

## Discussion.

**The President.** The PRESIDENT, in moving the vote of thanks, remarked that hydro-electric power-development was coming more and more to the front in all parts of the world. Therefore such Papers as the two before the meeting were of the utmost value to the members.

**Mr. Binnie.** Mr. W. J. E. BINNIE observed that the Papers were interesting as illustrating two different methods. In the one case—the Tata scheme—the reservoir was used for storage, and in the other case—the Arapuni—it was used to create an artificial head. It was remarkable how little variation there was between the dry-weather flow, the mean flow, and the maximum flow of the Waikato river. If the figures given on pp. 231 and 241 were compared, it would be seen that, calling the minimum flow 1, the mean flow would be 1·5, and the extreme flood 6·5. In ordinary Scottish rivers, some of which were connected with lakes of considerable size, the mean flow was 36 times the extreme dry-weather flow, and ordinary floods were 250 to 500 times the dry-weather flow. Mr. Handman's Paper did not explain why there was so very little variation in the flow at Arapuni. Probably lake Taupo had a very large area in comparison with the drainage-area, and acted to a certain extent as a natural storage-reservoir, thus damping out fluctuations in the flow of the river. Observations of flow had been made at the outlet of the lake from 1905 to 1923; and it would have added greatly to the interest of the Paper if a table had been appended giving the average annual flow, the minimum flow, and the maximum flow for each of the years for which records had been obtained. The pumiceous breccia described did not seem to be altogether suitable as a foundation for a watertight structure. The leakage through the Arapuni dam, which had been initially about 960,000 gallons a day, was fairly considerable. Did the Author think that that leakage occurred through the strata underneath the cut-off wall into the porous drains on the down-stream side of that wall? The leakage was composed of three parts: first, the leakage through the joint planes of the rock, which, he supposed, were visible below the dam, where the water issued; second, that which went into the inspection-tunnel, which, he supposed, was percolation through the concrete; and third, water picked up by the underdrains. In a case like that, where rock that could not be considered absolutely impermeable was being dealt with, it was advisable to put an earth

bank upstream of the masonry dam, sloping down as far as it was possible to get it. In the case under discussion it could be placed about as far, perhaps, as the upstream diversion-bank. That helped to reduce leakage by blinding any pores or slight fissures that might exist in the rock. The dam had been designed on extremely conservative lines. The radius of curvature was about 250 feet, and if advantage had been taken of that radius of curvature it would have been possible to reduce the quantity of masonry in the dam to about one-third. He presumed the reason why that had not been done was because the rock could not be trusted to take the thrust of an arched dam. The Tata Power Company's dam at 150 feet below top water level had a thickness of 108 feet. The corresponding thickness of the Arapuni dam was about 134 feet 6 inches. Thus the latter was much thicker, and indeed the Tata dam was very thin. The Periyar dam for the same depth of water was about 124 feet thick. The reason for that might be the difference in the weight of the concrete, which was given as about 140 lbs. per cubic foot for the Tata dam. The weight was not given in the case of the Arapuni dam, and it would be valuable if Mr. Handman would give it. Apparently heavy rock had been used, and he imagined that the concrete might have about the same weight. The compression tests on the  $1 : 2\frac{1}{2} : 4$  concrete for the lining of the tunnel gave 3,910 lbs. per square inch at 28 days, whereas the concrete of the same proportions used for facing the dam had a compressive strength of only 2,783 lbs. per square inch at the same age. There might be some explanation of that. It was very satisfactory to find that the concrete tunnel-lining had withstood the high velocities. Of course, the time it had been in use was short, and it was only used occasionally. He had had to examine the sluice-culverts of the Assuan dam in October and November, 1928, and it was remarkable how few signs of erosion the granite as a whole showed, although the velocity at the lower sluices must sometimes reach about 60 feet per second when the dam was full. But just at the bottom of the gates, in exactly the same place as that eroded in the Arapuni tunnel, a small pocket about 9 inches deep had been cut in the granite at each side of the gate. He thought the probable cause of that erosion was the impingement of the water as it was turned at right angles at those points. Mr. Handman stated that erosion was most marked where there was a sudden change of pressure, and put that down to the action of dissolved oxygen. He thought that was a correct explanation. The same phenomenon was well known in the case of screw propellers. The cavitation of screws led to the surface of the blades being attacked at certain points owing

Mr. Binnie. to the reduction of pressure. He had found that, if there was a very high pressure on one side of a sluice-valve and a much lower pressure on the other, cast iron was severely attacked. It was not a question of erosion, because gun-metal lasted perfectly well. He had had to change the design of valves on that ground, and in cases where there was a sudden reduction of pressure he now used only gun-metal.

Mr. Meares. Mr. J. W. MEARES remarked that the Papers were interesting as showing the contrast between two methods of hydro-electric development—one quite ordinary, and the other (the Tata scheme) confined entirely to India. The three schemes in the Western Ghats in Bombay were the only ones in the world on any appreciable scale in which there was no river proper at all. The Tata Power Company's scheme did, in point of fact, have headworks at the junction of two rivers, but for 9 months in the year there was very little water in them. The dam collected the whole of the monsoon rainfall in the course of 3 or 4 months and stored it, and there was flow during most of the year. There had to be enough storage to carry over if necessary for, he believed, 3 years. It was interesting to observe that the discharge had originally flowed about 2,000 miles across India into the Bay of Bengal, and that now the tail-race ran into the Indian Ocean. In view of those three schemes, of which that under discussion was the crowning one, it was rather surprising to read in a recent publication<sup>1</sup> that there were very few countries in which anything had been done in the matter of water-power investigation at all, and that India was not one of them. Furthermore, in that publication India was classed with Siberia and China as a country still remaining to be exploited. Engineers who had spent their lives in India were rather proud of the civil engineering works there, especially in connection with irrigation and water-power; and they rather resented being classed with China and Siberia as being hopelessly in the background. He did not know whether the late Sir Michael Nethersole had ever published any results of his investigations into the question of the surge-chamber, some of which Sir Michael had shown him at one time. He did not think they had appeared anywhere, and he would like to put that interesting work on record. The general formula for the height of the surge on instantaneous closure was

$$S_i = V_c \sqrt{\frac{L}{g} \times \frac{A_2}{A_1}}$$

where  $S_i$  denoted the height of the surge in feet,  $L$  the length of the

<sup>1</sup> "Power Resources of the World." World Power Conference, London, 1929.

conduit in feet,  $V_c$  the velocity in the conduit in feet per second, Mr. Meares. and  $A_c$  and  $A_s$  the areas in square feet of the conduit and surge-chamber respectively. In that formula no account was taken of loss due to change of direction of flow or of eddying due to change of section; so that a constant  $C$ , less than unity, should be inserted before  $V_c$ . The value of that constant could not be determined otherwise than graphically, as it would vary with the velocity  $V_c$ . Hence for a fixed value of  $C$ ,  $S_s$  would vary not with  $CV_c$  but with  $CV_c^2$ . Sir Michael Nethersole, when investigating the problem of the surge-chamber of the Tata Power Company, had tentatively adopted a constant  $C = 0.065$  for instantaneous closure. But clearly the closure must in practice always be gradual, and Sir Michael concluded that it would be safe to assume  $S_r = 0.8S_s$ . The final formula then became

$$S_r = 0.052 V_c^2 \sqrt{\frac{L}{32 \cdot 2} \times \frac{A_c}{A_s}},$$

from which the value of  $A$  might be calculated from

$$A_s = 0.000084 V_c^4 \times LA_c/S_r^2,$$

or, if the surge was to be confined to the level of the reservoir behind the flume, then  $h_c^2$  might be substituted for  $S_r^2$ . He thought that Sir Michael should have the credit for that revised formula, because it certainly was very useful, and, so far as he had read, new.

Mr. EVAN PARRY observed that he had a peculiar interest in Mr. Parry. Mr. Handman's Paper because he had primarily been responsible for the choice of the site as one of the three sources of power for the supply of the North Island of New Zealand under the national scheme of electrical power development. The site had several very important advantages. The first was that it was within a very few miles of the centre of the mass of the population of the North Island. The second was the remarkable uniformity in the flow of the river. According to Mr. Handman's figures, the extreme variation was from 4,800 to 32,000 cusecs—and the higher figure he thought was rather doubtful. That uniformity was due to the retarding action of lake Taupo, which was 238 square miles in area and formed about one-fifth of the total catchment-area. In fact the variation that did take place was due to tributaries which joined the Waikato river below the outflow from the lake. The next great advantage the site had was the very low cost of development. Some figures had been given by Mr. Handman; but it was

Mr. Parry. almost certain that when the development was completed the total cost would not exceed £13 15s. per electrical horse-power of plant installed in the power-house. That, he submitted, constituted a record under post-war conditions, and corresponded to about £10 per horse-power under pre-war conditions. The capacity was adequate for the purpose. The station was rated at 160,000 HP., or a little more. Mr. Handman had described the geological formation very thoroughly, but he had not mentioned the care taken to examine the foundations. Mr. Parry did not think any other foundations had been so thoroughly and fully explored. Two shafts had been sunk, one on each side of the river, and connected by a tunnel about 20 feet below the river-bed. Tunnels had been driven 30 feet from the bed of the river up to the top of the cliff, and those tunnels had been connected by galleries, so that the whole of the site of the abutments and foundations had been practically honeycombed. Some hundreds of tests had been made to determine the strength and porosity of the rock. The heading of the diversion-tunnel had been driven for nearly the complete length in order to explore the site again. He desired to supplement what Mr. Handman had said in regard to the capacity of the tunnel for discharging water. The precedent in regard to tunnels involving high velocities of flow was the No. 2 conduit of the Ontario Power Company. That conduit, which was 6,646 feet long and 18 feet in diameter, had been put into service in 1910, and carried water at velocities varying according to the load up to 28 feet per second—a very high velocity for regular service. In 1918, after 8 years service, it had been very thoroughly examined, and there had been no trace of wear or cavities, the paint marks even having been still intact. It would be found, if the data were applied to the tunnel under discussion, that one would get the dimensions, the cross-sectional area, and the level at the diversion dams, allowing, of course, for a loss of about one-quarter the velocity head at entry and about one-half the velocity head for the gates.

He was sure the members very much regretted the sad circumstances of Mr. Cursetjee's death. His Paper was remarkable in several ways. It was noteworthy for its very full information and complete description of the works, and for the detailed statement of costs. It would be found that the unit costs of the dam and of the tunnel were remarkably low. Another very low figure was the proportionate cost of the supervision and general expenses—about half what was usual in such cases. Further, after adjusting the costs for the sixth pipe-line and for the fifth unit, it would be found that the total cost of the works, including the headworks, the pipe-lines, the

power-house and the plant, amounted to only £22 to £23 per electrical horse-power—which was a very low figure. He noticed that the telephone-lines were placed within 33 feet of the power lines and between the two lines of towers. It was stated that the telephone-lines were transposed, but it was not stated whether the power lines were transposed. The telephone-line was already provided with drainage-coils and transformers, which were usual in the circumstances. He would not expect any trouble under normal working-conditions, but he would like to know whether, if an insulator broke down, or in the event of any unusual occurrence, communication could still be maintained over the telephone-lines. Mr. Parry.

Mr. F. H. CLOUGH observed that the 12,500-kva. synchronous condensers at the Tata Power Company's receiving-station were somewhat unusual. They had been built for 22,000 volts, and with that voltage there was apt to be difficulty due to undue potential-gradient across air-spaces. The slot portions were dealt with by the usual and simple method of compressing the mica so that there were no air-spaces, but at the end portions of the coils that potential-gradient had to be carefully adjusted by means of shields so that no corona appeared, with consequent formation of nitrous oxides and attack of the insulation. A good deal of research work had been done on those machines in that direction, with the ultimate result that the coils had withstood a test-pressure of 45,000 volts—nearly three times the working-voltage—before corona appeared, and subsequent results had shown that that was entirely satisfactory. Mr. Cursetjee had made reference to the Trades Facilities Act. At the time the order was placed, owing to the war and to the geographical position of this country, manufacturers had not had much experience in either high-voltage apparatus or hydro-electric equipment. In addition to the actual value of the orders, experience had been gained in both those directions which had been very valuable in executing orders subsequently for high-voltage plant in this country. Mr. Clough.

Mr. B. D. RICHARDS remarked that Mr. Cursetjee's Paper was of great interest to him as providing a detailed description of the third and largest of the three great hydro-electric schemes supplying energy to Bombay. He had been closely associated with the first of those, the Tata hydro-electric scheme. All three schemes were similar in that they provided for the storage on the edge of the Ghats of the rainfall of the south-west monsoon, and for the leading of that water through the watershed to down-take pipe-lines which descended to the plains below on the seaward side of the Ghats. The first scheme differed somewhat in lay-out from the two later Mr. Richards.

Mr. Richards. schemes, in that the water was led from the lower end of the lakes by a canal to the head of the down-take pipe-lines. That was possible because of the existence of a khind or saddle from which the adjacent village of Khandalla took its name ; that was the only break in the Ghats for many miles, and through it ran the Great Indian Peninsula Railway and the main road to Poona. That arrangement gave the advantage of a lower draw-off level and less dead water. The Ghats were a long continuous range of hills, the escarped edge of which formed the watershed of India. On the seaward or westward side the hills descended almost precipitously to the plains below. On the eastward side the plateau fell very gradually right across India to the Bay of Bengal ; from the escarpment ran inland a series of ridges which formed long, flat valleys providing very suitable sites for storage. Such valleys had been utilized in all three schemes for the storage of water. The late Mr. R. B. Joyner, M. Inst. C.E., in his original conception of the Tata hydro-electric scheme, proposed two long dams across the valley of the saddle, which would have formed a very large lake and would have provided 200,000 HP., or more than the total present installed capacity of the three schemes. However, the magnitude of the project, and the facts that it would have entailed a considerable diversion of the Great Indian Peninsula Railway and of the road and that at that time storage for power on so large a scale was a great novelty, together with the considerable opposition generally aroused, led to its abandonment in favour of a smaller scheme then designed, consisting of a chain of three lakes, as actually carried out.<sup>1</sup> The general feature of all those Ghat schemes was the comparatively small catchment-area, the high intensity of rainfall lasting over a short period of the year, and the high percentage of yield. In the two later schemes the ratio of catchment-area to lake-area was higher than in the first. On the other hand, the catchments of the later schemes extended much farther back from the edge of the Ghats, and consequently the average rainfall was considerably less. The Paper gave very few hydrological data, the treatment of which formed one of the most difficult and important problems in a scheme of the nature described. For the original Tata scheme very extensive rainfall data were taken, a record of which he had presented to The Institution.<sup>2</sup> If any such data were available for the new scheme, their publication would be very valuable. While the south-west monsoon was extremely regular in its arrival and practically never

<sup>1</sup> Minutes of Proceedings Inst. C.E., vol. ccvii (1920), p. 29.

<sup>2</sup> *Ibid.*, p. 405.

failed, the amount and the intensity of the annual rainfall varied Mr. Richards. widely. In the Tata hydro-electric scheme the storage provided not only supplied water for the 8 or 9 dry months of the year, but also balanced to a very large extent the annual variations of rainfall. It would be interesting to know to what extent balancing was carried out in the Tata Power Company's scheme. As Mr. Meares had pointed out, those schemes were very novel in regard to their storage. At the time the original scheme was carried out, storage for power on such a scale was quite a new feature in water-power development. The original scheme, which would always be associated with the names of the late Mr. Joyner and Mr. Alfred Dickinson, M. Inst. C.E., had not only paved the way to the two later schemes of the Tata Company, but had also pioneered practically every water-power scheme in India, because the physical conditions of the country were such as to make almost every other scheme follow rather similar lines, the seasonal nature of the rainfall calling for a large storage and for high heads, for reasons of economy. As an instance of that, in 1920 he had proposed and prepared preliminary designs for an interesting project in the Nilgiris in South India. The arrangement provided for a dam across the Pykara river which would give a high degree of balancing storage. The water would be let down the river for about  $3\frac{1}{2}$  miles, picked up by a canal, and led to a natural basin adapted as a capacious forebay, which would form the intake of the down-take pipe-lines. Those pipe-lines would descend to the plateau below, giving a head of about 3,250 feet. The tail water was again to be diverted by a natural water-course and short canals to a pipe-line descending the great ravine known as the Mysore Ditch and giving a further head of 1,100 feet. A syndicate had been formed to promote that undertaking, and a concession had been obtained, the object being to carry the power to Calicut, a port on the west coast 64 miles from the upper power-station, for use in electro-chemical industries. However, there had been great difficulty at the time in getting chemical manufacturers to establish the works required to utilize the power, and as the Government of Madras had contemplated the possibility of developing the scheme themselves, an arrangement had been come to between the Government and the syndicate for a return of the concession, and for all the plans and investigations to be handed over. He believed the scheme was now being developed by Government. An interesting point in the Paper by Mr. Handman was the scanty amount of hydrological data that the engineers appeared to have had for their design. That was a difficulty which often faced water-power engineers—the making of bricks in the shape of power

**Mr. Richards.** estimates with an inadequate supply of the straw of hydrological data. In some countries, particularly the United States and Canada, engineers were very fortunate in having at their disposal a great number of special data collected by the governments. In a good many other countries conditions were improving as the importance of their water-power resources was realized, and as special departments were created. It was a great pity that the hydro-electric survey of India had come to so untimely a close. It would have been invaluable in collecting data for future developments. It was important that rainfall or run-off data should extend over a sufficiently lengthy period. In districts affected by the south-west monsoon, the period should be if possible 22 years or more, which was the apparent cycle of the monsoon. In schemes where a high degree of storage-balancing was required the sufficiency of hydrological data was all the more important, to ensure the present economical development of a site while providing for its ultimate complete exploitation. The quantity of construction plant used on the Tata power scheme was remarkable for India. Many large schemes had been, and were still being, carried out in India with very little plant. That state of things was changing. Labour rates were rising, and that, together with the difficulty of the periodical exodus of labour for agricultural operations, tended to the more extended use of plant on construction works where the time required for completion was an important factor.

**Mr. Gibbs.** **Mr. H. P. GIBBS**, replying on behalf of the late Mr. Cursetjee, observed that Mr. Meares had suggested that the reservoirs of the three hydro-electric developments under the Tata management stored sufficient water to carry over 3 years if necessary. The lakes of the Tata Hydro-Electric and Andhra Valley Companies carried, when full, a reserve quantity of water equal to approximately 11 months' supply. There was little or no flow of water in those streams during the dry season, which lasted 7 to 9 months each year. Mr. Richards had questioned the hydrological data and the extent of balancing carried out in the Tata Power Company's development. No reserve capacity was necessary, as during any possible condition of minimum rainfall the run-off would be much in excess of requirements. The Bombay Public Works Department had carried out a system of gauging along the Ghats and had produced a map showing irrigation works carried out and projected, on which the rainfall zones were delineated, giving a general value of 250 inches along the edge of the Ghats. The lines were shown on Fig. 1, Plate 4. At Lonavla rainfall readings had been taken for about half a century. As on the other sites the period of time during which readings could have

been taken was insufficient to give reliable data, a ratio between those taken and the Lonavla results had been established and forecasts were made accordingly. Each season thereafter the actual run-offs had been carefully measured and checked back. The Tata Power Company had the largest and most prolific catchment of the three developments. The method of the second and third projects was dissimilar to that of the first, as the water flowed through pressure-tunnels to the pipe-lines. When the lakes were full there was a pressure due to a head of 110 feet at the outlet of the Andhra tunnel and 150 feet at the outlet of the Tata Power tunnel. He had discovered the sites of the second and third projects and conducted the surveys and investigations, and he had been responsible for all the design and carrying out of the works. Under extreme conditions of unbalanced static effect the telephones became very difficult to use. There were several stations along the transmission-line which the inspection staff made their quarters, and at such times, as a rule, they relayed through from point to point. He had visited the works after the transmission-lines had been in commercial service for 11 months, and during that period of continuous service there had been no case of transmission-line trouble. Unbalanced electrostatic conditions were rarely met with on any of the systems unless one or more insulators broke down completely, when, as a rule, the action of reverse-power relays at the receiving end of the transmission-lines and the overload relays at the other end cut out the defective circuit automatically. The region over which the transmission-lines functioned was remarkably free from lightning, and since insulators without cement had been adopted there had been very little transmission-line trouble on any of the systems.

Mr. HANDMAN, in reply, remarked that the small variation in the flow of the river Waikato at Arapuni, as Mr. Binnie had rightly assumed, was due to the action of Lake Taupo as a natural storage-reservoir. Later in the discussion, Mr. Parry, who had an intimate knowledge of the district, had given further information in that respect. No data were available for comparing the run-off from the lake with the flow at Arapuni, and the proportion due to natural storage from 1905 to 1923 therefore could not be determined. For the purpose of comparing the variation of the river-flow at Arapuni in the manner suggested by Mr. Binnie it would be correct to use only the figures on p. 241, which included those on p. 231, and to eliminate the very exceptional and doubtful flood of 32,000 cusecs in 1907. Calling the dry-weather flow 1, the mean flow would be 1.45, and the flood-flow 2.76, these figures being means taken in each case over

Mr. Handman. a period of 6 years. The ratio of the lowest recorded flow (4,800 cusecs) to the highest (24,000 cusecs) during the same period was 1 to 5. The examination of the rock at the site of the dam had been thoroughly carried out by the New Zealand Public Works Department by means of the shafts and drives referred to by Mr. Parry, and those investigations had proved that the dam would be founded on the lower deposit of pumiceous breccia. A number of compression tests had been made on the rock found in the shafts and drives ; but the variation in the results was so wide that it was difficult to arrive at the actual bearing-value. A few results higher than 100 tons per square foot had been obtained ; on the other hand a number of tests had given results of about 50 tons ; but the bearing-capacity of the rock at the actual foundation-level was probably higher than the latter figure. The maximum stresses in the dam were 9.4 tons per square foot with the reservoir empty and 6.25 tons per square foot with the reservoir full, the calculations being based on concrete weighing 140 lbs. per cubic foot and no allowance being made for uplift. The actual weight of the concrete was about 143 lbs. per cubic foot. In view of the variable and comparatively low bearing-value of the foundation rock the Government engineers had rightly exercised great caution, and the very conservative design of the dam was, in the Author's opinion, entirely justified. The formation of the cliffs on which the dam abutted was described in the Paper, and the ground could not be considered suitable for taking the thrust from a dam designed for arch effect ; and in that case also the Government engineers had been justified in not calculating for such conditions. The proportions originally proposed for the mass concrete of the dam were  $1 : 2\frac{1}{2} : 5$ , but they had been subsequently modified to  $1 : 3 : 6$ , with a compressive strength of 117 tons per square foot. In view of this high compressive strength of the concrete and the low shear stress at the base of the dam (2.63 tons per square foot) the proportions of the concrete could have been again modified and further economy effected. The leakage of water at the dam had been referred to by Mr. Binnie in terms of gallons per day of 24 hours—initially 982,000 gallons and subsequently 695,000 gallons. Expressed in those terms the figures, although somewhat more impressive, were not alarming. Had there been an increase of the leakage under the full hydrostatic pressure, instead of a decrease of about 30 per cent., there would have been reason for some uneasiness, but the fact that the reduced leakage had remained constant under full pressure indicated that it might not be due to excessive porosity of the pumiceous breccia or to any erosion of the leaking joint-planes of the rock. It was not possible to determine the source of

the leakage water discharged by the porous drains (55 per cent. of Mr. Handman. the total leakage) but as the leaks in the cut-off walls had been effectually sealed by pressure grouting, he was of the opinion that the water came round the cut-off walls rather than underneath them, and thence into the porous drains. Where the water could be seen as it issued from the joint-planes on the downstream side of the dam the indications were that it came partly through the country round the dam, and partly from drainage of the cliffs immediately on the downstream side of the dam. He attributed the difference in the average results of the 28-day compression tests between the concrete for the lining of the river diversion-tunnel and the concrete for the facing of the dam, referred to by Mr. Binnie, to the facts that the mixing-time of the former was 2 minutes or more, as compared with 65 seconds for the latter, and the concrete for the tunnel-lining had a lower water-content than the concrete for the dam. The concrete for the tunnel-lining had been delivered in trucks and placed by hand, and the water-content therefore had been only sufficient to make it of a workable consistency. The concrete for the dam had been poured from shoots fixed at an angle of 24 degrees from the horizontal, and greater fluidity had been required to enable it to flow freely in the shoots. He desired to thank the members for the interest taken in the Paper. He also wished to take the opportunity of referring to the New Zealand engineers who had been associated with him in carrying out the works. Of a total staff of fifteen engineers, eleven had been New Zealanders. Although New Zealand did not perhaps offer so wide a field of experience as did older countries, he had found the engineers there to be none the less competent and progressive, and the success of the critical operations carried out at Arapuni was, in no small measure, due to their loyal co-operation and skilled assistance. He wished to acknowledge with thanks the assistance given by Mr. J. A. Howe, O.B.E., Assistant to the Director of the Geological Survey of Great Britain, in reviewing the section of the Paper on the geology of the site.

### Correspondence.

Mr. A. T. ARNALL remarked that those who had known Mr. Cursetjee Mr. Arnall. as well as he had done would agree that his untimely death had robbed them of a sincere friend and India of an able engineer. A matter of interest in the recent development of electricity supply in Bombay was the extraordinary growth of two independent overlapping