Discussion.

The Author introduced the Paper with the aid of a series of lantern slides. He observed that the standard of track which would result from the application of the procedure contained in Table I was high, but it was recognized that, desirable as it was to attain that standard, some slight amendment of the procedure might be necessary in the light of future experience.

Serviceable rails weighing 87 lb. per yard were regarded as the equivalent of new 85-lb. rails, and that explained the reference to that weight of rail made in Table I, under " material to be used " for renewals in secondary lines.

With regard to the renewal of rails on the score of age, a series of tup tests had been made recently on pieces cut from rails which had been in the East Coast main line for more than 25 years. That type of test was severe, and might be regarded as something of a safety-valve, but other considerations, as for example, chemical analysis of the rail steel, would require to be taken into consideration to complete any investigation into the question of age at which rails should be removed from the track. Nevertheless, although the scope of the tests was limited, the results had suggested that the stipulated life of 25 years was on the conservative side, under normal conditions of traffic.

Of the 12,000 running-miles of single track on the system, 45 per cent. were classified as primary, 34 per cent. as secondary, and 21 per cent. as tertiary. Some goods lines were included in all three classifications, approximately 68 miles of track in goods lines being included under the primary classification.

The system of track marking which was carried out throughout the London and North Eastern Railway was of undoubted value in relation to the question of renewals. The District Engineer, his Assistant, or his Chief Permanent-Way Inspector marked in detail each length on the district at least once a year. By that means the District Engineer was able to keep a close watch, not only upon the general standard of maintenance, but also upon the condition of the materials in the track on each length. Reference to his notes on the marking sheets enabled him to check up on the proposals put forward by the Permanent-Way Inspectors and ensured that track which should be proposed for renewal was not overlooked.

The Chairman said that there could be no doubt about the value of having so comprehensive a record of the practice of the London and North Eastern Railway with regard to the renewal of permanent way. The general principle was similar on most railways, although all differed in minor respects. The Paper might cause those responsible for permanent

way renewal on other railways to review their own procedure, and an interchange of ideas on the subject would be very helpful.

Mr. L. G. B. Rock observed that the use of the new 85-lb. rails depended upon the availability of serviceable second-hand rails from the relaying of main lines, and it was therefore a question of establishing a balance between what was released from such renewal and the needs of secondary lines. On the Southern Railway primary lines were in the majority and sufficient serviceable 95-lb. rails were recovered for the renewal of the secondary lines, so that the use of new 85-lb. rails was not found necessary.

The particulars to be given on the proposal form used by the Southern Railway followed, in general principle, those on the L.N.E.R. form, but the Southern Railway found it very useful to introduce a small key diagram showing the location of plain line work, in relation to mile-posts and curvature, and of the switches and crossing in relation to adjoining connexions, particularly in a busy yard. That facilitated inspection for anyone who had not been actually concerned with the preparation of the recommendation itself.

Mr. Rock agreed that accuracy was particularly needed in rail weighing, in cases where test-rails were under observation. Since, however, within a given length recommended for renewal, rails varied quite considerably, he felt that the prime need was for a means of obtaining rapidly a general assessment of the section of the rail at as many places as possible along the length recommended. The practice on the Southern Railway was to take a large number of calliper measurements throughout and also to check the degree of side wear, which, for uniformity of practice, was classified in three categories, namely, " slight," " medium," and " heavy." That was regarded as a sufficient degree of accuracy with which to describe the rail, from the point of view of its section, for the purpose in question.

The Southern Railway turned out eighteen sleepers per ½ mile for inspection, as a general rule, but did not normally turn out the chairs and fastenings.

The inspection by the Area Engineer, or his Assistant for Maintenance, certainly ensured uniformity of assessment of the standard for renewal and enabled the Area Engineer (or the Maintenance Engineer, in the case of the Southern Railway) to obtain a fair general picture of the condition of the track over the whole system.

With regard to *Fig. 9*, there were apparently three cases in which a length of between 4,200 yards and 4,500 yards had called for a speed-restriction lasting only two weeks. Mr. Rock assumed that the work had been done by the crane renewal method, with pre-assembled track, and, if that was the case, it showed the speed at which relaying could be carried out by that method; but that speed would be limited by the length of speed-restriction at any one time. He assumed that the work had been done at the rate of about one-sixth of a mile per day or per night,

and that, in front of the one-sixth of a mile being relaid, another sixth of a mile was being opened up for the following night's or day's relaying. He also assumed that behind the relaying there was a length of track which had been lifted and ballasted, and he wondered what time was considered necessary to elapse before the removal of the speed-restriction on that length of track. If a period of four days was considered adequate, there would be altogether a length of 1 mile at any one time over which the speed-restriction would operate.

Mr. D. H. Coombs observed that the London Passenger Transport Board endeavoured to give, in the progress report, the output, in yards per man hour, and the price per yard where the price was the direct labour cost of the work. It was found that the price per yard was a measure by which the financial estimating and costing could be balanced, and the output, in terms of man-hours per yard, was useful in gauging labour requirements for a given programme of work.

He considered that the Author's statement that the general adoption of in-situ inspection would entail some risk of error on the part of inexperienced inspectors was a little unjust to the inspectors, because all proposals appeared to be well inspected by the District Engineer, the Permanent Way Adviser, and the Area Engineer, and certain selected items were inspected by the Chief Engineer. If the risk of error was confined to the inspectors, it would seem that subsequent inspectors would not be interested in the removal of sleepers from the track. He believed that District Engineers were interested in checking their judgement of the in-situ condition by seeing sleepers laid out as a sample.

The comments in an Area Engineer's notes on renewal proposals in a primary line, quoted in the Paper, did not appear to be markedly different from the general comments with which proposals were often put forward in the first instance by inspectors. The comparative measure of quality did not appear to be brought out very clearly.

Mr. Coombs considered that estimating was primarily a technical function, while cost analysis and comparison were properly accounting functions. He could not appreciate the Author's difficulty with regard to the matching of rails. The rails taken up to the London Passenger Transport Board were not marked for relaying in a given order, and generally there was not much difficulty in matching them.

Probably the distinguishing characteristic of the London Passenger Transport Board's miniature railway was that it had more trains per day (up to 500) than other railways, and two major consequences followed. Firstly, the question of unprogrammed work, in comparison with programmed work, was determined by the high rate at which depreciation occurred, so that there was probably more local devolution of authority for putting work in hand than would be regarded as proper on a main line railway. Secondly, more reliance had to be placed on day-to-day inspection for the ordinary maintenance work than was necessary in the

case of a main line railway. Since the work of the Permanent Way Inspectors on the L.P.T.B. was concentrated in a smaller district, it did not appear to be desirable to carry functional organization so far as to appoint independent Relaying Inspectors.

The rails were subject to wear differing in kind and incidence from that generally experienced on the main line railways; there was a great deal of battering and side-cutting, but it was not often necessary to take out rails for loss of depth. That meant that over the greater part of the Board's area synchronization of rail renewals and sleeper renewals was generally not practicable.

Mr. M. G. R. Smith said that there appeared to be very little difference between the practice of the London and North Eastern Railway and that of the Great Western Railway in regard to the classification of lines, but there was more difference in the standards of materials in relation to that classification. On the London and North Eastern Railway the engine routes did not appear to be taken into account. On the Great Western Railway the engines were given various colours, according to axle loadings, and the lines were given various colours on the engine route-map, according to the strength of the underbridges, with the result that what might be described as a primary line for renewal purposes would actually have more than one colour for engine routes, and minimum weights of rails were given for the engine routes. For a double-red route the minimum weight was 85 lb. per yard; for red, 80 lb.; for dotted red, 75 lb; for blue and dotted blue, 73 lb.; for yellow, 70 lb.; and for uncoloured, 65 lb. That appeared to be a logical and very economical method of obtaining the greatest possible wear from a rail.

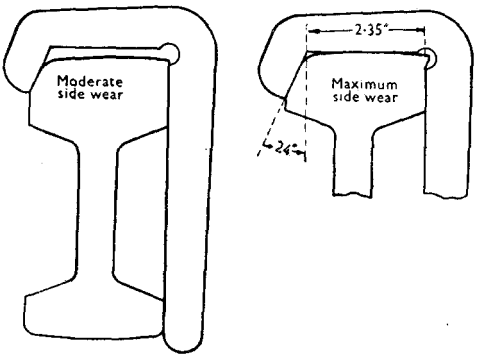
Mr. Smith considered that the form for track-history records gave insufficient information. The Great Western Railway used what was called a "timing-of-trains diagram," which was a fairly large sheet. Each sheet included 15 miles of up- and down-line and showed the gradient curve, cant, speed of trains, rail section, and date of relaying or re-railing or re-sleepering. Up-to-date copies were kept mounted in folders in the Chief Engineer's Office, and the appropriate sheets for the Divisions were kept in the Divisional Offices.

The renewals proposal form given in the Paper appeared to require more information than was necessary. Rail maker's initials, the average weight and the minimum weight of rails, the percentage of serviceable sleepers to be recovered, the nature of the ballast, and the average and maximum speeds, were not essential on a renewals proposal form. In any case, he was very doubtful whether the percentage of sleepers recoverable or likely to be fit for re-use could be assessed by a mere inspection from the top. It would be necessary to turn the sleepers out, and six sleepers per $\frac{1}{2}$ mile of track were not really enough. The Great Western Railway worked for a whole rail-length and did not take six sleepers at any particular point.

With regard to the estimating of rail weights, he suggested that probably for plain line work, and almost certainly for crossing work, the condition of the timber sleepers and fastenings was really the deciding point and that, for all practical purposes, callipers and a side-cut gauge were sufficient, except for special cases. He did not know how the callipers shown in *Fig. 4,* with the rail weight read directly on the back, would be used in crossing work, as there appeared to be insufficient room for them when taking the wing rail depth.

Fig. 10 showed the Great Western Railway side-cut gauge, as applied to a rail of moderate side wear and also to a rail of maximum side wear.

Fig. 10.



GREAT WESTERN RAILWAY GAUGE FOR SIDE-CUT RAILS.

The gauge had been first designed to measure side-cutting in the form of a degree of side-cut rather than loss in pounds per yard, and the degree was measured by inserting between the gauge and the top table of the rail a taper or step gauge, which measured the space between the gauge and the rail. If that taper or step gauge, which was slid into the gap, were calibrated in pounds lost a very accurate measure of the weight lost by side-cutting would be obtained.

Mr. W. F. Beatty observed that Table I showed that re-sleepering might be carried out for primary lines when the rails had a further life of 15 years, but that did not apply to the higher category; were there any other differences between the higher-than-primary and the primary category, and were any other factors, such as higher minimum-rail-weight, taken into account in the former category ?

The use of pegs of different colours for the various years of renewal was a very good idea; presumably the number of colours on view at any one time would bear some kind of inverse relationship to the man-power and materials available.

Could the Author explain why the weighing of rails removed from tunnels might not give accurate results, and why the rail-weights were

usually on the low side ? Was the effect of rail galling determined only when casts or photo-sections were taken, and how was galling taken into account in assessing the necessity for renewal ?

Mr. C. L. Heeler observed that one method of estimation of rail weights, brought into use some years ago throughout the London, Midland and Scottish system to obtain uniformity of method, consisted of the use of a logogram based on the depth of the worn rail and the width of the bottom flange (*Fig. 11*). The dimensions were measured by sliding callipers and the estimated weight of the rail section was read directly from the graph. Tabulated at the side of the graph was a series of positive and negative constants to be applied when the weights of various old-pattern pre-grouping rails were estimated. Also included on the chart were four cross-sections illustrating varying degrees of side-cutting, with the recommended weight reduction in each case. That method of estimating weights was fairly quick in use, but for several old-pattern rails the error might be considerable.

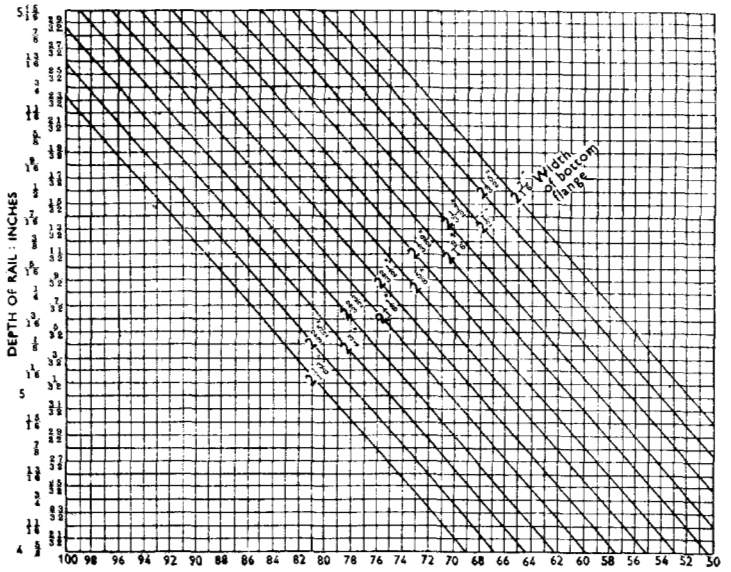
Another method, similar to that described by the Author and in use on the London and North Eastern Railway, employed a cast or photo-section. A beechwood mould, about 1 inch thick, in two sections, each carrying a thin lining of plasticine, was placed round the worn rail, which had been previously cleaned with a wire brush and dusted with french chalk. Steel clamps were placed round the two sections of the mould and tightened, thus shaping the plasticine lining to the form of the rail. Surplus plasticine squeezed out by the closing mould was removed with a knife. Two studs, at the top and the bottom of the mould, gave correct alignment, and small knives at the top and the bottom cut through the plasticine before removing the mould. After removal the mould was re-assembled and a daylight contact-print of the rail section, as delineated by the plasticine, was taken and developed. The area of the section was measured by planimeter. *Fig. 12* showed a mould constructed for use in estimating the weights of conductor rails on electrified lines. The method was laborious, but it was very useful in cases in which the logogram was suspected of giving false results, due to corrosion and heavy side-cutting.

In view of the divergence of opinion on the allowable limits of wear of rails in running lines, the results given by the logogram appeared to be sufficiently accurate for all practical purposes.

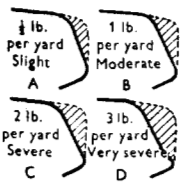
Mr. H. H. Jenkins said that in Table III the mileage for the previous year was given as 188¾ and the arrears from that year were 22¼ miles, leaving 166½ miles to be carried out, which the Author suggested should be the basis for the current year's programme. That would allow only the first three items in column (B), Urgency Nos. 1, 2 and 3, to be carried out, and, if the 22¼ miles carried forward from the previous year, had not been included in the proposed mileage for the year, only Urgency Nos. 1 and 2 and part of 3 could be included, in which case there would be a large carry-over for the next year.

A better method of arriving at the total mileage for the year was to take the total single-running line mileage in each classification and divide it by the " weighted " average life of the track in that classification. It

Fig. 11.



In the case of B.I. rails where the bottom flange is worn more than $\frac{1}{16}$" the width of the head to be used in conjunction with the depth



TYPICAL CASES OF SIDEWEAR

For other sections the following constants to be added :-

B.S	85 lb.	2·0 lb
L.N.W. B.I.	103	2·0 "
" "	90 "	0·5 "
" "	84 "	0·5 "
" "	80 "	6·0 "
" "	75 "	6·0 "
MR	100 "	-2·2 "
"	85 "	2·1 "
L & Y	86 "	6·0 "
N.S.	90 "	5·8 "
Furness B.3	88 "	12·5 "
C.K.& P	84 "	19·0 "
M & C	80 "	12·0 "
G.W. 00	97½ "	1·5 "
G.W.	92 "	-3·5 "
G.W.	95 "	-0·5 "

ESTIMATION OF WEIGHTS OF WORN 90- AND 95-LB. RAILS.

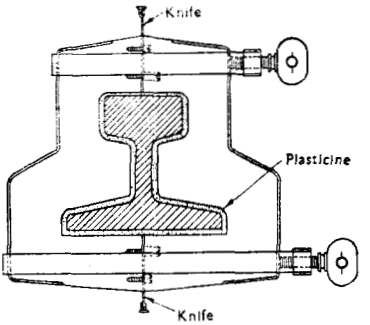
should be sufficient to divide by the known average life of the track in that classification to obtain an approximate figure to be entered in each category. That was somewhat similar to the method used, with very good results, on the Great Western Railway. The statistical statement published

under Abstract A showed that for the five years prior to the war there was uniformity in the relaying programme on the Great Western Railway.

If, instead of taking the known average life of the track, a " weighted average " were calculated by making special allowances for track in tunnels, at water troughs, and on sharp curves, it would be possible to arrive at a figure close to the economical minimum figure required. The ideal programme would consist of the minimum constant annual amount which would ensure that the whole of the system was renewed as soon as its renewal became necessary.

A wealth of information could be obtained from the track-record diagrams. It was possible, provided information existed of all track laid in for a period extending over at least 25 years—or, in other words, beyond the normal track life—to predict with a fair degree of accuracy

Fig. 12.



LONDON MIDLAND AND SCOTTISH RAILWAY'S APPLIANCE FOR TAKING RAIL MOULDS.

the average life of the track in the next 20 years. On the Great Western Railway for the last few years the average life of the track had been predicted with a fair degree of accuracy, but scope still existed for more detailed investigation.

Mr. Jenkins considered that new sleepers, and not serviceable, should be used where re-sleepering was essential and the existing rails had a further 15 years' life.

In *Fig. 9*, the fourth long length, DP 6, 50 chains of track, Northallerton to Dandy Wiske, showed an occupation for three Sundays and a speed-restriction for 19 days. Again, No. 7 (DP 90) showed no Sunday occupation, but the speed-restriction lasted for about 29 days. Those figures were very surprising. The normal practice on the Great Western Railway before the war, for 60 chains of track, was occupation for one Sunday and a speed-restriction lasting for 6 days—or about 25 per cent. of the period allowed for by the Author. The labour involved in carrying out that piece of work was 830 man-hours before the Sunday, 570 man-hours on the Sunday, and 920 man-hours after the Sunday. The length of track

in question was on the main line and in the London Division. Another example was 80 chains with a speed-restriction for 8 days.

Mr. Jenkins considered that, if possible, the shortest length of track renewed should be 20 chains, because when 60-foot rails were employed it was necessary to have at least twenty-four men to lift one rail. An approximate rule, which worked very well for such relaying, was one man per chain, therefore the most economical length would be about 20 chains, especially as speed-restrictions and occupation had to be arranged. Although at first that might mean that more track than necessary would be renewed, in successive periods when the track came up for renewal it would be in longer lengths, and, therefore, the sacrifice made at the commencement would be well worth while.

On the Great Western Railway special sleeper crocodiles had been in use for a long time and had proved very satisfactory, and special sleeper trains were being run.

Mr. W. H. Best observed that in the L.M.S. Engineer's department diagrams recording the age and history of all track in running lines were kept, whilst the practice in the submission and inspection of renewal proposals was very similar to that of the London and North Eastern Railway. The L.M.S. system, too, aimed at preserving a considerable degree of flexibility, to cater for unforeseen circumstances or changes in conditions, and the centralized headquarters organization undoubtedly made that a comparatively easy matter. The L.M.S. programme was always designed to embrace the maximum of complete renewal and the minimum of partial renewal, and he believed that desirable aim was realized to a greater extent than on the London and North Eastern Railway, owing to a major difference in practice.

He understood that the L.N.E.R. practice was regularly to remove rails from primary lines while there was still a very considerable useful life left in them, and to re-use them in both secondary and tertiary lines. The Author had stated the limiting weights at which rails were considered for removal from primary, secondary, and tertiary lines respectively, but he had not explained the considerations on which those apparently arbitrary limits had been based. For example, were there differing maximum axle weights for the differently classified lines ?

The L.M.S. practice was based primarily on the consideration of each rail section as a beam, and, by calculation, a limiting weight was obtained for the worn section, at which it was still able to support the normal maximum axle load of 22 tons, with a factor of safety of 5. That limiting weight for the 95 R.B.S. section was 78¼ lb., and that limit, or the appropriate one for the rail section which was under consideration, was applied to all running lines irrespective of their classification. Rails were often removed from the track, however, at weights appreciably above that limit, owing to other factors, such as excessive side-wear, chair gall, condition of sleepers and fastenings, and so on.

Since that system did not result in a sufficient quantity of good serviceable material being available for use in lower classified lines, second-class lines on the L.M.S. Railway were normally relaid with new 85-lb. materials, whilst the serviceable materials were usually employed for relaying third-class lines and sidings. All switch and crossing work in running lines was laid with new 95-lb. materials.

It would be apparent that, with the L.M.S. system, the life of materials in a particular location in the track would be appreciably longer than under comparable conditions on the L.N.E. Railway, and the " turn-over " of materials would be less frequent.

Mr. Best could not follow the Author's remarks relating to the weights at which rails were removed from the track. Was 85 lb. the minimum weight below which rails were not allowed to remain in primary lines ? And what was the average weight at which rails were removed from primary and secondary lines respectively ?

He was surprised that the L.N.E. Railway practice was to renew switch and crossing work on lightly-worked running lines with units manufactured from serviceable rail. The cost of fabrication and installation was the same whether new or serviceable rail was used as the raw material, and the experience on the L.M.S. Railway was that it was uneconomical to manufacture from serviceable rail. In fact, all switch and crossing work in running lines, and even in heavily worked siding connexions, was relaid with units manufactured from new 95-lb. rail exclusively. Other siding connexions were relaid with recovered switches and crossings, after reconditioning where necessary, and the manufacture of switch and crossing units from serviceable rail had been virtually eliminated.

Mr. Best believed that the removal of sleepers for inspection was a necessary practice, and he was surprised to note that the Author did not consider it essential in the case of all re-railing proposals.

He hoped that the Author would not regard his comments as being too captious. One was, perhaps, prone to regard the methods in which one had been brought up as the best ; as the Chairman had said, much of the value of a Paper such as the Author's was that it might cause engineers to question and re-examine their own methods.

Mr. A. H. Toms said that, in making a renewal inspection, it was very important to consider the condition of the foundation, the drainage, and the support which the rails obtained from the sleepers. On those accounts, he did not think it possible to make an accurate estimate of the strength of a rail as a beam, as suggested by Mr. Best. The Maintenance Engineer of the Southern Railway had under consideration a technical investigation into the matter, with the object of ascertaining whether something more definite could be established with regard to the limiting conditions in which rails should be taken out. Mr. Toms believed that on certain lines the rails carried fast traffic at a depth of $5\frac{1}{8}$ inches, but in

some places it was seemed desirable to take rails out at a depth of $5\frac{9}{16}$ inches, for example, in tunnels, where the rate of wastage in wet parts was very rapid and where chair galling and the corrosion of fastenings were correspondingly rapid.

Mr. Heeler's side-cutting chart (*Fig. 11*) showed four stages of side-wear, A. B, C, and D, and, in the slight condition, side-wear was shown extending for the full depth of the side of the head. Mr. Toms considered that an examination of the normal tire profile would show that it was impossible for side-wear to extend down the full depth of the head without the side-wear becoming exceedingly heavy.

Recently he had occasion to ask for the removal of sleepers from a length of track in connexion with a proposal for re-railing about 2 miles of track. Mr. Toms considered it was just as essential to take out sleepers when the proposal was for re-railing as when the proposal was for a renewal, because if that was not done sleepers might be re-railed which were not worth having a new rail put on them. It was a standard procedure on the Southern Railway for inspectors to take augers with them on inspections and to bore all doubtful sleepers which had not already been turned out, and that was often done in addition to the sleepers being turned out.

Mr. N. S. Cox observed that, whilst the work carried out in the prevous year might form a guide to what should be done in the current year, surely the latter would be that which inspection on the ground showed to be necessary.

The direct beam-calliper for ascertaining the rail weights was an excellent instrument and could be adopted with advantage on other systems.

Fig. 9 showed quite clearly the period of restriction and Sunday occupation; but presumably the "Additional Sunday work not requiring restriction period" had reference to the unloading of materials or the reloading after relaying had been done. If the second item on the list, YP 14, which was carried out on Sunday, 29 July, and required a restriction period from 23 July to 4 August, was the same as item Y PEG 14, under "Additional Sunday work not requiring restriction period," which showed that such work was done on Sunday, 16 December and Sunday, 30 December, the interval between the completion of the relaying and the loading of the materials appeared to be rather long.

Mr. J. Taylor Thompson observed that there were many varying weights and varying depths along a length of track under inspection for renewal, and he considered that, in the making of test measurements, extreme accuracy was not always necessary. There were two quite distinct kinds of rail weighings. In some cases, where some research had been carried out and the most accurate section was required, the weight had to be taken very accurately, but the method adopted in those cases would take far too long to carry out when proposals for renewal were being inspected. Some much simpler method was required, and the

calliper method was probably the best in the long run. The inspector should make some allowance for the condition of the rail—the side-cutting—either by measuring with a gauge or by his general judgement of the condition.

Generally speaking, the condition of the sleepers and the fastenings was the most important factor in deciding upon renewal, although the rail weight was also important.

With regard to the very interesting point raised by Mr. Best about how to decide when rails would not carry the traffic, Sir Charles Inglis [1] had treated that question in some detail in a Paper presented to The Institution; but in the discussion on that Paper it had been made clear that it was almost impossible to devise any theoretical basis on which to decide when a rail had become too light. The condition of the support was so variable that a few badly packed sleepers would upset all the calculations. The strength of the track came down in the long run to the strength of the ballast. If every sleeper was propped up perfectly, a quite light rail would carry the traffic.

Mr. Best had also referred to the question of whether new or second-hand material should be used in the manufacture of points and crossings. Mr. Thompson believed that they were made from serviceable rails in deference to the views of the accountants, who considered that second-hand rail was worth much less than rail a few pounds heavier which was called new. Mr. Taylor Thompson had no details of the Sunday possessions to which Mr. Cox had referred, but he believed that, in one case, a water-trough track was affected and that in the other some special flat-bottomed track was laid and the District Engineer had taken care to get sufficient possession to make a good job of it.

*** **Mr. G. W. Brown** observed that on a rail scale (*Fig. 13*), which had reached the demonstration model stage upon the L.M.S. system, the scales were mounted back to back upon a durable medium and protected from damage by transparent plastic. A gauge plate in the form of a rack was mounted, as shown, to the left side of the scales. All the necessary dimensions could be taken with plain callipers and it was unnecessary to convert the calliper settings to unit measure.

In practice a "width of bottom flange" was first obtained and the callipers, as set, were applied to the appropriate scale in such a manner that the left limb was in contact with the rack previously mentioned.

If no general corrosion had occurred, the right limb of the callipers coincided with 0 on the scale marked 0 to 10.

The scale provided for wastage up to 10 lb. per yard which, if present, needed to be deducted from the "callipered weight", described below.

The second operation was to calliper depth and apply the calliper

[1] "The Vertical Path of a Wheel moving along a Railway Track," J. Instn Civ. Engrs, vol. 11 (1938-39), p. 262 (Mar. 1939).

*** This and the following contribution were submitted in writing.—SEC. I.C.E.

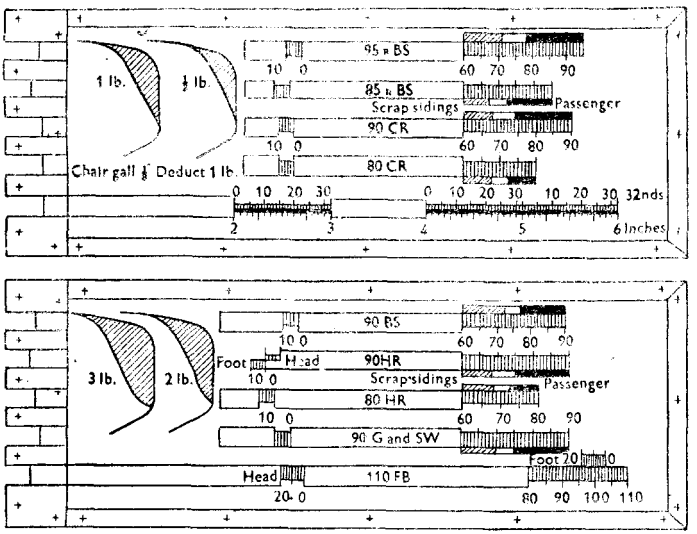
setting to the appropriate rack as previously used. That second measure read direct in lb. per yard and, subject to a correction for " width of flange," was sufficiently accurate for most purposes.

The permissible wear in passenger lines and in sidings was represented alongside the weight scales by block black and block white indications.

A metric scale in 32nds of an inch was included if actual dimensions were required in addition to estimated weights.

The scale marked 110 FB was of topical interest, and in that case width of head and foot were plotted as a measure of general wastage.

Fig. 13.



The particular arrangement of scales illustrated was produced in response to a request from Mr. Frazer, Scottish Divisional Engineer, L.M.S., Glasgow,

Mr. Brown was indebted to Mr. W. K. Wallace, M.I.C.E., Chief Engineer, L.M.S. Railway for facilities in investigating the subject and also for permission to offer the conclusions as a written contribution to the discussion.

Mr. J. C. Loach regretted that the fundamentals involved in the subject of the Paper had not been more fully discussed. For instance, on p. 4, *ante*, the Author had stated that it would clearly be uneconomical to introduce into secondary and tertiary lines permanent way of as heavy a section as was necessary in primary lines. Obviously it was economical to use in secondary lines the rail regarded as unsuitable for further service in primary lines; but it would be interesting if the

Author would analyse the validity of his reasons for buying any new 85-lb.-per-yard rail.

Mr. Best had explained that L.M.S. practice was always to use 95-lb. per-yard rail in point and crossing work, even if it was for use in secondary lines, but Mr. Loach wished to take the argument farther.

The cost of a 95-lb.-per-yard rail was about £14 10*s.* per ton. Assuming that 25 lb. was lost in wear and corrosion during its useful life, then the remaining 70 lb. was regarded as scrap and sold at £5 per ton (or thereabouts). The 70-lb. portion merely served to give strength to the rail as a girder, so it would seem that the greater the quantity of metal that could be put on that, the longer would be the life of the rail. The usefulness of a rail might be expressed as the ratio

$$\frac{\text{lb. per yard lost in service}}{\text{lb. per yard original weight.}}$$

What then, was the justification of buying new 85-lb. per-yard rail, even for secondary lines, and even if their scrapping size were reduced to 67 lb. per yard ? Admittedly, there was the question of sleeper renewals, but if new rails imposed in secondary lines could serve for twice as long (even if they lasted for two or more sleeper lives in the track concerned) it would mean buying only half, or less than half, of those 70-lb. per-yard portions at £14 10*s.* per ton and selling the same material again at £5 per ton. That was a long-term policy, whereas buying 85-lb. rail appeared to be " penny-wise and pound-foolish."

In that respect, Mr. Loach considered that the head of the new 113-lb.-per-yard flat-bottom rail should have been deeper than that of the 95-lb. bull-head rail of which it was a copy, so that its life would be longer.

What precautions were taken about fishplates when rails were transferred from one class of line on the London and North Eastern Railway to a lower class ? Was any ill ever experienced from fitting 18-inch fishplates to rail ends on which 9-inch plates had previously been used ?

The Author, in reply, expressed his thanks for the reception accorded to the Paper.

Mr. Rock had referred to the restrictions for the three lengths of track renewal of between 4,200 yards and 4,500 yards shown in *Fig. 9*. *Fig. 9* was included in the Paper as a typical example of the method of recording the speed restrictions required over a period—in that case the last six months of the year. Thus the restrictions shown for those three lengths referred only to their completion, the restrictions for previous work on those same items having been shown on the diagram for the preceding six months.

The method of indicating in *Fig. 9* the items renewed by crane could be followed by reference to Item No. Y.P. 10 on the up line between Selby and Riccall.

The period of restriction for the track renewal on the up line extended

from 6 to 31 August, and it would be noticed that, under "additional Sunday work not requiring restriction period," two Sunday possessions of the down line were allocated to that item. Those were required for working the cranes.

In reply to Mr. Coombs on the question of in-situ inspection of sleepers, the word " Inspector " was used in its widest sense and was not intended to refer solely to Permanent Way Inspectors.

In reply to Mr. Smith, the engine routes had been taken into consideration in deciding the classifications of the various lines, but axle loads were not necessarily the deciding factor. For instance, some secondary lines were used as alternative routes in emergency for the heaviest engines, but naturally at reduced speeds.

No difficulty had been experienced in using the callipers shown in *Fig. 4* for measuring wing rail depths in crossing work, provided that there was sufficient lateral clearance between adjacent rails for the arc of the instrument. In measuring depths of wing rails at or near the throats of the crossings the callipers would be offered to the outside of the rails and the weight read before removal of the callipers.

In reply to Mr. Beatty, the only variation in the renewal procedure for the East Coast main line as compared with that for primary lines was in respect of the re-sleepering, as shown in Table I.

The weighing of rails removed from tunnels might lead to inaccuracy by reason of galling in the foot of the rail over the chairs.

The result of dividing the actual weight of the rail by the length of the latter, in yards, was an average figure for the weight per yard, that being something larger than the weight at the galled places and something less than that between those places.

At locations in the open, reduced rail-depths due to galling were measured with callipers, and a separate rail weight at the galled sections was entered on the proposal form. Access for callipering was obtained by moving the sleeper.

The mould for determining the weights of flat bottom current rails described by Mr. Heeler was of special interest, but no doubt it had been found necessary to widen the recess for the head of the rail when the mould was used for sectioning running rails, so as to allow for lipping on curves.

In reply to Mr. Best, a minimum weight of 85 lb. per yard, below which rails should not be allowed to remain in primary lines, was the standard which had been set, although, as pointed out in the Paper, some slight variation from that figure might be made in exceptional circumstances. It was difficult to give a figure for the average weight at which rails were removed from primary and secondary lines, as by the application of the procedure set out in Table I that would depend upon the condition of the sleepers in the various items.

Mr. Best had expressed surprise that it was not considered essential

to remove sleepers for inspection for all re-railing proposals, and Mr. Toms had also remarked upon that. An example of the exception to the instruction referred to in the Paper would be that of a length of track in a primary line in which the life of the rails was, say, 3 years. Complete renewal would be required every three years, and under those conditions it would seem a waste of labour and material to remove sleepers from the track for inspection.

The method of testing sleepers referred to by Mr. Toms was interesting, but the Author feared that boring might accelerate the deterioration in the condition of the sleepers.

The Author was indebted to Mr. G. W. Brown for his most interesting contribution to the discussion on the Paper.

Mr. Loach had submitted an argument against the purchase of 85-lb. rails which might have been strengthened by a reference to the saving which would result from the ultimate elimination of stocks of fittings for that section of rail.

A deficiency in suitable recovered rails for secondary line renewals would necessitate the adoption of one of the following courses of action: (*a*) to renew with new 95-lb. rails; (*b*) to recover rails from primary lines before they were worn to the limit; and (*c*) to renew with new 85-lb. rails. The objection to course (*a*) was that, in the Author's opinion, the more important lines should have the benefit of the new 95-lb. rails, and course (*b*) would necessitate unnecessary work and consequent expense. The only alternative would therefore seem to be course (*c*), although it was the intention to purchase new 85-lb. rails in diminishing quantities.

With regard to Mr. Loach's reference to fishplates, it was the usual practice to replate with new plates when rails were transferred from one class of line to another. Eighteen-inch fishplates were not fitted to rail ends on which 9-inch plates had previously been used as, owing to wear on the fishing surfaces of the rails over the shorter length, proper bearing between fishplate and rail was difficult to maintain throughout the longer length. Maintenance fishplates were of particular value in those circumstances.

MADE AND PRINTED IN GREAT BRITAIN BY WILLIAM CLOWES AND SONS, LIMITED, LONDON AND BECCLES.