

Mr. R. HASSARD asked permission, as the engineer by whom the Vartry scheme had been originated, to state the reasons which had guided him in the selection of that locality. He had paid a great deal of attention to the subject some years previously, as it was evident that when the agreement, between the corporation of Dublin and the canal companies, for the existing water supply terminated, a new system would have to be adopted. He believed that he investigated every locality from which the city could be supplied. To the south of Dublin there existed a high range of mountain land, the northern and western slopes of which were drained by the Liffey and the Dodder, and from those streams a large quantity of water might be obtained; but much of the ground was occupied by mills and manufactories, and there would have been a considerable interference with ornamental property. Besides a great portion of the upper part of this drainage area was covered by beds of dense peat, so that the water for a large portion of the year would have been highly coloured, while the existing supply had at least the merit of being colourless. This objection appeared so serious, that Mr. Hassard came to the conclusion, that if pure water for the supply of Dublin by gravitation was to be obtained, it would be necessary to seek for it in some locality not draining into the Dublin basin. It then occurred to him that, if the water could be derived from the eastern slopes of the hills, the current being reversed from thence by pipes or aqueduct to the metropolis, supplying *in transitu* the districts of Killiney, Bray, Dalkey, Kingstown, &c., it would be a desirable course of proceeding, as the revenue from those districts would more than counterbalance the extra cost involved. It was at first thought wild and chimerical; but public opinion respecting it had greatly changed. He did not desire to speak of his own personal connection with the project. No doubt others besides himself had had schemes, to which they had devoted much time, labour, and money, taken out of their hands, and carried out by others. As regarded any professional credit attaching to the engineer who devised the scheme, he certainly laid claim to it; and Mr. Neville was equally entitled to all the credit of carrying out the works to a successful issue.

Mr. BELOE said, having had considerable experience in such matters, as Chairman of the Liverpool Waterworks for many years, he thought great credit was due to those who had carried out the Dublin works, for the financial results of the undertaking. He was greatly surprised to hear that the total cost of the works was only £607,000. They were nearly of the same magni-

tude as those at Liverpool, which had cost about £2,000,000. He had been struck with the wonderful talent with which the engineer had managed to buy up all the compensation water that would otherwise have had to go to various owners. In Liverpool they had a few years ago to deliver no less than 70,000,000 gallons weekly as compensation, which was useless to those who received it, while the loss was a great detriment to the town of Liverpool. He had never seen any works so complete and so efficient as those at Dublin.

Mr. S. C. HOMERSHAM said he supposed there was some reason for screening the water after it was filtered. It appeared to him that if the pure water basins, after the water was filtered, had been covered, and if the service reservoirs near the town had been covered, there would have been no need for screening. The water would then have been delivered in a much better condition than by being collected after filtration in open reservoirs near to the source, and subsequently left in open reservoirs near to the town, and then screened. With regard to the relative cost of the Dublin and the Liverpool works, the elements of comparison were not the same. No doubt a large amount of compensation had been given to millowners, and the purchase of the riparian rights upon the streams at Liverpool had cost an enormous sum, in addition to which the old works in the hands of private companies had to be bought up. The Dublin works, he believed, had been in the hands of the corporation from time immemorial, so that the interests of old companies had not to be purchased.

Mr. BELOE said the cost of the Rivington works was about £1,500,000; but that did not represent the entire cost, for they had had to pay for other works besides. The compensation to which he alluded was compensation in water, and not in money.

Mr. HOMERSHAM said the reservoirs must be made of sufficient capacity to give the compensation in water, and that involved a money expenditure.

Mr. VIGNOLES, Past President, said Mr. Beloe would be doing good service if he would distinguish the mere cost of the water supply from the various collateral expenses, particularly the compensation in the several forms of money, works, and water. It was impossible to institute a fair comparison between the Liverpool and the Dublin works without knowing the various circumstances of the case.

Mr. G. J. SYMONS said there was one lesson that might be gathered from the Paper. He did not desire to go into a long disquisition as to the history of the Dublin Corporation Waterworks

and their connection with rainfall; but that connection was very intimate, and he believed would prove to be extremely instructive. When the works were laid out, the only data as to the quantity of water that could be gathered on the hills consisted of two sets of observations, one set made by the Royal Engineers at their office in Phoenix Park, and another set made at a station called Fassaroe, the fall being much larger at the latter station than at Dublin. When the Vartry scheme was brought forward it was attacked on the ground that the Fassaroe gauge was not to be trusted. There was considerable discussion on the subject. On the one hand it was said that Fassaroe, if anything, showed too little; that inasmuch as it was at an elevation of only 200 feet, and much of the gathering-ground was considerably higher, it was necessary to add a certain percentage to the Fassaroe values. On the other hand, it was contended that the Fassaroe gauge was not to be trusted at all, and that the only thing to do was to take the Dublin gauge with some slight increase. That, he believed, speaking from memory, was taken at 28 inches or 29 inches, while Fassaroe was 35 inches. It appeared that a series of observations had now been taken over several years, and a result obtained such as might have been anticipated. The plateau on the eastern side of the range of hills was the very place where the largest rainfall might be expected. It was not usually obtained on the south-west side, where the wind came driving up; but when the air had been cooled by rising to a considerable height, and by the coolness of the ground over which it had passed its capacity for holding water was diminished, the rain fell. He had been much astonished at some of the views enunciated on the subject when the scheme was before Parliament in 1861. The results already obtained showed that it was not wise, when a rain gauge gave a result not exactly agreeing with one's desires and expectation, forthwith to conclude that it was wrong. It was also shown that it was possible, by calculation and observation of the fall at a low level, to make a fair approximation to what the result would be at a higher level in the same neighbourhood.

Mr. A. R. BINNIE thought some explanation should be given as to the reason for filtration. It was stated that the Dublin water was equal in quality to that of Glasgow, obtained from Lake Katrine, which, as was well known, did not require filtration; but the analyses in the Paper showed that it was of a less pure quality. The account of the difficulties and dangers experienced in consequence of the leakage through the culvert, showed the care that should always be taken in constructing outlet works. Had a tunnel been

driven through solid rock, without interfering with or underlying the embankment, he thought the danger would not have existed.

Mr. TELFORD SIMPSON said the works could not now, owing to the rise in price of material and labour, be constructed for less than £800,000. He had understood that the Liverpool works had cost considerably more than £2,000,000, probably, including all expenses, about £3,000,000. But the circumstances were very different in the two cases. The Vartry scheme was almost entirely a new one. He believed the cost of the original works of the Dublin Corporation were not included in the £600,000. In that case it would only be fair to add another £200,000 or £300,000, making in all £900,000. Then the population of Liverpool was 500,000, while that of Dublin was only 300,000. These circumstances would bring the figures somewhat nearer, but still there was a large discrepancy, and the Liverpool works might be considered as having cost twice as much as those at Dublin. But the former had been added to and patched up from time to time, which was always a more costly process than carrying out an entirely new scheme on a large scale.

Mr. ALEXANDER FRASER asked if there had been any appreciable effect upon the health of the population of Dublin in consequence of the substitution of soft water for the previous supply of hard water, which had been provided for many years. He supposed, from the small area of the filter beds, that the water was almost of uniform quality, and that the district was not subject to floods, or to any cause that would make the water thicker at one time than at another. He observed, however, that larger filter beds were about to be provided.

Dr. POLE expressed regret that more information was not given respecting the distribution of the water in the city. He had endeavoured to make out the quantity consumed per head. He found that the total quantity of water was recorded; but as there was no information as to the population actually supplied, it was not possible to calculate the quantity per individual. There was, however, reason to think that the consumption within the city was large, probably amounting to 40, or more, gallons per head per diem. The question of distribution of water in large towns, under the constant supply system, was at present one of the most important problems in regard to water supply; and it had an especial interest, owing to what had lately taken place in regard to the metropolis. There had been much discussion as to the introduction of constant supply into London. Laws had been passed and official regulations had been drawn up; and although nothing had been practically done, the question only slept, and would soon

be revived. The difficulty was, how to introduce constant supply with the least possible inconvenience to the inhabitants, and yet without incurring unnecessary loss to the companies by waste of water. The experience in large towns was very discordant; in some, as in Manchester and in Norwich, the change had been effected with economy and success; while in others, as in Glasgow and in Liverpool, the waste was excessive. Hence it was important to get the results of experience gained in all large towns where a change of system had been introduced. It was probable that the waste or economy of water largely depended on the nature of the rules and regulations adopted for the distribution, and on the degree of stringency with which they were enforced. Hence the conceived information on these points in regard to Dublin would be of much utility, not only to the profession, but to the public at large.

Mr. ROGERS FIELD said, when the question was discussed before Parliament in 1861, it was stated by the opponents of the measure that the loss of water by evaporation and absorption would be much larger than in ordinary hill districts, on account of the peculiar formation of the ground, the contention being that it was not really a hill district, but a large plateau. It appeared that the water had been gauged regularly, and it would be interesting to know not only the rainfall but the amount of water that had run off. It was stated in 1861 that the loss by absorption and evaporation would be something like 18 inches; while in the Paper the loss was given as 15 inches, but it was not clear whether this was the actual measured amount, or merely an estimate. The Author said his experiment proved that the quantity of water calculated by the usual formula for the flow of water over weirs was larger than the amount actually discharged. It would be interesting to know what was meant by the usual formula, seeing that there were a number of different formulæ applicable to different cases. It was also stated that the 33-inch main discharged a larger quantity than was calculated. He should be glad to know whether it had continued to discharge that quantity. It was a well-ascertained fact that large mains discharged a greater amount than that given by the usual formula, but he believed in most cases it was found that the amount gradually fell off. This had been the case with the 48-inch pipes in the Glasgow works. In the first instance the amount was something like 50 per cent. larger than that given by Eytelwein's formula, but it gradually diminished, though the pipes still continued to discharge more than the amount given by the formula.

Sir JOHN COODE said he was connected, though not professionally, with the case of a small town where the waterworks were laid out by Mr. Hawksley; the pressure was about 200 feet, and the consumption in the first year was about 9 gallons per head per day. The service, which was constant, was entirely new throughout the town, and the smallness of the quantity consumed was owing to the absence of waste—a result due to the stringent regulations adopted with regard to the service-pipes. No plumber who was not on the Company's list was allowed to be employed.

Mr. HASSARD, in replying for the Author, said, with regard to the necessity for filtration, there was no analogy between Loch Katrine and the Vartry Basin. Loch Katrine had a drainage area of 22,000 acres, and the water surface was 3,000 acres, or $\frac{1}{7}$ th of the total drainage area. Vartry had a drainage area of 14,000 acres, and a water surface of 400 acres, or $\frac{1}{35}$ th of the drainage area. When the Vartry scheme was first projected a flood water-course was proposed, by which the dirty water brought down in a flood could be shut off from the reservoir; but a doubt arising as to the amount of the rainfall the corporation thought it best to impound all the water, and, if necessary, to construct filters. That was thought to be the safest course. The area of the filters was not unusually small. They were designed according to the usual rate of 700 gallons per day for every square yard of filtering surface. The cost of the works, £610,000, included every expenditure,—£72,000 for the old works, £66,000 for laying new mains, and also the amount expended in application to Parliament for other schemes. The population supplied was 300,000, excluding the township of Rathmines. The daily consumption was 45 gallons per head. The distribution was constant. The large consumption was no doubt due to the circumstance of a new supply being brought in at a high pressure where only old fittings existed. In another town in Ireland, where he had constructed waterworks under similar conditions, there had been a comparatively low pressure for many years, and when the water was brought in at a pressure of 190 feet, almost every house service-pipe in the town had to be renewed. The 33-inch pipes in Dublin continued to deliver 18,000,000 gallons daily until the consumption was somewhat checked. With regard to the effect of the change upon the health of the population, he could only say that every one was loud in its praise; it was simply substituting pure for impure water; and if any evil effects had arisen, something would have been heard of them.