Discussion.

Mr. Hart. Mr. J. W. Hart said it appeared upon the plan accompanying his Paper (Plate 7, Fig. 3), that there were certain filter-beds for future extensions. Those extensions had been partly carried out. It was also stated in the Paper that provision had been made for the cost of extensions and additional pumping-engines and boilers. Those pumping-engines and boilers were now in the course of construction, and the engines would pump 200,000 gallons per hour into the water-tower. The available space for the additional engines and boilers was therefore being occupied, and the additional capital stated as likely to be required would be called into use by the extensions which were being carried out.

Mr. Orange. Mr. Orange desired to read an extract from a letter written to Sir Robert Rawlinson by Mr. Osbert Chadwick with reference to the Tytam reservoir. He had made an examination of the dam, especially to see what damage had occurred from a great rainfall at Hong-Kong, in May 1889, when 27½ inches of rain fell in twenty-four hours, and 3·4 inches in one hour; and he stated in his letter:—"I have made a careful inspection of Tytam. The heavy rains did no damage to the structure. Some of the ornamental slopes of made ground were washed down, that is all. The by-wash was abundantly large. The water poured over it upwards of 4 feet deep, being at the rate of 5 inches of rain flowing off the area per hour. The work looks excellent. The masonry only shows a few weeps, which are evidently taken up. There is, however, a considerable leakage at the flanks through the solid ground, and some springs show themselves in the valley below the dam. They may to some extent be natural. All the water from these leaks comes out brilliantly clear, only depositing some irony matter. In short the dam is perfectly tight, no water goes through it or under it. The only leakage is through the solid rock, and this will take up, as a deposit of silt forms in the reservoir. In fact the whole is as stable as it can be." The strong point with regard to the dam at Tytam was the inner skin. It was not claimed that the whole mass of rubble concrete was water-tight; in fact he knew that it was not water-tight. In order to assist the water which might percolate into the hearting to get out, perforated iron pipes or small perforated bamboos were put in at the various steps. The water-tightness depended upon the skin of the fine concrete behind the ashlar inner face; the rest was mass and weight. He did not know that this principle was novel, but he had never heard of it before in the construction of a dam. With regard to the tunnel, it might be said that the cost was heavy; explanations had been given in the Paper of the cause. Work was carried on day and night, including Sundays, throughout the year for forty-seven months, and he did not know what more could have been done. Very careful experiments were made, and the cost was due principally to the very refractory material which had to be dealt with. Mr. Orange.

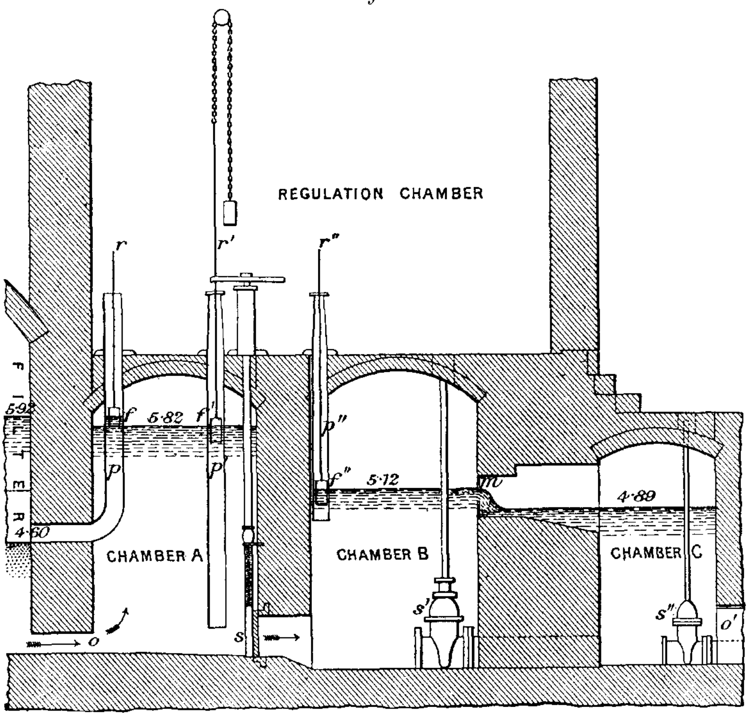
General A. De C. Scott wished to make a few remarks with reference to the difficulties mentioned in the Paper on the Shanghai Water-Works, in connection with dealings with the Chinese, as he had had a good deal to do with Orientals in his time. He ventured to suggest that the works described in the Papers possessed special interest, due to the localities in which they were placed, and that there were circumstances connected with them which rendered it desirable to bestow on them a somewhat exhaustive attention. They stood, as it were, on the fringe of countries which had been in the highest degree exclusive, and the inhabitants of which had repelled for hundreds of years, and successfully repelled, the efforts made by European nations to extend their intercourse over the interior. Diplomatists had tried to find the "open sesame" which would unlock the door shut in their faces. They had only succeeded in opening some few ports to trade, and the country to opium. Merchants had tried their hand, but the literati and mandarins despised trade, and progress towards the interior had been arrested. Missionaries had been at work for centuries; but they had not yet induced the Chinese to warm to foreigners, and for political reasons they were disliked by the officials. To his mind it was the engineer who stood the best chance of breaking through the crust of prejudice, distrust, and dislike, which still formed a barrier to intercourse with Europeans, and to the material progress of those countries. He stood before those people as the creator by his skill and knowledge of works which, by the benefits they conferred on communities, were humanitarian in their scope and intention. The very ethics of the people were in his favour. The pious Oriental, who wished to secure his own happy transmigration, commonly planted a grove to shade the wayfarer, or built a road or bridge to aid his progress. He dug a well or a tank for irrigation and the production of food, and not seldom was the Government engineer in India called in to give shape to those good works. In the cases under consideration, 459,000 Orientals at Hong-Kong, Shanghai, and Yokohama were enjoying the benefits of the Euro- General Scott.

General Scott. pean system of water distribution. Each one of them was an agent, more or less active, in disseminating a knowledge of the advantages which he enjoyed. Some stress was laid on the fact of the hostility shown by the officials and others in the native city of Shanghai to the introduction of the water-supply owned by the European Corporation. But it should be recollected that it was not only water which it was proposed to introduce, but a company, and allowances should be made for the Chinese, who very probably might think that there would creep in with the water indefinite claims. He fully believed that before very long there would set in a current of Chinese opinion in favour of the European engineer and his methods, and that members of the engineering profession, and of the Institution, would find in those countries vast opportunities for the exercise of their abilities. Those who were acting there as the pioneers of the profession, and strenuously working against initial difficulties and prejudices would, he was sure, receive the sympathy and support of the members of the Institution, and also the aid which full discussion would give them in the shape of advice and information. He was glad to recognize in Major-General Palmer, mentioned in one of the Papers, an old friend and brother officer in the corps of Royal Engineers, who had, as Chief Engineer, completed the Water-Works of Yokohama, and gained the confidence of the Japanese Government. With reference to the Shanghai works, the system for regulating the filtering seemed to be that of maintaining automatically an adjusted head of water on the filter-beds, such adjustment being made from time to time by a superintendent, and regulating the outflow by a valve. As soon as filtration commenced, the head of water on the filter tended to change, because the filter became foul and a greater head was required. What was really required in filtering was to determine the quantity of water that should be passed through in a given time, in order to give the most efficient filtration; that rate ought to be adhered to, and if that were done it would theoretically involve a continuous alteration in the amount of head placed on the filter. He had seen, in Berlin, a very satisfactory arrangement, in which that principle was carried out by Mr. Gill, who, as the Constructor and Chief Engineer in charge, had made the water-works in that city so admirable an example of what such works should be. Three small chambers had been constructed (*Fig. 4*), which he should call A, B, and C. A abutted against the outside wall of the filter, B abutted on the outside wall of A, and C on that of B, so that the chambers formed a row extending outwards from the filter. A pipe passed through the wall common to A and the filter, the mouth being just above the bed of sand. The pipe, after entering A, was bent upwards and carried through the roof of A into a room built over A and B; floats and rods were fitted to that pipe, to a second pipe in A open to the water, and to a similar pipe in chamber B. Those rods were carried up into the upper room through hollow standards, and graduations and indices were provided in the usual form, so that by means of the first float was read the height of the water on the filter-bed, by the second the height of the water in chamber A, and by the third that in chamber B. In the wall of A, common to the filter, and at the floor-level, was an aperture opening into the latter at its base, and through which filtered water was free to pass. In the wall of A common to B, and also at the floor-level, was an aperture opening into B. That could be closed wholly or partially by a sluice-shutter worked in the upper room. In the wall separating B and C was formed an aperture rectangular in elevation, with its sole about 1 metre 56 centimetres (5·12 feet) above the floor of chamber B, and opening into C. To that aperture, and flush with the face of the wall in B, was fitted a brass or gun-metal plate, having cut in it a rectangular orifice with bevelled edges. A pipe, controlled by a sluice-valve, passed at floor-level from chamber B to chamber C, and gave the means of flushing out A and B when necessary. In C were outlets controlled by valves, and by which water passed to the filtered-water reservoir or to waste, as the case might be. The object of the whole arrangement was to enable a constant head of water to be maintained in chamber B on the thin-lipped rectangular orifice in the metal plate already referred to, and thus to secure a constant discharge from the filter. That constant head on the orifice was secured by the action of the shutter at the bottom of chamber A, regulated by the readings of the gauge-rods and floats in chambers A and B. The flow of water to the filter was also regulated by a sluice-valve, which was automatically controlled so as to maintain a constant depth of water on the filter. As the filter became gradually foul the flow through the material would tend to decrease, but by adjusting the valve in A so as to increase the aperture into B, the charge on the metal plate could be kept up and also the water in A would fall, giving a greater head on the filter required to maintain the normal rate of flow through the sand. At last the water-level in A would fall to the normal level of that in B, when the regulated flow through the orifice could no longer be maintained. The supply was then shut off, and

General Scott.

General Scott. the filter cleaned. The work of regulation was carried out with perfect ease and certainty, and the rate of flow through the orifice was not allowed to exceed 2 gallons per square foot per hour, or 432 gallons per square yard in twenty-four hours. *Fig. 4* had been derived from a plan kindly given him by Mr. Gill. The references

Fig. 4.



Scale $\frac{1}{80}$.

f f′ f″ Floats for indicating level of water surfaces in filter and in chambers A and B respectively.
m Metal plate with rectangular orifice through which water is delivered into chamber C.
o o′ Outlets for water from filter into chamber A. and from chamber C to pump well respectively.
p p′ p″ Pipes acting as guides to floats *f f′ f″* and open at both ends.
r r′ r″ Graduated rods attached to floats *f f′ f″*.
s Sluice shutter for maintaining level of water-surface in B. Regulates also water-level in A.
s′ s″ Sluice valves for emptying chambers and lowering water in filter-bed for cleaning.
The figures at water-surfaces indicate in metres, relative maximum levels in ordinary working, and normal level in B.

at foot would enable the details to be understood. With regard to the water-tower, looking to the great value of the property in the European settlement at Shanghai, and the heavy losses previously incurred by fire, he presumed that the considerable expense of

General Scott.

£11,849, for constructing a tank containing 150,000 gallons, was unavoidable. Practically, it meant a supply of water for about an hour and a half for a fire. It was evident that without extravagant outlay much could not be done in that way by such constructions. He hoped that some member, conversant with mechanical engineering, would give information with regard to the best adaptation of engines, boilers, and pumps, to meet, in the most economical way, the condition of sudden and considerable variations in the rate at which work had to be done, for this was what scanty storage implied. At Shanghai the winter, he believed, was severe, and there was a considerable degree of frost. He should be glad to know if any difficulty had been experienced in filtration arising from that cause. If frost got into the filtering material, of course filtration ceased. It had been found necessary, in Berlin, to cover in all the filters. There were arches on brick piers covered with concrete and earth. They were, of course, expensive, costing, he believed, £14,500 per acre of filtering surface, as against £7,500 for filters of the open kind. In China, in such a latitude as that of Tientsin, he thought covered filters would have to be used. Some remarks had been made with reference to the subject of waste. It appeared that the rate of consumption was 17 or 18 gallons per head per day. Looking to the habits of the natives, this did no doubt imply waste to some extent, but compared with London, where 30 gallons per head were required, the burden of supply was small. The policy of not stinting the quantity was a wise one. In the Paper on the Tytam Water-Works some account was given of the mortars and cement used; and reference was made to shell lime, and to red earth found on the island. It was curious that a substance which might be considered inert, such as red earth, should produce a good mixture. He had used shell lime in India with burnt brick in powder with good effect as regarded hydraulic properties. That was a different material altogether, having a certain activity and certain powers of combination. He could not understand how the mixture of Portland cement with lime mortar or lime concrete could have any good effect. He thought that home experience had shown that where cement was not very well made, where there was lime in it, which had not been taken up by the alumina, some difficulties resulted; the cement set quickly; the lime mixed with it hardened slowly, being a slower setting material, and in that process of molecular change there was a disturbance, cracks being produced in the quick-setting material by the material which was slow-setting.

Sir Frederick Bramwell.

Sir FREDERICK BRAMWELL wished to ask a question with regard to the Tytam works. He had no doubt, however, that the answer would be so obvious that when it was given he should regret having asked the question. It appeared that the tunnel absolutely passed under the arm of the reservoir where the by-wash was, as shown in Plate 8, Fig. 1; and he wished to know why the entrance to the outlet tunnel could not have been made near this point through the solid rock, thereby saving, say 700 feet of tunnel, and avoiding the outlet in the dam itself.

Mr. Orange.

Mr. J. ORANGE held that it was very desirable to have a clear sight for lining a tunnel nearly 1½ mile long. The point indicated by Sir Frederick Bramwell was simply a creek or arm of the reservoir between two hills; at that point the surface of the ground was about 30 feet below the level of the by-wash, and 70 feet above the level of the lowest outlet of water for the reservoir. A canal 70 feet deep at the tunnel line would have had to be cut leading to the deepest part of the reservoir near the dam, and principally through solid rock, so that the reservoir could be emptied and used. The site was not convenient for the erection of machinery. The question of a well at this point might be suggested from a glance at the plan of the reservoir, but a brief examination of the locality would show the preference for a clear end for the tunnel and well, either in the dam or near it. The tunnel at Tytam could not have been commenced till the 70-foot shaft had been sunk, which would have occupied fifteen months at least. A slight saving of £300 or £400 might have been made, though he was not certain of even that advantage.

Sir Frederick Bramwell.

Sir FREDERICK BRAMWELL said he could understand that there might have been local circumstances justifying what had been done, but it appeared from the statement of Mr. Orange that several hundred pounds might have been saved. For himself he should have preferred to spend a few hundred pounds in doing as he had suggested.

Mr. Burstal.

Mr. E. K. BURSTAL could not perceive the reason why it was impossible to put a valve-shaft in the reservoir. That had been recently done in the Liverpool Water-Works with great success. It appeared to him an objectionable practice to take the pipes through the outside. The use of lime in combination with cement also was a point upon which he should like to have some further information. He could understand the saving of expense, but he thought there were practical objections in the course adopted. He should like to know whether any experiments had been made as to the different rates of expansion, and whether the different times of setting had any effect. In the Shanghai works, and he believed in the other works, cast-iron pipes had been used. He wished to enquire whether the carriage of the pipes some little distance up the country did not rather point to the use of wrought-iron in preference to cast-iron. He should be also glad to know whether there had been any analysis of the water at Shanghai. In the Paper on the Yokohama Water-Works it was stated that "the service-pipes of the various districts are joined at suitable points, so as to allow of rapid draught in case of fire. The junctions are closed by stop-cocks when the districts are being specially examined for waste." He thought that the system of joining up districts by means of stop-cocks was liable to create confusion. In the first place, in putting on a service every stop-cock in the district must be turned off. Three or four stop-cocks might have to be opened to obtain a full flow. By opening one or two the water was circulated in the district, and the manager naturally thought that he had a full supply. The turncock's business was to open them all, but in nine cases out of ten he did not do so, and thus a false sense of security was created. With reference to the effect of frost on filters, the difficulty generally was to keep up the supply of water to the town; there was no difficulty in getting it to pass through the filters quickly, or it might be obviated by simply laying off one or two of the filter-beds. He was unable to understand the method of regulating the supply for the filters at Berlin. It seemed to be done, not by personal observation of the filter-beds, but by a self-acting apparatus. He thought the regulation could be obtained by simpler means than by that in use in Berlin. Mr. Burstal.

Mr. M. W. Hervey said it had been stated that the water passing from the Shanghai water-tower was measured by a meter, and that the discrepancy indicated the loss between the pumping-station and the tower. He should be glad to know whether the meter showed that the pumps were delivering as much water as they were supposed to deliver, and whether any allowance was made for slip in the pump-valves. With reference to the filter-beds, it was stated that the average rate of percolation had been 540 gallons of water per square yard per twenty-four hours. Mr. Hervey imagined that during a great portion of the day the rate of filtration would far exceed that amount. The average rate of filtration with the London water companies was between 300 and 400 gallons per square yard in twenty-four hours. The Author had further stated that the filter-beds required cleansing when about 9,000,000 gallons had passed through them, which would be Mr. Hervey.

Mr. Hervey. in about sixteen days. Nothing was said about the condition of the river during various times of the year; no doubt matter in suspension was much more abundant at some seasons of the year than at others, and this would affect the endurance of the filter-beds. With regard to the reservoir, the Author had stated that flushing took place three or four times in the year; it would be interesting to know what amount of sediment was obtained during that time. The settling-reservoirs of the London water-works did not need flushing in many years. Three or four times a year seemed very frequent for cleansing purposes.

Mr. Taunton. Mr. J. H. TAUNTON remarked that no reference had been made to the great expense of the foundations of the water-tower. It was a very well designed construction; but, the base of the tower being 1 chain square approximately, it appeared to him that £4,371, about £1 per square foot, was a large sum of money to pay for it. He had carefully followed the remarks of Mr. Hart with reference to the desirability of substituting a monolith of concrete for the usual preparation of the foundation by piling. But he was disposed to think that if cylinders either of brick or of iron had been used, and the columns had been carried down, especially taking into consideration that important member in the construction, the central shaft, 6 feet in diameter, that would have proved a much cheaper mode of construction. He thought the water was taken from a very bad source; he supposed because a better was not available. There was the refuse of the shipping, of the municipalities and of the native city draining into the river. He would ask if any borings had been taken to ascertain if a subterranean supply was obtainable. The water was described as being full of sediment and creating great difficulties in the filters. Would it not have been worth while to have tried, by a deep boring, whether subterranean water could have been procured and to what extent? And if that was not possible, could not a tunnel have been driven in the gravel, if gravel existed, so as to obviate the taking of the water from so contaminated a source? With regard to the Tytam Water-Works, the conduit, only 3 miles long, and costing £34,700, appeared to be a very expensive work as compared with the cost of similar works in England. He should be glad to know why it was constructed in the way described, and why pipes were not used. There were 18-inch pipes to the town of Victoria beyond the service-reservoir and filters, and he would ask why cast-iron or wrought-iron pipes were not put down, which, he supposed, would have cost only one-third or less than one-half of the amount expended?

Mr. Vernon-Harcourt.

Mr. L. F. VERNON-HARCOURT said that the Tytam dam, as compared with other dams, considering the height to which it might be raised, appeared to be rather narrower at the base than was usual. Also, taking the lines of resultant pressures, with the reservoir full, the line extended beyond two-thirds of the width from the inner face at the top of the foundation block; that was, there was less than a third of the whole width of the dam between the resultant line and the outer face. Now, comparing it with other dams, if the Tytam dam was made the full height contemplated, about 103 feet from the top water-level to the base, it would have a width at the base of 62½ feet as at present. At the Vyrnwy dam, at 103 feet from the water-level, there was a width of about 108 feet. At the Furens dam, one of the highest dams erected, at the same depth there was a width of 87 feet; and at the Gileppe dam there was the large width of 155 feet at the same depth; but, as he had pointed out in a Paper read before the Institution a year ago,[1] that dam was much wider than was necessary, and it was considered that it might possibly be raised 33 feet more to retain a larger quantity of water, and supposing that was done, the width at the same depth would be 117 feet. The width, therefore, of the Tytam dam at the base, taking the additional height into consideration, was smaller than that of any of the principal masonry dams that had been constructed; and remembering that it was a concrete dam, he thought it was undesirable to give it so comparatively small a width at the base. It was a wise plan to have a thoroughly water-tight layer at the inner face of the dam, because there was no doubt that if the water could get into the mass of the dam it would be very difficult to keep it water-tight. At the Gileppe dam, a good deal of water oozed through, in spite of its great thickness; and the same occurred at the higher and slighter Furens dam. As to the making of the concrete, it was always supposed that the concrete was better if it could be kept clean, and, like a previous speaker, he was surprised that some of the earthen materials were added to the concrete, and were found to improve it—a result which he should have thought was almost impossible, unless the material used possessed some peculiar composition not mentioned in the Paper. With very sharp sand, he could understand that it might be impossible to get the concrete thoroughly solid, and that it might be advisable to add some finer sand to ensure compactness; but the addition of material of an

[1] Minutes of Proceedings Inst. C.E., vol. xcvi. p. 188.

Mr. Vernon-Harcourt. ordinary earthen character could not, he thought, be advisable for such a purpose. He should be glad to know if Mr. Orange considered it advisable, with the line of resultant pressure with the reservoir full coming so far over towards the outer face, to add 10 feet more in height to the dam. At present, this resultant pressure extended beyond the middle third; and with 10 feet additional height, it would be thrown considerably nearer the outer face. It would have been better to reduce the very ample width at the top, and to have widened the base. He thought it was unadvisable, except in cases of paramount necessity, to convey the supply of water through the dam; and in the present instance, this arrangement involved a considerable additional length of tunnel, without apparently any special compensating advantages.

Mr. C. Hawksley. Mr. CHARLES HAWKSLEY said it would be interesting if the Authors of the Papers would add a little more information as to the prices paid for labour and carriage in the several countries where the works were erected. Some materials had to be conveyed from very great distances, which in England would appear to be almost prohibitory. With reference to the Shanghai Water-Works, General Scott had referred to the mixture of cement and lime, which was generally in England thought to be prejudicial, although he remembered having heard of one case in which it was said to have been used with success. For his own part he would rather avoid it as being open to the difficulties to which General Scott had referred. The water-tower was a structure of unusual beauty, and in that respect formed an example to engineers at home, who did not always sufficiently study beauty in designing their structures, especially those of iron. Mr. Hart had said that it was at times desirable to work with a varying head of water, in which case the pressure from the water-tower was shut off. In water-works it was usually considered better to work with as steady a head as possible; but probably Mr. Hart had some explanation why at Shanghai it was desirable at times to use a varying head. He observed that there was a reflux valve between the tank and the pumping main, and therefore he concluded that no supplies were afforded from the pumping main on its way to the tower, the object probably being to enable the water to be measured by the meters as it left the tank, but he should be glad to be informed on that point. With reference to the settlement of the tower foundations he did not quite follow the tables given in the Paper. The total settlement appeared to have been $2\frac{1}{2}$ inches, of which $2\frac{1}{4}$ inches seemed to be due to the weight of the foundation, and $\frac{1}{4}$ inch to that of the superstructure; no further settlement having

Mr. C. Hawksley.

taken place when the tank was filled with water. Then again, the test block subsided only $1\frac{1}{2}$ inch when sustaining a somewhat heavier load per square foot than that which caused the main structure to subside $2\frac{1}{2}$ inches, a difference the cause of which he did not understand. Mr. Hart had stated that the reason for placing the pumping works and the intake below the city was that the water was there more free from contamination than it was above the city. That might perhaps be due to the presence of a larger quantity of fresh water than was to be found higher up the river; but it appeared to him that as the sewage had to travel down from the city towards the sea, there must at all states of the tide be sewage at the point of intake, since the sewage, which was carried seawards by the ebb-tide, must necessarily be brought back by the flood-tide to a point somewhat lower down the river than that at which it originally entered it, and thus gradually progress towards the sea. The walls and floors of the settling-reservoirs were stated to have been founded on rubble. Perhaps Mr. Hart would explain whether that meant dry rubble or rubble in mortar. A very careful and effective method appeared to have been adopted in building the concrete walls so as to ensure the overlapping of the vertical joints, which was very desirable in walls where reliance was placed on the concrete for water-tightness, and where they were not puddled at the back. The importance of washing the sand for mortar, and even for concrete, appeared to have been fully recognized not only at Shanghai but also in the case of some of the works described in the other Papers under discussion. He was somewhat surprised to find that in one instance earthy material had been mixed with lime. Usually the adoption of that course would result in failure; but there were certain materials which did not appear to operate in that way. He believed that at the present time Mr. Hill was using at the Thirlmere Works material which was locally known as scammel; it had the appearance of being mixed with clay, yet it made a most excellent concrete, and was used instead of sand. Care, however, had to be exercised in the selection of that material, because if inferior scammel was used, the results, he believed, were not satisfactory. At Shanghai balance-valves were mentioned as having been used as inlets for the filter-beds. Similar valves had been introduced by his father when he first constructed the filter-beds at the Derby Water-Works about forty years ago. They answered their purpose exceedingly well, and he had no doubt that the valves described in the Paper and which were even of a more delicate construction, would be found to operate satisfactorily. It would be interesting to learn from Mr. Hart the

Mr. C. Hawksley. amount of the settlement in the foundation of the chimney, which was apparently subjected to a heavier pressure per square foot than the foundation of the tank. General Scott had referred to the liability of the filter-beds to be frozen. He believed there was only one instance in which covered filter-beds had been used in England, namely, at the Weardale Water-Works where the filter-beds were situated at an elevation of nearly 1,100 feet above the sea, and where it would have been almost impossible to keep open filter-beds in order during a severe winter. The filter-beds to which he referred had now been in regular use for the past nine years, and were worked without difficulty, never having had more than a very thin skin of ice upon them; they were cleaned regularly during the winter, and no difficulty whatever had been found in working them continuously throughout the severest frosts. The roofs were constructed of timber carried on brick walls and iron columns, and were boarded and slated. In the side walls were openings for light and ventilation, which could be closed at will by shutters and large sliding doors in the end walls afforded access to the filter-beds. With regard to the Paper on the Tytam Water-Works, he had found it somewhat difficult to follow the description of the stratification beneath the dam, and he thought it would conduce to a better understanding of the description if the Author would indicate the stratification on the longitudinal section of the dam. He observed that the supply from the reservoir during "ordinary summers" was referred to in the Paper; but when determining the capability of water-works it was essential to reckon only on the supply that could be derived during the driest summers, or rather during such a dry period as could be tided over by the reservoir. If calculated on any other basis the supply would only be intermittent, and would fail in a dry period just when the water was most wanted. A section was given of the draw-off valves, which were placed at various levels apparently with a view of utilizing the upper stratum of water in the reservoir, the object, he supposed, being to obtain the clearest water; but, having regard to the fact that the valves were placed on the internal diaphragm in the valve shaft, and not on the apertures through the external wall communicating with the reservoir, it appeared to him that the object in view would not be attained, because the water was free to enter at any of the five apertures, between the draw-off well and the reservoir, which happened to be submerged at the time. A considerable quantity of puddle appeared to have been conveyed a distance of no less than 80 miles, and it would be interesting to learn how it was

Mr. C. Hawksley.

conveyed and at what cost. There seemed to be only a height of 2 feet between the sill of the by-wash and the top of the dam. That was a very small margin, and from what the Author had stated it appeared that the water on one occasion flowed over the sill of the by-wash 4 feet in depth, and must, therefore, have risen to a height of 2 feet above the top of the dam, depending in that instance for its retention within the reservoir on the parapet wall built on the top of the dam; had that wall given way the water would have flowed over the top of the dam and fallen with great force down the front. With reference to Mr. Turner's Paper on the Yokohama Water-Works, it did not appear very clear why a pumping-station was needed. Indeed, from the section of the pipe-line which was given (and which, he thought, required, to make it clear, to be continued as far as the intake), it would seem as if the pumping-station could have been dispensed with altogether. It might be, however, that the pipes followed the lowest available line, and that without a pumping-station considerable cuttings and tunnels would have been necessitated. No doubt there was a satisfactory explanation, otherwise a pumping-station would not have been erected, but it would be well if the Author would afford the needful information. An ingenious apparatus, which, so far as he knew, was novel, was described in the Paper, for recording the differential height between the surfaces of the water on the inlet and the outlet sides of a gauge. The Paper referred to the expansion of the pipes, consequent on their exposure to the great heat of the sun whilst being laid and to their subsequent contraction. He thought it was very fortunate, even from that point of view, that lead joints were adopted and not bored and turned joints; otherwise the difficulty experienced would have been increased. It seemed that in the town ball fire-hydrants were used. In England great difficulty had been found with that form of hydrant, inasmuch as dirt got into the hydrant box, and when the pipes were emptied the ball fell and admitted the dirt into the pipe. It was to be feared that a similar difficulty would be experienced at Yokohama. That difficulty had led to the more general adoption of the screw-down hydrant, in which a valve (opening upwards) was held on to its seat by a screwed spindle, and therefore always remained closed except when the spindle was raised and the valve was lifted by the pressure of the water beneath. The puddle used seemed to have withstood with great success the shocks of earthquakes to which it had been subjected. He had known the masonry wall of a reservoir, even in Great Britain, to be so damaged by a shock of

Mr. C. Hawksley. earthquake as to necessitate its being pulled down and rebuilt. He understood, however, that in Japan the earthquakes were of a rather different character from those experienced in many other places. They were described as taking the form of a long undulating motion, and therefore not so liable to do damage to masonry or puddle structures as the earthquakes sometimes experienced in Europe.

Mr. Hart. Mr. J. W. HART, in reply, said that General Scott had referred to the feeling against companies in Shanghai, as a reason for the disinclination of the Chinese to encourage water-works so introduced. He was entirely in error in that respect. Shanghai possessed a great many companies, and many subscribers were the Chinese themselves. In the water-works they owned a large proportion of the capital. They had no aversion whatever to companies.

General Scott. General SCOTT said he referred to associations in general of English people called companies, and to the feeling of the Chinese as to the introduction of foreigners giving rise to indefinite claims.

Mr. Hart. Mr. J. W. HART observed that the works were entirely within the scope of the foreign settlement, and the supposition of General Scott could not possibly apply. Foreigners had a perfect right to form companies there, and the chief contributors were Chinese shareholders. Those who mainly objected to the water-works were dealers in water, water guilds who retailed buckets of nauseous water at high prices. General Scott had also referred to the water-tower as being a convenience in the case of fires only. That, however, was only one of its conveniences. It was important, if there was occasion to stop the engine, that the town should not be left without water. It was also important to have a reserve for night service, enabling the engine to be at rest. No inconvenience, such as had been suggested, had arisen from frost in connection with the working of the filters. The question of the varying rate of filtration, and the balance-valves for supplying the filters, appeared to have raised an issue far more important than was ever intended. The chief reason for introducing the valves was to prevent the Chinese from running the water to waste. The valve at the outlet-well was only regulated to accommodate the rate of percolation intended, but if the water had not been carried away it would have run to waste; the inlet-valve would have been opened wide by the Chinese, and a result would have been brought about such as he had described. The balance-valve was controllable when the filters were in operation, and the head of water could be increased as was thought proper. Reference

Mr. Hart.

had been made to the cost of the foundation of the water-tower, and the suggestion put forward that it would be more desirable to have built the foundation of cylinders. That, however, was an erroneous idea. There was a firm stratum of about 20 feet below the surface, and below that, liquid mud. In the case of a bridge built about fifteen years ago, screw-piles were driven through the firm stratum, and the bridge tumbled down by its own weight before a single passenger had passed over it. The suggestion as to boring for water was not a new one. Twenty-five years ago there was a boring of nearly 200 yards for that purpose; but from the mere fact of its being an alluvial deposit, it was almost certain that a boring might be pierced to an indefinite depth, without striking a water-bearing stratum. Any attempt, therefore, to bore for water was out of the question. It had been stated that settling-tanks in England were not cleansed for years. He was glad to hear it. He could only say that if such a practice was followed in Shanghai it would only take two or three years to fill them with deposit. It was impossible to arrive at any direct or absolute statement as to the amount of sediment because it varied so much with the state of the river. Sometimes large volumes of water came down bringing an extraordinary amount of deposit, while on other occasions, when the weather was fine, the water was comparatively clear. Such variations might take place five or six times in a month. It was, therefore, a most difficult matter to form any direct conclusion as to the amount of deposit taking place, because no two periods of the year were exactly alike. The tanks were cleaned out three or four times a year, and about 18 inches to 2 feet of mud were always removed. He thought the Author of the Paper on the Yokohama Water-Works was in error in stating that there was no drainage system in Yokohama. There was a perfect system of drainage by Mr. R. H. Brunton, M. Inst. C.E., as early as the year 1870. Mr. Hart had reported on a water-supply for Yokohama in that year, and he felt sure that Mr. Brunton and other engineers had done the same.

Mr. Orange.

Mr. ORANGE, in reply, said that the red earth used in Hong-Kong was of a very greasy nature, and it was the common material for mortar of the country; it was a first-class hard mortar, was extremely suitable for brickwork, and would set very well even under a slight head of water. He had never compared the constitution of the red earth with puzzolana; but Mr. Price used to call it a sort of puzzolana. He had not used any of the shell-lime with the red earth in the Tytam dam. In the case of other dams from 30 to 40 feet high, he had used the red earth and shell-

Mr. Orange. lime with a small amount of cement, which he found on experiment considerably quickened the hardening and increased the strength, and he thought it was worth while to spend a little money in order to get on with the work more quickly. He had also experimented with the red earth and cement with no lime at all, when the ordinary English Portland cement, mixed with red earth, set very well indeed. He had given some examples of rough tests with briquettes of cement and red earth. If iron pipes had been used for the conduit instead of masonry, the cost of the conduit would have been doubled. The carriage of the iron pipes would have greatly increased the cost. Mr. Taunton should remember that the cost given in the Paper was for a road besides the conduit. As to the question of the section of the dam, it was impossible for him to enter into it off-hand. He could only say that the dam was built and was still standing, and there had been a depth of 2 feet of water above the top of it; he thought, too, that it was one of the driest dams in existence. The Furens dam, mentioned by Mr. Vernon-Harcourt as a good dam, leaked like a sieve; the Tytam dam did not. With reference to the sand, what he meant to say was, that if the sand was very sharp, when cement was put with it the water ran through and carried it away. It was impossible to make a close concrete with very sharp sand; it had to be a little thick, loamy and close, in order to make a close concrete. That was why, when the sand was sharp, he always used a certain portion of the siftings of the stone from the stone-breakers, which was almost dust, in order to make the mixture close. It was a rule in the profession that for strength sand should be clean and sharp, but for closeness he did not want it too sharp. It would be very difficult to show the stratification by a diagram, because it was so irregular, and he thought it had been sufficiently described in the Paper. A question had been asked with regard to the level of drawing off the water in the valve-well. Opposite each valve in the mid-feather, which divided the wet from the dry well, was an opening into the reservoir through the dam; so that it was equivalent practically to the valve being on the outside of the dam. There was a head of 4 feet over the by-wash; in other words, 2 feet above that of the dam. The fence-wall was a continuation of the ashlar inner face and the concrete inner face. It was a strong structure, made to withstand any possible head of water.

Mr. Turner. Mr. J. H. T. Turner, in reply to Mr. Charles Hawksley, stated that the pipe-line followed the lowest available line of country. The fall of the River Sagami was such that it would have been possible, Mr. Turner.

by extending the aqueduct for several miles, to dispense with pumping. But, taking into consideration the cost of carrying the main-pipe higher up the river, the severe character of the floods, the large variation of water-level in the narrowing cañon, and the increased difficulties of access to works situated at any point higher up than Mii Mura, it was found to be desirable and economical to establish small pumping-works at the intake, to raise the water at all times into the conduit, whence it flowed 27 miles by gravitation to the Nogeyama reservoir. It might be correct to characterize Japanese earthquakes generally as large waves of earth. But of course the period and rate of propagation of the waves depended upon the proximity of the point of observation to the seat of disturbance. At Yokohama, he had seen walls split, and solidly built brick chimney-stacks projected through the roofs of the houses by the violence of the earth-waves. From his own observation of such effects, and from personal sensations during one particularly destructive earthquake, he considered that it would be imprudent to rely upon obtaining water-tight structures of brick, masonry or concrete, without puddle, at least in that immediate locality. As to the drainage of Yokohama, Mr. Hart must surely be misinformed. During the progress of the laying of some 50 miles of pipes in the streets, he became well acquainted with the drainage system as it existed in 1885. Excreta and urine were removed in pails from the houses and were carted away for manure. But the ordinary street drains, in five-sixths of the town, consisted of wooden shoots about 6 inches square in cross section. The main drains had flat wooden floors and covers and stone sides, with open joints. Many of the drains were choked with slime, and all that were opened were surrounded by earth saturated with sewage. In the remaining sixth of the town there were brick drains, which lacked adequate ventilation and flushing arrangements. He therefore considered himself justified in alluding to the absence of a good drainage system at Yokohama.

Correspondence.

Major-General Palmer.

Major-General H. S. Palmer, as the Engineer of the Yokohama Water-Works, wished to say a few words by way of supplement to Mr. Turner's Paper. First, as to the works at the intake. To any one unacquainted with the local features and conditions, the questions might very well occur:—Why was pumping resorted to at all at the head of a gravitation supply; and why, in the second