*Discussion on Paper No. 6738**

The new Buenos Aires power station

by

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and

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Mr A. E. Powell (Senior Partner, Messrs Merz & McLellan) said that exports were very much in the minds of everyone, and it was perhaps appropriate that the presentation of the Paper should have so nearly coincided with the Government statement covering export policy. He thought, however, that it was appropriate to underline the fact that the Paper dealt only with the civil engineering side of the construction of the power station.

152. In doing so, he did not wish in any way to denigrate the efforts of the civil engineering side, but the whole contract, which included the supply of all the plant, together with the foundations and buildings, was secured in the face of severe world-wide competition and represented the largest single order for plant which had come to Great Britain for many years.

153. In referring, as the Authors did in the section describing the problems encountered, to financial difficulties, there was, perhaps some danger of wrong emphasis. The financial difficulties to which the Authors referred did not, in fact, apply to the same extent to the plant side of the contract. The financial arrangements for the supply of the plant from Great Britain were undertaken by a group of British merchant bankers, and so far as the British manufacturers were concerned, similar difficulties of finance did not arise. It should therefore be emphasized that the difficulties to which the Authors referred applied to the Peso content of the whole contract, and the catalogue of financial stresses and labour difficulties, etc., should not necessarily be construed as an awful warning against the pitfalls of overseas work.

154. In § 62 the Authors referred to difficulties of co-ordination between the head office and a site situated some 10 000 km distant. He thought that the Authors took a rather more gloomy view than was justified. He was sure that they would agree that the project as a whole had been carried out with complete harmony and co-operation between client, contractors, and consultants during both stages, first when AYEE was in control and later when SEGBA took over.

155. In that connexion it must be remembered that the client was dealing with what was to him an entirely novel set of circumstances. Hitherto he had been used to controlling his own projects, and one of the major problems to be overcome in the early stages was to build up confidence in the arrangement to the extent that the matters of design could be safely left in the hands of the designers and contractors without continual interference from the client. In Mr Powell's opinion, such difficulties as existed were confined largely to that earlier period, and while possibly

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* *Proc. Instn civ. Engrs*, 1964, **29** (Sept.) 101–136.

different in character from those occurring in the United Kingdom, were not greater in aggregate than those which normally arose during the design and construction of a project of that size.

156. The Authors had dealt in some detail with the duties of the Consulting Engineers. One of the main reasons for both Consultants being employed in their normal role was to enable evidence to be produced to the Purchaser of the experience in Great Britain in the design and construction of large power stations on which the Purchaser laid great stress in the tendering stage. The contract was awarded with the Consultants playing their normal role.

157. The Consultants were charged with the duty of ensuring on behalf of the Partnership and the Purchaser that the power station represented the best current British practice—the words used in the contract.

158. Turning to more detailed matters, Mr Powell paid tribute to the architectural design of the buildings, which were in many respects quite novel; regrettably, the illustrations in the Paper did less than justice to the architecture. It was also a matter of regret that the Authors were unable to show illustrations of the interior of, say, the turbine house which was most pleasing.

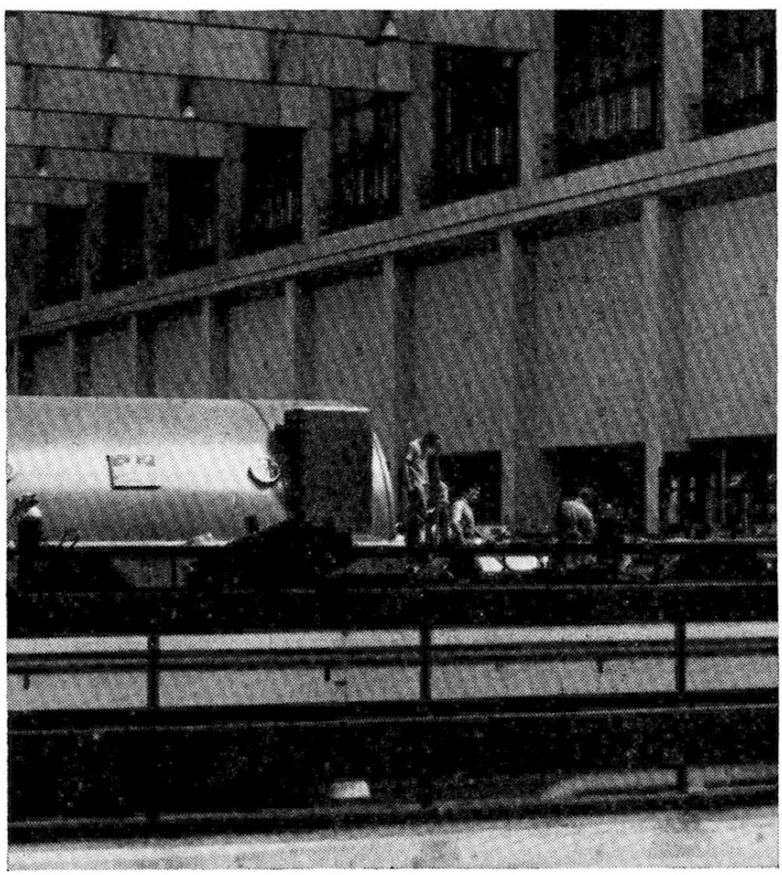

FIG. 15: INSIDE THE TURBINE HALL

159. He would like to confirm the view of the Authors that the finished product, so far as the civil engineering work was concerned, compared extremely favourably with some of the best work done in the United Kingdom.

160. The Authors were to be congratulated on an excellent record of a first-class piece of construction.

Mr J. M. Whitaker (Managing Director, Richard Costain (Civil Engineering) Ltd.) said that his claim to speak was a limited knowledge of thermal power stations but some knowledge of working in Argentina.

162. His reading of the general paper required him to ask the Authors to clarify who, in fact, was the employer for the civil engineering contractors—was it the Consortium or the Client? He read that the civil engineering contractors worked as a group, and he took it they were responsible to the English consortium. Was this the case, or were they employed by Agua y Energia Electrica? Was the form of contract the international civil engineering form or an Argentinian one?

163. From his analysis of Figs 10 and 13 of the Paper, it seemed that the volume of work which was done between mid-1962 and mid-1963 increased considerably, whereas in fact there was a large reduction in the labour. What was the reason for this?

164. He also asked the Authors how they would view the number of employees compared with a similar contract in the United Kingdom. It seemed that the number of employees was high, which might indicate low productivity or a low ratio of mechanization to labour. His company was working some 800 miles north-west of Buenos Aires in the Province of Tucuman and they were finding that the standard of the worker was good and that the workers were quick in picking up the handling and techniques of machines. Their pay was low but, in addition to wages, the contribution that the employer had to make for social security was high.

165. He wondered whether the loading bay at the north end of the turbine house, with the two cranes in the turbine house, was satisfactory, as often that layout inhibited the use of both cranes in the loading bay at one time.

166. He spoke with some knowledge of the steel versus concrete superstructure controversy in Argentina because his company had also been faced with that problem. Did the Authors feel that there had, in fact, been a delay in the completion of the works due to the insistence on the reinforced concrete construction frame as against steel frame construction?

167. The problems mentioned in § 61–97 were well known to him, and he could only admire the patience of the United Kingdom consortium in solving them. The unfortunate aspect about such problems was that they used tremendous resources of manpower and time which could more usefully be employed in productive work. Nevertheless, British exporters must never assume their methods were necessarily better, cheaper or more acceptable. Everyone could learn by experience.

168. To construct works in a country with a free rate of exchange in a period of inflation was a risk that few contractors or companies could take. In the case in question the arrangements originally made for local expenditure, which were subsequently changed as described in § 68, must have created tremendous problems and delays for those concerned. In his experience, solutions to those problems were achieved only through patience, knowhow, and tenacity, which the Authors and their staffs had shown.

Mr S. Moss (Manager, BTH/ICL Partnership) said that he felt that the meeting might be interested to hear in a little more detail how the contract came into being.

170. He believed that, at the time, it was a major innovation. The project was actually born in October 1956, when the Argentine Government issued a decree law

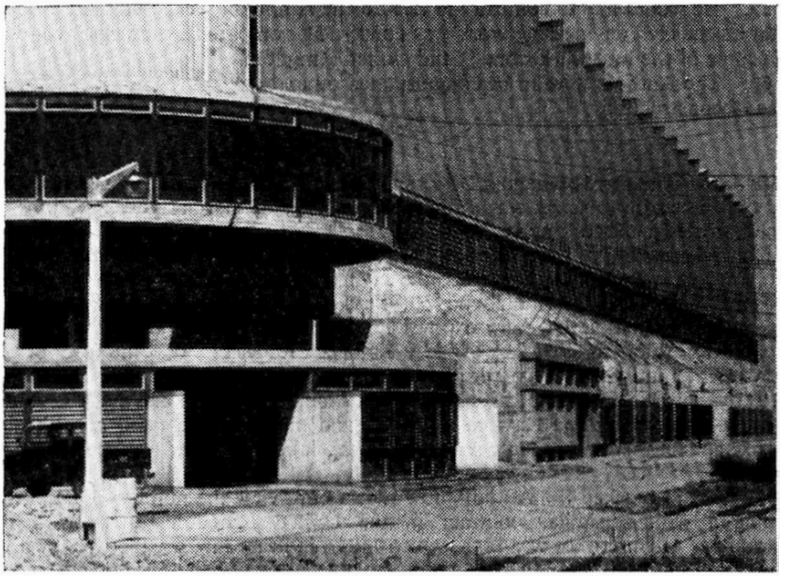

FIG. 16: WEST ELEVATION OF THE TURBINE HALL AND CIRCULAR CONTROL TOWER

authorizing the AYEE to put out an inquiry for a 600 MW power station in Buenos Aires on a turnkey basis and on long-term credit. American contractors and Continental contractors were quite used to that sort of inquiry, and, indeed, were well organized to handle it. But the pattern of power station building in the United Kingdom had followed a considerably different concept, whereby British manufacturers supplied and perhaps erected and commissioned their own particular part of the power station, acting under the co-ordinating control of consulting engineers appointed by the purchaser. But in the case of Buenos Aires it had to be done on a turnkey basis. The customer was not employing consulting engineers, and therefore, it was difficult for British manufacturers to quote, particularly against international competition.

171. It was quickly realized that the job was too big for one manufacturer to deal with, even assuming that one contractor might supply the whole of the electrical equipment of a power station—the turbo-alternator, the condensing and feeding plant, the switchgear, transformers, the cabling and the lighting. Even then it would not amount to more than about 40% of the total contract value, and obviously, the one manufacturer was loth to act as a main contractor for that proportion of the value of the contract. The boiler manufacturer's share of a project which also involved coal and ash handling plant would probably amount to about the same as that for the electrical manufacturer. Therefore, it was logical that the electrical manufacturer should collaborate with the boiler manufacturer, thus making approximately 80–85% of the equipment.

172. As a beginning the B.T.H. Export Company Ltd., formed a Partnership on a 50%/50% basis with International Combustion (Export) Ltd. But it was soon realized that further progress could not be made without some very essential and high-powered technical assistance, because neither company was geared to design power stations.

173. Consequently, two consulting engineers were approached with a view to

collaborating with the partnership in the preparation of the tender for the project, including the preliminary designs. If the tender was successful, then those consulting engineers would be retained as consulting engineers on the contract. As he had said, he believed that it was a major innovation whereby the seller was including the services of first-class British consulting engineers in his offer to the purchaser.

174. In the tender stage the consultants concentrated on the basic designs, leaving the partnership to organize the finance. The tender was submitted in June 1957, and negotiations followed. The Partnership was given valuable assistance by both consultants, Merz and McLellan and Sir William Halcrow & Partners, during those stages, and eventually the Partnership was awarded the contract.

175. As a matter of interest, six tenders were considered—two British, one Italian, one combined Italian and French group, one American, and one German, also seven incomplete tenders were received but were not even considered. The Partnership's tender was the higher of the two United Kingdom bids, but it was lower than all the others. The actual value on which the contract was taken was £25 609 000 sterling and 1050 million Pesos.

176. He thought that there were several reasons why they were eventually awarded the contract. First, their tender was more complete and complied more closely with the customer's requirements in the specification than any of the others. He thought that there was no doubt at all that one of the basic reasons for this was the close collaboration between the two consulting engineers and the Partnership during the preparation of the tender, and in his opinion there was no doubt that the customer greatly appreciated the offer of the services of two such well-known consultants included in the overall offer financed on credit, which meant that the customer did not have to pay them.

177. Perhaps one other point that might have helped a little was that in an endeavour to keep the sterling content as low as possible they had negotiated with six Argentine contractors to form a group and accept a contract from the Partnership as sub-contractors for the civil work under the control of Sir William Halcrow & Partners.

178. The contract was signed in January, 1958, and No. 1 turbo alternator was started up at the end of 1962, and at the present stage all five sets had been commissioned and provisionally accepted.

179. As a representative of the Partnership, he wished to say how successful this method of working had been, and he thanked the consultants, Sir William Halcrow & Partners and Messrs Merz and McLellan, for their efforts in this respect. He was convinced that this was an ideal way for British manufacturers to approach export business.

Mr H. B. Johnson (Partner, Messrs Merz and McLellan) said that there were a number of details about the station which interested those who worked on the electrical and mechanical sides which the Paper seemed to have passed over fairly quickly. For example, in § 23 the Authors had stated that the beams were post-tensioned using the B.B.R.V. system of prestressing.

181. Reference had also been made to the ventilation of the turbine and boiler houses through controllable louvres along the sides of the main building. These were designed in conjunction with large awnings on the boilerhouse roof to give natural ventilation of the powerhouse with predominantly cross-air flows sweeping the turbine house and a vertical flow in the boilerhouse. Experience over a cycle of seasons had shown that the ventilation had performed satisfactorily in accordance with predictions and had justified a decision taken during the early stages to provide a fully enclosed boilerhouse which at the time was economically similar to an arrangement of an outdoor boiler plant.

182. A temperature differential of 20°F (11°C) was assumed as basic in relation

to an average ambient temperature of 82°F (27·8°C) and the 50% control of louvres and windows had taken care of the wide range of ambient variations which occurred.

183. The total air flow for the building might be of the order of 4 m. cu. ft/min. (113 500 cu. m), including supplies to the boiler forced draught fans, but no undue air velocities had been observed to date.

184. With regard to the cooling water system shown in Fig. 6, the intake pumps were variable pitch axial flow lift pumps designed to fill the culverts in the powerhouse. The variable pitch vanes were controlled by electrically driven oil pumps actuated by electrical signals from level control equipment in the culverts at the powerhouse. The condenser pump in the powerhouse, which drew from the culverts, supplied the syphonic part of the system, and suction intakes had been specially designed with a form of flat shelving to pare or scoop off the bottom layer of water in the culverts without creating a vortex in the relatively shallow water cover over the suction. Satisfactory large-scale operations had confirmed the anticipated performance indicated by model tests on that feature and, indeed of the system as a whole.

185. The river water was found to be very silty; containing as a typical sample some 33% of sand over 0·05 mm, 29% of silt below this to 0·005 mm, and 38% of clay below 0·005 mm. The cooling-water system was accordingly designed with water velocities to counter precipitation, and to make it as far as possible self-cleaning by scouring, at the same time avoiding erosion.

Miss Allison Downs (Architect, formerly with Sir William Halcrow & Partners) said that she was very pleased to have the opportunity to speak and to recall some of the years she had spent working in the office of a firm of consulting civil engineers.

187. She was sure that some of those present would remember the meeting held

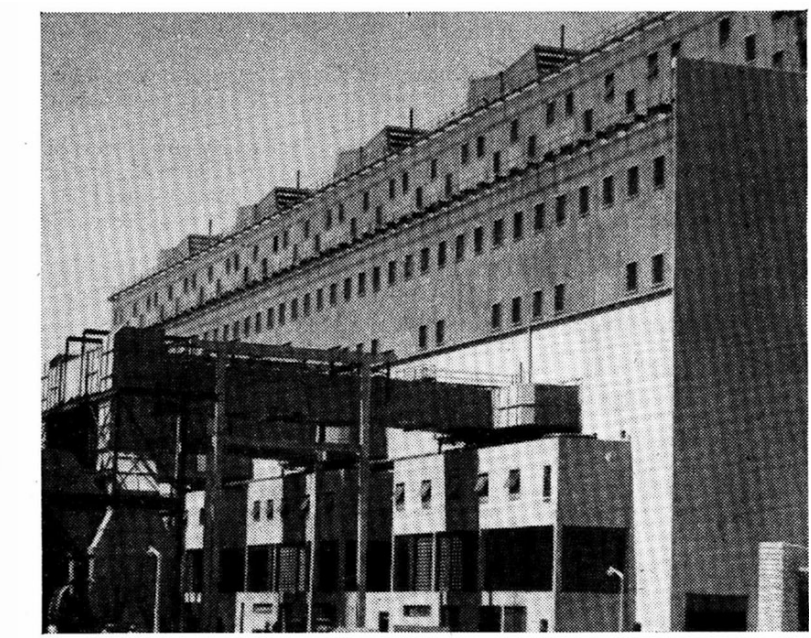

FIG. 17: EAST ELEVATION OF THE BOILERHOUSE

more than five years ago to talk about architects and engineers working together. The Buenos Aires power station was, in fact, an example of where that had actually happened.

188. Her architectural colleagues and she herself had worked with the Engineers on the project for something like four years, when the main problem had been to meet the architectural requirements of a power station in the climate of Buenos Aires; a climate with a wide range of temperature, and often high humidity. The solution was made easier by the Engineers working alongside the Architects in the same office.

189. The inside of the turbine hall shown in Fig. 15 indicated the level of natural lighting without direct sunlight.

190. The turbine hall concertina is shown in Fig. 16 and the louvres referred to by Mr Johnson could be seen at the bottom of the concertina. The air flow through the louvres could also be augmented if necessary by opening the windows incorporated in the folds of the concertina. The building on the left is the circular control tower and the beginning of the administrative precinct.

191. The east elevation of the boilerhouse is shown in Fig. 17. There the enclosing structure had to keep out the elements and provide controlled ventilation, but since the building housed massive items of plant which were virtually self-shading, no sun control was necessary. The ventilators on the roof of the boilerhouse shown in Fig. 18 were a good example of engineering needs influencing architectural form.

192. The layout of the group of ancillary buildings, Fig. 19, had been fixed by the Engineers, but the Architects were very pleased about it. Had the buildings been spread over the whole of the area shown, the visual effect would have been different and in her opinion, far less satisfactory. The auxiliary boilerhouse, the workshops and stores and the water treatment plant could all be seen but the cooling water pumphouse did not appear as it was just to the right of the figure.

Mr M. W. Leonard (Director, Soil Mechanics Ltd.) said that in reading this interesting Paper, his attention had been drawn to § 12 where it was stated that the scheme was *initially appraised on a geological and not an engineering report on the ground*. He did not know whether there was any implicit reflexion in that, but he had only to read further to see that it was the tenderer who asked for a further investigation of the ground conditions. That was not surprising.

194. *It seemed to him that in undertaking any major engineering project*, and all power stations were such, to consider a site without a study of the ground conditions in engineering terms must only lead to uncertainties, some of which could only be resolved by large additional expenditure. He did not believe that there was a substitute for undertaking an adequate site investigation prior to the commencement of the design for a major civil engineering project, and that was equally valuable to those undertaking the construction of the works.

195. If that was not done, the engineers responsible—he emphasized that he was speaking generally and in no way in connexion with the Authors of the Paper or the firms with which they were associated—had to ask themselves whether they had responded to their obligations to a standard consistent with present civil engineering thinking.

196. The cost of such investigations was relatively small compared with the total cost. Could the Authors give any indication of the costs of the total site investigation for the Buenos Aires project?

197. The Authors referred in § 13 to the term *Tosca*. He had found a reference in a gelogical memoire to the effect that *Tosca* deposits occurred in central and western Argentine and consisted of 1400 m of brownish sandstones and shales with inter-bedded conglomerates, continental in origin and of the upper-miocene period.

198. The deposits mentioned by the Authors were probably marine upper miocene beds of the Entre Rois formation which consisted of 70 m of tuffs and sandstones.

These deposits thicken towards southern Buenos Aires where they attain a thickness of 700 m. There is also a change in lithology of the beds to reddish and brown shales succeeded by grey and greenish shales.

199. It was possible that locally the term *Tosca* was a generic one, because the description in the Paper of *Tosca* as 'a silt which has been preconsolidated by desiccation and is finely honeycombed' was difficult to reconcile with that given in the memoire.

200. The soil conditions met on the site might be much younger than the true *Tosca* and might possibly be estuarine deposits of the quarternary period which overlay *Tosca*. This was supported by the fact that the subsoil consisted of layers of silts separated by soft clays, which were more likely to be quaternary and not upper miocene.

201. Physical properties which were not inconsistent with that appraisal were shown in Fig. 3(a). It was a rather obscure point, and he would be grateful if the Authors could enlighten him by giving a little more information about the soil.

202. He wondered whether the Authors had any data available on the pile testing results, and if so, whether they would be prepared to put them forward to the Institution for inclusion in the record of pile tests to be built up in the library for the use of other engineers.

203. The difficulties in driving piles to the required depths due to the presence of *Tosca* strata were referred to in § 16, and it was stated that pre-boring through the *Tosca* layer was resorted to in order to get the piles home.

204. Such conditions prevailed more often than anticipated on sites, and it was only when initial attempts to drive piles, which could only just penetrate hard overburdens and often failed in being driven through them, lead to anxious thoughts on site as to the choice of method of piling; very often the work had gone too far to offer an economy by changing to another method.

205. Such work was often bedevilled by poor pile test results, and extra piles had to be driven to meet the possibility of insufficient piling capacity; when this was so, the engineers had to ask themselves whether this could have been avoided by undertaking an adequate site investigation prior to the commencement of the work.

206. In the case of the Buenos Aires Power Station works, the alertness of the engineers to the potential difficulty of piling through the *Tosca* led to preboring. This expedient could be expensive as it combined features of both bored and driven piling techniques.

207. The more recent developments of large diameter boring equipment provided a means to form piles to considerable depths necessary through ground conditions which otherwise would make driven piling untenable.

208. He was of the view that when pre-boring was envisaged consideration should be given to forming an in situ pile within the boring. There was enough evidence to satisfy most engineers that such piling was satisfactory.

Mr L. Richardson (Midlands Project Group, C.E.G.B.) said that, with reference to § 118, it would seem that so far as the piling was concerned the Authors committed themselves to using precast piles on technical grounds. Would this in all cases rule out in situ piling in heavy foundations? Would the Authors say whether it was impracticable to construct in situ piles? They had in any event, presumably, to provide boring rigs and casings, possibly imported, and they had difficulty in providing the heavy driving plant. So far as their precast piles were concerned, to what extent did they under-bore for them, and did they rely entirely on nosing into the *Tosca*, discarding any latent or frictional support that they might have retained in reserve in the length of the pile? Also, were they satisfied with the dynamic or driven set, or were some static load tests made in addition? If the Authors could give some of the settlement characteristics it would be interesting.

210. He had known piles driven into somewhat similar material, but they had given quite unacceptable settlement under static loads. In that case bored piles were taken to a slightly greater depth than piles could have been driven, and it provided a satisfactory solution. A full description of the whole of the piling would be helpful.

211. It was stated in § 21 that the intake and discharge culverts passed through the turbine block foundations. He wondered whether any special precautions were taken to allow for any long-term differential settlement that might occur between the concentrated pile group and the lightly loaded culverts external to the blocks, because as the relatively thin stratum of *Tosca* was on a compressible clay, as the Paper stated, there could well be a likelihood of that occurring in time.

212. Mention had been made of the limitations on the use of structural steelwork because of import difficulties, and that had twice been stated as the reason for the concrete turbine house structure. He wondered whether the use of in situ concrete for the turbine house columns could not be justified on economic grounds.

213. The Midlands Project Group of the Central Electricity Generating Board had used and was currently using in situ concrete columns for two reasons—speed of overall construction and economy. It was having difficulty at one station, where there were steel turbine house columns.

214. He thought it strange that it had been decided to insulate the boiler house walls inside. It was not usual in the United Kingdom to insulate boiler house walls. It would seem that, even in an extreme climate, in operating conditions at the higher boiler gallery and drum level, the inside of the building would always be hotter than the outside. Perhaps the Authors would care to comment on that.

215. He wished to ask the Authors for some particulars of the chimney. Reference had been made to sulphate resisting cement used in its construction. The diagram given in the Paper was very small, and it was not clear whether the chimney was lined or otherwise. He wondered whether sulphate resisting cement was used in an unlined chimney or whether the material was simply used in mortar for the brickwork.

216. Presumably the sheeting was designed for 27 lb/sq. ft according to the B.S. Code of Practice. He and his colleagues were finding that adequate for the sheeting rails, but it was necessary to make sure that the fixings were designed for the gust experience. He would like to know what the experience of the Authors was, because he and his colleagues had had adverse experience at one particular station.

217. He wondered whether the design allowed for any earthquake tremor. Was that a condition of the design?

Mr R. L. Triggs (Edmund Nuttall Sons & Co. (London) Ltd.) said that he would like to thank the Authors for including the section 'Problems encountered'. That kind of information, particularly when it was about a large project carried out in a distant country, was very valuable to engineers when they had to work abroad.

219. He thought that the crux of the matter was in § 78, which stated that once the financial situation was resolved the rest of the problems were minimized.

220. He had gathered from the Paper that the main financial problem was the shortage of hard currency. That was supported by the fact that plant used was 50 or 60 years old. However, now Mr Sancha had told them, if he had understood him correctly, that at one time at least there was foreign currency available but no Pesos.

221. He wondered to what extent the financial muddle distorted the design of the project. At the end of the Paper there was a table of costs which showed that the whole project cost £11 million, and of that sum £2·7 million, roughly a quarter, was spent on sterling materials. It seemed to be quite a high proportion and must be something like half the total cost of the materials in the work. He wondered whether that was intentional. Did it arise from some condition of the contract? Were the Authors attempting to minimize or maximize the hard currency content?

222. The pump house, for example, was built inside an imported steel sheet piled

coffer dam. A local alternative could have been to design and think of it in terms of a caisson. He wondered whether that was considered, and if so, why it was rejected.

223. Again, turning to the river retaining wall, he had made a guess that about 5000 tons of imported piling was used. He wondered whether something else could not have been done there. He had been sufficiently interested to turn out an old book, and there he had discovered a description of the construction of the Madero Docks in Buenos Aires. It stated that when operations were commenced in 1912 a series of dams was formed of earth or *Tosca* so as to enclose the site. The face of the dock was protected by stone taken from a local quarry, and that also served as material for the breakwater.

224. So there were at that time, and he supposed there still were, some local sources of materials, probably poor ones, but nevertheless good enough to build, for example, a breakwater. He did not know whether the breakwater was still there. He imagined that it was.

225. That seemed to him to open up quite a large question which was important for both engineers and contractors if they went to distant places in that they should be able to build as far as possible with local materials and keep the costs in foreign currency down to a minimum. He wondered whether in the present instance that was the intention and whether the picture had been distorted by the financial difficulties which the Authors had described.

The Chairman said that perhaps the Authors would allow him to make a comment which he hoped would not indicate to them that he had not understood the very

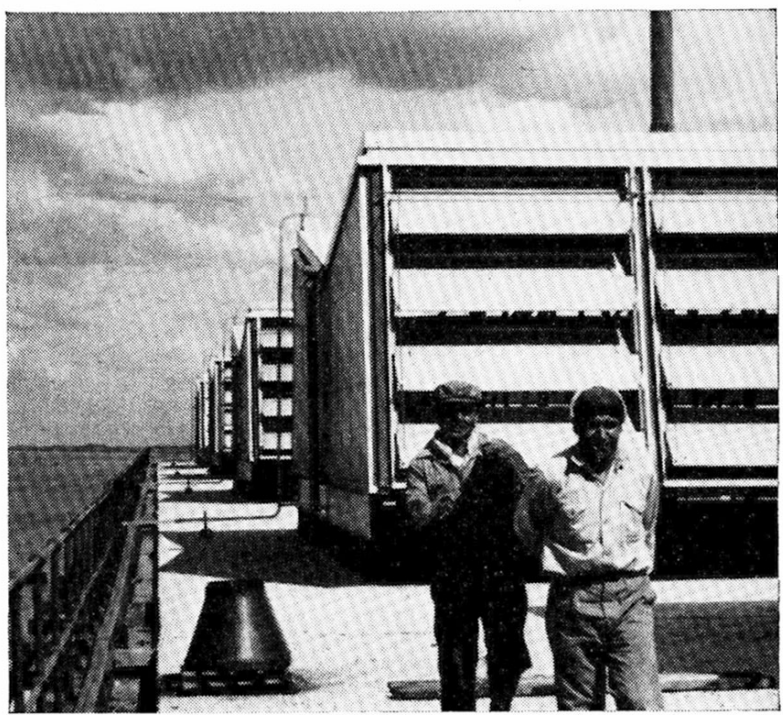

FIG. 18: BOILERHOUSE ROOF VENTILATORS

complicated procedure set out in §§ 85–88. It would be recalled that the Authors began briefly by stating in § 4 that the civil engineering contract was a normal admeasurement type of contract, but he would have thought that the extremely complicated and very difficult procedure explained in §§ 85–88, which as far as he could make out meant recalculating the unit contract rates again every four months, must be regarded as a very abnormal type of rise and fall clause.

Mr E. F. Humphries (Senior Engineer, G. Maunsell & Partners), said that like previous speakers, he had also been interested in the use of the relatively small diameter piles which had had to be bored into the ground and then driven down to a set. It seemed that there were three layers of the *Tosca*, each with soft clay between them. The design adopted put the piles into the second layer and there was another layer of soft material below that. Therefore, he assumed that an appreciable predicted settlement must have been allowed for. Could the Authors state what it was or what they hoped it would be; perhaps it might or might not be the same?

228. He wanted to take up a further point made by other speakers about having a bored hole and then driving a pile inside it. In the light of more up-to-date experience, particularly of the last few years with large diameter bored cylinders, would the Authors use such cylinders and then go down to the layer which was described as a 15-m layer of stiff clay and sand? Would a smaller number of much larger cylinders taking several hundred tons each down to that level have been more economical, using less plant overall and also perhaps lessening the amount of settlement?

229. He had a point to raise regarding the oil tank. From experience he had found that it was difficult to get sufficient piles in a circular slab to take a heavy high tank. He presumed that some circular pattern of piles was used, but perhaps Mr Haswell would add a comment on that, as it would be useful for future reference.

230. The cooling water system indicated that surge tanks were used and also that there were two sets of pumps, one in the pump-house and one in the turbine house. In one power station in the United Kingdom the culverts had been taken at deep level into the power house, and pumps in the floor at the side of the turbine blocks used to push the water into the outfall culverts. He wondered whether a similar system of single pumps with a deeper culvert level had been considered and why surge tanks were needed on the supply side of the cooling water pumps.

231. Regarding the wharf, everyone who designed wharves was interested in the salient facts about the berthing velocity and approach angles assumed in design. He wondered whether the Authors would give this information for future reference.

232. A further factor affecting fending design was the proportion of energy which was to be taken by the fenders and by the vessel itself. Perhaps these figures could also be given. He presumed from the Paper that rubbing timbers were fixed only on the steel box piles and that no fendering was placed between them. Did that mean that the jetty was not used for smaller vessels? Often one had to have a major fending system and then a smaller fending system in between. A brief comment on that might be helpful.

233. The Paper stated that the joints between the precast concrete units of the roof beams were made with mortar. He would have thought that a dry concrete rather than a dry mortar would have been more effective and usual. Whereas a mortar could be hammered in for caulking purposes, concrete would be used between precast units. Would the Authors comment?

234. Lastly, there was the point of the administration of the complicated contract with visits at infrequent intervals from head office. He wondered whether the Authors could say what amount of supervision was necessary from a distance of 10 700 miles. For example, how often did the Partners in charge visit the site? Were such visits allowed for at the tendering stage? How was the site to be administered? He would be grateful for a little more information on these points.

The following contribution was received in writing:

Mr A. W. Shilston (Consulting Engineer) said he wished to comment solely on the administrative background to this very interesting project. It was fairly clear from the Paper that the working relationships were continually being adapted to meet changing circumstances. Whilst that empirical approach appeared to meet the demands of that particular situation, even those consulting engineers who felt strongly that imaginative working relationships were a necessary part of overseas involvements might be pardoned should they feel a little confused after reading the Paper if a working basis for similar projects did not clearly emerge. He hoped that the discussion and the Authors' replies would provide a fruitful source of basic material for those responsible for composing the administrative framework of future overseas ventures.

236. Was it a requirement of the Enquiry Specification that the civil engineering element of the work be undertaken on a measure and value basis or did the Partnership feel, on the advice of their civil engineering consultants, that it would be unrealistic to submit a tender on any other basis, having regard to inadequate sub-soil survey information and other factors? At whose instance was the make-up of the unit rates, prepared by the group of local sub-contractors, submitted with the Partnership's original tender? Did the Consultants prepare the tendering bill to the I.C.E. Standard Method of Measurement?

237. The reference in § 4 to the installation of the Plant being on a cost basis was interesting. Could the Authors say whether the original tender allowed for the installation of the plant on a price or dayworks basis? If the former, was the change at the instance of the Client?

238. From §§ 63, 64, 67, and 68, it appeared as if the progress of the civil engineering work was dependent on the prevailing financial standing of AYEE, implying that the contract between AYEE and the Partnership withdrew from the latter the responsibility for progress payments to the civil engineering sub-contractors. In particular § 64 referred to the advance payments that AYEE should have made to the sub-contractors. In Great Britain sub-contractors, whether nominated or otherwise, were not in contractual relationship with the employer as defined in the main contract and looked to the main contractor for payment. But on the other hand § 67 referred to the contract between the Argentinian group and the main contractor which suggested that as the Partnership received no extended credit or bridging accommodation from United Kingdom sources (§ 2) to finance local expenditure, it was relying on a regular flow of progress payments in the usual way to meet its obligations. Could this point be clarified?

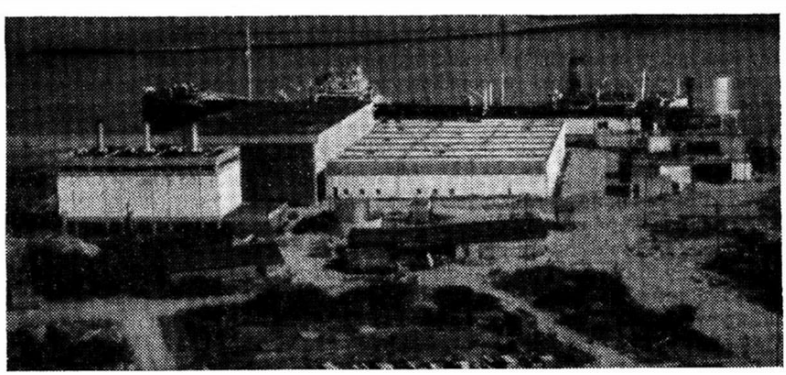

FIG. 19: ANCILLARY BUILDINGS GROUPED SOUTH OF THE POWERHOUSE

239. Where delays occurred in United Kingdom contracts, outside the responsibility of the contractor, despite the absence of express terms in the standard civil engineering form of contract to deal with such a situation (putting Clause 66 to one side for the moment), redress of grievance could be obtained in other ways. Was there a background of general law in the Argentine to protect a contractor whose programme was slowed down because of the actions of the employer? Or were there express terms in the Contract to deal with such matters? It would be of great value if the Authors could shed light on this seemingly equivocal situation.

240. There was no suggestion in the Paper that the Consultants until the beginning of 1962 were acting other than in the best interests of the Partnership, i.e. in the customary relationship existing between professional adviser and client. Accordingly it was rather surprising to read the Author's remarks in § 81. Would an employer anywhere look at a consulting engineer differently in matters of certification and payment as long as the consultant was acting for the other party to the contract?

241. From the Paper, Mr Shilston thought that perhaps a turnkey bid might include an offer of professional services to the potential client as an inclusive feature of the bid, in the form of a provisional or prime cost sum allowance, in which event the consultant would act in the traditional way towards the employer if the bid were successful, notwithstanding the fact that the consultant might have been retained by the contractor to assist in the preparation of his bid.

242. To transfer one's professional allegiance halfway through a contract, to the employer from the contractor, however, was a much more imaginative procedure. It was presumably outside the scope of the Paper to indicate the mechanics of such an operation, but Mr Shilston thought this was a good example of how British consultants had not remained unaffected by the wind of change!

The Authors in their reply first wished to thank Mr A. E. Powell for his valuable contribution to the Discussion. In particular, it was, of course, quite appropriate of him to outline the fact that the Paper dealt only with the civil engineering aspect of the power station. The Authors appreciate that very often the civil engineer tended to forget the primary purpose of his contribution to a power station project which was in the simplest terms, the provision of foundations for, and the housing of, very large and important electrical and mechanical plant.

244. Mr Powell had also recorded financial problems which was very helpful. With regard to the question of the 10 000 km distance between Head Office and Site, the Authors had really been comparing this with thermal power stations in the United Kingdom where Head Office visits were usually paid once a fortnight: here there was also a monthly meeting on site to consider the progress of the work, and coupled with the use of the telephone gave one a complete interchange between Head Office and Site. It was not the Authors' wish to give the impression that the lack of this communication created impossible difficulties but owing to co-operation from all concerned, problems were successfully overcome. The Authors also wished to thank Mr Powell for his remarks concerning the duties of the civil engineer and also the tribute he paid to the architectural design of the buildings. His remarks regarding the workmanship at Buenos Aires were appreciated and indeed the position compared favourably with much of the present power station quality in the United Kingdom.

245. Mr J. M. Whitaker had referred to the question of the organization of the contractors and had asked who was the employer of the group of contractors. There was no question that the group of contractors constituted a legal entity as such, and their direct employer was the BTH-ICL Partnership, the main contractors for the project. The point to bear in mind was that the BTH-ICL Partnership had no financial interest in the execution of the main civil engineering works; in other words, any money paid to the Argentine group of contractors went from client to contractor. They had, however, an obvious interest in that the purpose of the exercise was to build a power station, which one could not do without the civil engineering works.

246. As to the relationship between the Argentine group of contractors and the Argentine authorities, under the BTH-ICL Partnership the Argentine authorities were originally AYEE and later SEGBA, and for practical purposes they functioned as the direct Employer of the Contractor—the Argentine group of six firms—with the consulting engineers acting in their normal manner.

247. The rate of expenditure graphs shown in Fig. 10 are based on actual certificates at basic rates issued to the Contractor and not on actual value of work constructed during the period. Consequently they give a somewhat distorted picture of the rate of construction as not only is the time lag between construction and payment reflected but also the moment when new rates were approved and allowed for in certificates.

248. It should be noted that as mentioned in § 5 of the Paper, at the beginning of 1962 SEGBA took over the power station and the pesos costs of the civil engineering works were financed by the IBRD. As a result of both these factors many outstanding contractual matters (pending whilst the financial situation was uncertain and the transfer of ownership of the power station was being considered) were resolved.

249. In addition, from the purely engineering point of view and allowing for the factors mentioned above, the construction of the oil tanks on piled foundations contributed to the peak in expenditure shown in the first half of 1963, but this work consisting basically of piling and simple foundation slabs required a smaller number of men for an equivalent value constructed than the more complicated reinforced concrete structures for the power house, ancillary buildings, cooling water system, etc. The fact that these were constructed after the main civil engineering work was practically completed is due to the wharf and river-works contract not being signed until August 1961 (cf. § 9 of the Paper)—subsequently these structures determined the commissioning programme.

250. Mr Whitaker had also suggested that the number of men employed was rather more than would have been necessary in the United Kingdom; in that the Authors would agree. If one picked out a section of the Works which could be isolated such as the structural steelwork, the number of men employed was similar to what would be expected in the United Kingdom. In regard to the other sections of the work, it had to be borne in mind that these were six different contractors. The financial implications of the civil engineering works were far more than any single local firm could undertake. Hence, six contractors existed each of which could cope with, say, a sixth of the total value of the work; each firm had, of course, its own organization. This was one of the factors which meant that more men were employed than would have been expected. Apart from that, the organizations were not as mechanized as British organizations would be.

251. As far as the permanent works are concerned, Mr Whitaker's question in § 165 is entirely an electro-mechanical matter and outside the scope of the Paper. As regards the construction of the station, the area south of turbine block No. 5 was used as a loading bay and an opening was temporarily left in the west wall of the power house to allow the access of lorries. This proved invaluable for the civil engineering works and for plant erection.

252. Both Mr Whitaker and Mr Richardson had raised the question of the relative merits of structural steelwork and reinforced concrete. According to the Authors' experience each had been in vogue. Up to some 25 years ago structural steelwork was used for both Boiler and Turbine houses. Then there came a period when Turbine Houses were constructed in reinforced concrete and a few power stations were built in the United Kingdom where Boiler Houses had also been framed in reinforced concrete. In the last five years the tendency had been to revert completely to structural steelwork. In Buenos Aires reinforced concrete for the Turbine House was a prerequisite and in the event it appears to have been the correct answer but it made matters somewhat difficult on the question of complying with a very tight programme.

In the context of construction in the Argentine it was a question of trying to save as much money as possible on the sterling element of the Contract.

253. The Authors were very grateful to Mr S. G. Moss for his kind contribution in which he gave much useful data about the background of the project: apart from his personal help to the Authors during the project, it would not be inappropriate to record that they regarded his personal contribution as having been of special merit in co-ordinating the two consulting engineers and the six Argentine contractors.

254. Mr H. B. Johnson had made a valuable contribution in connexion with the electrical and mechanical aspects of the project for which he had been responsible during the construction period at Buenos Aires.

255. Mention had been made also of the cooling water pump house constructed with the use of a circular cofferdam. The Authors considered that this had been a success both in terms of money and of time. This was considered important in power station construction where the average time for building a pumphouse was in the order of 75 weeks and this was often a critical factor.

256. The Authors were very pleased that Miss Alison Downs had contributed to the Discussion in giving some interesting and useful information on the architectural design involved in this project.

257. Mr M. W. Leonard had properly referred to the value of site investigation before the undertaking of any major project. The sum spent at Buenos Aires was £33 500 as shown in Table 4 of the Paper: the Authors considered that this was a modest sum for a good site investigation.

258. The Authors agreed that it was axiomatic that there was no substitute for undertaking an adequate site investigation prior to the commencement of the design for a major civil engineering project. Unfortunately, it was also true to state that many Undertakings did not appreciate this fact.

259. Mr Leonard's reference to the use of the term *Tosca* is surprising. Having discussed the matter fully with Professor A. J. L. Bolognesi in Buenos Aires, the Authors reached the conclusion that the geological memoire mentioned by Mr Leonard must apply the term *Tosca* in an unusual way not generally accepted by South American authorities.

260. A sound and simple definition of the *Tosca* was given at the beginning of last century by the English traveller J. A. B. Beaumont Esq. in his book published in 1828 "Travels in Buenos Aires and the adjacent provinces of the Rio de la Plata with observations, intended for persons who contemplate emigrating to that country; or, embarking capital in its affairs", as follows:—

261. 'At a considerable depth, rarely less than 50 ft below the surface is generally found a material called *Tosca*; it is a hard clay containing calcium'.

262. An interesting description is given in the book of a well sunk by an Englishman to a depth of 174 ft that took three years to complete. The purpose of the well was to study the water supply for the city of Buenos Aires but the strata encountered are described such as a 15 ft thick layer of *Tosca* at a depth of 83 ft.

263. The *Tosca* is also described in Chapter V of the "Voyage of the Beagle" although not by name by Charles Darwin. In August 1829 Darwin travelled by land from Bahia Blanca to Buenos Aires and wrote:—

264. 'The plain, at the distance of a few miles from the coast, belongs to the great Pampean formation, which consists in part of a reddish clay, and in part of a highly calcareous marly rock'.

265. To locate Mr Leonard in the geological time, the Authors would refer him to the blue clay mentioned in § 14 of the Paper, that is plio-miocene. The final division of the tertiary period is the 20 metres thick layer of sand on top of the blue clay. The *Tosca* described in the Paper is embedded in the Quaternary *Pampeano* formation.

266. Professor Felix Gonzalez Bonorino, the leading authority on Argentine geology describes in *Anales de las Primeras Jornadas Geologicas Argentinas* (Tomo

III 1962, Buenos Aires) a boring sunk in Buenos Aires at Palermo down to *Gneiss* at 289 metres below ground level. The top 44 metres were the Quaternary *Pampeano*, from 44 metres to 83 metres is the Tertiary *Paranense* and from 83 metres to 289 metres below ground level is the *Arcilla Parda* (Guaranitico).

267. The comprehensive site investigation carried out by Professors Bolognesi and Moretto was fully consistent with Professor Gonzalez Bonorino's boring some 6 miles north of the Power Station site. Initially 14 No. 3 in. borings and 1 No. 8 in. borings were sunk to a depth up to 71 metres below ground level. In those borings were carried out tests for the standard penetration, liquid limit, analysis and undrained triaxial strength. The junction of the Quaternary and the Tertiary was also found at about 44 metres below ground level but as this was a few metres below the level at Palermo the junction of the two periods would also differ by a few metres as might be expected.

268. On the question of pile test results, the Authors would be pleased to make these available to the Institution. Mr Leonard had mentioned the use of in-situ piling when pre-boring was envisaged and in this connexion the Authors had some reservations as in their experience borehole piles in practice had shown inconsistencies one with the other in the matter of settlement under load.

269. The Authors welcomed Mr Richardson's contribution, especially as they had worked with him on a previous major power station project. Mr Richardson had also raised the question of the relative merits of in-situ and pre-cast piles: this had been referred to in the reply to Mr Leonard's contribution. The Authors' view was that on important structures such as heavy machinery foundations for turbines the pre-cast pile was considered to be technically a very much better solution than an in-situ pile: the latter was very much more subject to human error in workmanship. While the danger of placing reliance upon a driven set to evaluate the load carrying capacity for a pile was well known, its use to ensure that the load carrying characteristics were sensibly similar was another matter.

270. The Authors quoted the case of a power station on which they had been in association with Mr Richardson when pile tests were carried out both on bored and driven piles and showed quite different orders of settlement when driven into rock, much to the disadvantage of the in situ pile.

271. Mr Richardson had referred to the question of the economic comparison between the two types of pile providing the right type of pre-cast pile was selected. It had fortunately in the past been advantageous from the point of view of cost. On the question of settlement characteristics the Power Station had been designed for an angular distortion of 1 in 1200 or an inch in 100-ft and the Authors considered that this was now accepted practice for turbine houses. Other structures had been designed for anything between this figure and 1 in 600 depending upon the function of the structure to be supported.

272. Mr Richardson had referred to the use of Sulphate Resisting Portland Cement: the chimneys were lined with bricks set in quadrile in accordance with United Kingdom practice with a separate lining to reduce the temperature gradient. It was felt that with the high quality of Sulphate Resisting Portland Cement recently put on the market in the U.K. it was correct procedure to use it for the top 50-ft or so of a reinforced concrete chimney: at a small additional cost it was an added insurance. This cement has a slightly different chemical composition from Ordinary Portland Cement limiting the amount of tricalcium aluminate to not more than 5%.

273. On one occasion wind gusts of 70 mile/h had been recorded and the power house cladding stood up perfectly to this severe test.

274. Buenos Aires was outside the earthquake zone and no provision was made in this respect.

275. Mr Triggs had raised the question of currency: the Authors wished to state that there was nothing peculiar about the situation. A proper balance had to be struck between the import into the Argentine of essential materials such as structural

steelwork and sheet steel piling which were not available and the use so far as was possible of indigenous materials. The difficulty arose not in the sterling payments but because at one time the Client was short of pesos; this created a not unnatural difficulty for the contractors and a problem not usually encountered in the United Kingdom. In Latin America, international finance agencies do not normally make loans for expenditure in local currency.

276. As regards the Pumphouse construction, it should be remembered that there was little time in which to design and fabricate a caisson; in any event there would have been the trouble of lack of local skilled men for construction. The Authors believed that the circular cofferdam was the right technical and economic solution in the circumstances.

277. Mr Triggs had also referred to rock which could have been used for filling: that was another question. Strictly speaking, in the time that the breakwaters were constructed, rock could be imported from Uruguay, but for many years that had not been permissible owing to trade restrictions, and any rock which could have been used on the site was to be found only at a place 300 miles away, and so the economies were out of balance.

278. The Chairman made some forcible remarks about the normal admeasurement type of Contract. The complicated procedure was only in relation to the Contract Price Adjustment: this increased the amount of paper work involved. The procedure with regard to Interim Certificate Measurements was also somewhat involved as the overall number of signatures required for one Measurement was in the region of 7000.

279. Mr E. F. Humphries had first raised the question of the piled foundations. To begin with it should be stated that the main Power House structure was planned so that the differential settlement gave an angular distortion of 1 in 1200. The other structures were designed for something greater depending upon their relative importance.

280. The maximum recorded settlement in the powerhouse was 1·5 cm and the average overall angular distortion about 1 in 2500. The settlement of both chimneys was 1 cm and the average recorded settlement of the cooling water pumphouse was 2·5 cm.

281. Advantage was taken of a sub-basement as otherwise longer piles would have been considerably more expensive. Equipment for the smaller sized piles was available in the Argentine, and therefore, the larger cylindrical type of pile, although considered, was not adopted. Obviously where both type of pile are available the final selection, their economic advantage once decided, would depend upon the acceptable angular distortion of the structure.

282. Mr Humphries next raised the question of possible difficulties in driving piles in close proximity as had to be done for the oil tank foundations. As the piles were pre-bored no difficulty was experienced. Normally one has to evolve some sort of circular pattern working from the centre outwards and this is often simplified by working away from one diameter.

283. The cooling water system was at a high level purely on a question of economics. The Authors had been connected with a low level cooling water system for a power station in the United Kingdom but this involved rock tunnels and the levels were decreed by the great range of tide in the Severn Estuary. Here again a perfectly good solution would have been a high level system with a form of intake chamber.

284. The use of earth dry mortar proved highly successful enabling the beams for the turbine house roof to be prestressed three days after caulking of the joints was completed.

285. Mr Humphries' last point concerned the number of Head Office visits to site and the Authors stated that this amounted to only six. Ideally, there should have been perhaps double this amount but the cost of each visit was high.

286. Mr Shilston was concerned with the administrative aspects of the project. Most points raised by him have been answered by the contribution of, or the replies to, other speakers.

287. One serious difficulty that might be mentioned in dealing with many undertakings in South America is the lack of continuity of the senior executive staff and the boards of directors. As anywhere in the world, regardless of the administrative framework, it is fundamental to establish sound personal relations and mutual confidence between all parties on a project. In Buenos Aires, the senior administration of the power station changed twice with AYEE and twice with SEGBA in a period of 4 or 5 years. This change of individuals with whom one had to discuss problems arising was more important than the change in the overall contractual relationship.