Mr. Moir. Mr. MOIR said in reply to the question as to who had suggested the shield should be lowered down the shaft in the way described, that the first suggestion was due to Sir William Arrol.

Mr. Preece. Mr. W. H. PREECE, C.B., Vice-President, thought the Institution might congratulate itself on having brought the session to a conclusion with an extremely valuable and interesting Paper, and with a discussion perhaps of as great interest and as high in tone as any discussion that had taken place in the Institution during recent years. He was proud to think that an engineering work of that grandeur could be carried out with such marvellous results in regard to its effects on human life. It was something to say that so much money and so much time had been spent in driving a roadway beneath the Thames without the loss of a single life. That he thought must redound as much to the credit of the County Council as it did to the credit of the body of engineers represented in the Institution.

Correspondence.

Mr. Elwin. Mr. C. ELWIN remarked that as long ago as 1881 part of the engineering staff of the Metropolitan Board of Works had been engaged, under the late Sir J. W. Bazalgette, in preparing designs and estimates for subways crossing under the Thames at various points below London Bridge; and during the parliamentary session of 1884, the Board had promoted a Bill for the construction of a subway under the river near Nightingale Lane, Wapping. It was to consist of two openings, one for vehicular and one for pedestrian traffic, with inclined approaches on both sides of the river, together with hydraulic lifts on the north side. The Committee of the House of Commons had declined to pass the Bill, and intimated that in their opinion, in order to provide suitable additional means of crossing the river below London Bridge, there should be a low-level opening bridge near the Tower, and a subway at Shadwell. The Tower Bridge had since been constructed by the City Corporation. A scheme for a subway between Shadwell and Rotherhithe had been prepared before the Nightingale Lane subway scheme had been brought forward, but the estimated cost was very large, and the Board were not disposed to proceed with it. In 1886 the Blackwall Tunnel scheme, at a smaller estimated cost than that of the Shadwell Tunnel, had been prepared, and in 1887 parliamentary powers were obtained for its construction. It was not realized in the first instance how

difficult was the task proposed, but as the various borings proceeded and revealed the character of the strata through which the subway would have to be constructed, it became more and more evident that the work would be one of no ordinary kind. In addition to the method of construction by tunnelling, various other methods, more or less practicable, had been considered. Construction by means of comparatively short lengths of caissons or cofferdams, &c., sunk or driven into the river-bed, although suggested, was soon found to be impracticable on account of the river-traffic and strong tide. A scheme had also been prepared for constructing the subway in a long iron or steel tube which was to be floated over a trench previously dredged in the river-bed and lowered into position. Eventually it became apparent that, in spite of the unfavourable conditions for such work, tunnelling with a shield aided by compressed air was the only practical method of constructing the subway. Brick construction, to be built up inside the back part of the shield, was in the first instance proposed, but subsequently it had been decided to adopt cast-iron segments. These were so proportioned as to make a ring sufficiently strong in itself to resist all the pressures which could be brought upon the subway without any assistance from brick or concrete lining, which obviously could not be added till after the cast-iron rings were completed and had been liable to the full pressures. The cut-and-cover portions of the subway were designed so as to allow buildings to be erected over them. Sufficient land had been purchased by the County Council to enable a second tunnel to be constructed in close proximity to the present one. The question of the need for mechanical ventilation for the tunnel had always been felt a difficult one to decide, and even now it might be an open question if during certain weather it would not be necessary to have such mechanical ventilation. Probably on many days in the year, the wind would blow along one or the other of the open approaches, and on these occasions there might be too much ventilation. As stated by the Authors, means of ventilation had to some extent been provided and could be completed if mechanical ventilation should be found necessary in the future. Mr. Elwin.

The question of the cost of lifts as compared with that of inclined approaches in connection with the Blackwall Tunnel had been discussed at some length soon after the County Council succeeded the Metropolitan Board, but, taking into consideration first cost and working expenses, it did not appear, at any rate in the case of the Blackwall Tunnel scheme, that any saving would be effected by the adoption of lifts, if these were to be of sufficient

Mr. Elwin. capacity to accommodate an amount of traffic in itself large enough to justify the necessary expenditure on the portion of the tunnel which must, in any case, have been constructed between the sites of the lift-shafts on the opposite sides of the river. It might be that for approaches to tunnels where the value of the properties required to be purchased was much greater than at Blackwall, the more economical course would be to adopt lifts in preference to inclined approaches, but this point could only be decided according to the particular circumstances of each case.

Mr. Tapscott. Mr. R. LETHBRIDGE TAPSCOTT observed that, having regard to the difficulties encountered in constructing the tunnel under the Thames and the simple arrangement of depositing clay on the bed of the river from hopper barges, it was gratifying to hear that success had been attained, and that no difficulty had been experienced in maintaining the line of the tunnel through the bad ground. It appeared, therefore, that no serious break occurred in the continuity of the strata beneath the tunnel such as to require any special work in making foundations by heavy timbering. The shield must have been of considerable weight to maintain itself at the same level, as it was driven forward by the hydraulic jacks, and would probably have had a tendency to dip, thus necessitating guiding to some extent.