(*Paper No. 1868.*)

"Canal Navigation in Belgium."[1]

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THE first portion of this Paper deals with the improvements recently proposed for what the Author calls canals of *mean* section, in which the depth of water is not less than two metres nor more than three (say from 6½ to 10 feet). The second portion treats of *maritime* canals, defined as having not less than five metres (say 16½ feet) depth of water; and investigates the various plans lately brought forwards in Belgium for canals of this class. The expression "average annual traffic" is taken to denote the tonnage arrived at as the quotient when the total ton-miles resulting from a year's traffic in both directions are divided by the length of the canal. "Freight" includes all expenses pertaining to towing, boats, boatmen, and return of empties. Interest on capital, maintenance of works, and working of locks, together make up the "tolls."

I.—CANALS OF MEAN SECTION.

In reports on the improvement of canals of this class in France, drawn up in 1872–74 by M. Krantz, and in 1878 by the minister of public works, M. de Freycinet, the conclusion arrived at by both authorities was that in any country it was highly important, alike for agriculture and for other industries, that there should be a network of canals, running somewhat parallel to that of the railways, wheresoever there was altogether traffic enough to pay the interest on both the canal and the railway capital: to which the Author adds that, in order to ensure co-operation instead of competition, both modes of carriage ought to be under one and the same management, which he considers ought to be controlled by the government. The chief aim of improvements should be to bring about uniformity of section, which is sadly wanting in the present canals

[1] This Paper (appearing in the "Revue universelle des Mines," 1881, vol. ix., pp. 356–400, 469–490; and vol. x., pp. 95–134), formed part of a competitive essay, which was written in 1880, on the Development of Belgian Commerce, and which was adjudicated a work of more than ordinary merit: eliciting the comment that, in dealing with the question of canal navigation, the accuracy of the calculations employed and the fairness of the views advanced were evidence of a thoroughly sound acquaintance with the subject.

in France and elsewhere, as pointed out both by M. Krantz and by M. Théophile Finet, a Belgian engineer. French canals are classed as "main" and "secondary," the former being under government administration, while the latter are leased with or without subsidy. The main canals are required to have 2 metres = 6½ feet depth of water, with locks 5·2 metres = 17 feet wide and 38·5 metres = 126 feet long. The administration of the main canals by the government is understood to imply their maintenance by the State, and the working of the locks, subject to the tolls; the option of the tractive power to be employed is also reserved to the government, which however undertakes no responsibilities of any kind in regard to the actual conveyance of the traffic. For the working of the canals it is considered essential in France that the bargees with their families should continue, as hitherto, to live in their boats.

In Belgium views have latterly been advanced which are altogether contrary to those current in France. In his book of 1878, M. Finet recommended single-width canals worked on a similar plan to railways, doing away with the bargees, and making up a train of barges with a tug in front and a steering barge in rear, all the intermediate barges having flat vertical ends, slightly rounded below water-line, instead of anything like prow and stern. Since the power required to tow a boat is independent of its length, the expense of towing would thereby be reduced to a minimum. The whole train might carry 1000 tons, in five to ten barges containing 200 to 100 tons each; its total length would be about 140 metres or 460 feet, and it would want only two men on the tug and either one or two men on the rear barge. The locks would have to be 150 metres or 490 feet long, in order to avoid breaking up a train.

Cost of Carriage by Canal and by Rail.—In advocating his own ideas, M. Finet charged railways and bargee-canals with not being able to carry goods cheaply enough. The Author proceeds therefore to examine the net cost of carrying heavy goods by the best ordinary canals on the bargee system, and by railway: and to show that M. Finet's single-width and long-lock scheme with train of barges would not carry more cheaply than could be done by the present system when improved as it ought to be. In his report of 1874, M. Krantz assumed that canal traffic, like that of railways, ought to pay, including interest and redemption, 5·65 per cent. on the capital sunk, which averages for canals 180,000 francs per kilometre (£11,500 per mile); it must also pay maintenance of works, and working of locks, which together are taken to average yearly 1450 francs per kilometre (£93 per mile); and further it must pay "freight" (as already defined), which he assumes as an

invariable charge of 1·5 centime per tonne-kilom. = 0·234 penny per ton per mile. On these assumptions it is readily shown in a tabular form how largely the net cost of canal carriage is affected by the total amount of the traffic: thus, with an average annual traffic of only 50,000 tonnes-kilom. (say 30,000 ton-miles) the net cost would rise to as much as 24·74 centimes per tonne-kilom. = 3·853 pence per ton per mile, which is as high as carting by road would be; whilst twenty times as much traffic, or 1,000,000 tonnes-kilom. (say 600,000 ton-miles), would bring the net cost down to only one-ninth, or 2·66 centimes per tonne-kilom. = 0·414 penny per ton per mile. To the freight charge of 1·5 centime per tonne-kilom. = 0·234 penny per ton per mile, derived by M. Krantz from the canals in the north of France, exception is taken by the Author, who examines separately the several items that go to make up the freight—towing, boats, boatmen, and return of empties.

Steam Towing.—On the Willebroeck canal, which runs north from Brussels past Willebroeck and enters the river Rupel opposite Boom, all boats except steamers are towed by a steam tug working on a chain. The length of the canal is 28 kilom. = 17½ miles, divided into five levels; and the locks are large enough to take in six or seven boats at a time, along with their tug. The towing is done by a company, from whose scale of charges and year's balance-sheet the Author deduces 5 millimes[1] per tonne-kilom. = 0·078 penny per ton per mile as the actual price paid for towing, the total annual traffic amounting to 25,200,000 tonnes-kilom. (say 15,400,000 ton-miles). But if the actual dividends were reduced to the rate of 4 per cent., which prevails for Belgian government securities, and if certain economies were effected which he believes to be practicable, the Author considers the charge for towing might be brought down to 3 millimes per tonne-kilom. = 0·047 penny per ton per mile, including empties free.

Horse Towing.—On two Belgian canals, the Louvain and the Charleroi, horses are employed for towing. The Louvain canal is semi-maritime, with 3½ metres = 11½ feet depth of water, and runs north-west from Louvain to the river Senne, which flows into the Rupel about 1 kilom. or ⅝ mile further north-west. Its length is 30 kilom. = 18¾ miles, divided into five levels; the total tonnage of the boats and ships passing through it in 1878 is estimated by the Author at 273,000 tons, and the charge for towing averages 6 millimes per tonne-kilom. = 0·093 penny per ton per mile. The Charleroi canal, winding northwards from Charleroi to Brussels by

[1] That is the one-thousandth part of a franc.

a circuitous route of 75 kilom. = 47 miles, is of small section, and its boats all alike carry only 70 tons; hence the charge for towing is higher, amounting to 8 millimes per tonne-kilom. = 0·125 penny per ton per mile. Including return of empties, the Author estimates that horse towing might be done on government canals for 5 millimes per tonne-kilom. = 0·078 penny per ton per mile; while Dr. Meitzen, a German authority, has arrived at an estimate of from 4·2 to 5·1 millimes = 0·065 to 0·079 penny.

Boats, Boatmen, and Empties.—The 110-ton boats in general use by the carriers on the Willebroeck canal make weekly the double journey from Brussels to Antwerp and back; the distance by the canal, the Rupel, and the Scheldt, is 45 × 2 = 90 kilom. = 56 miles there and back. The boatman gets 70 francs = 56*s.* per week for himself and his boat. With a full load both ways, this would give 7 millimes per tonne-kilom. = 0·109 penny per ton per mile. When the Charleroi canal is enlarged, the Author anticipates a large traffic right through from Charleroi to Antwerp, a distance of 120 kilom. = 75 miles; a single journey per week would then bring the cost down to 5·2 millimes = 0·081 penny. German estimates by Dr. Meitzen range from 4·8 to 6·4 millimes = 0·075 to 0·100 penny. Whence the Author takes 5 millimes per tonne-kilom. = 0·078 penny per ton per mile as the cost of boats and boatmen, with a full load both ways, travelling 17 kilom. or 11 miles per day, including all stoppages. One empty return in two double journeys is as much as occurs in Belgium: this is equivalent to making every journey with three-quarters of a full load, whereby the above figures would be increased one-third, giving 6·6 millimes per tonne-kilom. = 0·103 penny per ton per mile.

Net Cost of Canal Carriage.—Applying the foregoing estimates to an assumed average annual traffic of 1,000,000 tonnes-kilom. (say 600,000 ton-miles), the Author arrives at 18·2 and 20·2 millimes per tonne-kilom. = 0·284 and 0·315 penny per ton per mile as the net cost of canal carriage, with steam and horse towing respectively. These amounts are made up as follows:—

		Millimes per tonne-kilométrique.	Penny per ton per mile.
TOLLS	Interest and redemption, at 4 per cent.	7·2	0·112
	Maintenance, and locking	1·4	0·022
FREIGHT	Steam towing	3·0	0·047
	Boats, boatmen, and empties	6·6	0·103
	Totals, with Steam towing	18·2	0·284
	Horse towing, excess over steam	2·0	0·031
	Totals, with Horse towing	20·2	0·315

Net Cost of Carriage by Rail.—From French statistics of 1867 M. Krantz arrived at 38 millimes per tonne-kilom. = 0·592 penny per ton per mile as the actual minimum charge for the carriage of heavy goods by rail, which he considered might be subdivided nearly as follows:—

	Millimes. per tonne kilom.	Penny. per ton per mile.
Locomotive power	9	0·140
Rolling stock	5	0·078
Wages and maintenance	5	0·078
Interest and general charges	19	0·296
Totals	38	0·592

Subsequently he gave 35 millimes = 0·545 penny as the minimum charge practicable. At this rate he argued that a canal could not compete with a railway, unless it could secure a traffic averaging yearly at least 600,000 tonnes per kilom. (say 370,000 tons per mile). But in the absence of railway communication a canal would pay with only one-quarter to one-sixth of that amount of traffic.

In Belgium, where interest on capital is about all the profit the State railways are expected to earn, the net cost of carriage comes nearer to the charge made for it. The lowest charge is stated by M. Sainctelette, the Minister of Public Works, to have occurred in 1878, and to have amounted to 31 millimes per tonne-kilom. = 0·483 penny per ton per mile. The coal traffic from the province of Hainault to Paris was charged in the same year 35·8 millimes per tonne-kilom. = 0·558 penny per ton per mile by the Northern Railway of France; notwithstanding this competition, the canal navigation of 283 kilom. = 177 miles from Belgium towards Paris had a coal ton-mileage amounting to nearly half as much as that by rail. M. Sainctelette concludes that, in spite of new or improved canals, the railways will continue to carry large quantities of coal and to earn an important revenue for the State; while at the same time, however low be the charge for carriage by rail, the freight by water can be made lower still. That 31 millimes = 0·483 penny is about the lowest charge practicable for goods traffic on the Belgian railways is confirmed, in the Author's opinion, by the fact that their passenger fares have lately had to be raised 5 per cent. in order to yield the required revenue. The canal charges, already arrived at, of 18·2 or 20·2 millimes = 0·284 or 0·315 penny, are therefore seen to be fully one-third less than the minimum charge for carriage by rail.

M. Finet's scheme of Single-width Canals.—The tempting prospect of towing a train of ten 100-ton barges with scarcely any more

power than would be required to tow only one of them, and the alluring advantages of speedily loading each separate barge, and of detaching and attaching barges at intermediate wharves along the canal's course, are considered by the Author to disappear when looked into practically. A single-width canal would lose the great advantage which the ordinary double-width canals now possess over railways, of allowing boats to stop at any spot whatsoever, for loading or discharging cargo. A regular time-table would have to be strictly enforced; all boats would have to be made up into trains, involving loss of time at starting; there would be delays at the turn-outs, where the canal was widened for allowing the return trains to pass; and steamers could no longer go where and when they pleased. Bridges and locks, being already of single width, could be built no cheaper; while the proposed long locks of 150 metres = 490 feet length, to take a train of barges, would cost vastly more than the present French locks of 38·5 metres = 126 feet length. Even with very few locks, a single-width canal would not come more than one-ninth cheaper than the ordinary canals of double width; at the outside therefore it would not take off more than 1 millime per tonne-kilom. = 0·016 penny per ton per mile from the tolls. Under the head of towing, the only possible saving would be in consumption of coal in the steam tugs, which on the Willebroeck canal costs about $\frac{1}{2}$ millime per tonne-kilom. = 0·008 penny per ton per mile; if half this were saved on a single-width canal, $\frac{1}{4}$ millime = 0·004 penny would be all the economy thereby effected. As for dispensing with bargees on all except the tug and the rear barge of a train, the Author considers it would be practically impossible to work a train of rudderless barges round the bends of a canal, and a most tedious and difficult job to handle the barges separately at the wharves and docks where the train has to be made up or dispersed; moreover the cargoes would not get properly watched, with so few men to look after them. The total saving possible on a single-width canal, of $1\frac{1}{4}$ millime per tonne-kilom. = 0·020 penny per ton per mile, would be swallowed up, the Author believes, by the extra management expenses consequent upon having to organise the canal service on a similar plan to that of railways. He points out also that interest on original capital has been omitted from M. Finet's estimated cost of canal carriage, which is charged only with the interest on capital expended in improving the existing canals, thereby vitiating the comparison with carriage by rail; while the unexplained assertion that 1 millime would cover the "freight" on a single-width canal is met by the Author's foregoing analysis, which shows 9·6 millimes per

tonne-kilom. = 0·150 penny per ton per mile to be about the actual minimum. In preference to any such scheme as that of single-width canals, the Author recommends the plan of navigation already carried out upon the Willebroeck canal, where boats and boatmen are hired yearly by carrier firms, and goods are conveyed as safely and punctually (except in frosts) as by rail. This plan he expects will undergo a vast extension, as soon as ever there is a good system of canals reaching from Antwerp to Charleroi, Mons, and Paris, and from Antwerp to Ruhrort on the Rhine.

Canal carriage compared with Sea.—While long sea voyages, in which thousands of tons are carried thousands of miles, offer too great a contrast to canal navigation, the latter may very fairly be compared with short sea passages and coasting trips, in which a few hundred tons are carried only a few hundred miles. From London to Antwerp, a distance of about 350 kilometres or say 220 miles, the freight by steamer is 21·5 millimes per tonne-kilom. = 0·335 penny per ton per mile, which agrees very closely with the Author's estimate of 18·2 to 20·2 millimes = 0·284 to 0·315 penny for canal carriage. The canal charge covers maintenance of waterway and interest &c. on construction; the sea charge, while free from both of these, includes other costs not incident upon canals.

II.—Maritime Canals.

Terneuzen Canal.—Referring to the powerful advocacy of MM. Colson, De Maere-Limnander, and De Grandvoir, in favour of constructing ship canals in the provinces of Brabant, Flanders, and Liége, the Author points out that their arguments are altogether of a general character, and are not backed up with detailed estimates of profit and loss, such as ought to be made out beforehand in connection with each of the several projects. He recommends watching the results that will ensue from the deepening just commenced of the existing Terneuzen ship canal, constructed in 1824–7, which runs northwards 34 kilom. = 21 miles from Ghent to Terneuzen in the estuary of the Scheldt. The upper level of this canal, extending 20·854 kilom. say 13 miles north from Ghent to Sas-de-Gant (Ghent Lock), has only 4·4 metres or 14½ feet depth of water, so that no vessels of more than 4 metres or 13 feet draught can get up to Ghent; while in the lower or northern level of 13·187 kilom. say 8 miles length, the depth increases from 4·32 metres or 14¼ feet at Sas-de-Gant to 5·66 metres or 18½ feet at the sea-lock at Terneuzen, where vessels of 5·3 metres or 17¼ feet draught can accordingly enter at the lowest tides. The bottom is now to be deepened throughout the canal's

entire length from Terneuzen to Ghent, to a uniform depth of 4·02 metres = 13·2 feet below Dutch datum A.P.,[1] so as to give 6·5 metres = 21·3 feet depth of water in the upper level, and 6·05 metres = 19·8 feet in the lower; the two locks, at Ghent and at Sas-de-Gant, are to be made 0·25 metre = 10 inches deeper still than the new bottom, with a view to the canal being further deepened to that extent whensoever the time may come for a new sea-lock to be constructed at Terneuzen.

Competing Ports.—Six general considerations are advanced by the Author in respect to the question of constructing maritime canals. In the first place, the advantage of competing ports is illustrated by the virtual monopoly at present held by Antwerp, where all traffic (except rails and ores) that does not come in river boats has to be carted at a cost per ton of $1\frac{1}{2}$ franc = $14\frac{1}{4}$ pence and upwards; the consequence is that certain large works in the Liége district avoid Antwerp by making Terneuzen their port instead.

Avoidance of Transhipment.—Secondly, the minimum charge of $1\frac{1}{2}$ franc = $14\frac{1}{4}$ pence per ton for transhipment at Antwerp would carry the goods by rail a distance of 48 kilom. = 30 miles, taking the railway rate previously arrived at of 31 millimes per tonne-kilom. = 0·483 penny per ton per mile. The saving of transhipment will benefit any canal in the inverse ratio of its length.

Propinquity of existing Canals.—Thirdly, it will not pay to make a ship canal through a district already served by an ordinary canal, unless there be traffic enough to ensure a profit after debiting the ship canal with the loss it will entail upon the existing canal, which is certain to be thrown idle.

Travelling night and day.—Fourthly, the present custom in Belgium is for canal boats to travel by day only; but they might safely do so by night also, provided it were arranged that the up and down traffic should go on alternate nights. In that way, for instance, the present six days' journey from Charleroi to Brussels would be completed in only four days, the boats travelling two alternate nights and stopping the other two. More men would then be wanted for the ordinary canal-boats, as well as for the locks; but ships have of course an ample crew already.

Sea-borne Commerce.—Fifthly, ship canals attract to sea-borne commerce capital which would not otherwise be so embarked. The importance of capital in this connection is illustrated by the success which has attended the Amsterdam ship canal, and which Flushing, despite her quays and cranes, so signally lacks. Had

[1] *Vide* Minutes of Proceedings Inst. C.E., vol. lxii., pp. 4 and 32.

Brussels, out of her redundancy of capital, dowered Antwerp with adequate means of warehousing cotton and corn, the Author believes a highly lucrative trade in both these commodities might already have been secured to Belgium; and he looks forwards to the advantages which will accrue from rendering Brussels a large sea-port through the projected ship canal of 30 kilom. = 19 miles to the Scheldt.

Net Cost of Carriage by Ship Canal.—Sixthly, taking a 1000-ton steamer to burn coals to the value of 225 francs = £9 per day when doing her 360 kilom. = 225 miles in 24 hours at sea, this is equivalent to 62·5 centimes per kilom. = 9·58 pence per mile. On the Erie canal, with locks 8 kilom. = 5 miles apart, the goods steamers do 64 kilom. = 40 miles per 24 hours. Assuming only 60 kilom. = 37½ miles per 24 hours on ship canals in Belgium, and the same consumption for this lower speed as for the higher speed at sea, the coal burnt on the ship canal will cost 37·5 francs = £1 10*s.* per day. Interest, redemption, insurance, and wages, may be taken to make up a fixed charge of 400 francs = £16 per day. Hence the freight is altogether 437·5 francs = £17 10*s.* per day, or 7·3 millimes per tonne-kilom. = 0·114 penny per ton per mile; and adding one-third as before to allow for empties, the actual freight becomes 9·7 millimes per tonne-kilom. = 0·151 penny per ton per mile, or very closely the same as the freight previously arrived at for the ordinary canal-boats. According to their size, the proposed ship canals in Belgium would cost for construction and maintenance, some of them about twice and others about three times as much as the ordinary canals; their depths of water would be 5 metres or 16½ feet and 6¾ metres or 22 feet respectively, and they would be large enough for steamers up to 1000 tons and 3000 tons respectively. The tolls previously ascertained, of 8·6 millimes per tonne-kilom. = 0·134 penny per ton per mile on the ordinary canals, with an average annual traffic of 1,000,000 tonnes-kilom. (say 600,000 ton-miles), would therefore become 17·2 millimes = 0·268 penny, and 25·8 millimes = 0·402 penny for the same amount of traffic on the smaller and larger maritime canals respectively. The net cost of carriage on the two sizes of ship canals would accordingly stand as follows, in millimes per tonne-kilom. and pence per ton per mile:—

Depth of Water in Canal . .	5·00 metres	= 16·4 feet.	6·75 metres	= 22·1 feet.
Tolls	17·2 millimes	= 0·268 penny	25·8 millimes	= 0·402 penny.
Freight . . .	9·7 „	= 0·151 „	9·7 „	= 0·151 „
Totals .	26·9 „	= 0·419 „	35·5 „	= 0·553 „

As examples of the advantages resulting from ships being able to make their way up to inland ports at a distance from the sea, the Author refers to the large amount of traffic passing up the Seine in sea-going vessels to Rouen, a distance of 124 kilom. = 77 miles inland from Havre. On the Terneuzen canal the tonnage going up to Ghent in ships was trebled from 1870 to 1878; while in the same period that going up the Scheldt to Antwerp was only doubled. The Amsterdam ship canal, of 28 kilom. = 17½ miles length and 7 metres = 23 feet depth of water, has already, since its opening at the end of 1876, caused a rapid increase in the commercial importance of Amsterdam. From official statistics compiled for the Belgian Parliament[1] in 1878 by the late Baron Jacques Behr, the seven Belgian ports rank in the following order of commercial importance:—Antwerp, Ostend, Ghent, Louvain, Brussels, Bruges, Nieuport. Antwerp alone takes 85 per cent. of the entire sea tonnage of Belgium, leaving only 15 per cent. for the six secondary ports together. In the British Isles the proportions are 40 per cent. for London and Liverpool jointly, and 60 per cent. for the one hundred and twenty-two secondary ports. In France also the same proportions obtain: Marseilles and Havre together absorb 40 per cent., leaving 60 per cent. for the seventy-three secondary ports. The inference is that, if Belgium had secondary ports easily accessible for large ships, these secondary ports would enjoy a share of traffic corresponding with that of similar ports in other countries. The traffic at Antwerp by ships, railways, and river and canal-boats, is analysed by the Author; and the physical geography of the Belgian sea-coast and of the Scheldt estuary is described, which clearly points out the Scheldt as the great highway to the sea for Belgium.

Proposed Maritime Canals.—The Author examines in detail the commercial and engineering aspects of the several ship canals proposed within the last eight years for the provinces of Flanders, Brabant, and Liége. The Flanders project[2]—for the construction of a harbour and sea-lock on the coast at Heyst, and thence of two ship canals with 7 metres = 23 feet depth of water, one of 12 kilom. = 7½ miles to Bruges, and the other of 50 kilom. = 31¼ miles to

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[1] *Vide* "Travaux Hydrauliques," No. 174 of Belgian Parliamentary Papers, dated 24 May, 1878, containing detailed descriptions and illustrative plans of the projects for extending the sea commerce of Belgium; Plate 3 represents graphically the statistics here referred to.

[2] *Vide* "Travaux Hydrauliques," section 1.

Ghent, as proposed by M. de Maere-Limnander—is shown to hold out no prospect of financial success.

M. Colson's plan for maritime canals in Brabant[1]—from the Scheldt to Brussels, Malines, and Louvain—would alter and utilise the existing Willebroeck and Louvain canals, enlarging them to $6\frac{3}{4}$ metres or 22 feet depth of water, with 20 metres = $65\frac{1}{2}$ feet width at bottom and $53\frac{3}{4}$ metres = $176\frac{1}{2}$ feet at surface, so as everywhere to allow two vessels to pass. Instead of both canals falling into the Rupel as at present, the Willebroeck or Brussels canal would be prolonged to enter the Scheldt just above the confluence of the Rupel, opposite Rupelmonde; the Louvain canal would join the Brussels canal at a little more than 8 kilom. = 5 miles from Brussels; and a branch of 8·8 kilom. = $5\frac{1}{2}$ miles would connect Malines with the Brussels canal. The distances from Antwerp would be 45 kilom. = 28 miles to Brussels, 61 kilom. = 38 miles to Louvain, and 34 kilom. = $21\frac{1}{4}$ miles to Malines. There would be five levels, as at present, for the total fall of 10·78 metres = $35\frac{1}{2}$ feet from Brussels to the Scheldt; and the locks would be 14 metres = 46 feet wide, with a clear length of 120 metres = 394 feet. A lengthened investigation respecting traffic leads the Author to the conclusion that the Brabant plan, besides being easy of execution, will prove from the very first a profitable undertaking, and will largely aid the development of Belgian commerce.

A maritime canal from Liége to the Scheldt, with 5 metres = $16\frac{1}{2}$ feet depth of water, is proposed by M. de Grandvoir, passing through Tongres, Diest, and Aerschot, and joining the present Louvain canal near Campenhout lock. Below this lock both the present canal and the Rupel would want deepening. The distance would be 127 kilom. = $79\frac{1}{2}$ miles by the new canal from Liége to Sennegat, the outlet of the Senne into the Rupel; and from Sennegat to Antwerp 28 kilom. = $17\frac{1}{2}$ miles by river: making a total of 155 kilom. = 97 miles from Liége to Antwerp by water, against the railway route of only 108 kilom. = $67\frac{1}{2}$ miles. The existing Campine canal from Liége to Antwerp, which takes a longer course northwards of the proposed route, would be laid idle by the ship canal. From traffic considerations which he investigates, the Author believes the carrying out of the Liége project could not result otherwise than in loss.

Conclusion.—While engineering talent has for half a century past been brought to bear upon the development of the railway

[1] *Vide* "Travaux Hydrauliques," section 3.

system, canals have been almost neglected. The Author has aimed at showing the importance of their now receiving very careful attention; he recommends examining the present state of canal navigation in other countries, and watching closely the Canadian ship canals, as well as the ordinary canals in America, particularly the Erie canal. Great results may yet be achieved, he is confident, by the scientific study of canal navigation.