

Discussion

The Author introduced the Paper with the aid of a series of lantern slides.

The Chairman said that when the mechanical department was being reorganized, he had wanted Mr Brass to be in it. He had been asked why—since Mr Brass was a civil engineer—he had replied that that was the very reason. After 30 years' experience, he had found that agents needed somebody in the central office to whom they could talk and who understood their problems and could sort out their difficulties for them, while the mechanical men gave attention to making sure that the wheels went round. The decision had proved to be both popular and wise. He had discovered later that Mr Brass had taken a degree in mechanical engineering and had then spent two years in works.

124. The Paper might be thought to be a simple one, but really it enshrined a creed which the Authors had evolved, and to which he, the Chairman, subscribed. Like all creeds it sometimes invited a little persecution; but the Authors had practised that creed as far as they could.

125. The question of depots was very important and he had studied it for many years. If a contractor was starting business he could not afford to build an enormous depot at the outset, for if he did so he would have no capital left to carry on his work; but as he progressed he must look ahead to two things: either, at the best, he would expand his business, or, at the worst, he would go out of business. As there was always the risk that one day he might be forced out of business, he could well spend some money in building a property which would have at any rate a residual value; he should, if he thought that he was going to expand, choose a site for a depot which would enable him to expand. There could not be too much room. He had seen many cases where firms had regretted the size of site which they had been compelled to choose. Moreover, if a firm over-economized and tried to work in slum conditions, it would only attract slum workmen. It did not cost much more to do the job properly than it did to build a slum. That had been proved on several occasions.

126. The Chairman had said in the discussion of a Paper at the Institution of Mechanical Engineers that if a depot was suddenly submerged by a mass of returned material, it could rapidly become a mechanical Belsen.

127. If one did a little calculation in connexion with a depot, one would find that a derrick with a 120-ft jib could store as much material without moving as one-quarter of a mile of track with a 5-ton crane, without allowing for the 20-ft swathes that the crane sterilized.

128. One of the most important things in a workshop was the height. The interesting reports of a visit to American factories by Mr William Allan, published by the Building Research Station, emphasized how the Americans had pressed him to consider the question of height because it was the one dimension which it was cheapest to build and most expensive to alter. When the depot described in the Paper was being built, the Chairman's firm had studied several different depots and shops, including the workshops of the Transport Board for buses and trains at Chiswick. He did not think it was an indiscretion to say that the people at Chiswick had pointed out how much better it would have been if their shops had been higher. The result could be seen in the new shops which had been built on the Watford by-pass, which were very high indeed. In building the depot described, they had also got a lot of help from the firm of Jack Olding and had inspected their shops after the proposed dimensions had been chosen. The first few bays had been too low; the next series of bays had therefore been built higher, and the final bays had turned out to be of the same dimensions as the Authors of the Paper had chosen.

Mr A. P. Lambert (of John Mowlem and Company, Limited) said that Members were very much in the Authors' debt for covering such a large subject so adequately and

yet keeping within the confines of a normal Paper. It was a specialist Paper and there were only a number of points on which comment could usefully be made.

130. The first matter that he wished to discuss—the operator's viewpoint—was not referred to at any length in the Paper. Did the Authors feel that, in the development and the treatment of plant, the operator—the driver and not the owner—was receiving all the consideration that he should? On large machines there were servo-assisted and pneumatic controls, but was the driver's point of view being considered throughout? Mr Lambert's solicitude for the driver was *not entirely on humanitarian grounds*; it was very good business as well to make the driver comfortable. If he was to drive a machine flat out for 9 or 10 hours a day, there must be the minimum of fatigue.

131. Mr Lambert then referred to §§ 61–68 which dealt with inspection. Inspectors arrived on a job every 3 weeks and examined all the equipment on the site and wrote a report on it in the few hours at their disposal. The Authors had pointed out that most of the plant was working, so that the inspectors could not do very much more than ask the opinions of the driver and the foreman fitter. What was the cost of this inspection service expressed as a percentage of the administrative cost of running a plant department? The point was that, at the same time as the inspectors were making periodical visits, there was the excellent log sheet (Appendix II in the Paper) which was filled up every week for every piece of plant. On that log sheet somebody was called upon to report on the condition of the machine. If there was anybody on the site competent to complete that log sheet and report on each machine, he felt that that person must know far more about the state of the plant on the job than the inspectors could find out in their fleeting visits. He therefore felt that the money might be better spent on a first-class fitter and foreman fitter on the site.

132. Another point that he wanted to mention was the difficult question of the real cost of ownership of plant and the correct hire rate to charge for it. Fig. 24 showed the history of a certain machine. After 4 years that machine had just got out of the red and was showing a profit, but the diagram did not allow for inflation. It would not really be out of the red, for, because of inflation, there would only be enough money to buy half an excavator instead of a whole excavator. However, the point that he really wanted to make about the diagram referred to the upper part of it. The machine had been given a complete overhaul after 4 years at a cost of about £1,500. The expenditure curve of the machine was markedly steeper after overhaul than it had been before. The Authors said that because the curve was converging with the curve of receipts from the machine, it was therefore still an economic proposition, and that was the point that he challenged. Economic to whom? Economic to the plant owner, perhaps; if he could find somebody willing to go on hiring the plant he was on a good wicket. But a contractor must look at things from the overall point of view. The reason that the curve had become so steep, he imagined, must be that it has broken down more frequently in its latter years. If so, then the cost to the contractor from those breakdowns far exceeded the cost of repairing the individual piece of plant. If it were a crane, for instance, handling concrete skips, then if the crane broke down not only the crane stopped, but also the mixer, and the traffic running the concrete, and the placing gang—but the overheads did not stop. The overall cost to the contractor, though intangible, might be much more than the cost of repairing the crane.

133. Mr Lambert finally referred to § 54 in which the Authors stated "There are few circumstances more likely to impair good relations between contracts and depots than to return a piece of plant covered with mud and concrete from end to end." He could think of one other circumstance which was equally likely to impair good relations between contracts and depots, and that was the apparent belief held by many depot and plant managers that a piece of plant was necessarily restored to first-class mechanical condition by giving it a coat of paint! A coat of paint had nothing whatever to do with the mechanical condition of any piece of machinery.

Mr N. D. Pirrie (Sir Robert McAlpine & Sons Ltd) said that there was a growing interdependence between the mechanical engineer and the civil engineer; the Authors had

mentioned that the plant department must be able to answer the civil engineers' questions. He would go further and say that it was the responsibility of any plant department to be able to tell the civil engineer what could be done with the plant, and possibly this could best be done by publishing an information bulletin. That was necessary because the civil engineer had to plan jobs and also to prepare tenders, and unless he knew of the latest methods he was unable to do that. The plant department had a positive role to play and should not just sit and wait for the questions to be put to it. New methods should be known and examined, and not go by default.

135. With regard to the scope of the plant available to contractors, the Authors, in dealing with the excavation plant, had restricted the bucket size of universal excavators to $4\frac{1}{2}$ cu. yd; presumably because that was the largest made in Britain. Walking draglines were available with bucket capacities of 25 cu. yd or more.

136. Mr Pirrie showed some slides demonstrating a method of shifting muck by belt conveyors which he felt was worthy of study. He said the slides illustrated another point made by the Authors that contractors must have the ability and facilities to produce a one-off special machine to meet a special purpose quickly. A 90-ft inclined rotating conveyor was shown mounted on a $\frac{3}{4}$ -cu. yd excavator and driven from the existing machinery; it was capable of spreading muck at a height of 30 ft with a capacity of 400 cu. yd/hr.

137. The Authors had touched briefly on future developments. Mr Pirrie felt that the greatest advance in plant would come from improvements in the control of machines. The output of a machine could be severely reduced, if the driver was given awkward and ill-assorted controls requiring effort. This was one reason, among others, for the growing popularity of torque converters with contractors. Although they had lesser mechanical efficiency, they did improve the driver's efficiency, and very often the overall efficiency of the machine was so much improved that the overall output was increased.

138. Another advance could be made on sites. The condition had been reached where there were good machines, good operators and effective maintenance. One thing remained. That was the training of the site management to handle big tools in an efficient manner.

Mr C. H. S. Howkins, O.B.E., T.D. (Director and General Manager of Plant Division, Howard Farrow, Limited) commented upon safety and modifications. One of the difficulties that he had found was that, for example, a portable circular saw bought in the Midlands, might have trouble with the factory inspector if put on a site in London; or bought from, say, East Anglia and then placed on a site in the West Country, trouble might arise there. He asked that factory inspectors should have some general rule suitable for all areas of the country in the matter of safety guards.

140. On the question of modifications, it had been his experience that contractors, when they bought new plant, made certain modifications of their own. They passed the information on to the manufacturers and then, when later they bought another machine of the same type and make, they found that, although the manufacturers had said that the modifications were good ones, they had not been incorporated.

141. Although by its title the Paper was confined to civil engineering construction works, towards the end mention was made of building work; it was indeed very difficult to draw a line as to which was a building site and which was a civil engineering site; in fact, it was often a matter of considerable argument between two divisions and departments in a company. Although the Authors had mentioned tower cranes was not this an instance where a design team should come in at an early stage so that the building could be designed and a suitable crane found which would operate over the whole area? He thought that much could be done to facilitate both building and civil engineering work by the design team, including a plant engineer, at an early stage so that impossible tasks were not set for the mechanical side.

142. Reference was made in the Paper to "production engineers" at the depot. Had the Authors instituted work study in their own depot (since presumably that was the logical conclusion from production engineers) and had they been able to draw up standard costs for maintenance? In his own much smaller organization they had tried to work out

standard costs for repair work. He thought it would now have to come down to work study and the working out of costs on very small units, breaking the machine down to quite small parts with regard to costs.

143. Finally, on the subject of hire rates, Mr Howkins queried the 40 weeks a year in § 104—was that to be considered an average figure? In his own organization they had never been able to take such a high figure as 40 weeks of the year for calculating a hire rate, but he agreed that the only reasonable way to let out plant to one's own sites was at a hire rate.

144. Mr Lambert had mentioned the question of inflation. He would be interested to hear the Authors' views on the question of enhanced replacement costs, because if the price increase at 5 to 7% per annum at compound interest was accepted then plant bought 3 years previously at a cost of £100 would now cost £140 at 5% or £160 at 7%. He thought it was very arguable whether that should be included in the hire rate and then taken out of the plant department's profits and put on one side for replacement in the future, or whether it should be a levy on the profits of the operating divisions. What was the Authors' opinion on that matter?

Mr T. W. Stanier (General Sales Manager, Marshall Sons and Company, Limited) said that the Authors had described at considerable length the apportioning of responsibility in the selection of and advising on plant as between the mechanical and the civil engineering side. He had sometimes thought the dividing line between them was too rigid. It was all very well having returns as to when the plant was serviceable and when it was unserviceable, when it required repair, and so on, but that was not quite the full story. So far as he could see, there was no reference in any of the returns to the amount of work done by the particular plant. In order to get a consecutive costing picture of what the plant was really doing over a long period one needed to know its gross output and production. He believed that there was a case—and he thought that some contractors recognized it—for having an independent work study department which could go round and study plant methods and usage and recommend new methods of increasing output. That referred particularly to production plant. In his own mind he had always made a very big distinction between production plant as against utilitarian plant. The main production plant—the big excavators or tractors or scrapers—were the “glamour boys” which had all the advertisement and made the money—they produced the muck. But there was a great deal of less glamorous plant; smaller items, which were necessary on contracts, and their quantity was always surprising. That volume of plant had to be looked after just as much as the big production items.

146. He supported the Authors with regard to the medium-size machine. When cutting an alternative Suez Canal or something of that sort, the biggest possible plant was needed; but for other types of job, the run-of-the-mill jobs, very often it was the medium-size plant that gave the better service, was more transportable and reduced the danger of a breakdown holding up the whole works.

147. It seemed to Mr Stanier that there was a trend at the present time towards the unnecessary complication of plant. Again separating the plant into production and utilitarian items, with a large 300-horsepower tractor and scraper, obviously everything should be done to increase its output and to make the driver's task easier. A well-trained man could be put on it and the extra output that was obtained fully justified the complications; but on the utilitarian plant, that was not so, and the more things could be kept simple in this mechanical age, the better from the engineering point of view.

148. The Authors had touched on the question of plant going overseas. There it was often not a question of getting the maximum output out of a plant; in the Middle East, and in all under-developed countries, it was a question of keeping the plant going at all. The importance of simplification should be paramount in future thinking regarding equipment; all complication should be avoided as much as possible. It was not only the contractor who asked for these complications and refinements. It happened in the manufacturers' own organizations. The salesmen wanted extra selling points. They were not concerned if the plant broke down a year after it was sold and could not be

repaired because there was not a mechanic at the place who could cope with the particular item; they wanted something that would give them a selling point. The manufacturers were therefore all the time being badgered by their own salesmen to put in this and that extra refinement which often was quite unnecessary.

149. Mr Stanier suggested an alternative. When a major overhaul, as distinct from a repair, was necessary should it not be the job of the manufacturer to overhaul it? It was not the custom in Great Britain for manufacturers to repair plant, but it seemed to him logical that the manufacturer ought to be able to repair plant of his own make much more economically than the contractor who, however good his workshop, had hundreds of different types of plant with which he could not keep himself fully familiar. Furthermore, modifications and improvements could be incorporated by the manufacturer if he had the plant going through his own repair workshops. Mr Stanier knew that contractors probably felt very much the same as the engineers had during the war, when they had felt that if they sent a piece of plant to Ordnance they would never see it back again. That might be so. But Mr Stanier felt that there might be a case for more overhaul by manufacturers of their own equipment; doing it in batches in close co-operation with the contractors concerned, thus leaving the latter's own workshops to concentrate on urgent repairs as distinct from major overhauls.

Mr D. Shennan (Senior Civil Engineer, John Mowlem and Company, Limited) said that there was sometimes a tendency to ignore the advantages of the older types of plant. For example, jubilee track could be extremely useful in cases where normal road access was difficult to prepare. There was a further great advantage that on jubilee track the driver of a loco had to follow a set path, whereas when at the wheel of a dumper or lorry or other more mobile vehicle, he was apt to get "lost" on one of the larger sites.

151. Similarly, it was sometimes forgotten that a great deal could be done with rollers and a crowbar, possibly with the addition of jacks, in, for instance, the installation of heavy stationary plant, which was the sort of operation one encountered at the start and the finish of a contract. There was a tendency to think that if anything heavy had to be lifted a crane was essential.

152. Little was heard nowadays of steam plant, except in the case of pile driving, but the old pulsometer pump, with its freedom from mechanical parts, had much to recommend it, as indeed had steam plant generally, from the point of view of reliability.

153. With regard to pile driving first thoughts tended to be towards a piling frame, ignoring the possibilities of an automatic hammer with extended legs, held on the end of a crane bond, which was a most adaptable tool.

154. Referring to modern equipment, Mr Shennan said there seemed to be a very big future for short-wave radio, particularly in cases of work being carried out over the water, and on such contracts as large road jobs, where the centre of activity was constantly moving.

155. The great advance in the potentialities of plant and its increased cost made the question of close supervision more important than ever. Where any section of a contract was highly mechanized, he thought there was a very strong case to be made for that section of the work being placed under the charge of an experienced sub-agent or senior engineer whose sole responsibility should be the efficient organization and handling of that plant.

156. On the question of cleanliness and proper site care and maintenance of plant, he thought that was primarily the responsibility of the agent on the site. Unless he conscientiously insisted on proper attention being given to that matter it would not be carried out thoroughly, and at least some of the plant would inevitably deteriorate.

157. For serving the plant yard, the mobile derrick on towers appeared to be ideal. Since so much thought had been given to the arrangement of the plant yard, Mr Shennan hesitated to criticize, but did wonder whether in the case of the loading bay something might not be said for the use there of a loco crane, bearing in mind that its speed of operation was quicker, and that it could be used in conjunction with 4-ft-8½-in. flats for the distribution and collection of material.

158. Finally, referring to Fig. 24, he said that in justice to the Authors there appeared to be an error in the dotted line, which should, he thought, be parallel to the lower expenditure line, and therefore rendered the situation less dismal.

159. The figure of 30% given for wasted space in the case of a loco crane appeared high and Mr Shennan suggested that a more realistic figure would be about 15%. Installation of a 20-ton crane in the workshops appeared at first sight to be extravagant, and he would be interested to know its uses.

160. The retention of skilled plant operators, during periods when there was no work for their machines, had always been a problem, but that was mainly a case of economics. If the operator was exceptionally able and adaptable, he was worth retaining even at a fairly high rate of pay. On the other hand, if assured of continuity of employment, he would be content with a reasonable retaining wage. Mr Shennan considered that there was a good case there for the extension of a firm's pension scheme to such valuable members of its organization.

Dr H. Q. Golder (Director, Soil Mechanics Limited) said that on first reading through the Paper he had been inclined to the view that the subject had been treated rather lightly, but had soon realized that the Authors' views merited serious consideration. (A possible exception might be the last paragraph.)

162. He applauded the attention paid by the Authors to the historical development and as a point of detail asked if the large pumping engines mentioned had actually been developed in coal mines, rather than in the Cornish tin mines—as he had always believed.

163. He found particularly attractive the Author's phraseology in § 13 but thought that the machine shown in Fig. 9 was "ponderous" rather than "regal" and that in Fig. 10 was "functional" rather than "elegant". He felt that if, in writing Papers for the Institution, engineers made more spirited use of the resources of the English language, they would do much to enhance the status of the profession.

164. He was surprised that in § 18 the Authors had expressed regret that such developments did not always reproduce the life and reliability to which users of the prototype were accustomed. The Authors were clearly well qualified to do something about it.

165. Compressed air was used in the civil engineering world in two different ways—as a motive force and as a geotechnical process. The references to it in § 23 were a little mixed. He thought that there should be differentiation between the motive force and the process, because quite different plant was needed and the applications were quite different.

166. Turning to § 26 he thought that the statement "the relative simplicity of the processes involved" was a bit sweeping. Road construction was not really a simple operation; it could be most difficult and complex. One of the great difficulties, of course, was that the delivery point for materials was constantly changing; that did not happen in most other civil engineering jobs.

167. Dr Golder objected to the seismic refraction equipment being called "unclassifiable material" in § 28. That was by no means true. Scientific instruments could not be classed as contractors' plant!

168. The Authors had said it was not good to keep specialist plant idle, but Dr Golder said that that was the one thing a specialist contractor had to do. Specialist plant had to lie waiting for the job, because when wanted it was wanted in a hurry—and then, of course, the hirer objected to paying more for it and said that the hire rate was too high; it had to be explained to him that it had been sitting in the depot for months just waiting for his special need, and if he wanted to buy anything like it, it would take him a year to get it—which would be too late!

169. In referring to § 79, he could not help quoting a remark of his one-time chief, Sir Reginald Stradling. In that paragraph the Authors said, "However, it can readily be shown. . . ." He had once used the phrase "It can be shown. . . ." in a report, and Sir Reginald had crossed it out and said, "You must not say that, Golder; it either means that it is obvious or that you do not know how to do it".

170. Finally, in § 104, the Authors said "The computation of depreciation charges is, of course, a financial exercise having no apparent connexion with engineering. . . ." That

was a pearl, a pure gem; having read that, he needed no more convincing that fundamentally the Authors and himself were on the same side. That made the Paper quite worth while to him.

Mr J. W. Hunter (Civil Engineer, Naval Works District, Portsmouth) said that it might be wondered why he, as an Admiralty civil engineer, had intervened in a discussion about plant. In his works district two-thirds of the work was done by direct labour, and consequently there was a plant depot at Portsmouth. It was as the user of plant and the maintainer of it that he was speaking.

172. Referring to § 104, in which the figure of 40 weeks was proposed for the purpose of assessing hire rates, he said that they had three different methods. At Portsmouth plant had to pay for its keep just like any contractor's plant, and plant which they expected to be used throughout the year was charged 52 weeks. Plant which came from their own organization was charged the time it worked. Plant was also drawn from their central depot—either from Inverkeithing in Scotland or from Wantage. Such plant was charged for the time it was out of the central depots. That compelled people to use or return the plant, because they had to pay for it all the time it was on loan—which was a good thing.

173. Plant was bought to do work. There was a slight tendency for plant depots to look upon plant mainly as something that had to be kept in good repair, and, not only that, but the paper work had to be kept right; plant, however, was essentially there to work.

174. Overseas he had found that some plant sent into the establishments had, after it had been there for some years, become very different from plant which had been sent out. In that matter there should not be too rigid control from above, and the engineer on the spot should be able to convert plant in such ways as he found necessary. He had in mind particularly a quarry set-up, where after 3 years in the quarry the rates that were being charged for individual parts of the plant bore little resemblance to the plant in the quarry; but it was good plant, paying for itself.

175. He recalled another instance of plant driven by electricity, originally generated by a combustion engine. That had been overseas, and had been altered to steam-fired plant because it had been found easier to maintain steam plant than to get spare parts for internal combustion engines. Mr Hunter made a plea for steam plant in suitable circumstances even nowadays.

176. When plant was being bought, its long-term use had to be considered as well as its immediate use. He knew of large special plant which had been bought and had worked splendidly on particular jobs, but it had been disposed of because it was not general-purpose plant. It might be said that the general-purpose plant was not good plant, but with an organization such as his large general-purpose plant was often of more use than highly specialized plant. He was thinking of a dredger which he had seen load 1,500 tons in 20 minutes, but had only been suitable where the haul was short and the material was right. What the Admiralty needed was dredging plant which would dredge wherever required.

177. Plant was there to earn its keep. He had found that with certain plant it paid to do things which were mechanically unfair to it; at times it was better, from the economic point of view, to repair the plant afterwards rather than to run it in such a way that it did not get damaged. He had in mind two cases at opposite ends of the scale. When working with an excavator it did not seem to him to matter if lorries were slightly damaged. He had had trouble because inferior lorries had been put under the excavator to save damaging better lorries: that was uneconomic: an excavator paid for the best under it. The other case was a dredger dredging rock. There were several ways in which that could be done. Either break the rock first using a rock-breaker with a 10- or 15-ton ram, or blast it; but often it paid just to dredge it, hit it with the buckets (and, if possible, rock picks) and break it. This might reduce the output of a particular dredger from 50,000 yd/week to 1,000 yd/week, but it was profitable to do that and run the risk of damaging the dredger. There had been another case of dredging rock overseas where that had been the only method of doing the work, and there was no doubt that the dredger had

been damaged, but it had paid to do it that way. When the mechanical engineer had spoken about the clearances in the dredging gear in thousands of an inch, it had been pointed out to him that they were dredging rock and that was the way to do it. The plant maintenance section should not determine the economics of a job.

Mr R. W. Goslin (Civil Engineer, C. E-in-C's Department, H.M. Dockyard, Portsmouth) said that he wished to add some remarks to what Mr Hunter had said and also to give a short description of how a Government Department organization worked as opposed to contractors. Naturally, each dockyard or works district carried the normal equipment—concrete mixers and the general run of things—and then, as Mr Hunter had said, there were two main depots from which they drew specialized equipment. He thought that compared with the contractor who hired plant. Like most contractors, they had difficulties in getting what they wanted at the right time, but generally they managed very well.

179. At Portsmouth, so far as the plant repair side was concerned, they were in rather an advantageous position in that they carried out all their own dredging repairs to twelve or fifteen dredging craft, and consequently they had extra workshop facilities and were able to employ approximately 150 men. They were able to meet the peak periods when plant came in for repair by transferring some of the men from the dredging craft, and *vice versa*, though not to a great extent. The dredging repair section tended to help the plant repair section more than the plant department the dredging repair department. Normally there was a major check on all plant after 1,500 hours and then any necessary major adjustments were made. After 3,000 hours it was completely dismantled and given a major overhaul. These major overhauls were normally carried out at the plant depot at Wantage, but a lot was done at Portsmouth because of the dredging repair organization.

180. Machines on site were checked approximately once a month by having a fitter who travelled round from site to site where the plant was working. He checked the plant and carried out any minor adjustments. Any major adjustments which he considered were wanted he reported back to the plant depot, which then sent out the necessary replacements.

181. Mr Goslin thought that one advantage at Portsmouth over possibly most contractors was on maritime work. Normally more specialized equipment was carried for routine work, such as piling rafts, grab dredgers, hoppers, and barges, in addition to the resources of all the other dockyard departments—the naval constructors' department and the engineering department—which had extensive workshop facilities. There were also such items as floating cranes.

182. Two recent small jobs tended to illustrate his remarks in this respect. The first had been to trench a pipeline across one of the small creeks in the harbour. A bridge restricted the size of craft and the depths on the site were shallow, but the job had been done much more cheaply departmentally than by contract because it had been possible to bring a small dumb-grab dredger from Devonport which would just go under the bridge and grab the trench out. Moreover, the craft had, during slack periods, been employed on normal dredging work which was not a charge to that actual job. The second small job had been the demolition of a dolphin which had a concrete slab weighing 60 to 80 tons, which could not be blasted because it was near one of the armament depots; also it had been undesirable to break it up on site and drop the concrete into the water and then dredge it out. By borrowing a 100-ton floating crane from the engineering department of the dockyard they had been able to sling it, cut the box piles with a burning torch, lift it off and float it to a suitable place, drop it, and dispose of it at leisure.

**** Mr J. G. Barber** (of Messrs Ruston and Hornsby Limited, Engineers, Lincoln) observed that he was especially interested in § 15 because it had always been his understanding that the caterpillar tractor had been originally produced in Great Britain.

**** This and the following contribution were submitted in writing after the closure of the oral discussion.—SEC.**

Examining some early illustrations he had noted that the fore-runner of the tank was the first caterpillar-track machine built at Grantham in 1904; it had been designed by David Roberts, then Managing Director of Richard Hornsby and Sons, and the Company had won a prize of £1,000 offered by the Government in 1905 for a military tractor which would run for 40 miles carrying its own fuel.

Mr C. M. Strachan (Manager, The Northern Civil Engineering and Harbour Construction Company, Limited) remarked that he had long sought a convenient method of arriving at the cost of owning, maintaining, and operating constructional plant; he thought the Author's suggestion in § 107 of stating the costs as a percentage of the capital investment to be excellent.

185. Could the Authors say what figures had been obtained for various types of equipment at present in use.

The Authors, in reply, said that there had been some very interesting comments on the Paper and some very searching questions.

187. The Chairman had spoken of the composition of the plant department for which the Authors were responsible.

188. Having a civil engineer in the plant department had seemed very attractive in theory, and it had worked out very well in fact. They seemed to manage to get through the work, and there was a great deal to be said for having both points of view represented in the plant department.

189. The Chairman had expressed interest in the depot, and it was true to say that he was one of the prime movers in its construction. He had also referred to the height of the construction of the workshop building, and it was true that they had been careful to ensure that adequate headroom was provided. There was a height of 22 ft under the crane rail, and that had been decided upon to enable them to make the highest lift they thought would be needed. There was certainly no reason to regret that height.

190. Before leaving the subject of the depot, he mentioned that the employment of an independent architect to develop the basic layouts prepared by the Authors, had been of the greatest assistance and had saved them a great deal of trouble.

191. Mr Lambert had mentioned the length of the Paper, and it was true that it was very difficult to keep a general Paper on plant down to a specific length. It had originally been longer, but a great deal had been left out of it, by the Institution and by the Authors, before it was printed. He hoped that nothing serious had been lost.

192. Mr Lambert had asked whether the operator was receiving consideration in the matter of simplification of controls. He thought there was a trend towards that now. He was himself a very strong believer in simplified and easy controls and operator comfort, and he would like to see that point of view studied a good deal more by the trade, particularly in the matter of uncomfortable seats and those controls which were what he would call "unsympathetic"—that was, where the operation of the control bore no relation to the result obtained, as when a lever was pulled and something rotated or went up or went down but did not produce the motion of the lever.

193. Mr Lambert had also mentioned the system of inspection described in the Paper, and he admitted that that particular system had come in for some criticism.

194. He knew that Mr Lambert considered that two people were a crowd and could not bear to see two people together at any time. The Authors had found that it was a matter of implementing their decision to have routine inspection of plant on contracts. The only way to ensure that an inspection did take place, was originally to detail two men to do it, so that they could, if necessary, detach one of them for something else of an emergency nature. With widespread commitments such emergencies frequently arose. If originally one man was detailed, it might happen that he might have to be taken off the routine inspection in order to be sent to a crane accident—and then the inspection would never take place. Whether the inspection should take place or not was another matter which Mr Lambert had raised, but it was an entirely different matter.

The Authors thought that inspection should be carried out and to ensure its being carried out, the two men were detailed to do it.

195. As to the remark that the log sheet gave the same information as was obtained by the inspectors, that was to some extent true, but he did not believe that one could reasonably rely on the accuracy of the machine condition and classification from the contracts. The men in general just did not have time to do it with sufficient accuracy to meet the needs of the plant department, and were, moreover, influenced by the fact that they lived with the plant, and had perhaps become accustomed to its shortcomings.

196. The exact cost of an inspection service, as such, was difficult to determine, since inspectors perform other duties not connected with routine inspection. However, there was no reason why the cost should exceed 5% of the total plant department administration costs.

197. With regard to the income and expenditure graph for the excavator, it was true that the income curve was less advantageous after its first major overhaul, but he thought that that was to be expected.

198. On the question of machines coming from the depot after having been "overhauled" with a coat of paint, that was a very old criticism and he did not really think it was justified. It was true that the depots sent out machines nicely painted when they were given time to do so. That was a good advertisement for the company and for the plant department, the machines were almost invariably painted. It was also true that a coat of paint covered a multitude of sins—but he did not think it was true to say that plant ever came in and then went out having just a coat of paint put on it.

199. Mr Pirrie had made a very valuable contribution to the discussion, and had not raised any awkward questions; he had emphasized the Authors' own views on the interdependence of the civil engineer and the mechanical engineer. Mr Pirrie's idea of the information bulletin for internal circulation was an excellent one—the only difficulty about it was to get people to read it. With regard to Mr Pirrie's point about the excavators mentioned in the Paper being restricted to $4\frac{1}{2}$ cu. yd, the Authors had had in mind excavators in general use by contractors. There were, of course, very large walking draglines, but he did not consider them as tools in general use by contractors.

200. Mr Howkins had spoken on the sore question of the return of plant from contracts covered with concrete and mud. Despite Mr Lambert's disclaimer in that respect, he did not think that the jobs were altogether free from blame. He would point out that the cost of applying a coat of paint was covered in the hire rate; the cost of removing a coat of mud or concrete was not.

201. The making of local rulings by factory inspectors was a great nuisance, but he did not know what could be done about it. He did not know if there was any way in which these rulings could be co-ordinated. He did not think there was, because factory inspectors as individuals, had to interpret a set of rules in the way in which they thought best.

202. The question of modifications to plant by manufacturers was a little difficult. If one acquired a piece of plant and found from experience that it needed modifications in certain directions, and took the matter up with the manufacturers, sometimes those modifications were incorporated, but in most cases they were not. He thought that was owing to the difficulty of introducing modifications. There were always a lot of things coming up before a machine got into production, and by the time it went into production the manufacturers were apt to take the line that they wanted to get on with selling it and forget the rest. There was, thus, a sort of mental barrier to modifications, and in a way one could not blame the manufacturers. In any case, the necessity for modification was not always universally agreed among the users, and manufacturers seemed invariably to be able to quote users who found the equipment to be perfectly satisfactory as originally produced.

203. With regard to designing a crane specially in conjunction with the building so that the best use could be made of it, he believed that that was to a certain extent done, but there was a difficulty. If a special crane was to be designed in conjunction with the building, he thought that there would hardly be sufficient time to get it constructed before

the building work started. If there was to be a special crane, it would be the first thing wanted on the site and it would have had to be made in a very short time.

204. Mr Howkins had also referred to the fact that the Paper mentioned the production engineer in conjunction with the depot organization. The Authors' firm proposed to introduce a modified form of work study of unit costs and it was for that purpose that they wanted the production engineer.

205. On the point about the hire rate being based on the premise that the plant would be employed for 40 weeks in the year, it was true that that was not always attained, but to cover that the life period taken in the hire rate was not rigidly adhered to; in fact, the machine almost invariably outlived its theoretical life; so they made up in that way for the fact that the machine did not receive full utilization during its theoretical life.

206. Mr Howkins had suggested that the question of price increases and the provision of money for the replacement of plant might be dealt with by a levy on the profit on works, as distinct from recovering it in the hire rate. He thought it would be a very desirable thing, because there was no way in which price increases could be allowed for in the hire rate. If one allowed for depreciation in the value of money and then that did not happen, the machine priced its owner out of work. He thought that the increased cost of replacement of plant should be provided for in the general funds of the company.

207. Mr Stanier had mentioned that Mowlem's, by tradition, kept their plant a very long time, and that was indeed true. They did not throw away plant merely for the sake of throwing it away. They had a good deal of old plant and quite a lot of new plant; but if old plant was in good order and they could continue to keep it in good order, and if it had not been superseded by something with a very better performance, then obviously they kept it. At that moment they were reconditioning some light electric cranes which had been bought in 1903—and very good cranes they were.

208. As regards repairs by manufacturers, there was no reason why the manufacturers should not do them, and he imagined that many contractors did have plant repaired at the manufacturers' works, but in general he thought that conditions were such that it was difficult for a contractor to put his work out to the trade where all control over priorities were lost.

209. Mr Shennan had mentioned the tendency to ignore older plant, such as tracked plant. This was possibly so. He thought there were still many occasions when the use of light-gauge rail track for civil engineering work could be advantageous.

210. With regard to the matter of materials handling by loco crane, as opposed to a derrick, he thought that the brief comparison given in the Paper by no means exaggerated the advantages of the derrick.

211. The figure of 30% for wasted space with a loco crane, or indeed for a mobile crane, was, in fact, correct, and moreover, that took no account of the load limitations at any significant radius for those cranes.

212. If load limitations were considered and the area commanded by the crane was restricted to that within the full load radius, the space wasted by the crane amounted to 62% of the total area.

213. Mr Shennan referred to the use of short wave radio, and experience had shown the value of that equipment on marine work. However, he questioned the necessity on the grounds mentioned by Mr Shennan, for its use on road work, at least, if the road work under reference was within the U.K. The uses of a 20-ton crane in the workshops was primarily for excavator repair work, which involved handling bulky and heavy single units, such as the carriage and the swivel.

214. Dr Golder had suggested that the last paragraph of the Paper did not merit serious consideration. It was not, in fact, meant to be taken too seriously, but the prediction had been made in America and the Authors were not sure if it had been made seriously.

215. The old steam pumping engines may possibly have developed from the necessity to drain tin mines, but were certainly used for colliery drainage at a very early stage. The first application of a Newcomen engine to that work was said to have been *circa* 1712.

216. Dr Golder had also mentioned the attractive phraseology of the Paper. He was

glad that Dr Golder had found it so. The Authors had been to some trouble in that respect, as they shared his views on the use of the resources of the English language.

217. Dr Golder objected to the listing of seismic refraction gear as plant, and pointed out that it was a scientific instrument. He would gladly accept that objection. His knowledge of the seismic refraction process was limited, but he had felt sure, at least, that if any trouble developed with the equipment, plant department would be expected to do something about it.

218. He was not aware of Dr Golder's encounter with Sir Reginald Stradling, but he was encouraged that an engineer of such eminence as Dr Golder had not scorned the possibilities of the expression "It can be shown . . .". As for the kind remark about the phrase which the Authors had used about depreciation, if Dr Golder liked he would show him the original MS. which was very much better.

219. Mr Hunter and Mr Goslin had made some very interesting remarks on the methods employed by the Admiralty. Although he appreciated that the Admiralty doubtless had good reason to own such things as dredgers and heavy floating craft, he would have thought that they would have found it much more economical to hire light plant, such as concrete mixers, and the like.

220. In conclusion, it was obviously in everyone's interest to make the greatest possible use of plant, but, on the other hand, there were other factors in it which could not be disregarded. Mr McGibbon then showed a slide to illustrate the fallacy of too much mechanization. It showed the famous machine designed by Emmett to do the work of three men and a boy, and if one looked closely, one saw that it required three men and a boy to operate it.

221. Mr Barber had commented upon the origin of the tracklaying tractor.

222. The "Caterpillar" tractor was illustrated because it represented a long period of continuous development, and it was not intended to infer that Benjamin Holt was the first and true inventor of the tracklaying system. That invention could, in fact, be credited to an Englishman—a patent clearly describing the tracklaying system was granted to Richard Edgeworth in 1770.

223. However, American inventors could claim the first invention which recognized that the machine could be steered by varying the relative speeds of the tracks. That patent was granted in 1859, and described a machine in which each track was independently driven.

224. That was of topical interest, since that feature had been recently re-introduced in the Euclid twin power crawler tractor.

225. Mr Strachan had commented on the method of relating costs to the capital value of the equipment.

226. On the question of repair cost percentages for various types of equipment, the figures used by the Authors were obtained from records, and were thus related to a specific system of costing. There might be some risk of error if those figures were applied to another system in which different cost elements might be embodied, so that the Authors asked to be excused from quoting such figures.

The closing date for correspondence on this Paper was 15 May, 1957. No contribution received after that date will be printed in the Proceedings.—Sec.