST. C.E.

21 April, 1914.

GEORGE ROBERT JEBB, Vice-President,
in the Chair.

It was resolved—That Messrs. E. R. Dolby, C. Hitchcock, S. R. Lowcock, M. Mowat, and H. F. Rutter, and Captain H. Riall Sankey, be appointed Scrutineers, in accordance with the By-laws, of the Ballot for the election of the Council for the year 1914–15.

The Council reported that they had recently transferred to the class of

Members.

WILLIAM STEWART BECHER, B.A.I.
(*Dubl.*).
HERBERT WILLIAM BOWEN.

ARTHUR EDWARD BROADBERRY.
WILLIAM BRODIE.
HAROLD EDWARD BYRNE, B.A.I. (*Dubl.*).