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The mechanization of railway civil engineering maintenance work†

by

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and

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Discussion

Mr C. W. King (Chief Civil Engineer, British Transport Commission) said that the Authors had rightly set down in the synopsis to the Paper the factors which conditioned maintenance work on British Railways, and it seemed not inappropriate to emphasize the paramount future necessity, as overhead electrification and signalling proceeded, of ascertaining that so far as possible movement space for plant was reserved.

79. In §§ 1 and 2 the Authors had set out concisely the advantages which accrued from mechanization, and Mr King commended to members' study the order in which they had been set.

80. It was important to realize that direct maintenance savings did not always accrue from the acquisition of mechanical plant. On occasions proposals for mechanical plant had been supported by the argument, "This machine will save the wages of twenty men and, the wages of twenty men for a year being so much, we shall save that amount of money". In point of fact, the District Engineer probably had not the twenty men to start with and, if he had, he probably transferred them to the repair of sidings or some similar work; the Commission therefore did not save at the time by acquiring the machinery! The Authors had gone on to show the trend in costs which resulted from pursuing over a long period a policy of employing mechanical plant concurrently with the doing of a number of other things.

81. Mr King was pleased to observe that the Authors had emphasized the great difficulty in separating the different constituents, for it had helped him when trying to explain to the Commission that they could not hope to sort out these things, but that in looking at the overall picture there was not the slightest doubt that what was being done was paying a worth-while dividend. The manpower figures, showing the number of men used to maintain and relay track on the railways, spoke for themselves.

82. When he had seen the most interesting figures produced by the North Eastern Region, he had felt it incumbent to see whether anything similar was being achieved by British Railways as a whole. His figures did not go back to the beginning of the period which Mr Dean had covered, but they were overall figures from 1954–58. Mr King had also plotted Mr Dean's figures, given to him at Headquarters, to make sure that his plotting was right!

83. The figures had agreed remarkably well. Although it did not reach the same aggregate as the Authors had shown, nor did it begin as early, the same trend could be seen from 1950 onwards, and Mr King was prepared to concede to the North Eastern Region that they were not behind other Regions in the development of mechanical plant. The figures for the cost of ballasting were extremely interesting. He had been unable to make a comparison here, because his figures for ballasting had not been separated from

† Proc. Instn civ. Engrs, vol. 14, p. 205 (Oct. 1959).

the overall figures. He hoped, nevertheless, that the results set down in the Paper would be noted by other Regions, because ballasting would be an important aspect of the work in the next few years and it would be worth while to watch the cost of it.

84. Mr King hoped that the question, "Where are we going next in the use of mechanical plant, and what do we hope to get out of it?" would be dealt with at the discussion. He was finding it increasingly difficult to predict the savings to be sought against the cost of new forms of track or of expensive equipment. He thought that further savings would accrue as a result of using long-welded rails and concrete sleepers. There were two pointers to that in the Paper.

85. § 24 had referred to the likelihood of the re-deployment of labour in the future. He was a little disappointed that Mr Dean had not been able to put an earlier date to when that might have a big effect. He had referred to the necessity to keep men on lengths for fog signalling and snow clearance, but surely as colour-light signalling spread, if only to distant signals, the necessity for fogmen would disappear fairly soon on many miles of railway. Even in Great Britain snow did not fall throughout the year, and presumably labour could be deployed to meet the need during the seasons when it was expected.

86. It was now necessary to take an entirely new look at relaying. There had been a suggestion of laying in 2½-mile stretches, but Mr King thought the authorities should go even further than that, and if anyone had to justify it, he was prepared to make the attempt. Unless it was possible to get in quickly long stretches of the new type of track, it would be a long time before British Railways began to get their money back. Moreover, with the arrangement of plant which had been illustrated by a number of slides, and which was also being developed in other Regions to suit train-operating conditions in them, it would appear that the best could be got out of it and the job could be done most cheaply if the plant was employed continuously for long stretches. He had in mind stretches up to 10 miles between one junction and the next, as a preplanned operation, with alterations to train time-tables and, as a sop to the operating people, an undertaking that once a stretch had been finished it would not be necessary to go back to that section of line for a further 3 or 4 years.

87. In Mr King's opinion the Paper would be a stimulant to thought for the future of engineering maintenance and for the development of new equipment to meet new circumstances.

Mr M. G. R. Smith (Chief Civil Engineer, Western Region, British Railways) pointed out that in Great Britain the railway civil engineer had had to do his own work very largely on the acquisition of plant for his department's use, which frequently involved adaptation of a standard type of machine. In America the reverse was the case, and he imagined that railway civil engineers there had to develop a considerable sales resistance to avoid buying far too much. In France, where so much work could be done by contract because of the lower traffic density, the situation of the railway engineer was much easier, because the contractor had to have in stock all the equipment.

89. Mr Smith then gave figures which indicated savings to the Western Region on the relaying of plain line, and which were recently aided significantly by the introduction of work study and payment-by-results. In 1946, the labour cost per mile for the whole year's new plain-line relaying—149 miles—was £1,318 which, at the 1958 wages rates, would have been £2,430. In 1958 the labour cost per mile for the whole year's new plain-line relaying, excluding tunnels, water troughs, and items under 10 chains long, was: manual, 67 miles at £2,000/mile; mechanized, 68 miles at £1,520/mile. This saving of £480/mile was offset by additional charges of £30 for plant and £20 for engine power giving, due to mechanization, a net saving of £430 per mile.

90. With regard to the effect of the introduction of work study and payment-by-results, in one district, where the gangs still comprised twenty-five men, the labour costs per mile were: manual, £1,920; and mechanized, £1,440; thus, the costs were falling. In another, where the gangs were down to nineteen men for relaying, the mechanized cost was £1,300/mile, and was still falling steadily.

91. Thus, from ordinary manual relaying at £2,000/mile, with full mechanization, work study, and payment-by-results, the figure for labour costs could be reduced to £1,300, offset by £50/mile for machine costs and additional engine power. Those labour costs were complete and included pre-assembly and all other depot costs.

92. Would the Authors say whether the figures in Table 4 included point-and-crossing work as well as plain line?

93. The length of items also had an effect on the cost per mile. In 1958 the average length of items was: manual, 33 chains; and mechanized, 54 chains. Those figures again excluded tunnels, water troughs, and items under 10 chains. The need, as stated in the Paper, was to increase the length of items in order to reduce the costs per mile.

94. If the total length of new plain-line relaying carried out in 1958 had been fully mechanized under work-study and payment-by-results conditions, and if it had been in items 1 mile long, the labour cost of the year's work would have been reduced by £65,000. That would have been impracticable, of course, but it showed the importance of mechanization, work-study, and payment-by-results and lengthening items towards 1 mile. To go beyond 1 mile under present arrangements on the Western Region would probably increase the cost per mile. Perhaps there could be savings up to 1½ miles, but with the conditions in Western Region the costs per mile were inclined to rise above that distance.

95. The lengthening of items for relaying in future inevitably involved the premature relaying of some track, and would lengthen the extent of temporary restrictions of speed, but there was reason to believe that from an operating aspect it was better to have 1 mile of track restricted at one time than to have two separate restrictions of ½ mile each in successive weeks.

96. Referring to Fig. 7, Mr Smith would ask the Authors whether "about 20 days" was the normal duration for temporary restriction of speed on a relaying item 1 mile long; in his opinion that seemed a rather long time. From Fig. 7 it appeared to be about 20 days.

97. To assist in reducing the effect of the occupations or possessions of lines during the relaying operation, which nearly always took place on a Sunday, great benefit would be derived if a machine could be developed which would require to occupy only the line being relaid. At present the twin jib crane used for mechanized relaying had to work on the line adjoining that to be relaid, thus closing both lines, at any rate for a period. There were prospects that such a machine could be produced which would lay new track in 60-ft lengths with timber or concrete sleepers curved to the required radius.

98. A development contract had been, or was being, drawn up with the makers, and if the machine proved capable of its expected performance it would indeed be a helpful addition to the railway civil engineer's plant.

Mr A. K. Terris (Chief Civil Engineer, Eastern Region, British Railways) said that in all questions to the user of plant, particularly of the "on track" kind, there should be at least two objectives continually in mind:—

- (1) to produce out of a renewal of track item, or other associated programme track work, a permanent way of the kind now understood as modern, i.e. track which would be suitable for the speeds and forms of traction of the future, and
- (2) to accomplish that task with the maximum of efficiency and the minimum time of possession, and therefore interference with traffic.

100. A complete realization of those objectives was not so very far off. Ballast cleaners, or ballast shifters as he preferred to call them sometimes, mechanical drain-making machines, ballast hoppers and mechanical tampers, and, of course, single-line track-laying Morris machines, were all available. The only machine that could be improved on meanwhile was the Morris which, good as it was, and although in the 1930s it could lay track as cheaply as by manual means, did not provide the speed of operation which a machine of that kind must produce if it were to meet present-day requirements.

101. An attempt had been made on the Eastern Region to develop such a machine which would be an improvement on the speed of operation and could operate in all circumstances. When the project had reached a very advanced stage, it had been discovered that the design had certain limitations regarding first cost, and the amount of track that could be dealt with at one time. Consequently, development had been held up because other machines were becoming available that would probably prove more satisfactory under those headings and, moreover, which would make use of an installation procedure for long-welded rails.

102. When the single-line track-laying machine of the type required became available, and as and when facing cross-overs were installed in the appropriate places under the modernization plan, the stage would be reached when the operating department would say to the civil engineer: "You can have complete possession of one of these tracks for the time required to do this job as efficiently as you would wish." That era was not very far away, said Mr Terris, and to substantiate his statement, he pointed out that the railways in Great Britain were about the only railway administration in the world where the present pattern of week-end and Sunday working existed.

103. Having reached the stage when modernization had been effected by the plant available, he thought, nevertheless, that all such plant as single-line track-layers would not be part of the *modus operandi* for renewals in the future. As welded rails and concrete or hardwood sleepers were installed, whichever were preferred, the method of renewal would be by rerailling in long stretches and spot sleepers as required.

104. He also agreed with the Authors that the pattern of day-to-day maintenance work would change rapidly during the next decade or so, and the deployment of the labour force would be completely different under incentive bonus procedures. Routine maintenance of the more heavily-worked lines was likely to remain mainly manual, while on the lightly-worked traffic lines it would be almost entirely mechanized. Mr King had perhaps been thinking along the same lines!

105. Because of the charts which the Authors had produced, it was possible to take heart at what railway engineers were achieving.

106. It was very difficult, however, to assess how much machinery should be held in stock, and what the maintenance arrangements of such plant should be. Even though this could be documented and costed, it remained a problem to fully justify the holding of plant which might, or might not, have sufficient continuity of use.

107. It was always to be remembered that on their various doorsteps in the Regions there was sufficient plant for immediate hire. On the Eastern Region, where much modernization work had been in progress, a good proportion of the plant, other than "on track" plant, engaged on the permanent way works and that being used by contractors, had been obtained by hire.

108. The cost of such hire had been about £250,000 a year; if capitalized, that charge represented about £1½ million of plant investment. There was a financial problem, therefore, in deciding how much plant should be held in Regional ownership, and how much could well be obtained, with advantage, from other sources.

Mr A. N. Butland (Chief Civil Engineer, London Midland Region, British Railways) said he was particularly pleased that the work of the engineers' department had been recognized as the work of people, and that due regard had been paid to the training and encouragement of staff. He was also glad that reference had been made to traditional differences which governed so much the form of development that should take place in any Region.

110. For example, he knew that the L.N.E.R. had been generous in the provision of plant in shops, including metal-working machinery as well as wood-working machinery. That had brought with it a generation of men competent to use lathes and shaping and planing machines, and competent to build some of the prototypes—and certainly to do the plant maintenance which was so essential to a lively plant department.

111. Similarly, he knew that at York, with generations of ash underneath most of the line, there was an ideal cushion for the new top ballast, and therefore the proportion of

blanketing work which would have to be done in conjunction with rebalasting would vary between other Regions. He was sure that Mr Dean would agree. Similarly, the question of possession varied from Region to Region, and would probably vary from year to year. At present Mr Butland was able to get on to an important line for 4 hours per night for the use of tamping machines, and in those 4 hours a $\frac{1}{2}$ mile of tamping was being done. If the railways were to get and hold the additional traffic which was to be the end product of the modernization, he would probably lose his 4 hours' possession.

112. Speaking for himself and his Region, Mr Butland stressed that two points on plant must be studied carefully. First, what could a machine do? Secondly, what must a machine do?

113. In the London Midland Region they were tamping with a machine of hydraulic operation from which they were getting $2\frac{1}{2}$ miles of tamping in 24 hours' possession at the week-end, going off the line quite frequently. At night they did a $\frac{1}{2}$ mile in a 4-hour period. They had developed the ability to do squeeze tamping. That was done by operators correcting the cant and lifting the track by a small degree, determined by means of sighting boards, and without the use of jacks. Bearing in mind the Western Region's development work on the frictional resistance of ballast against buckling, the London Midland Region had had an additional tamper built on to the machine to tamp the boxing ballast between sleepers. Economies would be made by getting rid of the jacks altogether, and providing a machine capable of lifting track to any predetermined height. Contact would be made with a wire stretched between two high points, using a 24-volt current and a servo. That would hold the equipment up while every fifth sleeper was tamped. A pendulum mechanism could be added so that the driver could see the cant while he was tamping. There was every hope that ultimately, instead of having individual machines working ahead of the tamper unit, everything would be built into the tamping machine itself. Tamping would then be done not as a follow-up of two frames and an intermediate machine, but as one machine with simply two high points. That showed that by studying carefully what a machine could do, one could get out of it more than was at first realized. It had certainly surprised him to find that a man could correct the cant without getting out of the machine. But he wanted to get rid of operator judgement.

114. Engineers must specify exactly what a machine should do. He had found that at present the ballast cleaners were a source of trouble in maintenance. They were dependent on other people and were having frequent breakdowns. This led Mr Butland to think that instead of using the European market so much, they should get down to specifying exactly what they wanted their machines to do, and should then go out to a world-wide tender for precisely what they were prepared to accept.

115. They had also developed a small ballast cleaner for shoulder ballast cleaning. It would be capable of dealing with the minor digs for minor drainage channels close to the ballast shoulder to about 2 ft 6 in. below the rail level, as well as cleaning shoulder ballast. That would be the next work to follow the big under-track ballast cleaner. The machine had two of the digging units, one on either side. The ballast was screened and dropped through the hopper, and the waste taken away.

Mr A. H. Cantrell (Chief Civil Engineer, Southern Region, British Railways) found difficulty in understanding Table 3, and although Mr Dean's explanation in his first slide had been helpful, he hoped that the Authors, in their reply, would explain it more fully. Certain figures ran down the column headed 1951. Under 1952 there was the addition of hopper ballast wagons and mechanical plant, but it did not seem that the equipment charge in the section reflected all that expenditure, since a smaller figure was given than that shown for 1951.

117. While appreciating that further mechanization was bound to govern railway maintenance, there were still great difficulties to overcome. On the Southern Region especially, possessions were very short, so that it was difficult to find time for putting big plant on to the track. The plant, though most efficient, needed longer possessions. It would be necessary to persuade their colleagues in the Traffic Department to grant

longer occupations of the track. That was a difficult problem for both the Engineer's and Traffic Departments, and if full use was to be gained from increased mechanization, a longer length of time would have to be obtained.

118. On the Southern Region there was a plant-maintenance organization within the Civil Engineering Department which was working extremely well. A Central Maintenance Depot was situated in London, where the major overhauls are carried out, and it was not usually necessary to send equipment to the makers.

119. A routine maintenance organization existed on the Districts where an establishment of inspectors and fitters was employed for carrying out regular inspections and minor maintenance work. It was so designed that the plant remained in action, and with such planned preventive maintenance, a piece of plant seldom had to be taken into the Shops for repairs, except at the time of its major overhaul.

120. For any piece of plant valued at more than £5,000, the operators were graded fitters. By arranging for someone to drive the plant and also know it inside out, better performance was obtained. If slight trouble occurred during a possession of the track at night, the fitter could usually put it right himself.

121. He was not sure what was the ultimate aim of the training of technical staff, as shown in the Paper. He appreciated that it was essential on a Civil Engineer's staff to have someone with a considerable knowledge of mechanical plant: that was necessary in the Districts as well as at Head Office. He was not sure, however, where the training which had evidently been started on the North Eastern Region would eventually lead the men. After 4 years' training, the men's final job might be a dead end and there would not be many posts of a sufficient calibre to attract staff. Could Mr Dean elaborate on that?

Mr P. S. A. Berridge (Assistant Engineer (Bridges), Western Region, British Railways), referring to the Authors' contention that the term "maintenance work" included the complete replacement of assets, pointed out that there was no mention in the Paper of equipment for bridge-erection work. That was particularly unfortunate as the existing practice of using heavy, slow, and cumbersome breakdown cranes was wasteful in both time and money.

123. The electrification programme might force the issue, since it was not going to be easy to work jib cranes below the overhead conductors. In 1927, when the North Western Railway (India) had bought two 25-ton bridge-erecting cranes for work on the new 308-ft spans of the Attock bridge¹, care had been taken to specify that each of those cranes should be capable of erecting a 40-ft plate-girder span, weighing 12 tons, ahead of itself.

124. Mr Berridge showed a film of such an operation on a single line of 5-ft 6-in. gauge railway, where the work had been completed well within a 3-hour occupation. It was perhaps significant that on the Indian railway there was no different time-table for Sunday working, and no pay incentive to make long occupations attractive. The film also showed one of those cranes in use with a 70-ft-long jib driving piles for a bent some 45 ft ahead, ready for placing a 40-ft span in position with the other crane equipped with the maker's shorter jib. He did not suggest that the type of crane used on the North Western Railway was wanted on British Railways, but the film demonstrated the greater efficiency resulting from the use of equipment specially built for a particular work and in the hands of the engineers doing the job.

Mr J. D. West (Assistant Engineer (Bridges), Eastern Region, British Railways) pointed out that there were many approaches to the problem of single-line relaying, and lifting and transporting devices could be of the simplest kind, but for the railways of Great Britain the limitations of the loading gauge in relation to the size of the track

¹ References 1 and 2 are given on p. 218.

components, in particular the length of sleepers, presented an effective barrier to many ideas.

126. Basically, a track-laying train must have a good route availability in the matter of clearances and axle weights. It should be capable of laying at least ten 60-ft lengths of track per hour, and be equipped to dispose of the old track as it was lifted. It should handle bull-head or flat-bottom rail in combination with timber or concrete sleepers and, within the loading gauge, operate on curves of 25-chains radius and accept a cant of about 4 in., also without interference with the overhead equipment on electrified lines, where that applied.

127. Fig. 15 showed in perspective a proposal that had been developed in some detail, in the essentials of the design, for a machine which would measure up well to the requirements outlined. The nucleus of the machine was a bogie vehicle which would straddle a 60-ft section of track to be relaid. The superstructure of this vehicle formed a tunnel longitudinally for the accommodation and operation of a travelling beam. The reciprocating motion of the beam was effected by an electrically-operated winch, and hoisting ropes were provided for the raising and lowering of sections of track in such a manner that one length each of old and new track could be lifted and transposed simultaneously from the track to the relaying train, and *vice versa*.

128. When relaying track on a curve, so that the sections of track in transit on the travelling beam might follow a curved path within the loading gauge, the extremities of the travelling beam were so arranged that they would impart a slewing movement transversely to the curvature of the track and thereby compensate for "throw".

129. It was intended that lifting bails should be hydraulically operated to avoid the necessity for slingers to climb on to the vehicles.

130. The relaying unit which was located in the centre of the relaying train, was fed by two trolleys operated from the centre, which were remotely controlled in respect of lifting and moving operations.

131. The total length of track which might be accommodated on the relaying train was important to the relaying operation. It was limited by the length of siding accommodation and overall weight of the train from the point of view of motive power. It seemed that up to $\frac{3}{4}$ mile of timbered sleeper track could be carried, although the requirement might be $\frac{3}{4}$ mile only in areas of intensive traffic.

132. With concrete sleepers it was necessary, because of increased thickness, to reduce by one the number of tiers carried, and the relative figures would then be $\frac{1}{2}$ mile and rather less than $\frac{3}{4}$ mile, respectively.

133. This might prove restrictive when compared with the more generous loading conditions, which, obtained with crane relaying under double-line occupation, where a considerable length of the material train was not taken up with a relaying unit, as must be the case with a single-line system.

Colonel D. McMullen (Inspecting Officer Railways, Ministry of Transport) said that while the cost of the maintenance and relaying of the permanent way had gradually been declining, it was satisfactory to know that the incidence of train accidents as a result of defective permanent way had also been declining in the comparable period. Brigadier Langley* had issued a report² that day, which showed that although the number of accidents on account of track defects was slightly higher last year, that was not indicative of a general trend which was, in fact, downwards.

135. Colonel McMullen had been interested to hear about staff training in the correct and efficient operation of the machines referred to. He pleaded that in this training men should also be taught to look after themselves. The machines were nasty looking animals and potentially dangerous to human beings, and anything which could be done to impress on men the importance of not causing accidents to themselves would be all to the good.

* Chief Inspecting Officer (Railways), Ministry of Transport.

136. In that connexion, he pointed to the problems of overhead electrification. It had been said that that would restrict the use of cranes, but it must also restrict the movement of men. If the man shown in Mr West's film had been aloft on that machine on a line where there was 25-kV overhead electrification, he would not have been long aloft!

137. There had been more accidents in 1959 than for many years, through engineers on steam engines being electrocuted by overhead contact wires, and special meetings on the subject had been held with the British Transport Commission and the Unions. It was also a problem for the civil engineer. It was necessary to impress on men that not only must they not touch the 25-kV lines, but they must get nowhere near them.

Mr A. G. Ticehurst (Plant and Machinery Assistant to the Chief Civil Engineer, British Railways, Western Region) said that any mechanization scheme was only as good as the staff that ran it, and it was to be noted that the Authors had a training scheme on the North Eastern Region. Such a scheme as that described covered new intake, but it might also cover older hands—established staff that had been using the plant for a long time. It was necessary to keep them up to scratch.

139. The trouble was that with the present labour turnover the education and instruction of staff was a continuous operation. From week to week one was telling men something which all their mates had been told during the previous weeks. This made it an arduous task and left loopholes in the training curriculum. There might be trouble through the ignorance of the operator causing injury to himself or others.

140. The changeover in plant also made it difficult for District Engineers and Chief Civil Engineers to hold together even a nucleus of proficient people. The railways staff scheme did not lend itself to holding together a strong and proficient body of specialists—and all plant people must be specialists. They must not only be thoroughly trained, but must also be given incentives to remain on the job and to use their training and experience to the best advantage.

141. Even if that were attained, what about promotion? It was a question of waiting for some unexpected vacancy or for dead men's shoes. Once having attained a certain grade, with the necessary proficiency, the plant people were likely to stay in it. Mr King had asked: "Where do we go from here with plant?" Another question was: "Where do we go from here with the staff?"

Mr Dean, in reply, referred to the observations made by Mr King, and said that the trend in the magnitude of the whole labour force on the North Eastern Region, when related to the trend in the whole wages costs involved in track maintenance and renewal, provided clear evidence of an intimate relation between the two, providing adequate confirmation that the reduction in labour force being achieved was in fact real. Mr Dean confirmed the desirability of carrying out re-laying in long sections of up to 10 miles, even though a substantial proportion of such long lengths might not in the first place be quite due for renewal. If pursued carefully and with due regard to the availability of sites for the re-use of good-quality recovered material, such a future pattern of renewals as Mr King suggested could be attained.

143. Mr Dean indicated that from his experience within the normal range of traffic facilities which were obtainable for the carrying out of track renewals, minimum cost was achieved with renewal sections of about 1 mile in extent. With certain (at present) abnormal traffic facilities, he had evidence that up to lengths of, say, 5 miles, the unit cost could be less than the cost of carrying out five separate renewal sections each of 1 mile.

144. Referring to the figures quoted by Mr Smith as to the relative costs of carrying out track renewals by hand and by mechanization, Mr Dean indicated that the costs recorded on the North Eastern Region last year were very similar to those quoted by Mr Smith. An average difference in wages cost as between renewals carried out by hand and by mechanized means was recorded as about £600/mile, while there was an increase in the cost of equipment utilization of about £100/mile. An anticipated saving

FIG. 15.—RE-LAYING UNIT

of £200/mile, arising from the use of cranes for pre-assembled track-renewal work, was sufficient to justify the provision of such cranes for this work.

145. Commenting further on the contributions made to the savings set out in the Paper by the utilization of mechanical equipment, Mr Dean indicated that in his view efficient utilization of ballast hopper wagons, together with the increasing use of the cheap ballast drag ploughs, probably made the biggest contribution to the economies achieved.

146. Commenting on Mr Berridge's plea that expensive cranes should be held by the civil engineering departments for bridge-renewal work rather than that motive-power-department cranes should be used from time to time on this work, Mr Dean indicated doubt as to the economic justifiability of pursuing such a course. He expressed the view that if the whole costs of such special cranes were charged out on a proper utilization basis, it would most likely be found, despite the relatively high charges made for the utilization of motive-power-department cranes, that the provision of such special cranes could not be justified.

147. Mr Dean welcomed the observations made by Colonel McMullen, and confirmed his awareness of the need to inculcate within staff training, a keen appreciation towards safety precautions.

148. Commenting on the future, arising out of the implications and developments in the present, Mr Dean foresaw that with the wider use of hardwood timber, and particularly of prestressed concrete sleepers, in track construction, spot changing of deteriorated sleepers, and continuous re-railing carried out as required, section by section rather than complete renewal, would become the standard practice for the future.

149. Looking ahead to the time when extensive milages of primary line would be subject to the limitation of a continuous overhead electric traction distribution wire, but with tracks well ballasted, Mr Dean foresaw the need for suitable mechanical equipment for the maintenance of the track ballast bed and for the periodic lowering of the level of the track as a starting point for a further period of normal track-maintenance practice. It was with this in mind that the "six-foot and shoulder ballast-removal and cleaning machine", referred to in the Paper, was being developed. In association with the use of the ballast drag plough, Mr Dean was satisfied that mechanical means would thereby be available to meet the more restrictive conditions of the future.

The Authors, in a joint reply, dealt first with Mr King's observation regarding the re-deployment of labour in the future. There was no doubt that the more widespread introduction of colour-light signalling would progressively reduce the demand for widely dispersed permanent-way staff to fulfil hand-signalling duties. The extension of modern signalling did, however, often result in the elimination of local signalboxes, so that unless there was widespread provision of switch heating installations (either automatically controlled or controlled from a distance), adequate manpower would have to be available to secure the free working of switches, particularly under conditions of heavy snow-fall. Furthermore, drastic changes in the organization and deployment of permanent-way manning could not be effected within a short period of time. It must remain a long-term aim, with a recruitment location aspect pursued over a period of years to secure a gradual concentration of permanent-way maintenance manning focusing on a limited number of geographical centres.

151. In reply to Mr Smith's question as to whether or not the figures in Table 4 included for renewals of point-and-crossing work as well as plain line, the answer was in the affirmative. The figures tabled in the Paper related to the whole renewal work of the Region for renewals carried out in new and serviceable material and covering plain-line and point-and-crossing renewals. Periods of speed restriction relating to renewal of plain line only were appreciably less on the average per mile than the figures tabled in the Paper.

152. Mr Butland was correct in his appraisal that the use of ash ballast over a prolonged period on many of the lines within the North Eastern Region had probably

reduced the trouble arising from clay formations, thereby reducing the need for carrying out deep track blanketing works.

153. Regarding the observations made by Mr Cantrell on the figures set out in Table 3*, the Authors agreed that further explanation was desirable. The figures set out within the section of that Table designated "1951 cost per 100,000 tons" showed the uplift, year by year, reflecting the increasing unit cost of wages, engine power, etc., in the cost of execution, with the same labour force and equipment utilization as required in 1951, appropriate to each of the succeeding years tabulated. If it was appreciated that all the yearly costs from 1952 onwards, as tabulated, reflected a better utilization of labour, engine power, equipment, and hopper wagons per 100,000 tons, the reduction in certain figures to which Mr Cantrell referred was clearly a reflection of better utilization.

154. In reply to Mr Cantrell's reference to the ultimate aim of the training of technical staff, with particular regard to the maintenance and utilization of mechanical equipment, the Authors indicated that the whole training of those men covered a much wider field in relation to the civil engineering work of the department than just that of mechanical equipment. Their place within the future organization would be such that they would be intimately concerned with the detailed pre-planning of works primarily involving the use of mechanical equipment and in the organization of such works, and the briefing of operatives who would be concerned with their execution.

REFERENCES

1. W. T. Everall, "The reconstruction of the Attock Bridge across the River Indus on the North Western Railway, India". *Min. Proc. Instn civ. Engrs*, vol. 230 (1929-30), p. 234.
2. C. A. Langley, "Report to the Ministry of Transport on the accidents which occurred on the railways of Great Britain during 1958". H.M.S.O. (Nov. 1959).

* In presenting the Paper Mr Dean had pointed out the following corrections:—

In Table 3, under 1951, the figure £15,200 should read £16,200.

In Table 4, under 1952, the figure £239,900 should read £234,900.

On p. 214 in the text relating to "Real cost trend—reballasting and packing of track", it would be more accurate if the wording were "Reballasting and mechanical packing of track".