Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Wednesday, March 13th, 1968

The President (Mr. H. W. HADAWAY) in the Chair.

The Minutes of the Technical Meeting held on February 8th, 1968, were read and approved.

The President introduced and welcomed to the meeting Messrs. R. A. Bagnall (Associate) ; W. A. Mellin (Technician Member) ; J. C. Fowler, C. L. Ackerman, R. B. Parker, R. P. Little and F. W. Harris (Students) who were present for the first time since their election to membership.

The President then invited Mr. J. V. Goldsbrough to read his paper entitled " Overlaps (British Practice)."

Overlaps (British Practice)

by J. V. Goldsbrough (Member)*

1. INTRODUCTION

The primary object of this paper is to provide a brief summary of the subject for the use of our Student and Technician Members. Whilst it is referred to in the various booklets published by the Institution, the pros and cons have not been collected together under one heading for reference purposes, and the author feels that this should be a useful purpose for the paper.

In addition, for those who may consider the subject to be rather well-worn, it is apparent that in the not too-distant future when train describer, automatic or computer route-setting comes into use, we shall have to consider other methods for the operation of functions now performed by signalmen ; and selection of overlaps by automatic means may well prove necessary. The discussions which follow the presentation of a paper to the Institution are often as valuable as the paper itself, and it is hoped that many contributions will be forthcoming on this new aspect of the subject so that they can be duly recorded in the Institution Proceedings for future reference. As will be appreciated, once the basic Block Regulation requirements have been satisfied, the subject of overlaps is more a matter of opinion rather than regulation. It is these opinions which the author wishes to be recorded, for they will need to be kept constantly in mind when we try to make a machine give a decision which will be based only on logical assessment of available information.

2. THE ABSOLUTE BLOCK REGULATIONS

The Absolute Block Regulations issued, and from time to time amended, by the various former Railway Companies, and

*A EI-General Signal Ltd.

later by the Regions of British Railways and the British Railways Board, all contain the following clause with identical intention, if not in the exact words :—

" Except where instructions are issued to the contrary, the line must not be considered clear, nor must a train be allowed to approach from the box in rear in accordance with Regulation 1, unless the line, or at a junction the line for which the facing points are set, is clear for at least $\frac{1}{4}$ mile ahead of the home signal, and all the necessary points within this distance have been placed in their proper position for the safety of the approaching train."

Notice the phrase : " Except where instructions are issued to the contrary." This means that the Regulation is provided with means of modifying the $\frac{1}{4}$ mile requirement to suit the many and differing physical conditions encountered in practice, e.g. permissible speed over the section of line, gradients, weather conditions, spacing of signal boxes and signal sighting distance etc.

Thus, in the acceptance of a train by a signalman, a safety margin is made available beyond the home signal to allow for misjudgements in braking. If this margin is not available it is permissible, where authorised, to accept a train under the Warning Arrangement of Regulation 5. In this case, the train must be brought to a stand, or nearly to a stand, at the entrance signal to the section before the signal is lowered to allow it to proceed.

3. THE HUMAN ELEMENT

If the overlap is provided to allow for misjudgement, then we must consider the man involved, i.e. the driver. Quite apart from his personal skill as a driver, there is another factor often overlooked which relates to the demands of economics. In the early days of railways, a locomotive and its crew were almost inseparable ; if the crew was off duty, so was the engine. Thus, not only was the driver familar with the route, but he knew the performance and capabilities of his own engine to a fine degree. This was an ideal, but uneconomic situation. Now, he has to take any engine rostered for the duty without previous knowledge of its individual peculiarities, other than those common to its class. He is still expected to be able to run to schedule and to stop his train within a few yards of a fixed point despite ignorance of these peculiarities, quite apart from other variables related to weather, train loading and braking characteristics. This is not an easy task, and it is right that our signalling systems should make allowance for it.

Some investigation was carried out by the Medical Research Council in 1962/63 on the subject of passing signals at danger, which can presumably also be related to the question of misjudgement. In contrast to commercial market research, which might be said to try and establish how many people react in the same way, the report wisely recognised that human beings are not alike, even although they may have reactions in common. A tendency for some individuals to be careless, or perhaps " accident prone," was suggested ; but this is well known, as also are the effects of fatigue after prolonged concentration.

From a signalling point of view there is one very important conclusion which can be related to approach-control of signals. If a driver is confronted with a signal aspect which differs from that which he expects as a result of previous experience of working the route, then there is an increased possibility of his making an error. In certain respects, approach control is inevitable ; how else (other than by complex signal aspects or speed indications) can a train at present be brought under control before taking a route which demands low speed ? If approach control did not have its inherent disadvantage of anticipated clearance, we might have been able to consider abolishing the complications of the overlap at junctions and intersections by introducing approach control of the outer signal whenever the inner signal is at danger. Such a practice would be considered as unduly restrictive, but it could otherwise effect considerable economies. No doubt, automatic speed control will ultimately solve this problem, but its universal application is still far off.

4. THE OVERLAP IN PRACTICE

4.1. Length of Overlap

Various formulae have been used to calculate the appropriate length of an overlap, except that in low-speed, power-signalled interlocking areas they are commonly chosen by reference to convenient track circuit block joints, with, of course, due regard to minimum distances. Although the formulae may differ in detail, they usually all include factors of maximum approach speed, average braking capacity and efficiency, gradients, signal sighting distances where difficult conditions occur, and allowance for weather conditions where significant. In certain interlocking areas where low speed limits are in force, specially selected overlaps have actually been eliminated, and it has improved layout flexibility and simplified signalling controls without any apparent loss of security.

With the overlap as a braking margin, it is interesting to consider with respect to our main lines what the overlap would have to be if it were necessary to extend it to provide for maximum braking effort as on London Transport. The so-called 'W' curve issued by British Railways shows that a locomotive-hauled, heavily laden passenger train of 11 coaches, with worn brake blocks, and two brake cylinders out of action, requires a service braking distance on the level of 2 230 yd from 100 m.p.h. to a standstill. Even a loose-coupled unbraked freight train needs approximately 880 yd to stop from 30 m.p.h. Even if these distances were reduced to terms of maximum braking effort, their use as overlaps would severely restrict service intervals on main lines, and could not be contemplated economically.

An analysis of 13 reported over-runs at colour light signals in 3- and 4-aspect areas over a period of 12 months showed the average to have been 112 yd. Whilst all statistics and averages must be carefully analysed, these figures were not selected for this purpose and exclude cases where signals were actually missed or mis-read, and can be said to refer only to misjudgements. On this basis alone, the choice of overlap distances by British Railways for standard practice as given below, is shown to be both appropriate and safe.

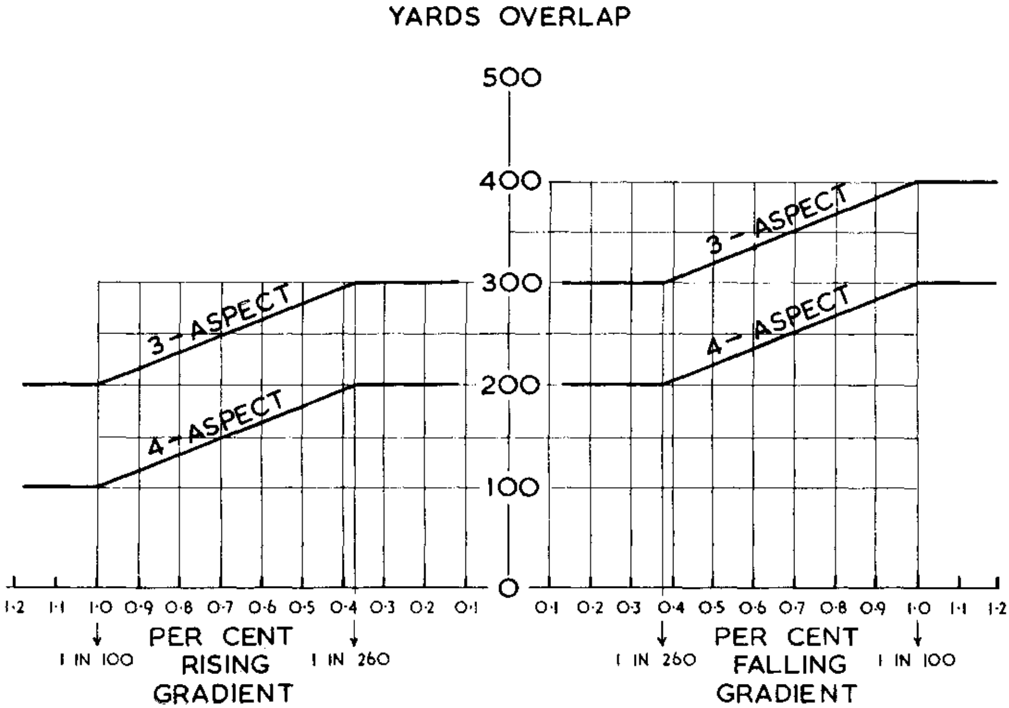

Fig. 1. B.R.B. overlap adjustment for gradient.

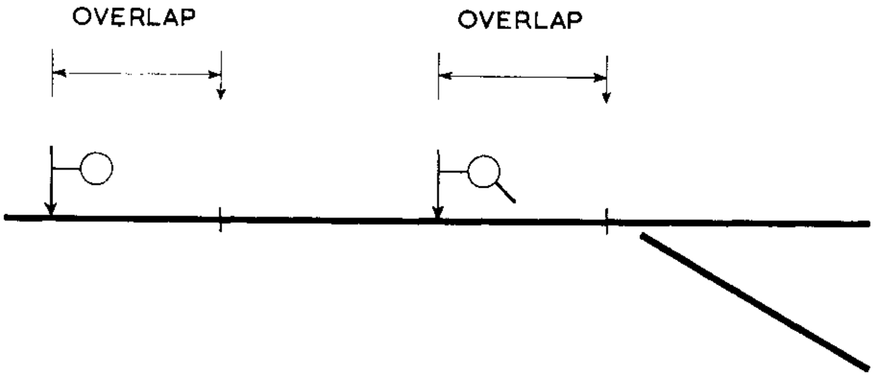

Fig. 2. Overlaps without separate track circuits.

4.2. The British Railways Board Standard Signalling Principles

Because of the varied operating requirements encountered on the Regions of British Railways, the British Railways Board, with the agreement of the Ministry of Transport, has prepared a number of Standard Signalling Practices to achieve a measure of uniformity in treatment. Whilst these are generally available to Railway Officers, it will not be out of place here to summarise the requirements for overlaps in colour-light signalled areas :—

(a) No separate overlap track circuit is to be provided unless it is required for other purposes.

(b) The basic overlap lengths should be:—
300 yd in 2/3-aspect territory
200 yd in 4-aspect territory
adjusted as necessary on account of gradient and/or other factors.
Fig. 1 shows how the length is to be adjusted in respect of gradients.

(c) Where restricted approach arrangements are in operation, an overlap of 50 yd should be provided where practicable. There will be special cases where a reduction of the distance will be necessary.

(d) The restricted approach should be subject to proximity and speed considerations.

(e) Trailing points in the overlap, and opposing signals applying to the

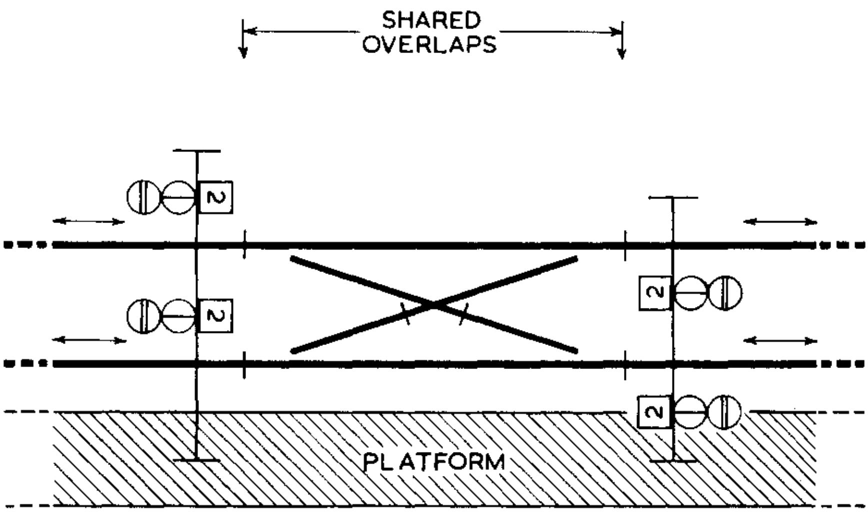

Fig. 3. Typical shared overlaps.

overlap, must be locked until the route is cancelled or the movement has come to a stand.

(f) Facing points in the overlap may be moved if they have time to operate and an alternative overlap is available.

Requirement (a) is derived from electrified areas where impedance bond track circuits necessitate keeping the number of track circuits to a minimum. Here, the block joint is located at overlap distance from the stop signal as shown in fig 2. Although this gives delayed aspect replacement, the arrangement is now in general use and is accepted as both safe and economical.

Shared overlaps are not referred to as it is difficult to define precise requirements. Generally, they are acceptable in low-speed station areas, and fig 3 is given as a typical example. All such arrangements must be determined by individual consideration and by operating requirements.

4.3. Point Detection.

No general rule has been established regarding continuous detection of overlap points in the controls of the outer signal. Continuous detection, but not the setting and locking, of trailing points is often disregarded on the argument that a trailing run-through is unlikely to derail a train. Whilst this is generally acceptable, the author inclines to the view that if the points nearest to the protecting signal of an overlap are trailing and are within 50 yd, they should be continuously detected as a form of trap protection against irregular movements occurring where they are most likely to foul short over-runs.

With facing points, the best practice to adopt is that if they give access to a choice of overlaps, then, if one overlap is obstructed, either by track occupation or use in another route, facing detection diverting the overlap away from the obstruction should always be continuously proved. If the obstructed overlap forms part of another route, that route should also include continuous proving of the overlap diversion, so that mutual protection is given.

One practice, which has much to commend it, is " detection at the time of clearing." This means that when the overlap is set, detection is initially included to ensure that the points have set and locked as required, but is not continuously proved afterwards in the outer signal. In this system, if a change of overlap is made, both overlaps are proved clear during transit of the points. When detection of the new overlap is complete, continuous detection is relaxed.

These practices are all associated with the problem of avoiding interruption of the outer signal controls when a change in overlap takes place. There is, however, an approved solution which is simple in circuit form and satisfies all desirable precautions. Where there is a choice of overlaps, the principle is continuously to prove all track circuits in all of them, and to detect only those facing points which divert the overlap away from any one which may be obstructed.

This is illustrated in circuit form in fig. 4 and means that if all point detection in an overlap fails, the outer signal will not replace if all tracks in all overlaps remain clear.

In these circumstances it is pertinent to question the likelihood of potential failures. Points rarely lose detection completely once they are static after having been set and locked. The majority of detection failures occur immediately after actual transit when the new position fails to establish detection due to obstruction, etc. Fine detection can " bob " with the passage of a train over the points, or on adjacent lines, but the fact that detection was properly proved in the controlling signal before the train entered the route, and the points are held conditionally locked, means that there is little chance of danger with an over-run in such circumstances.

The coincidence of both a static detection failure and a braking misjudgement at a stop signal may seem remote, but it is essential that every possibility should always be given proper consideration to maintain the traditional safety of railways.

5. LONDON TRANSPORT

5.1. Principles

Probably, few transport authorities in the world carry such a responsibility for the safety of the travelling public as the London Transport Board. The main-

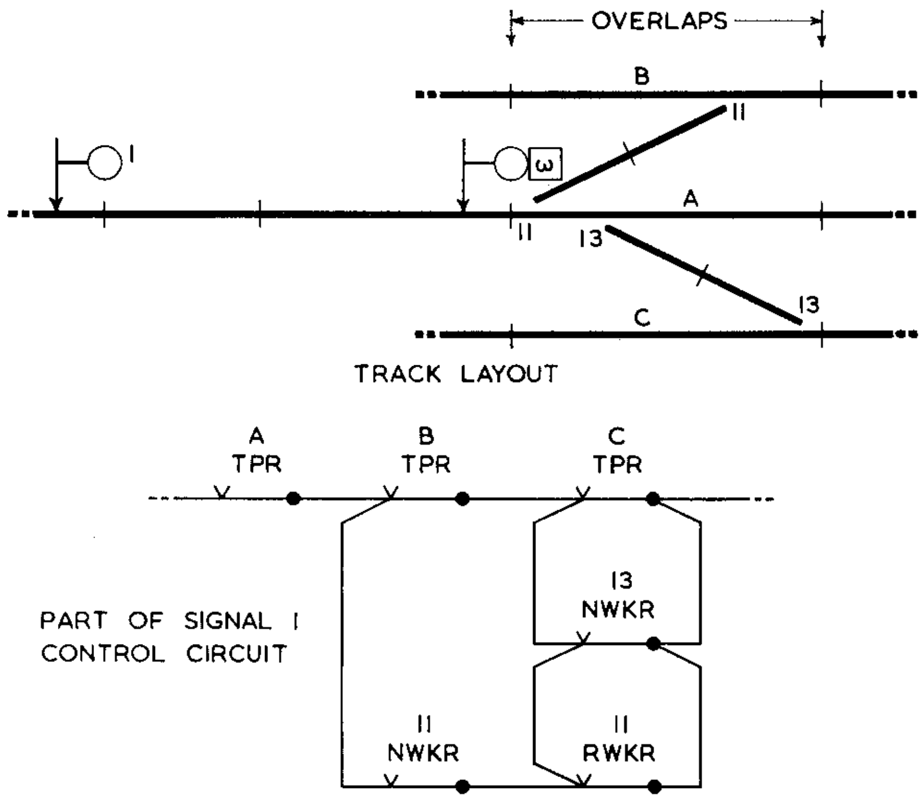

Fig. 4. Overlap controls in outer signal.

tenance of a very close headway on lines partly in tunnels demands exacting attention to safety measures, and the overlap has received its due attention, not only in precise methods of calculation, but also in ingenious and very effective arrangements of overlap adjustment for measured approach speeds.

The calculated overlap on London Transport is based on the braking distance required by a train at its maximum service speed when the brake line is exhausted, either by the train being "tripped," or the maximum braking effort being exerted. An allowance of 30% is added to the distance to cover contingencies such as brake maladjustment or heavy loading etc., and a further adjustment is made to allow for the approach and overlap gradients. At stations where all trains stop, the overlap at the starting signal is calculated for 20 m.p.h. with the same allowances. The swinging or switched overlap is not employed; the overlap points are held by the outer signal which is backlocked to maintain the previously set overlap until released by delta track occupation and time element. In push-button route control systems, separate route buttons are used for the outer signal to select the overlap corresponding to the inner route to be subsequently selected. The delta track or rail circuit is described in the paper on "Automatic Junction Working and Route Setting by Programme" (R. Dell, 1958). A principle which is given much attention in all signalling problems on London Transport is that of endeavouring to avoid any necessity of bringing a train to a stand, as this can have serious repercussions on headway. It is achieved whenever possible, by exercising control over the approach speed of a train to the signal. The methods employed for this are fully described in comprehensive papers, previously read to the Institution, on "Speed Control Signalling" (W. Owen, 1949); "L.T.

Methods for the Control and Locking of Junctions." (H. W. Hadaway, 1961); and "Victoria Line Signalling Principles" (V. H. Smith, 1966). The student is recommended to study these examples of how trains can be kept on the move and yet observe the very necessary restrictions imposed.

5.2. *Calculation of the Overlap*

Calculation of the overlap is based on the maximum service speed which a train can reach at the signal. This is obtained from a speed/distance curve supplied to the Chief Signal Engineer's office by the Chief Mechanical Engineer. If the train is "tripped" at this speed it must be able to come to a stand within the overlap; and the factors, apart from speed, which will decide this are the braking efficiency and the gradient of the approach and of the overlap. The braking efficiency of L.T. rolling stock on the level is maintained to achieve 12% in tunnels, but is reduced to 10% in the open air to allow for adverse weather conditions (e.g. wet rails). If the gradient of the approach or overlap is falling it will reduce the braking efficiency, and increase it if rising. Accordingly, the length of the overlap is subject to a gradient compensation, and this can be done directly by calculating the percentage net gradient, rise or fall, and adding it to or subtracting it from the braking efficiency percentage in the formula :—

$$\text{Length of overlap in feet} = \frac{4{\cdot}34\ V^2}{n\% \pm \text{overlap net gradient } \%}$$

where V = Maximum speed of train at signal (from speed/distance curve) in mile/h.

n = Braking efficiency, 10% in open air, 12% in tunnels.

The constant 4.34 in the formula is derived from 3.34 (the factor relating V mile/h. and n which is a percentage of g (acceleration due to gravity in ft/sec^2) + 30% = 4.34.

The gradient compensation for the approach side of the signal is introduced only when the approach gradient is falling, and then only if it exceeds the falling overlap gradient. The approach gradient is taken as an average over the train length (420 ft), but as the weight of the train is assumed to be concentrated at its centre, the overlap plus 210 ft is considered to be the available effective braking distance. Hence :— Gradient Compensation = Average % Gradient =

$$\frac{\text{Total rise or fall}}{\text{Overlap} + 210 \text{ feet}} \times 100$$

A standard table is available, relating braking efficiency with maximum approach speed; and from this, the overlap distance can be directly determined.

It may be of interest to note that it is common practice in rapid transit systems in other parts of the world to use a full block as an overlap. Whilst this gives adequate security, it may mean shorter block sections to achieve minimum headway and does not give the precise results achieved by London Transport. These results, however, are by individual calculation of each overlap and subsequently by precise location of block joints. Whether the apparent additional costs of this procedure can show an advantage over the simplicity of the double-block system is debatable. Even in double-block, detailed and individual work is still necessary to arrive at correct signal spacing to achieve the desired headway and in allowing for rolling-stock braking and acceleration, gradient and layout characteristics.

6. THE SWINGING OVERLAP

6.1. *General*

There is no doubt that this aspect of the subject of overlaps is probably the most interesting and controversial. The extremists, on the one hand, hold to the mechanical interlocking practice established many years ago where an outer signal locked the overlap points to ensure that there was no possibility of the points being moved if an over-run occurred at the stop signal protecting the points. To achieve this object to the full, it is necessary to backlock the outer signal until the train can be proved at a stand at the protecting inner signal. Before the advent of electrical safeguards, however, such backlocking was difficult to achieve, and it appears possible, then, that this form of locking served only as a reminder to a signalman that he was obliged to hold the overlap for the approaching train. Without backlocking, it needs only the replacement of the outer signal to release the points at the very time when the locking is progressively becoming more important.

On the other hand, there is no doubt that to make the maximum use of a layout and to keep its essential flexibility, the holding of a selected overlap from the time that the outer signal is cleared, until the train comes to a stand at the inner, constitutes an appreciable hindrance. However, condition (f) of the Standard Signalling Practices gives the required relaxation of this hindrance, so that freedom to change the overlap points can be maintained safely, until completion of their movement can no longer be assured.

It is, of course, possible to site the stop signal at overlap distance from the first facing points, when the problem immediately disappears, but it will be evident that few layouts in complicated locking areas can accommodate sufficient clearance in rear of the stop signal for long trains. This fundamentally sound practice is favoured by London Transport whenever feasible, but it too often happens that the layout or sighting distance precludes it, and the signal has to be sited at the points.

To maintain flexibility with a swinging overlap it is essential that freedom shall remain until the last possible moment, e.g. by provision of a 100 yd approach track to the stop signal. This is contrary to the British Railways Board principles in keeping the number of track circuits to a minimum, but if circumstances can justify the provision, this is the only way to achieve the maximum benefit. In many cases short approach track circuits have other purposes and may be justified accordingly.

If the release timing is commenced on occupation of a full-length approach

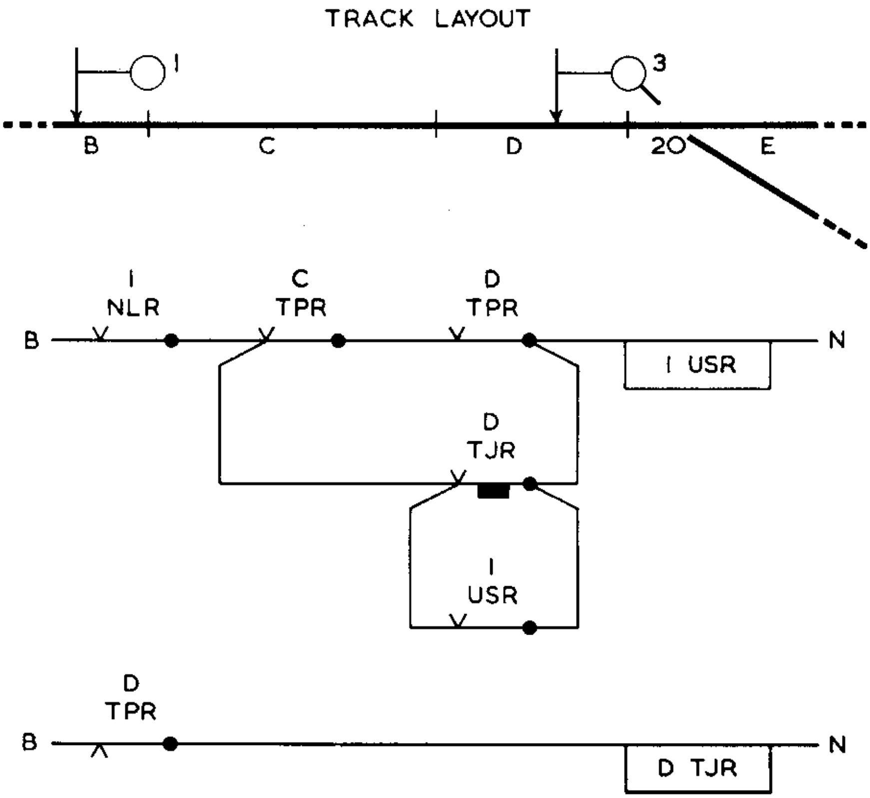

Fig. 5. Overlap route stick relay and time release.

track circuit, it has to be related to the type of traffic using the line, For freight trains with a low approach speed, the time interval must be long to prove the train at a stand. If the same time interval is used for stock with better braking efficiency, it will result in delay because the overlap is held longer than necessary.

A study of B.R. Standard Principle No. 6, relating to the approach control of junction signals, shows a similar problem and a practical solution, but the requirements are in certain respects contradictory; for overlap release the train must be proved at a stand ; for the junction it requires only that the speed shall be under control.

These problems will be more easily solved when fully-fitted stock becomes universal, and braking efficiencies for all classes of train approach a common factor.

6.2. *Holding the Overlap*

The method generally adopted for holding the overlap is by a normally-operated route-stick relay, released when the outer route is set. Once released, it cannot be re-operated until the outer signal has been replaced to normal and the train has cleared all track circuits between the outer and inner signals, or is proved at a stand at the inner signal by time occupation of its approach track. The circuit of a typical route-stick relay is shown in fig 5. Two very important circuit requirements arise from this arrangement ; firstly, the route-stick relay must be proved to release before signal 1 is allowed to show a proceed aspect, thus proving holding of the overlap. Secondly, the time element relay D.TJR must be proved normal in the controls of signal 1 to guard against premature timing due to

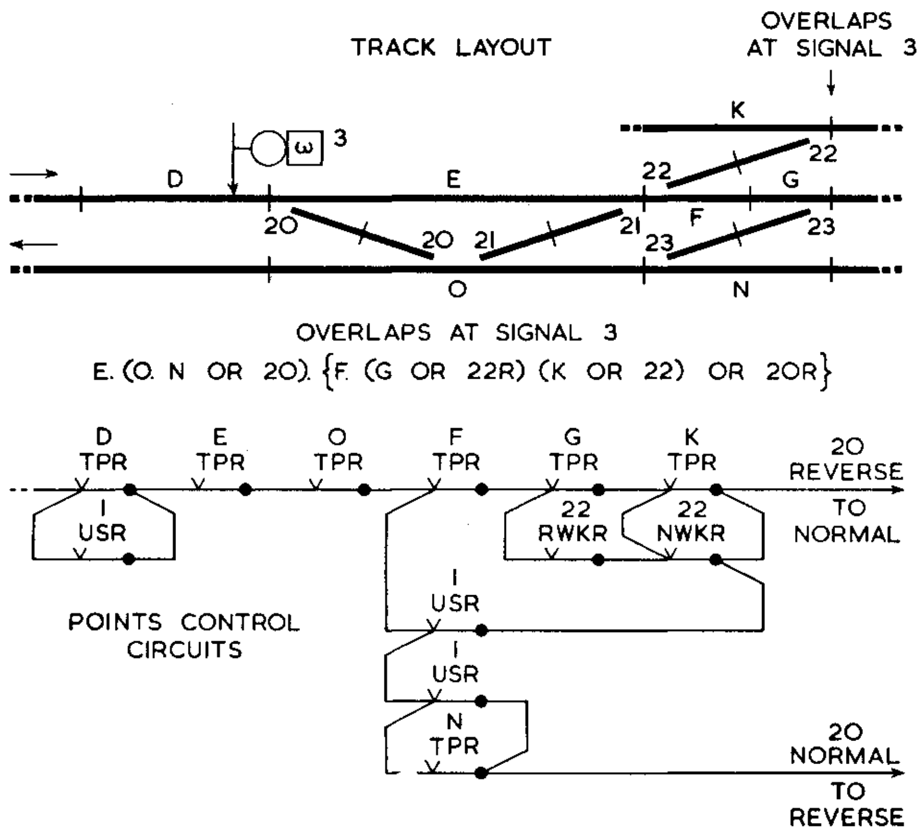

Fig. 6. Points controls for swinging overlap.

a circuit supply or other failure to D.TPR. Note that in the event of replacement of signal 1 without the train taking the route, the overlap will be held by the approach lock of 1 because 1NLR cannot re-operate after replacement until the approach lock conditions have been satisfied.

Consider now the way in which the route-stick relay is used to impose additional locking and control conditions on the points in the overlap. This is shown in fig. 6, the track layout of the alternative overlaps available at signal 3. The circuit diagram shows part of the points circuit controls for 20 points. When no overlap is held, only track circuits E and O are included, but immediately the outer signal route is set, 1.USR releases and the following conditions are added :—

Normal to Reverse : Track D or time release, Track N.

Reverse to Normal : Track D or time release. Tracks F. (G or 22R). (K or 22).

Notice the useful facility given by 1.USR in respect to D track control in the points. This track is added to the points controls only for a movement from the outer signal i.e. overlap swinging is prevented as soon as D is occupied and until time-released. However, if there are shunt movements involving reversal at signal 3, these movements will not be hindered by having to wait for time release before moving off again.

These points circuits are shown in full detail in I.R.S.E. Booklet No. 22, the small modification to the control tables in respect of track D having been made in the circuits illustrated to provide the shunting facility.

It is always desirable in swinging overlaps to enforce the sequence of points operation ; i.e. when swinging, the first facing points in the overlap should not be permitted to move until all the new overlap beyond them has first been set and proved. This can be arranged in the circuits by the use of the route-stick relay to impose the sequence conditions when an overlap is held.

6.3. Panel Control of the Overlap

The methods employed for swinging an overlap are subject to many variations of opinion. With most relay interlocking control panels, the facility of using the individual points keys is generally accepted, but the view is taken, in some quarters, that these points keys are for emergency use only, and should not be used for such a purpose. This attitude is difficult to understand because properly-circuited points keys are virtually no different from an individual lever in a frame, and the same locking conditions should apply for key-setting as for route-setting. If keys are provided for emergency purposes with circuits which exclude any locking, then they should be sealed to prevent irregular use.

On panel control systems which use entrance and exit buttons for route-setting, a system is often employed whereby a route with a choice of overlaps is set by three buttons : entrance-exit-overlap limit. Swinging the overlap is effected by operation of the route exit button as an overlap entrance, and the button at the extremity of the new overlap. Whilst this is simple enough to perform, control panels tend towards having too many buttons, particularly where, in addition to those for overlap selection, alternative routes and aspect selection buttons are also provided. If panels are to be simplified for quicker operation in large control areas, and few will dispute that they should be, the only answer is to provide automatic operation of as many facilities as possible.

7. THE AUTOMATIC OVERLAP

7.1. General

It is probably fair to say that a signalman operating a large power-signalled interlocking does spend a measurable time in selecting and/or changing overlaps in complicated track layouts. Whilst this is necessary, and requires intelligent anticipation of subsequent traffic movements, it is strange that few efforts have been made in the development of signalling control to relieve the signalman of this obligation. The reason for this is, however, apparent, for at most signal boxes there is ample time available, except at certain periods of the day, to allow for overlap selection. Nevertheless, with the present-day objective of concentrating larger areas of control in one signal box, any development which can assist a signalman in speedier and more efficient traffic handling with safety, must be considered an advantage. Operating Department representatives with whom the author has had discussions, are generally agreed that they can name one or two signal boxes in their respective areas where automatic overlap selection would assist in traffic handling at peak periods. At the same time, they are naturally concerned that their signalmen shall not become " button-pushing-morons." This same argument can be used against driverless trains, programme machines and computers, but it does not arrest progress in these directions because the ultimate results of such progress are to eliminate tedious employment and call for fewer, but more skilled operators. We still need the local knowledge and skill of our signalmen, but we are going to use it in a different way. It will be needed to make essentially human decisions which a machine cannot be expected to do, because of the limited amount of data at its disposal.

There is a coming development in which preliminary work is already proceeding, and which will soon necessitate serious consideration being given to the automatic overlap. This is in respect of route-setting, initially by train describers and ultimately by computers. Control by train describers will obviously come first, and because only a very limited amount of information about future traffic movements is available from a describer, the selection of a suitable overlap will have to be achieved by automatic means. When route setting by computer is eventually adopted, will its task not then be complex enough without the additional burden of selecting overlaps ? For this reason it would seem prudent to develop the automatic overlap while we are solving the problems of describer route-setting, and the installation will then be ready for the ultimate introduction of a computer, without concern for overlap selection.

7.2. *Requirements*

The requirements of automatic overlap selection and diversion are comparatively straightforward and can be stated as follows :—

(a) Where more than one overlap is available at a signal, route-setting of the outer signal shall automatically select an overlap which is proved clear ; if more than one is available, then that corresponding to the existing position of the facing points shall be selected. In certain circumstances it may be desirable for the circuits to be loaded and to have the facility of giving preference to selected overlaps, e.g. one which corresponds to the most commonly used inner route. Also, to avoid the selection of others (except where no other overlap is available), which may obstruct further movements if they have to be held for any length of time.

(b) After the outer route has been cleared, the overlap shall remain free to be changed, either by key-setting, or by route-setting, to a new overlap proved clear prior to the change. Facilities for manually holding a particular overlap for any reason, must be provided.

(c) If another route is initiated which requires to use part of a held overlap, then provided that an acceptable alternative is first proved clear, the new route shall divert the overlap to secure a free path for itself. Detection of the diversion must be continuously proved in the new route.

(d) Changes in overlap will be permitted until the approaching train reaches a position beyond which the completion of movement of overlap points cannot be effected before the train could reach them. After this position, the existing overlap must be held until time-released by occupation. Changes in overlap must always commence with the points furthest away from the protecting signal, so that the first facing points are the last to move, being subject to approach-track control.

It may well be argued that if the distance between inner and outer signals is comparatively short, there is no purpose in introducing an automatic overlap because little time is available for change. This, however, is not quite the purpose. The facility provided means that a route can be cleared as soon as a train is offered, or routes are demanded by a train describer. In a multiple-aspect area this means that the outer aspects are kept to a minimum restriction. There is no need to hold a train back until a preferred overlap is clear before setting the outer route. Provided that more than one overlap is available, the train can be kept on the move right up to the inner signal with a minimum of interference to other movements which can continue and divert the overlap if necessary.

So far as the author is aware, only one power-signalled installation for passenger traffic in Great Britain having these facilities (with the exception of (a) above), is in existence. It has received Ministry of Transport approval, and may thus be judged to be based on reliable safety principles. Although it cannot be said that the traffic density on this particular installation demanded such facilities, there are concentrations of traffic at certain times of the day when they have proved their value, and the Operating Department considers the additional circuit work to have been justified.

The circuit requirements in terms of extra relays and wiring to introduce the facilities are comparatively modest, and this leads to an obvious question. Should the facilities be provided on all overlaps on an installation so as to preserve uniformity in operation or should they be provided only where particularly useful? With describer or computer route-setting it will have to be universal, but on manual route systems, the author inclines to the view that uniformity in panel operation is always desirable, particularly where relief signalmen are concerned. However, since economy is equally an important factor, it should not be difficult for it to be suitably indicated on the diagram whether particular overlaps are automatic or otherwise.

8. OVERLAPS IN GEOGRAPHICAL SYSTEMS

The packaged circuits of geographical systems, with their many advantages, do present a number of problems in respect of overlaps including points. The reason is that an overlap lies outside the route proper, a problem also encountered in flank protection in such systems, and its extent is not determined by fixed geographical principles, but by physical layout considerations, traffic requirements and aspect class selection.

An entrance signal is given proof that a route from it has been set and is clear, but supplementary information has to be provided, not only of the identity of the route as determined by the selected exit, but also the route class applicable. Where overlaps are concerned, these may be a number of possible ultimate exits for the same route located at the extremities of the respective overlaps. It is clearly not possible to feed this information over the normal geographical levels back to the exit signal protecting the overlap because the information is only that an overlap, and not a complete route, is clear from this point. Even if the difference between an overlap and a complete route be proved safely, a difficulty still arises when an inner route comes to be set. There is the possibility that this can be cancelled, yet the outer signal must still hold an overlap if it is off-normal.

The treatment of these problems has been handled by two basic methods. Overlaps are arranged either by free-wiring tailored to the individual requirements; or the geographical principles are maintained by providing supplementary overlap levels between the route exit and the overlap limits in parallel with the usual geographical levels. The overlap levels comprise Availability, Selection, Setting and Locking, and Proving; and are directed through supplementary points sets which add the extra locking and controls imposed on the points when they are in an overlap. Where control panel buttons are used to select overlaps, the separate levels may terminate in an overlap button set. In this way the route and overlap are set by separate geographical levels and added together to form the complete route.

The economics of this system compared with free-wiring are difficult to assess; with free-wiring, only the necessary relays and circuits are provided, but more time has to be spent on circuit design. With true geographical sets there will always be circuits and/or relays not used, but provided to maintain standard arrangements and essential flexibility, but special circuit design is less often required. On large and complicated interlockings the use of separate sets attempts a uniform treatment of all overlaps ; but then again, treatment is rarely uniform even in the same interlocking area. Is it too much to ask for a consistent policy to be followed in overlap selection methods, even if a precise specification is not possible?

The methods of panel control for overlap selection are dealt with in Mr. J. S. Hawkes' excellent paper on Geographical Circuitry, given to the Institution in London in October, 1965, and no further comment is necessary.

It appears that the automatic overlap could be incorporated in a geographical system using separate overlap levels because Availability information is fed from the overlap limits back to the route exit, and proving of setting is also fed in the same direction, so that the first facing points would be the last to move in a change of overlap.

9. CONCLUSIONS

It is not easy to draw definite conclusions or derive any absolute standards on the treatment of overlaps. The British Railways Board Standard Signalling Principles were developed only after extensive discussions, and it is encouraging to see that they are phrased to recognise that there are always special cases where definite rules cannot cover all requirements. The omission of reference to point detection in the overlap is a pity, because it seems to the author that general rules are possible in this instance and their adoption could have led to simplification of needlessly complicated circuits.

So far as main line practice is concerned, the important points to note are :—

(a) The overlap is a margin, and does not demand the detailed protection given to the route proper. Nevertheless, before its integrity is imperilled, at least two co-incidental failures should occur.

(b) In straight overlaps, the location of the block joint at overlap distance from the stop signal is the most economical arrangement, and is to be encouraged.

(c) In swinging overlaps, freedom to change should be maintained until the last possible moment, consistent with safety, to allow maximum flexibility. Continuous facing point detection diverting an overlap away from an obstructed alternative is very desirable.

To the Student and Technician Members of the Institution, to whom this paper is specifically addressed, the author wishes to point out that it is in no sense an authoritative guide to the subject. It is only an introduction to a very interesting aspect of railway signalling which at some time in their careers will most probably demand study and attention on their part.

10. ACKNOWLEDGEMENTS

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DISCUSSION

Mr. E. A. Rogers congratulated Mr. Goldsbrough on choosing a subject which should produce a most interesting discussion. Overlaps was a subject on which many people held strong opinions and the paper should invite a ventilation of them. Together they would form a useful record in the *Proceedings* of the Institution. Mr. Goldsbrough need not worry about being criticised for expressing his personal views ; they would all like to clarify the subject if they could and so get something constructive on the records. Any comment he made was intended in that spirit.

The author had set down the standards for overlaps on both British Railways and London Transport, but he had not made it quite clear why there should be so much difference between them. British Railways used multiple-aspect signalling, three and four aspects, giving full braking distance between the first warning signal and the stop signal; and this was, in general, backed up by A.W.S. on the train. The overlap, therefore, was regarded purely as an overrun, an allowance for misjudgment, which was necessary and would continue to be so while the anachronism of the unbraked freight train continued to be accepted. When that had been abolished they might be able to rethink overlaps and, perhaps, reduce them to rather less than they were today. London Transport, on the other hand, used basically a two-aspect system with train stops at the red signals, and it was of course essential that the overlap should be of sufficient length to enable a train which had been tripped to come to a stand without risk of collision.

In considering the detection of points in the overlap it seemed difficult to avoid a measure of inconsistency. It was quite proper that they should detect facing points which led away from an obstructed overlap, but if they permitted swinging of the overlap by using the series selection arrangement which was shown on one of the figures, there was no detection proving at all when both overlaps were clear. Thus, if the points moved to select an available alternative overlap, there was no means of ensuring that they completed their stroke. This was accepted on the basis that, to create a dangerous situation, an overrun must coincide with a need to change the overlap and the failure of the points to complete their movement in making this change.

He was not convinced of the need to detect trailing points in the overlap since one would expect that the route-setting circuitry would have called for the appropriate points to operate and thereby locked out the possibility of making a movement which could foul the overlap. In section 6.1 reference was made to the need for approach locking of facing points ahead of a signal to ensure that they had time to complete their operation after the locking track circuit had become occupied. The signal did not need to be full overlap distance back from the points to avoid the need for an approach lock; it needed only to be far enough back for the points to complete their movement before the fastest train would reach them after passing the signal. For example, 132 yd for a 90 m.p.h. train with a 3-second machine operating time. Only if the signal was less than this distance from the points did one need to resort to approach locking.

In sections 7.1 and 7.2 the author mentioned the future prospects of automatic route setting. The rules he quoted were generally reasonable but until one reached the stage of using computers which would be able to predict several moves ahead of a particular route being set, there would be a risk that an overlap would be established which would inhibit a later, but perhaps higher priority, movement. Finally, in section 8 the author pleaded for a consistent policy in overlap selection methods, and the speaker had every sympathy for this plea; however, a little lower down, under "Conclusions," he noted that the author was encouraged to find that B.R.B. standard principles were phrased to recognise that definite rules could not cover all requirements. Would the author not accept that the second comment was the answer to the first?

Mr. Goldsbrough said in the course of his reply that a computer would cater for, perhaps, 90% of what was required of it, and even that was a high estimate; but it was the other 10% which was always the bother. Any automatic process, among which one might include programme machines, might possibly be regarded as a fairly simple form of on-line computer. An alternative manual control was always available, and this was essential. He felt that selecting an overlap which might prove embarrassing or difficult because of later traffic movements was one of the circumstances in which the signalman should step in and override the operation of an automatic overlap. That was why he very strongly emphasised that one of the conditions for an automatic overlap was that it should be capable of being overriden by manual control, and must always have this manual control, no matter what form it took.

Mr. V. H. Smith thanked Mr. Goldsbrough for his interesting and informative paper and joined with Mr. Rogers in congratulating him on producing a paper which would be used for reference in dealing with this subject. He also felt that the Examination Committee would look very closely at the paper when the time came to prepare future examination questions. One of the problems of the Examination Committee in setting questions was ensuring that adequate information was available on a subject for the student and for him to have acquired sufficient knowledge to answer the question. He thought the paper did this very thing.

Mr. Rogers had already made one comment on the relationship between British Railways and London Transport, and for his part he tended to regard British Railways as not having overlaps but only overruns. Referring to Mr. Goldsbrough's paper, Fig. 3 showed overlaps being shared by two or more signals. This was something that went against his nature. Its safety was dependent on the belief that trains moving in opposite directions would not both overrun their stop signals at the same time. On London Transport this arrangement was never adopted, and where trains could move in opposite directions, approaching each other, the distance between the two stop signals was always the sum of the two overlaps required.

Mr. Goldsbrough, in quoting the standard signalling practice, agreed with the British Railways Board "that the facing points in the overlap may be moved if they have time to operate and an alternative overlap is available." He himself felt that permitting facing points in the overlap to move with the train approaching the signal was a dangerous practice and should be prevented. In fact, Mr. Goldsbrough had pointed out in section 4.3 that points rarely lost detection once they were static, and if one interpreted "loss of detection" as meaning that the switches actually moved away from the stop rail, and not a detection failure as such, this meant to say that the possibility of switches not being closed on to the stock rail, and being in the position to derail the train, was likely to occur immediately after points had been thrown. This was the very dangerous condition that he was setting up. Here was the train running at the points, and he was permitting the points to move, with the subsequent risk of not completing their stroke. He thought it much better for the outer signal to lock the points, and then only to move them after the train had come to a rest, or virtually to rest, at the inner signal.

In section 4.3 Mr. Goldsbrough stated that where there was a choice of overlaps the principle continued to be to prove all track circuits and to detect only those facing points which diverted the overlap away from any one which might be obstructed. He illustrated this in fig. 4, but Mr. Smith did not think that the point detection contacts really detected the points as Mr. Goldsbrough had drawn them. He thought they were only there to cut out the track circuits which might be legitimately occupied if a parallel move were taking place. In section 7 Mr. Goldsbrough talked of the automatic overlap adopted on London Transport on programme machine installations, and he felt it should be included as a feature to assist the signalman if one must have the signalman. Having simplified the form of control for the operator to one entrance and one exit button per route, it seemed to him that the signal engineer's equipment was best fitted to devise the most appropriate setting for any swinging overlap, bearing in mind all other train movements taking place in the area. Experience had shown in the past that where the arrangement was left to the signalman, the optimum from the train service point of view was not obtained. In fact, at a fairly recent investigation it was discovered that, given similar circumstances, different signalmen at the same signal box chose a different order for trains which had to proceed over conflicting paths. Each signalman, he believed, did his job conscientiously and thought he was right. The system had now been automated, and he did not think the automatic arrangement agreed with any of the three signalmen who worked it. They did not arrive at the solution without a lot of thought and, in fact, some trial runs.

Mr. Goldsbrough had said he thought manual control was essential, and he would quarrel with him very much on that. He certainly would disagree with providing manual control which enabled a man to intervene and think he was doing better than a machine. The manual control on London Transport was only provided to cater for the emergency that arose where the service was gravely disordered. For instance, that very day there was an accident when somebody fell under a train and this caused a major upheaval on the line. In fact, he believed the line was shut down for three-quarters of an hour. Obviously they had not got that degree of disruption built in, and in those circumstances manual control was necessary, but he did not believe it should be there, nor should it be permitted to be used to allow the man to do, as he thought, better than the machine.

Mr. Goldsbrough agreed with Mr. Smith that an " overrun " was perhaps a more appropriate term, but he knew that the principles of main-line overlaps were absolutely horrifying to London Transport. He sympathised with the way they felt about it, but the fact was that the Ministry of Transport accepted them, and he could quote no less an authority than Mr. Fews as to how useful swinging overlaps were in the London Midland Region electrification. Mr. Fews had quoted in his paper the valuable minutes saved by using them and he considered that the extra circuit work to provide them was money well spent.

Mr. Smith had referred to Fig. 4, showing the overlap controls, and did not understand the case in which detection was included. If track circuit *B* was either failed or occupied, one would not get the outer signal unless one had continuous detection of 11 points normal.

Mr. Smith interposed that he preferred to put it the other way round—if *B* track was up, one was detecting, and Mr. Goldsbrough concurred.

Mr. Goldsbrough, continuing, dealt with the question of uniformity with automatic operation ; in that respect he agreed wholeheartedly with Mr. Smith, but not in the way he put the matter of manual intervention. This was because, no matter how clever a computer was, there would always be things which it could not solve and it would virtually have to appeal to the user and say : " please do something because I certainly can't." This was quite likely to happen with complicated traffic movements and attempting to assessing what was going to happen next.

One would always have this problem ; one could not programme a computer to do everything. One could programme it up to a point but one was bound to write into it the facility that if it found it had got a problem it couldn't solve it would have to come back to the programmer, and he, with his skill, would have to solve it. He thought this was the attitude one must take on all these matters.

He knew that a machine would do better than a man in many cases, but not in all. There would always be the situation in which the machine would say : " You'd better do this because I can't."

Mr. D. C. Webb added his thanks and appreciation to Mr. Goldsbrough for producing a most interesting paper. The previous speakers had made it clear that there were obviously very different problems on London Transport and British Railways. In the case of British Railways the overlap was purely to increase safety in the event of a driver failing to stop his train at a red signal, having already had a warning signal, and he found it interesting to consider how long the overlap should be. Mr. Goldsbrough had said in section 4.1 that the average of 13 reported overruns in one year was 112 yd but that was an average figure. He wondered if Mr. Goldsbrough could tell them what was the maximum overrun which of course could have produced an accident, and also whether these overruns were with A.W.S. in operation or not. He would like to know whether there were any further statistics available, which led him to wonder whether it would be very long before they could reduce the length of their overlaps by finding other methods of ensuring that the train stopped when it should. This was touched on by Mr. Rogers. When they lost the loose-coupled freight train they would certainly have an improvement and as their stock became more reliable, he felt it would be reasonable to think that the overlaps could be reduced. The ultimate object might well be to do away with overlaps altogether, but no doubt they would have to wait some time for that.

Mr. Goldsbrough said he was not at liberty to state the source of his information on reported overruns. But he could say that from the list he was given there were about 16. He eliminated three of them because it was quite obvious from the remarks put against them that the driver had no intention of stopping—he had not even seen the signal. No, there was no A.W.S. The maximum in the 13 reported ones was 400 yd. The minimum was only 15 yd but Mr. Webb would appreciate that there must be a number of overruns well under even 15 yd, that never got reported at all so that it would be very difficult to find an average figure. He imagined that quite a number of overruns were fairly short, and so it seemed quite reasonable to him that the B.R.B. figures were well chosen.

One or two people were disappointed that he did not include consideration of overlaps on the Continent and in the United States in his paper. He had not done so because it was difficult to get much information, but one thing he had found out was very illuminating. He wrote to the American Association of Railroads about overlaps because everybody here said that they never had overlaps in the United States; if they did not have them, why should we? The truth was that they did not have overlaps except on rapid transit systems with a full block overlap, which was a different case. What they did was to provide an excessive braking distance from the warner to the inner signal. We could not do that in this country because the geography of our railways was so closely knit that we had to pack our traffic in between junctions so close together that there would be no room to provide this excessive braking distance. Of course, if there *was* such a braking distance, it would be a pretty bad driver who could not bring his train to a standstill at a red signal when he was given more than adequate warning.

As was well known, in the United States very sophisticated methods of cab signalling were employed, which went to show that it was all very well to accept that somebody did not have overlaps, but when one looked behind it there was a very good reason for this. He, too, agreed that one looked forward to a time when the length of the overlap could be reduced because of universal brake-fitted stock. If we could ultimately reduce the length of an overlap, it would considerably economise in our signalling circuits and be of great satisfaction to everyone.

Mr. N. S. Hurford wished to emphasise the point about the terms "overlap" and "overrun." On London Transport the overlap was something to which particular care and attention were given. It was very carefully calculated, checked and cross-checked and had a very real significance; they knew that if a driver on London Transport took a train past a signal, that train was going to stop within that distance. It was very nice and comforting to know that, of course, but British Railways' use of the term was, as had been said in the paper and implied by previous speakers, was merely a margin for drivers' error. He wished that the term "overrun" was used rather than "overlap" because he thought there was a clear difference in meaning between those two terms.

He would also like to refer to fig. 3, the so-called shared overlap, which to anyone of London Transport sounded rather horrific. If, as he understood the arrangement, two trains were allowed to proceed together, approaching each other against the two back-to-back signals simultaneously, he really thought that the term was not shared overlap—the overlap was halved, and again if that term were used it would make the point rather clearer.

His next point concerned the vexed problem of the circuit in fig. 4. His training had been that in a layout like this quite clearly 11 points reversed would lock 13 points normal. If that was so, he did not think the contact 11 RWKR would be necessary.

Mr. Hurford referred finally to the calculation of the overlap in section 5.2 by way of amplification, because he thought the stress was not quite right. Mr. Goldsbrough referred to the braking efficiency of 12% in tunnels reduced to 10% in the open. He thought the stress should rather be that it was normally 10%, and they relaxed it to 12% in tube tunnels because in those conditions they knew the track would be dry and trains' brake blocks would also be dry. In fact it was only applied after the first "all trains to stop" station when a train entered a tube tunnel. In the sub-surface tunnels the 10% figure was applied, so that was the more normal figure.

Mr. Goldsbrough replied regarding fig. 3 that he rather regretted having used the word "typical" because it was not typical, it was rather special. He selected it because it appealed to him as showing many different overlap conditions that were possible. He might say that he knew of this particular layout in three separate places, and certainly in one of them the speed limit that applied was 15 m.p.h. He thought that these overlaps, as they stood in those limited conditions, were perfectly acceptable. If one considered the actual possibilities of two trains approaching the stop signals at the same time, it probably rarely occurred. The facility needed was, of course, to berth two trains at the platform and allow either one of them to pull out without involving movement of the other, so that it was rather a special case; but he agreed that they were halved overlaps rather than shared ones.

Returning to fig. 4, with the point detection, he had completely disregarded point-to-point locking in this. He was simply putting forward one argument, namely that where one had an obstruction, one must continuously prove detection away from that obstruction. He did not relate this to point-to-point locking at all.

On the question of braking efficiency; in present company it would be very unwise of him to make any comment about London Transport principles at all. He put them in the paper because quite obviously this information ought to be included in any study of the sort. He reported what he was told. The information given was produced in the paper and he might have seen some private opinions but he certainly did not think he should elaborate on them. However, he thanked Mr. Hurford for correcting the misunderstanding, or rather his misrepresentation of the respective braking efficiency percentages.

Mr. H. R. Broadbent said he was always a bit chary about speaking when the subject was not his own discipline. He remembered a curve showing braking distance against speed in which the distance was given as minimum braking distance, whereas it appeared to him to be the maximum braking distance. It was only after some while that he realised it was maximum braking distance for the C.M.E's department, but minimum distance for the Signal Engineer; and for that reason he feared that he might be referring to Signal Engineers' terms which might have a different sense to the C.M.E. Nevertheless, he drew attention to the author's reference to the calculation of overlaps in para. 4.1, where he said that although formulae might differ in detail they usually included factors of a maximum approach speed and so on. So far as he could see from the paper, none of those factors was used by British Railways in arriving at an overlap distance. Only two overlaps were given, 200 yd and 300 yd, and it would appear that except for gradient, none of the other factors—speed, average braking capacity, efficiency, signal sighting distance and so on—was used in arriving at the distances concerned. So far as he knew, the only system, at any rate in this country, which did take account of the relevant factors was London Transport.

The proposals for the use of the term "overrun" rather than "overlap" became obvious. The French used a rather grandiose word when they talked about their philosophy of signalling, philosophy of overlaps and so on. It was possible that British Rail might be persuaded to change their philosophy—their attitude—towards overlaps, and the reason lay in the introduction of A.W.S. As the author said, it was not reasonable to talk about a safety margin for misjudgements in braking. There was, for instance, no misjudgement in braking with A.W.S. It was no longer possible to quote the the cancellation of the brake by the driver and his subsequent control, when the fact that he might be dead was accepted and the A.W.S. was designed to cover this contingency. The driver's safety device was a further recognition of the possibility that a driver might die at his post. The position of British Railways was no longer tenable and the cosy feeling that an overlap was required to be no more than a cover for misjudgement in braking, could no longer be enjoyed.

There was already an overlap in the present system—the distance from the warning signal, A.W.S. control point, to the end of what was termed, by British Railways, an overlap—and it was this distance which should now be considered. On the L.M.R., for instance, where it had been the practice to cover for speeds up to 70 mile/h. on the maximum (minimum) braking distance to the home signal, and beyond that speed to provide a greater sighting distance, the introduction of A.W.S. had undermined the policy. Sufficient sighting distance did not allow for A.W.S. control and he would suggest that from now onwards, or from the moment A.W.S. came into full control, the position was not as stated in the paper and a rethinking was essential.

His other point was really only a somewhat minor one for London Transport, but as the paper was being addressed to students it might be as well that the fallacy of talking about braking efficiency as a percentage of g should be got rid of. Braking efficiency could not be a percentage of g, and a quotation from a glossary of terms produced by B.R.B. for braking should clarify the matter. Under the definition of the term braking efficiency, it was noted that the braking efficiency (or braking ratio as it was known on Western Region) was of no value where rates of braking were being considered, a rate of braking being a change in velocity in a given time. If a percentage of g was being quoted, the reference was to a rate of change of velocity in time; but the derivation of the braking efficiency formula was based entirely on initial speed and distance. It had no relation, therefore, to time and it could not be quoted in terms of a change of speed in relation to time. Braking efficiency was the ratio of the average retarding force during a stop to the equivalent braked weight, i.e. the static weight of the train with allowance of the rotating parts. Its conversion into a percentage of g on an assumption of constant retardation from brake initiation until the train had stopped was misleading and ended very often as an unwarranted figure of a demand on adhesion.

Mr. Goldsbrough replied that he was being put in a very difficult position in being asked to answer both for the British Railways Board and for London Transport. He did not think he should do this, but with regard to the questions about approach speeds, sighting distances and other factors; if he understood it correctly, the British Railways graph was not to be applied literally. It was a general guide, and if a Region considered that the particular circumstances at a particular signal merited more consideration being given, they were free to adjust the overlap as they considered necessary. It was a merit of British Railways principles that they were made to accommodate exceptions, and as they all knew, the number of exceptions which occurred was considerable, so he thought they must not be taken too precisely. They were as a general guide, and it seemed to him that they were a very useful general guide.

With regard to A.W.S., here again, perhaps, he should not make any observations, it should be done by British Railways. One of the points about A.W.S. was that it drew the driver's attention to the fact that he had passed a warning aspect and invited him to take charge of the situation. Now, he did know how many occasions there had been when a driver had dropped dead at his post or had passed out completely. He did not think British Railways ever had the idea that A.W.S. in every case would bring a train to a standstill at the stop signal. All he thought they were seeking to do was to make quite sure that the train did not run away out of control, and that was the merit in A.W.S. It was not possible to provide a system with precise results when one had a number of trains with so many different characteristics. London Transport were to be envied in that they could measure the performance of their rolling stock very accurately and they had taken advantage of it, as well they should, and had been able to produce, if such a thing were possible, almost a perfect system. They were to be commended for this, but one must not forget that it was not possible to do these precise calculations on the main lines of British Railways and one must accept certain limitations in the facilities provided. He invited comment from Mr. Rogers.

Mr. Rogers said that on the argument which had been put forward, if it was assumed that every driver dropped dead when he got an A.W.S. warning, they would not need an overlap; but the driver did not do so—invariably, if he were conscious, he cancelled the warning, he acknowledged it and took control of the train. Having established that position one must again allow for his misjudgement. They did not expect him to fly past the stop signal at a high speed—they expected him to stop at or about the signal—but it was much better that he should take control, otherwise the train would often stop very, very short of the stop signal. The driver's job was to get to the stop signal; for that they gave him the allowance of the overrun (if one liked to call it that); they still called it the overlap.

Mr. V. B. Orchard thought the question of overlaps was a hypothetical one. He had been told by an old locomotive man some years ago, that any distance he cared to name up to the signal at red was his. One quarter of an inch beyond that signal was not his and he shouldn't be there. He thought that was a golden rule which was sometimes forgotten, and the question of prolonging the agony, should one say, by providing overlaps of varying degrees, was evading the question. London Transport this evening had put their case against the use of overlaps on British Railways; even London Transport were failing in the exercise as he saw it. They provided a train stop at a signal. If the driver was not already stopping, that train was not going to stop at the signal. He'd now gone past it and they were equally as bad as they were on British Railways. That train should not be past the signal.

It was rather ironical that with a fairly recent inovation in braking equipment, i.e. the electro-pneumatic brake, they had now in fact a case where some form of overlap control was necessary because on a number of occasions he had personally witnessed a driver making the last brake application at a signal and the E.P. fuse had blown, and before he could think what was happening, and why he had no brakes, and had put his brake into full airbrake, he was, in fact, past the signal. Perhaps he was shooting himself down a little bit on overlaps, but he felt basically this was a bad design in the braking system, and this state of affairs should not be allowed to happen.

Turning to other matters in the paper, he remarked that in connection with approach release of signals at junctions, for speed control etc., one went to great lengths in preventing the signal from clearing in an attempt to get the speed of the train down to a safe speed for the junction ahead. What was not prevented was the actual movement of the points to the lower speed route. This seemed wrong to him because if the train was going to run past the signal and be basically out of control, then it was wrong for points actually to have been set for the lower speed route; and putting approach control on to the signal did not really alleviate the problem.

In fig. 2 Mr. Goldsbrough showed a junction signal with no separate overlap. He was quite prepared to accept no separate track circuit for overlap on an auto signal, but he was a little worried when it came to a junction signal, especially if there might be a station to the rear of this signal and a train had stopped to do station work with the signal off. The train could have come to a standstill with the driver and his engine beyond the signal. He had met such a case at a place which should be nameless. The signalman, realising the train was doing station work, enquired of the station staff how long it would be, and the station staff said 10 minutes. The signalman at that time had a light engine movement about. He put the signal back to danger, the approach locking timed out quite correctly, and the conflicting move was made at about the same time as the guard, willy nilly, decided to give the right of way to the train in the platform. He saw the signal at red and said, "Oh well I've just passed about two or three dozen others coming down from London that have been red by the time I saw them anyway" and gave the right of way. The driver was none the wiser because he was already past the signal, and the train started. At which point a light engine shot straight across in front of him. It was a lucky case in that the movement was all very smooth and no catastrophe ensued. He mentioned this point as he felt very strongly about it indeed, for it also applied in their recent question of track circuit joints and their positioning and fouling points etc., in connection with liner train vehicles.

Mr. Goldsbrough thought they must all agree with the principle that if one was $\frac{1}{4}$ in beyond the signal, one was in the wrong place. No one could question that, but it was apparently quite a difficult job to bring a train exactly to the right position and stationary at a signal in varying conditions. Regarding fig. 2, overlaps without separate track circuits, he had rather expected that one or two people would try to read more into the diagram than was actually there. It was put in only to show that by siting the signal back from the points at overlap distance, one was relieved of the necessity of considering the points in the overlap. He agreed that in dealing with the situation in practice, the circuitry and techniques for introducing point locking and protection would be quite complex. Regarding engines standing beyond the signal, this was quite a common practice and, in fact, rear indications were very often given on signals to allow an engine to stand forward; but in the cases he had come across quite extensive precautions were taken to prevent any irregular movements. He did not think this particular difficulty was really related to overlaps at all; it was just normal practice where a train was a bit longer than normal and where special provision was made for allowing the engine to stand ahead of the signal in a station. In any case, the train was at a standstill at the time the starting signal was given. Therefore the difficulties of problems normally associated with the overlap just did not exist.

Mr. J. W. Birkby said that for the last few years he had the honour of attending the Institution's meetings as a visitor. He had been interested recently in listening to the arguments for and against redundancy techniques as opposed to the existing signalling systems, and was glad therefore to see that the author brought two copies of his paper so that they did not have a failure in the lecture. One of the arguments against redundancy techniques was the claim that the existing signalling system was always fail-safe. With a three-channel redundancy system and majority voting, the advantages offered over existing systems were as followed:

1. The same order of safety.
2. Better reliability.

It could be argued that redundancy techniques used more equipment, but the equipment itself could be made to a very much less rigorous specification and therefore much cheaper. The advantages of better reliability were many both from a commercial point of view and also of safety. It had been pointed out on several occasions that many accidents occurred when the existing signalling system had failed and emergency working had been introduced. It was of interest, therefore, that in section 4.1 of the paper it was stated that the British Rail standard overlap, which he would emphasise was not an absolute overlap, was justified from statistical experience. Would the author consider applying the same reasoning to redundancy techniques?

Mr. Goldsbrough asked to be excused commenting on the fail-safe and redundancy aspect, which was the President's particular subject. Regarding the point in section 4.1, he admitted that he had accepted that the figures he had been given justified British Railways' choice of the distance of overlaps. He hoped more would not be read into it than was really there. All that happened was that he had asked a particular Region if they would be kind enough to give him some figures, and he was delighted to find, when he looked into them, that they did actually show the figures came inside the overlaps recommended by British Railways. He was not in a position to make a statistical investigation of this problem; this was a purely general and casual observation, and no accurate statistics were involved, or any research whatsoever.

The President (Mr. Hadaway) interposed to say he wondered if Mr. Birkby was proposing that in the interests of redundancy there should be three overlaps for every one!

Mr. D. Hotchkiss recalled that Mr. Rogers said they did not need to detect trailing points in overlaps, but in geographical systems the aspect lines would have to pass through the trailing point units in the overlap, and be routed over contacts according to whether the points were normal or reverse. He submitted that these contacts might just as well be detection contacts as contacts of any other point function, so one could say that it did not cost anything to detect trailing points in the overlap. On the other hand, one could say that if trailing points in the overlap were detected, and a detection failure occurred, then one was holding the outer signal at red as well as the inner signal. This could cause more delay to traffic.

Secondly, he wished to put the case for overlap buttons. Everyone seemed to have agreed that it was much preferable to swing the overlap by means of independent point keys, but as a circuit designer, he felt that, again with a geographical system, the method of overlap swinging employing overlap buttons enabled one to swing an overlap using the existing route-setting facilities. In other words, one treated it as a "mini-route," using the button of the inner signal as entrance and the required overlap button as destination. This was quite simple, but if the same thing was now attempted with an independent point key, one first of all had to seek out the new route and lock it. Then one had to swing the facing points themselves and thirdly one had to release the remainder of the old overlap. All with one point key. So this point key suddenly stopped being an independent point key and became a sort of route-setting key. The circuits one had to "hang" on to do this were, he would say, at least twice as complex as those for a commensurate case of overlap swinging by overlap buttons. It all added to the cost of the job.

Mr. Goldsbrough said he thought he had pointed out in the paper that in geographical circuitry, and in the system he was familiar with, the overlap levels were quite distinct from the normal route-setting levels, and therefore one could include trailing point detection or not as one wished. That gave the necessary flexibility; one was not tied to using the same conditions in the overlap as one had for the route; the two were quite separate. He agreed that overlap buttons on the panel were a good thing and he rather liked Mr. Hotchkiss's term "mini-route." His criticism about the number of buttons on the panel merely came back to the automatic overlap, and he felt that whilst they had buttons to do this and buttons to do that, if there was something they could do automatically, why not do it, and get quite a lot of benefit from it at the same time.

Mr. B. H. Grose said Mr. Goldsbrough perhaps found it better to stand aside from the vexed question of redundancy techniques, and he would like to step into the breach. Mr. Birkby had come up with the two old chestnuts which seemed to permeate all Research Department thinking. These were the reliability and the cheapness which could be offered by redundancy systems in competition with conventional fail-safe equipment. He had pointed out some time ago, at another meeting, that adequate safety could only be assured with inferior equipment by combining such items into voting circuits, and as a consequence there was much more equipment involved and therefore the reliability must suffer.

All that could be achieved by using inferior equipment in redundancy circuits was to prevent one wrong-side fault from causing a catastrophe. This improvement had to be bought at the cost of much heavier maintenance. If, for example, one-out-of-three logic was used then there must be three times as much equipment as would be employed by conventional circuits, on top of which must be added the extra equipment needed for the voting circuits. It was obvious that the overall fault rate of this equipment must be much worse than that of the good equipment it replaced, simply because there was more of it and because the basic reason for its being there was that it was of inferior quality. It was therefore simply not true that economical advantages were to be obtained if the Signal Engineer would only drop his apparently antiquated methods in favour of the latest ideas.

Mr. A. E. H. Jeffries asked how Mr. Goldsbrough felt about level crossings situated in the overlap a few feet away from a signal. A substantial obstruction might exist at the same time as a train was approaching a signal at red under Regulation 4.

Mr. Goldsbrough replied that he thought it would be very unwise indeed in the circumstances of the moment for him to make any comment at all. The position as he understood it was that so far as an overlap was concerned, a level crossing did not exist. He thought the reason for this was that since the line was well know, all the drivers are well aware that there was a level crossing in the overlap, and they adjusted their driving and exercised due care for that purpose. Signal Engineers were not, after all, the people who decided these things; that was the position, but he would rather not make any further comment at this juncture.

Mr. J. S. S. Davis said he had listened to the discussion with interest because at one time he did some research to find out how the practice of providing an overlap originated and what had determined the distance of 440 yd. He was not able to find any written information on the subject, but was told reliably at the time that the overlap derived from the emergency vacuum braking distances for express trains. This emergency braking distance was stated to be 640 yd and, therefore, if a driver was suddenly confronted with a stop signal at danger, it was calculated that he would, under normal conditions, be able to sight such a signal at 200 yd and accordingly would not be able to stop until some 440 yd past the signal. Mr. Goldsbrough had stated in his paper that the overlaps varied according to gradient and other factors and he could confirm that this was the case within his experience; and that according to the type, class and speed of traffic, as well as the gradient, the overlap could be varied.

He was in agreement with previous speakers that the time had come for revised thinking on overlaps and that with the introduction of multiple-aspect signalling and the assistance of the Automatic Warning System, the driver should be required to stop at the signal in the same way as he was required to stop at the buffer stops at the terminal station. The new systems of signalling, which the Research Engineers were at present developing, would certainly preclude overleps and would simplify and cheapen the cost of present-day multiple-aspect signalling if the Traffic Department would agree to relax its requirements. Mr. Goldsbrough had said that his remarks were directed particularly to the new generation of Signal Engineers and he hoped that they would succeed in this, as the removal of overlap requirements would considerably reduce signalling installation costs and at the same time would not reduce the safety of the signalling in terms of business risk.

The President (Mr. Hadaway) then brought the discussion to a close, remarking that the value and interest of Mr. Goldsbrough's paper made him feel keenly the restrictions of presiding that prevented him from taking part in the debate. He did, however, wish to make one comment, which was on the philosophy of the signalman stepping in to set an overlap when automatic means had gone as far as they could and asked to be extricated from a dilemma. He thought perhaps it would be better if the design philosophy of the machine was that, having gone as far as it could without producing a positive answer, it would still go on to give an answer of some sort, because it would do this better at short notice than the signalman, who did not know nearly as much as the machine. Therefore he thought there was still a case for saying that the machine could do better than the signalman.

The Signal Engineer was not able to do all he would like in the matter of safety, and this situation would be with him until the civil engineers and operators designed and operated the perfect railway. Some of the problems they had been discussing arose from situations which would not exist in an ideal environment.

The President then proposed a vote of thanks to Mr. Goldsbrough, which was carried with acclamation.

Provincial Meeting of the Institution of Railway Signal Engineers

held at

Glasgow

Wednesday, March 20th, 1968

The President (Mr. H. W. HADAWAY) in the chair

Mr. J. V. Goldsbrough (AEI-General Signal Ltd.) read his paper on "Overlaps (British Practice)."

DISCUSSION

Mr. Baldwin opened the discussion and complimented Mr. Goldsbrough on his paper, saying it would be of value to other members of the Institution quite apart from student and technician members. He remarked that the Ministry of Transport Inspecting Officer had spent an appreciable period during the inspection of the Perth installation in the relay room, studying the circuits associated with the automatic overlap before he accepted the principles involved. The principle of eliminating the separate overlap track circuit had been agreed so as to reduce signalling costs on all Regions, and not primarily to reduce costs in areas where d.c. traction had been adopted.

It was difficult to measure the value of providing overlaps in actual practice. Reports dealing with cases of signals passed at danger on two power installations in the Scottish Region last year revealed that they were mainly cases of misreading of signals as against cases of slide-past or overrunning. He asked whether there was a case for eliminating overlaps altogether, with a real reduction in signalling costs, where A.W.S. was provided and in areas where speeds were very low?

Mr. J. V. Goldsbrough replied that elimination of the separate overlap did prevent an early replacement of the signal, but this was considered acceptable. It must be remembered that overruns of 20—30 ft. often were not reported, but this did not mean that they did not occur. In one Region, in a year, the maximum reported overrun was 400 yd. and the minimum 15 yd.

Lines fitted with A.W.S. equipment should be provided with overlaps until it became possible for all trains to possess similar braking characteristics, when the overlap length might be reconsidered. It should be noted that overlaps had not been provided on many low-speed lines in the new Leeds installation.

Mr. Dean said it would be interesting to know how the figure of ¼-mile for a block acceptance overlap had come to be accepted initially and had been perpetuated for such a long time. The first record of this dated back to 1875, when ¼-mile was agreed after the Newark trials, and whether it had any relationship to braking distances was doubtful; but it was certainly accepted that under present conditions the overlap was provided to cover possible overrunning of a stop signal.

The provision of such overlaps did in some cases complicate signalling controls; but its necessity was proved on several occasions by the number of overruns even in modern colour-light areas. On this point, did the author think the present practice of eliminating an overlap track circuit at outer homes, etc. was a good thing, as this had deprived the signalman of a means of identifying overruns.

With regard to swinging overlaps; it was felt that a little too much importance was attached to these, as in his experience it was not normally necessary to change an overlap once this had been decided upon, because simultaneous train movements were normally known.

In regard to the question of variable lengths of overlaps; did the author think it was necessary to extend a normal overlap during foggy weather, bearing in mind the possible existence of A.W.S. equipment?

Mr. J. V. Goldsbrough replied that some Regions considered that the provision of swinging overlaps enabled valuable minutes to be saved. Mr. J. H. Fews' paper, "Planning Principles Underlying the L.M. Region Main Line Electrification Scheme", given to the I.R.S.E. in London on October 8, 1963, stated: "This facility (swinging overlaps) has proved particularly valuable during periods of heavy traffic at such places as Manchester (Piccadilly) and has enabled valuable minutes to be saved there."

The Eastern Region, in their many relay interlockings, had always provided this facility and its value was now well established. Subsequent train movements might be anticipated, but not accurately forecast, and the facility of a last-minute change was very useful. Whether one liked it or not, the automatic overlap would have to come to allow describer and computer route-setting. There was a reference to this last aspect under section 7.2. of the paper.

The extension of overlaps in foggy weather was strictly an operating matter. It would be expensive from a circuiting angle. In non-A.W.S. territory it was usual for speeds to be severely limited in fog and although overruns were more likely they would probably not exceed the overlap distance provided for normal approach speeds. If a signal was actually missed, no overlap other than a full block would allow for this.

Mr. R. C. Nelson said there was no need to provide approach-locking of facing points in an overlap which was in excess of 50 yd. ahead of the signal, because if an overrun occurred immediately after the points had been called to a new position, the points would have completed their movement before the overrun reached the points.

Mr. J. V. Goldsbrough agreed, but added that if the points were included in the overlap, the additional restrictions on their operation must still be imposed.

Mr. R. James asked if the author would comment on the positioning of runaway catch points within—or outwith the overlap on plain line remote from interlocking areas?

Such points were generally placed beyond (outwith) the overlap and whilst this was generally desirable, complications might arise where long trains had to be accommodated between the catch points and the next signal ahead. The position was aggravated by the usual closer spacing of signals on rising gradients, to maintain headway conditions.

Where standage space was limited, would it not be preferable to consider the overlap as a shared overlap between the movement approaching the running signal, and a possible breakaway approaching from the other direction, thereby permitting the catch points to be placed within the overlap and nearer the first signal?

Mr. J. V. Goldsbrough replied that this question should be answered by railway operators. Nevertheless, the principle of shared overlaps was accepted and in consequence it could be applied to this condition. The likelihood of a breakaway and a run-past occurring almost simultaneously was extremely remote. Even where shared overlaps were provided within low speed interlocking areas, as illustrated in fig. 5, the likelihood of two movements approaching signals at either end of the overlap at precisely the same time was fairly remote.

Mr. Henderson, remarking that the testing of the automatic overlaps at Perth was comparatively easy and proved to be very interesting, commented that the USR relay was proved in the released position before the route signal was permitted to clear. Was this control a matter of convenience or design?

Mr. J. V. Goldsbrough replied that it was always desirable to prove vital relays in the released position as far as possible, and the USR certainly had a vital function. The specifications for present-day relays were less critical than formerly, e.g. absence of jewelled bearings. There was a case for adopting lower standard relays for all functions which could be fully proved, but insisting on high standards for those which could not, e.g. TR and TPR.

Mr. D. A. Dickens thought the detection of trailing points positioned within 50 yd. ahead of the signal at the exit to a route did not seem necessary, since two overruns would have to occur simultaneously before a dangerous situation arose. A similar situation was already accepted with shared overlaps.

With automatic overlaps, changes in overlaps must always commence with points furthest away from the protecting signal so that the first facing points were the last to move. Therefore, an appreciable time lag might occur before an alternative overlap became available in concentrated point and crossing locations. When the alternative overlap finally became available, the key facing points might not throw fully to the new position due to an obstruction between the toe of the switch and the stock rail. This situation might be considered undesirable if a change in overlap were made whilst a train was approaching the signal at the exit of the route.

Since Mr. Goldsbrough's paper would be used for reference, it was considered that the method of deriving the overlap formula in paragraph 5.2. should be provided in greater detail. This might be done by adding an appendix to the paper.

Mr. J. V. Goldsbrough said in reply that it was considered desirable that trailing points in an overlap within 50 yd. of the protecting signal should be detected, especially if the points were double ended, to ensure that an effective trap in the form of flank protection was available if an overrun occurred.

Changes in overlap must be obtained by points moving in the correct sequence. This did not imply that the other points must move *in turn*. It meant that the rest of the new overlap must be proved before the first facing points were moved to it. If there were several other sets, they could move simultaneously if points interlocking permitted.

Failure of the first facing points in the overlap was an agreed hazard in the swinging overlap, but again it required both an overrun and a points failure to be a potential source of danger. It was accepted both by the M. of T. and by the operating staff, and with these assurances the signal engineer should accept it and use it to obtain the maximum operating flexibility. So far as he had been able to ascertain, there was no record of any fatality directly caused by this possibility.