Discussion.

Sir G. B. Bruce. Sir G. B. BRUCE, President, remarked that the Author had made extremely good use of his opportunities when abroad, and the members were much indebted to him for having put his information into shape, and laid before the Institution such a valuable *résumé* of what he had seen.

Mr. Vernon-Harcourt. Mr. L. F. VERNON-HARCOURT said that, through the kindness of Mr. Boulé, *Ingenieur en chef* of one of the sections of the Seine, and a delegate of the French Government to the Congress at Frankfort, he had the opportunity of visiting the two lifts in company with the French and Belgian engineers of those lifts, and he was struck with the difference in the views of those two gentlemen. The French engineer of the Fontinettes lift seemed rather afraid of trusting the navigation to it, and thought it fortunate that it was supplemented by the original chain of locks; whereas the Belgian engineer was perfectly satisfied with Louvière lift, and thought that the new canal, which would depend for its traffic upon the four lifts (three of which remained to be constructed) would certainly be a success. The Charlottenburg drum weir (Fig. 2) was the largest, he believed, in existence; and he had placed on the table detailed drawings of the weir, sent by the engineer of the work.[1] He had not had the opportunity of getting the details of the new bridges which traversed the Main near Frankfort in connection with the new station, but they appeared to him to be remarkably light in construction, when compared with the Putney girder-bridge across the Thames, now in course of construction. The cause of it, he imagined, was that German engineers gave a greater depth to girders than was usual in England; and it was known, from a Paper by Mr. Max am Ende,[2] that the most economical form of bridge was that in which the depth bore a much larger proportion to the span than was customary in this country.

Sir John Coode. Sir JOHN COODE, Vice President, was glad the Author dwelt at length upon the great advantages to be obtained by an extension of inland navigation, a question which the commercial community in this country might well take to heart, there being ample scope for such extension. He had hoped that some allusion would

[1] These drawings are in the Library of the Institution.

[2] Minutes of Proceedings Inst. C.E., vol. lxiv. p. 270.

have been made to an arrangement on the Grand Western Canal on the right-hand side of the Bristol and Exeter Railway, between Taunton and Wellington, an arrangement which appeared to him to be the germ of what had been done at Fontinettes and Louvière. It was a balance lift, having an ascending and a descending trough. The circumstances were somewhat different. In the one case gravity did the whole of the work, but in the other hydraulic power was brought to bear. Perhaps the Author was not aware of the arrangement on the Grand Western Canal, as it was almost a matter of ancient history. An account of it would be found with three illustrated plates, in a Paper by Mr. James Green, the originator of the proposal.[1] This lift rose 46 feet, nearly as much as the higher of the two lifts referred to in the Paper. The boats, which were much lighter, were ordinary canal boats, but they were passed, one up and one down, in three minutes. Mr. Green had truly said that the same method would apply to greater heights, and a larger tonnage. With regard to the advantages of an extension of water communication, he had been, within the last few days, much struck with a statement that in Germany in 1887, there passed, by internal water communication, no less than 17,568,000 tons, being an increase over the average of the previous five years of $22\frac{3}{4}$ per cent. in the merchandise conveyed, and $24\frac{1}{2}$ per cent. in the tonnage of the vessels employed. He thought that was a very significant fact, and one which the commercial community at home might seriously consider. The Paper under discussion was one which young engineers going abroad should imitate. They might not be able to get sufficient information with regard to any one particular work, but they might, like the Author, judiciously group a number of works together, and bring them before the Institution. The ports of Gustavsburg and Mannheim deserved careful study. They were instances in which very great advantage had been taken of the physical features of the ground. Mannheim had been exceedingly well laid out. The Mühlau basin might appear to be narrow, only 320 feet wide, and when two barges were lying abreast on each side there might be a difficulty in turning; but that had been provided for, because there was through communication, and the mode of linking up the rivers was well devised and interesting.

Sir John Coode.

Mr. A. GILES, M.P., Vice President, said that if young English engineers were gifted with the same industry that the Author

Mr. Giles.

[1] Transactions Inst. C.E., vol. ii. (1838), p. 185.

Mr. Giles. had exhibited, there would be no occasion for the remark in the Paper "that English engineers cannot afford to relax their exertions in the way of progress, if they are to keep in advance of their professional brethren on the Continent." He was glad, however, to find that they were indebted to English engineers for the designs of the lifts described in the Paper. He thought that, as the works were new, of considerable magnitude, and of some risk, it was better to follow the French engineer, and leave the old system of locks still in force in case of accident, instead of, according to the Belgian engineer, trusting entirely to the new works. It was like leaving gas-lamps as a stand-by when putting up electric lights. He was glad that the works at Frankfort were due to the genius of the English engineers, Mr. W. Lindley and his son, Mr. W. H. Lindley, the former of whom was an old pupil of Mr. Giles's father. He had done good work, both at Hamburg and at Frankfort. The English Government might well take a hint from the authorities of Frankfort and of other ports in helping public works more than they did. Public works in England were mostly done by private subscription and joint-stock enterprise. Many harbours of refuge, fishing ports, and other works were greatly needed; but no assistance could be obtained from the British Government. Efforts had been made over and over again to impress upon the Chancellor of the Exchequer the necessity of providing money for such objects, but without success.

Mr. Lloyd. Mr. E. J. LLOYD thought that some further information should be given as to the amount of economy that would result from the works described in the Paper. In England, as Mr. Giles had stated, such works were carried out by joint-stock enterprise, and the promoters were therefore not in a position to disregard the question of cost. He believed the Anderton lift had never been a commercial success, the reason being that it was never fully occupied. If some information could be given as to the cost of construction and working, and the tonnage capacity of the large lifts referred to by the Author, it would be very useful to the members. It was a matter of great importance, because if the inland canals in England were not enlarged, railway competition would probably render them to a certain extent ineffective.

Mr. Barry. Mr. J. WOLFE BARRY said that caution should be exercised in dealing with generalities, and it ought not to be too readily concluded that because inland navigation was of great utility on the Continent, it would be of equal utility in England. The experience of England up to now was certainly the other way. It had

been lately his duty in Ireland to inspect some important works of inland navigation made by the Government, who were more disposed to assist public works in Ireland than similar works in England. He had visited the very large and well-designed works for the canalization of the River Shannon. The whole traffic of the upper Shannon above Athlone produced £30 a year in gross tolls, while the cost of the works could not have been less than £150,000. Another Irish canal, from which great things had been expected, not only was not paying anything on the capital expended, but it was not even paying its working expenses. As to canal traffic in England, it should be remembered that it must compete with perhaps the most perfect system of railway communication in the world; that the railway companies had their ramifications extending to every town, and that the speed with which goods were conveyed by them compared most favourably with the *petite vitesse* on the Continent. The trader found that speed in the transmission of his goods meant the continuous employment of his capital, increasing his turn-over, and he could not afford the delays of English canal navigation. It might be said that many of the canals had fallen into the hands of railway companies who did not wish to work them for the benefit of the English market. There might be some truth in that in some instances, but in other cases he was certain that it was not so. The reason, he believed, why traffic was diverted from inland navigation in this country was the great facility of collection and delivery of goods by the railways, the inevitable delays of water traffic, and the want of facilities of collection and delivery, such as those which were possessed by the great goods-carrying railway companies. He could well imagine that on the Continent the condition of affairs might be different. There was a very long water traffic to be dealt with, and in such a case the inconveniences to which he had alluded were perhaps not so important as in the case of short journeys, in a small country like England. Engineers should, he thought, be very cautious before coming to the conclusion that there should be a great enlargement of English canals, and that it would be remunerative or of great utility. He knew that it was now the fashion to say so; but he himself doubted whether there was much truth in the idea. Certainly, so far as he had been able to form a judgment, it did not commend itself to his mind as being a thing that would be profitable to investors or convenient to the general traders of the country.

Mr. Barry.

Mr. H. J. MARTEN thought there was a smatch of railways, and railways only, about the observations just enunciated. He was

Mr. Marten.

Mr. Marten. professionally interested in a considerable number of inland navigations, principally in England, and he did not take so gloomy a view of their future as that presented by the previous speaker. There had no doubt been cases of failure, where, as in Ireland, large outlays had been made on waterways without due consideration of the sources of probable traffic, and where local enterprise, especially of that description which resulted in the development of a large amount of heavy goods traffic, was at a low ebb. Just as large outlays might, in some cases, have been incurred in constructing unnecessary, and consequently unprofitable, railways. He had found that, where there was a good and well-managed waterway, it could always hold its own, both in time and cost of carriage, in competition with railway-borne heavy goods traffic. Everything, however, depended upon the waterway being in good travelling condition, and upon its having a sectional area and being of a gauge suitable for the traffic to be carried along it. Almost all the canals for conducting the inland navigation of this country needed improvement. As a rule, they were much too small, many of them, in fact, being practically mere ditches. Provision was required for the passage of larger boats, to be propelled by steam or some other cheap motor, instead of by animal power such as horses, donkeys, &c. The existing boats were, in most cases, too small to carry their own propelling machinery with material advantage as regarded cost of transit, the weight of the machinery being in many cases from 20 to 25 per cent. of their cargo-carrying capacity, and consequently displacing that amount of profit-producing tonnage. This might be remedied by enlarging the locks, so as to pass trains consisting of three or four boats at one lockage, whereby, say in the case of one cargo-carrying steam-boat hauling a train of three ordinary canal-boats, the weight of the propelling machinery might be reduced to under 5 per cent. of the weight of the cargo, instead of bearing the large proportion named above. With a larger sectional area of waterway in proportion to the enlarged size of boat;—with the banks "wash," or "deep-walled" on either side of the canal, so as to reduce both the frictional resistance of the displaced water when passing to the rear, and the head of water in front of the boat;—with a proper bottom width and depth under the keels of the loaded boats, so as to enable them to travel and steer well;—by doing away with all the old-fashioned narrow bridge holes through which the traffic now had to be strained, and which were as objectionable on a canal as a single-line neck would be every few hundred yards on a main-line railway;—by en-

larging the locks so as to pass trains of boats at one lockage;— and by using lifts in certain cases where circumstances might render them applicable, he was satisfied that the inland water-communications of this country would more than hold their own, and that wherever there was sufficient traffic between any given points to support a railway, there would also be sufficient to maintain a well-regulated and well-appointed water-communication in profitable existence. With reference to the observation of Sir John Coode, to the effect that the total water-borne traffic of Germany was 17,568,000 tons in a year, he might state that there was a canal in the central mineral plateau of England, only about 150 miles in length, but principally on one level, the traffic upon which was upwards of 8,000,000 tons a year, or more than half the whole water-borne traffic of Germany. In his opinion the most important fact mentioned in the Paper, and one which materially bore upon Mr. Barry's observations, was that, in the two years since their completion, the improvements on the river Main had resulted, not only in a fortyfold increase of water-borne traffic, but that in the same time the traffic upon the competing railway systems on either side of the river had increased upwards of 36 per cent. In England, the fear had been frequently expressed that any increase of traffic in an improved canal could only be obtained by depriving a competing railway of a quantity of traffic equal to the increase on the canal. Assuming, however, the facts mentioned to be correct, they went far to remove that impression, and he felt much indebted to the Author for bringing them out. Mr. Marten's own view was, and always had been, that railways would be benefited by improved water-communication, because if heavy raw material could be cheaply conveyed by water to any manufacturing centre, railways would have the benefit of conveying from that centre the lighter goods manufactured by means of the cheap water-borne raw materials, and which light goods, requiring quick despatch, and being of a higher class, would yield enhanced and more remunerative rates to the railway companies than the low class and low-rated raw material. He was of opinion that the County Councils, upon whom now devolved the control and management of the main roads, would also be shortly looking into the question of improving the water-communications within their respective jurisdictions. So long as the County Councils did not trench upon the business of carriers, and confined themselves to toll-taking only, there did not appear to be any valid reason why the waterways should not be under their control and management, just as the macadamized roads were now. There were some precedents for

Mr. Marten.

Mr. Marten. this course, and he hoped and fully anticipated that, in the near future, the principle would receive further exemplification, as he was satisfied the manufacturing prosperity of many inland districts depended upon improved water-communication.

Mr. Clark. Mr. LYONEL CLARK said that a question had been asked with regard to the cost of the lifts. The only comparison necessary was between the cost of a hydraulic lift and the expenditure that would be entailed for locks to replace them. The mere fact that a certain lift cost a certain sum could not be of much interest, unless the particular style of work was known. Fortunately, with the Louvière lift, the canal comprised several locks having the maximum fall which was found by the Belgian engineers to give the best results, about 16 or 17 feet. Three such locks would be required to compensate for one of the lifts having a rise of 50 feet; and the difference in price would be in favour of the lift. The cost of the lift was 1,250,000 francs (£50,000); and the cost of the three locks would be about 1,500,000 francs (£60,000). The price of the lift might seem excessive, but it was Government work, and no doubt many engineers would say that Government work was not the cheapest. The exact cost of passing boats through was, of course, rather difficult to estimate. It must depend entirely upon the boats. The lift could pass 7,000,000 tons a year, and that was a great deal more than any single lock of 17 feet on the same canal could do. It was quicker to get two boats through, one up and one down, than to get a single boat through an ordinary lock. Reference had been made to a canal in the Midlands passing 8,000,000 tons a year; but that canal was on a level. He knew of no canal containing locks that would pass that amount of tonnage in a year. The lifts were not only cheaper, but quicker in operation. The average time of passing two barges of 450 tons, one up and another down, was only twenty minutes; so that 7,000,000 or 8,000,000 tons could be easily passed through in a year. The lifts mentioned by Sir John Coode were for boats of 30 tons, and there was no trouble in passing them over pulleys by means of chains; but he did not think there were many engineers who would care to take 1,100 tons up 50 feet in three and a half minutes by chains. It would be a great risk. That was why hydraulic power came to be applied to the lifts. In the Anderton lift, the first in England, it was not found practicable to use chains of that sort; and therefore Mr. Edwin Clark was called on to devise some form of hydraulic lift, and that form had been adopted for the lifts under discussion. They varied very little from the Anderton

lift which had been at work fourteen years. The fact that the latter did not pay did not militate against its engineering advantages. A canal in Ireland might not pay now, but that was no reason why a canal in England should not pay. He believed that it would be one of the greatest possible advantages to England to have a thoroughly good water navigation, capable of taking heavy goods, leaving the railways to do their proper work in the quick transit of lighter goods. Mr. Clark.

Professor W. C. UNWIN thought that the account which the Author had given of the dams was likely to convey an erroneous impression. To say that the Gileppe dam compared unfavourably with the Furens and the Villar dams was to convey a wrong impression; for there was an enormous difference between the amount of masonry in those dams. Some years ago he had abstracted for the Proceedings[1] a Paper from the "Civilingenieur" in which a careful comparison was made. From this it appeared that in the section of the Furens dam, down to a depth of 115 feet, there were 4,500 square feet of masonry; in the Villar dam to the same level, 4,800 feet; and in the Gileppe dam no less than 12,500 feet—at least two and a half times the amount of the others. The Furens and the Villar dams still stood, and he could not see why two and a half times as much masonry should be needed to stand the same water-pressure at Gileppe. All those dams were now, for engineering works, of respectable antiquity, a full account of the Gileppe dam having been published as long ago as 1877. It appeared to have occurred to the engineer of the Gileppe dam, that the right way to proceed was first to design what the Author had called the theoretical section (as to which no two engineers were agreed), then to design the section of a trapezoidal dam, and then to strike an average between the two. That being so, he did not think the Gileppe dam was a model to be held up for admiration; because, it should be remembered, in a structure of that kind adding masonry at random was as likely to weaken the structure as to strengthen it. The Author had referred to the water percolating through that enormous mass of masonry, and making a scale on the down-stream face. Professor Unwin had a piece of that scale in his pocket, and it was of a rather substantial kind. The fact was that for a large part of the area of the down-stream face, the dam, up to a defined horizontal line, was covered with stalactite an inch or two thick, formed by lime washed through the whole body of masonry by percolation. Professor Unwin.

[1] Minutes of Proceedings Inst. C.E., vol. lvi. p. 337.

Mr. Vernon-Harcourt.

Mr. L. F. VERNON-HARCOURT, in reply, said that it would be difficult to satisfy the conflicting views expressed with regard to the works that should be referred to in the Paper; for Sir John Coode would have liked the Grand Western Canal lift, constructed early in this century, to have been mentioned, whilst Professor Unwin appeared to object to a description of a visit to the Gileppe dam, because it had been completed, as stated in the Paper, about thirteen years ago. He had described the Grand Western Canal lift in a book [1] some years ago; but he had subsequently been informed that the lift was no longer in existence, and that a French engineer had searched for it in vain. He considered that a short reference to so important a work as the Gileppe dam was of interest, especially as pointing out how easily it could be visited. Mr. Giles, in preferring the caution of the French engineer in relying largely upon his flight of locks, to the boldness of the Belgian engineer in trusting solely to lifts, must bear in mind the difference between the two cases. At Fontinettes, the lift merely supplemented the existing flight of locks, on an old canal, where the traffic had become too large for the locks, and for the supply of water available. The Central Canal of Belgium, on the contrary, was a new work, along a portion of which, owing to a rapid ascent and a scarcity of water, flights of locks had been considered inadmissible, and, therefore, reliance had to be placed on lifts, or the scheme abandoned. Adopting Mr. Giles's simile, if gas had not been laid down, and could not be procured, it might be wise to rely upon electric light, rather than dispense with light altogether. Mr. Lloyd's request for further information about the lifts had been responded to by Mr. Clark; but he might add that the economy of the lifts must depend upon the traffic they accommodated, and the time and water they saved. Probably at Fontinettes, when the lift had got into thorough working order, the large traffic and the scarcity of water would give the lift a real commercial value. There was a good prospect of a large traffic along the new Central Canal of Belgium, on account of its forming a connecting link in a district of great industrial activity. The lifts, though costly, appeared the only means available for completing the waterway, and might, by a full utilization, afford a satisfactory return. The State also would have the advantage of reaping the indirect profits from any increase in trade resulting from, but beyond the limits of, the new canal, from which a company would derive no benefit. Mr. Barry had referred to unremunerative navigations and canals

[1] "Rivers and Canals," L. F. Vernon-Harcourt, p. 105.

in Ireland, and appeared to be opposed to the extension of inland navigation in England. No doubt it would be unwise to assume that every extension of inland navigation, or enlargement of existing waterways, must prove remunerative. Canals had suffered from inadequate size, absence of uniformity in depth, and in the dimensions of locks, want of energy in their development after the advent of railways, and diversion of attention and capital to railways. These defects had, however, been gradually removed in France; and traffic had been stimulated by exemption from tolls. Nevertheless, as he had pointed out in a Paper[1] read at the Canal Conference held by the Society of Arts in 1888, the traffic was quite small upon three-fourths of the length of the river navigation, and one-third of the canal system in France; and the very large traffic was confined to small sections in both. It was evident that, in spite of the improvement of the canals and river navigations in France, the greater portion of the system of waterways could not confer benefits on the community adequate to the cost of the works. Canal and river navigations might, indeed, be treated as roads, as, in fact, they were in France, being paid for and maintained by the State, and opened free of charge; but roads were absolutely essential for the whole population of a country, whereas waterways had a comparatively limited use; and it seemed hardly fair to tax the whole community for works which could be only advantageous to the few. If, however, waterways could not be considered as a universal public benefit or necessity, then evidently their improvement and extension must be restricted to those routes and districts where good prospects existed of a reasonable return on the outlay. He, therefore, quite agreed with Mr. Barry that caution must be exercised in proposing a great enlargement of English canals. He had, indeed, expressed a similar opinion in 1888, as shown by the following extract from the Paper referred to above: "The statistics, in fact, show that great caution must be exercised in the selection of canal routes for improvement, if they are to prove a commercial success, and that the scope for such schemes is strictly limited. Any attempt at a general revival and improvement of the canal system throughout England cannot prove financially successful, as local canals, through thinly-populated agricultural districts, could not compete with railways. Those routes alone should be selected for enlargement of waterway which lead direct from the sea to large and increasing towns, . . . or are suitably situated for the conveyance of coal, and general bulky

Mr. Vernon-Harcourt.

[1] Journal of the Society of Arts, May 25th, 1888, vol. xxxvi. p. 753.

Mr. Vernon-Harcourt. goods, to populous districts."[1] At the same time, the large traffic and good returns on canals, such as the Aire and Calder Navigation, which were favourably situated, and had, by successive extensions, kept pace with the growing requirements of traffic, and the enormous accession of trade created by the canalization of the Main, showed that, under certain conditions, the improvement and extension of inland water communication might be very remunerative to the promoters, and effect a great increase in the trade of a district. It would, in fact, be as great a mistake to argue that because certain navigations in Ireland had not attracted an adequate traffic, therefore all improvements of inland waterways in England must prove unremunerative, as to suppose that every extension of inland navigation would benefit the promoters. Professor Unwin's criticisms of the portion of the Paper relating to the Gileppe dam had surprised him. The design of the Gileppe dam had certainly not been held up for admiration in the Paper, as it was expressly stated that its superabundant width imposed an unnecessary pressure on the base, comparing unfavourably in this respect with the Furens dam. This, being a fact, could hardly convey a wrong impression as suggested by Professor Unwin. He had also stated elsewhere, that "the maximum pressure on the Gileppe dam is considerably greater than on the Furens dam, in spite of its greater base and the smaller head of water, owing to the excess of material employed in its construction."[2] It was possible to praise the workmanship, and admire the height of the dam, without approving of its section. The section of the Vyrnwy dam was unquestionably superior to the Gileppe section; but it did not reach the economy of material attained in the Furens section, especially in its upper part.

Correspondence.

Mr. Duncan. Mr. J. DUNCAN observed that grain was conveyed from Rotterdam to Mannheim, a distance of 354 miles, by water, at rates varying from 6*s.* to 10*s.*, and sugar was conveyed from Mannheim to Rotterdam for 3*s.* 6*d.* per ton. Where the traffic was large, $1\frac{1}{4}d.$ per ton per mile would pay a good dividend on a carefully-constructed canal.

[1] Journal of the Society of Arts, May 25th, 1888, vol. xxxvi. p. 758.

[2] Encyclopædia Britannica," 9th edition, vol. xxiv. p. 407.