Technical Meeting of the Institution

held at

The Institution of Railway Signal Engineers

Wednesday, October 13th, 1965

The President (Mr. J. P. COLEY) in the chair.

The Minutes of Technical Meeting held on 9th March, 1965 were read and approved.

The President introduced and welcomed to the meeting Messrs. A. B. Kar (Graduate), R. T. H. Platt and J. Hopkinson (Students) who were present for the first time since their election to membership.

The President then invited Mr. J. S. Hawkes to read his paper entitled " Geographical Circuitry ".

Geographical Circuitry

By J. S. HAWKES, B.Sc. (Associate Member)*

1. INTRODUCTION

The technique of creating a complete relay interlocking and signal control network, purely by suitable interconnection of special units of equipment, has been developed on the Continent in only the last decade, the spring of 1956 seeing the first installation at Dillingen in the Saar. Development has continued apace since then, and the success claimed during this time in overall economy and in the rapidity with which installations were completed has attracted railway engineers in many parts of the world.

The engineers of our own railway system have been no exception, and numerous visits have been paid to the Continent by Signal Engineers and other officers of British Railways, and other interested organisations. In particular, the conviction formed by the Chief Signal Engineer of British Railways, Mr. A. W. Woodbridge, that the new technique should be applied in Great Britain, to replace the conventional one of tailor-making each installation, resulted in the production by the British Railways Board of a specification covering " The Development of Geographical Circuit Technique."

It has been this document, in conjunction with associated discussions, which have formed the background to the formulation of new systems of signalling for use in this country, and utilising Geographical Circuitry.

*Westinghouse Brake and Signal Co. Ltd.

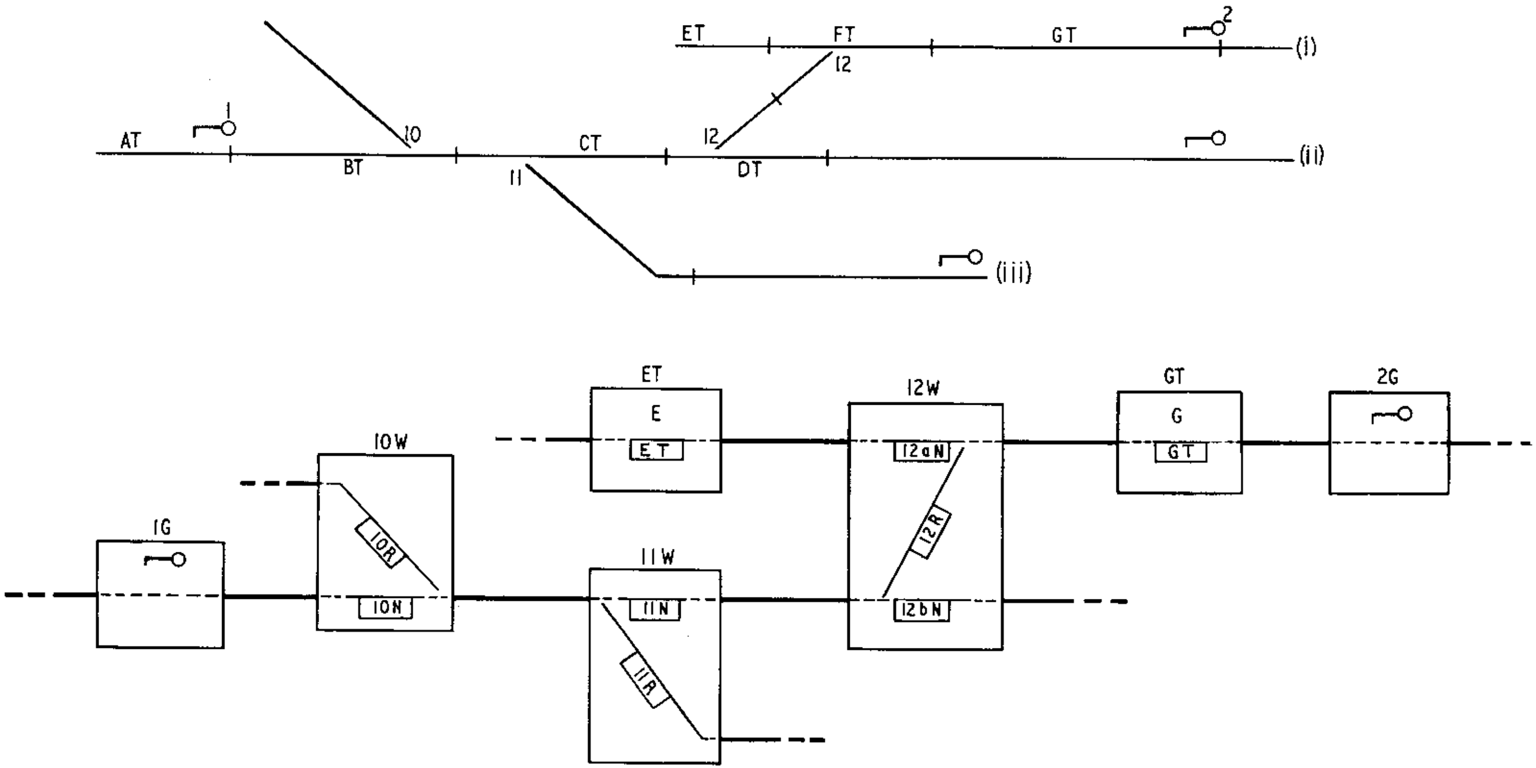

Fig. 1. Route Path Selection.

2. GEOGRAPHICAL CIRCUITRY

This term is a general one referring to a method of usage of assemblies of equipment. Broadly, any scheme comprising such assemblies, each applying to and forming the sole control of a particular signalling function, and each so connected by its operational circuits to those of the other assemblies as to form an electrical ' pattern ' corresponding to the track layout being signalled, may be referred to as a Geographical Circuitry System.

Ideally, it may be supposed, a system should consist of a definitely fixed and minimal number of assemblies or ' unit ' types, one per signalling function, each made to its own particular immutable drawings, and so arranged electrically to enable the interconnection between units to be direct and always the same; and to give for any logical sequence full and satisfactory operation of the signalling scheme. Such a system, requiring no special units or special or auxiliary interconnections, could be regarded as a ' pure ' geographical system. Unfortunately, such a rigid system has been found to be impracticable due to the wide variety of special movements required at one place or another, making the design of such a ' pure ' system hopelessly uneconomic.

Instead, a number of systems have evolved, each with ease of use and economy in mind, but to differing degrees of ' purity.' Whether one form will be found better than another will be shown only by experience over several years, to cover maintenance and layout changing; but without doubt it is with a system approaching the ideal that ease of application is to be found and likewise a ready understanding of the operation of the resulting signalling. Both these factors are of account in scheme planning stages as well as subsequently.

3. NATURE OF GEOGRAPHICAL OPERATION

3.1. Unit Selection

Although it is not the intention of this paper to be a technical circuit description of geographical circuitry it is felt that reference to a primary operation in such systems would be fitting.

The typical track layout in Fig. 1 is accompanied by a diagrammatic representation of the corresponding relay units.

Each unit is specifically associated with a particular track function, controlling or detecting as appropriate, and is linked to its neighbours in track order by the geographical connection. It will be appreciated that, from all the units making up such a geographical network as this, the sequence of units required to form a particular route must be picked out. Once selected and ' marked,' the selection of conflicting strings of units must be prevented and the circuits within the ' marked ' units must be co-ordinated and activated to clear the route.

It is this selection of units which is of interest; and a majority of current systems utilise a form of search circuitry, either energising or electrically releasing consecutive relays in cascade from unit to unit. The search is initiated by operation of the signal unit at the commencement of the route, and it fans out along all paths to the possible destination units. Only one of these units will be operated, so the search action is returned from this unit to the commencement, and then all intermediate units bearing the two directions of search are ' marked ' and form the required route.

However, a novel method of unit selection is one which incorporates the already-known system of one Route Lock Relay per route, and is one in which no selective relay action takes place until the interlocking for the whole route is shown to be free. The conventional Route Lock Relay first proved that there were no conflictions already set against it, and then, when operated, claimed its whole route, thereby inhibiting subsequent claims for any part of the route. It set all points as necessary and finally locked the whole route as aligned. The point control relays had to be set and locked by the route relays of all routes, from any direction, which read over, or otherwise affected, the points.

Fig. 1 shows a number of geographic units required for the route from signal No. 1 to signal No. 2, the end signal units defining the route and the intermediate ones governing the relevant portions of route, split up as points or tracks. The earlier single route relay can be considered as replaced by minor route relays, shown

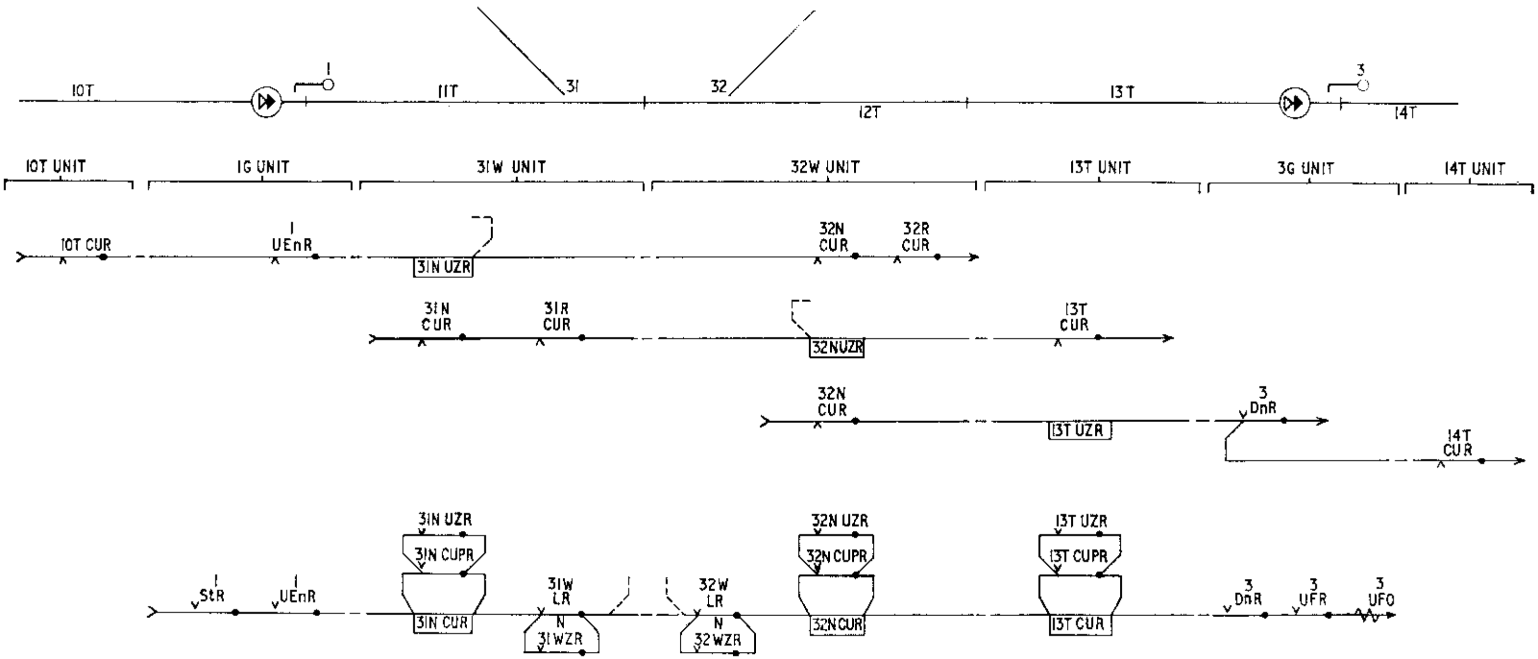

Fig. 2. Route Unit Selection (" Westpac " System).

diagrammatically as 10N, 11N, 12R, etc., which between them claim the route and set and lock the points required. Other routes utilise differing combinations of these, notably opposing moves such as 12bN, 11N, 10N. Also of note is the fact that the point control is now operated solely by the two or three minor route relays in the unit, thus regularising the point operating circuits regardless of the varying number of major routes involved and their direction.

To obtain the selection of the minor route relays required for a given route, it could be supposed these are simple series connected relays in the line circuit, in which case a positive feed applied by unit 1G and a negative applied by unit 2G would produce the desired result. However, to cater for routes of any length the arrangements shown in Fig. 2 are used. The units and part circuits are shown for a single route and the minor route relays, now termed CURs, are of the magnetically latched variety, whilst the ancillary UZRs are normally energised line relays.

Operation of the first signal button energises relays 1StR and 1UEnR, the latter breaking the upper circuit to prepare the first CUR of the route. Upon operation of the second destination button relays 3DnR and 3UFR are energised and these complete the series connection of all the CURs required for the route. This is the series form of selection already envisaged, but of great importance is the inclusion here of the complete basic interlocking feature. In general, conflictions occur at points, so that by associating each point CUR with the function ‘ Points correct or free to be set,’ whichever units are selected for a route, the CUR line will, in sum, contain the entire interlocking for the whole route; any locking not free will prevent completion of the line.

Upon completion, the full line voltage is applied to the operate winding of 31N CUR, since only the first UZR is de-energised. 31N CUR therefore picks up and latches, but is immediately itself by-passed by a contact of its direct repeater. However, with 31N CUR picking up, 32N UZR is dropped. As a result full voltage is now developed across 32N CUR, so that this in turn picks up, latches and is by-passed. This process then continues for the entire length of the route, whereupon the push button relays de-energise.

By this means not only are relay units selected for a route but selection commences only if the complete route is free to be set; further, once selected, points are set and held, and conflicting claims prevented.

3.2. Point Control and Locking

The point unit CURs set and lock the Point Control Relay (for example 32LR) by the circuit in Fig. 3, and the relay

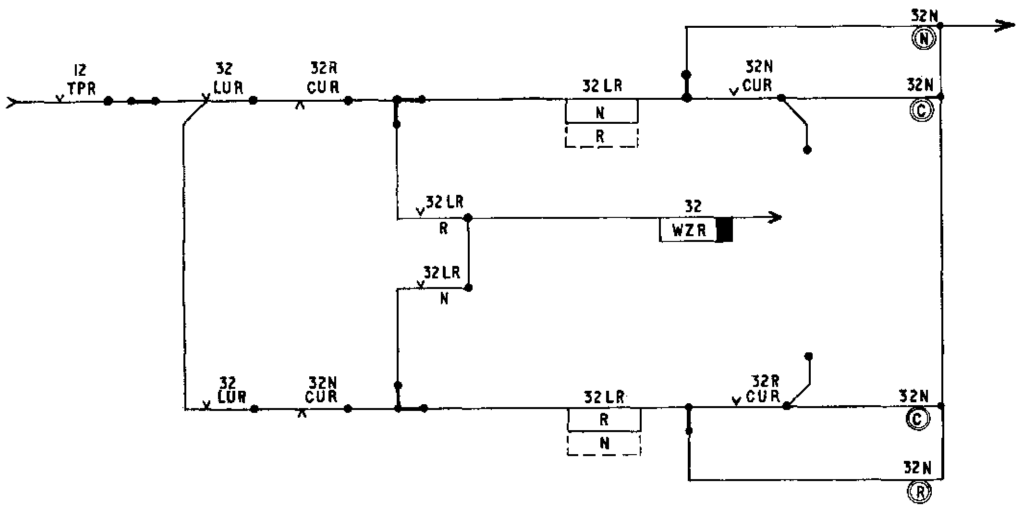

Fig. 3. Point Control Relay, 32LR. (“ Westpac ” System).

32WZR provides the function ' . . . or free to be set ' by detecting that the point LR is, indeed, free to operate. Operation may be by the Independent Switch, or with this in the mid position by, say, 32R CUR acting for all routes requiring 32 points reverse. It thus completes the ' Reverse ' circuit at right, whilst additionally holding the points by breaking the ' normal ' feed at left.

This break, with 32LR reversed, also de-energises 32WZR as the points are free no longer; as a result no route desiring 32 normal, such as in Fig. 2, can commence to set, as this setting line is open by 32LR not being normal nor being free to be set. This reasoning, applied to all points in the layout, provides the whole basic interlocking.

Once the required relay units have been selected by the CURs, and the points have been set, circuits can easily be directed along the chosen path. Fig. 4 shows such a circuit for relay 1 UCR, which proves, among other things, that all the track circuits of the route are clear, so that locking may be applied to the route. With 1 UCR energised, firstly approach locking is applied; and then, secondly, the locking relays LUR are dropped out. These again are latched relays, one per route portion as shown, and the release windings are energised successively along to the route destination.

Referring to Fig. 3, it is seen that by this means all point controls in the route become locked by the opening of front contacts, and proof of this having taken place is collected by relay 1 ULCR in Fig. 4. Finally, by combining relays 1 UCR and 1 ULCR, sufficient information is available for signal clearance.

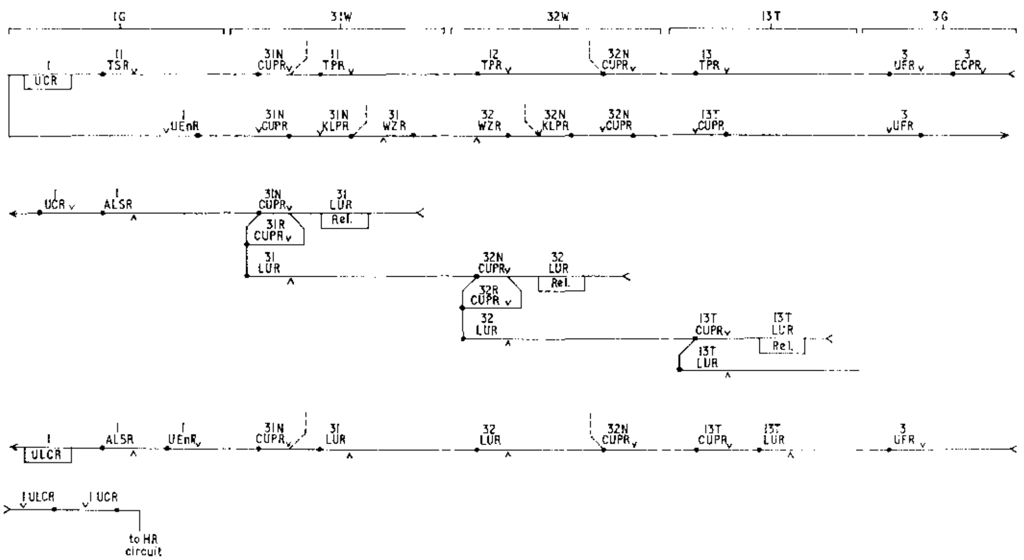

Fig. 4. Signal Clearing Circuits (" Westpac " System).

3.3. *Route Holding and Normalisation*

Relating to the circuits already shown, Fig. 5 depicts two chains of restoration circuits, one releasing the route calling CURs and the other re-energising the locking relays LUR. The operational sequence commences at the entrance signal unit with the signalman's normalising control which is at present customary, and also the essential relay determining whether any route releasing may be permitted.

Subsequent action is entirely track controlled. With a train occupying, say, 12 T.C. releasing proceeds over clear track circuits, as exemplified by 11TPR, so that up to the train, unit LURs are energised in cascade, with the CUR release windings following under control

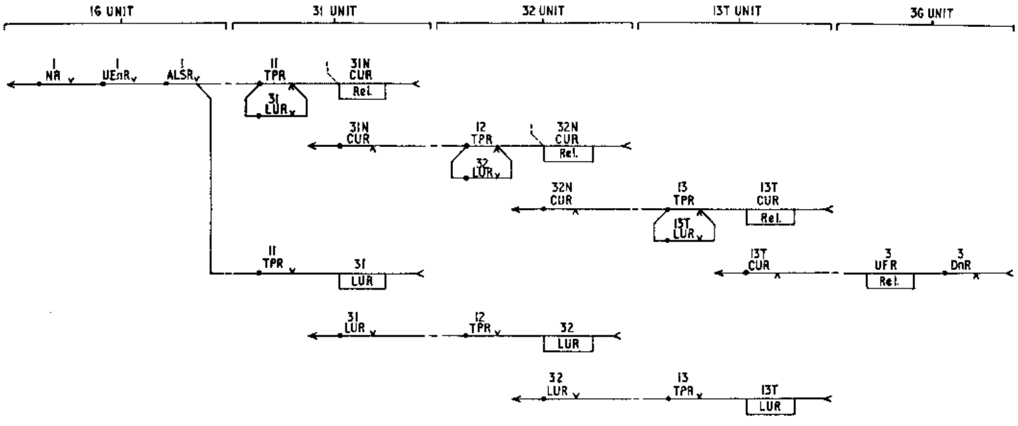

Fig. 5. Route Normalising Circuits (" Westpac " System).

of the LURs. At the occupied track, further energisation of LURs is not possible, but through back contacts of TPRs the CUR chain continues to release, as with 32N CUR. However, at the point from where the tracks are again clear, ahead of the train, no further action is possible thus retaining the remainder of the route fully held and locked as originally.

Release of units behind the train in this manner provides sectional release route locking, but it operates track by track, and is inherently provided. Much deliberation over the holding facilities required at an interlocking is thus avoided, and certainly the often-complicated route holding circuit work is avoided.

As is usual practice in this country reliance is placed on the efficient shunting of the track relays, and it is evident that this gives satisfactory results. The advantage of doing so is that a route can be normalised as soon as a train vacates it, whether by proceeding forward or by setting back, or in the event of non-arrival of the train. In contrast, Continental practice of releasing points by successive operation of the adjacent track circuits, results in requiring automatic normalisation ; it also requires special release facilities, usually demanding operation of an individual point control and a second control common to all point releases.

4. GEOGRAPHICAL SYSTEM FORMATION

The signalling becomes more elaborate with increasing complexity of layout. Provision has to be made for shunt signals, pre-set shunt signals, delayed aspects, variable overlaps, and so on ; and the need arises for a much greater variety of specialist relay units for these further functions. Those functions concerning signals are usually dealt with by elaborating the signal relay unit or group of units, but it is in dealing with the more involved track configurations that changes in the geographical pattern, or 'formation,' can be made to avoid creation of uneconomic relay units.

The geographic systems available, being designed to differing concepts of construction and use, will have equally differing ranges of relay units, which individually or in combination will be arranged to deal with the track configurations and other requirements to the best advantage. The problems and solutions differ considerably from system to system, but to provide examples of factors which have to be considered by designers and users further illustrations are taken from the system shown earlier.

The principal track units required are those for single points and crossovers, handed units being unnecessary as the geographic connections can be crossed instead. An avoidance of a double slip

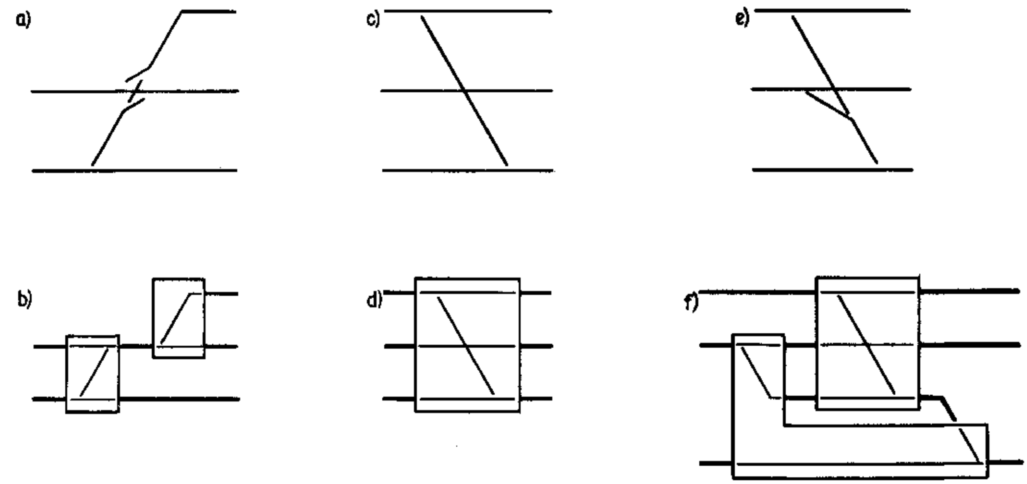

Fig. 6. Special Point Units.

unit is shown in Fig. 6 at a and b. However, the two track layouts shown at c and e could be covered by special units and connections as at d and f, savings being obtained in such combination units by the commoning of some geographical and/or control parts. Excellent and geographically correct as such units might be, if, nevertheless, quantities required are limited it might well be found more economical to use groups of more frequently occurring types of unit, as, for example in Fig. 7. By the use of crossover units both these cases become identical, except that in the first the geographic connections are arranged, for Fig. 7a, so that a route through A reverse can only continue with B reverse, and similarly with the straight centre road. In Fig. 7b, A unit R CUR is interlocked with B aN CUR to prevent the non-existent route being set, so that any route from the right operating B aN CUR will be unable to operate A R CUR and will therefore have to follow the straight road.

Another formation of interest is that of double crossovers, especially the left hand case in Fig. 7c with differently numbered ends. Standard crossover units can again be used as shown, the essence being that the constituents of a crossover can be independent. Thus Unit 19 can remain normal although 20a might be called reverse by 20b R CUR for a route through 20b/21, but 19 would be called normal by 20a for a route along the third track with 20b and 21 both being normalised anyway since the route setting network threads these units. In the right hand case, Fig. 7d, unit 16b would be called normal by 16a, but again line 3 would gain protection by threading units 15a and 15b.

To give an impression of the appearance of a geographical system network for a medium sized station area the layout in Fig. 8 has been drawn. The heavy line between units represents the geographical connection and the straightforward correspondence between this network and the track is apparent.

Further economy can be achieved by extending the use of units to cover minor variations in the standard requirements of a function. In the case of signals separate units are likely for 'shunt,' 'main,' and 'main with subsidiary,' but for smaller variations, for example for approach lock release, the alternative of equipping all appropriate units to cater for any of several requirements may be used.

A simple means of both selecting the operating characteristic required and of providing further facilities is through access points in the wiring. Selection would cover such items as form of approach locking, form of its release, form of signal replacement and so on, and facility extension is possible, say, for insertion of a selected fouling track into a signal circuit.

Similar provisions are also made in point units for special use, when forming part of a route, but particularly when away from the route or forming part of an overlap. Such a method of limiting the variety of units can be very useful but can increase the individual unit costs, as these units must contain at least elements of all the variations; the advantages and disadvantages require careful assessment.

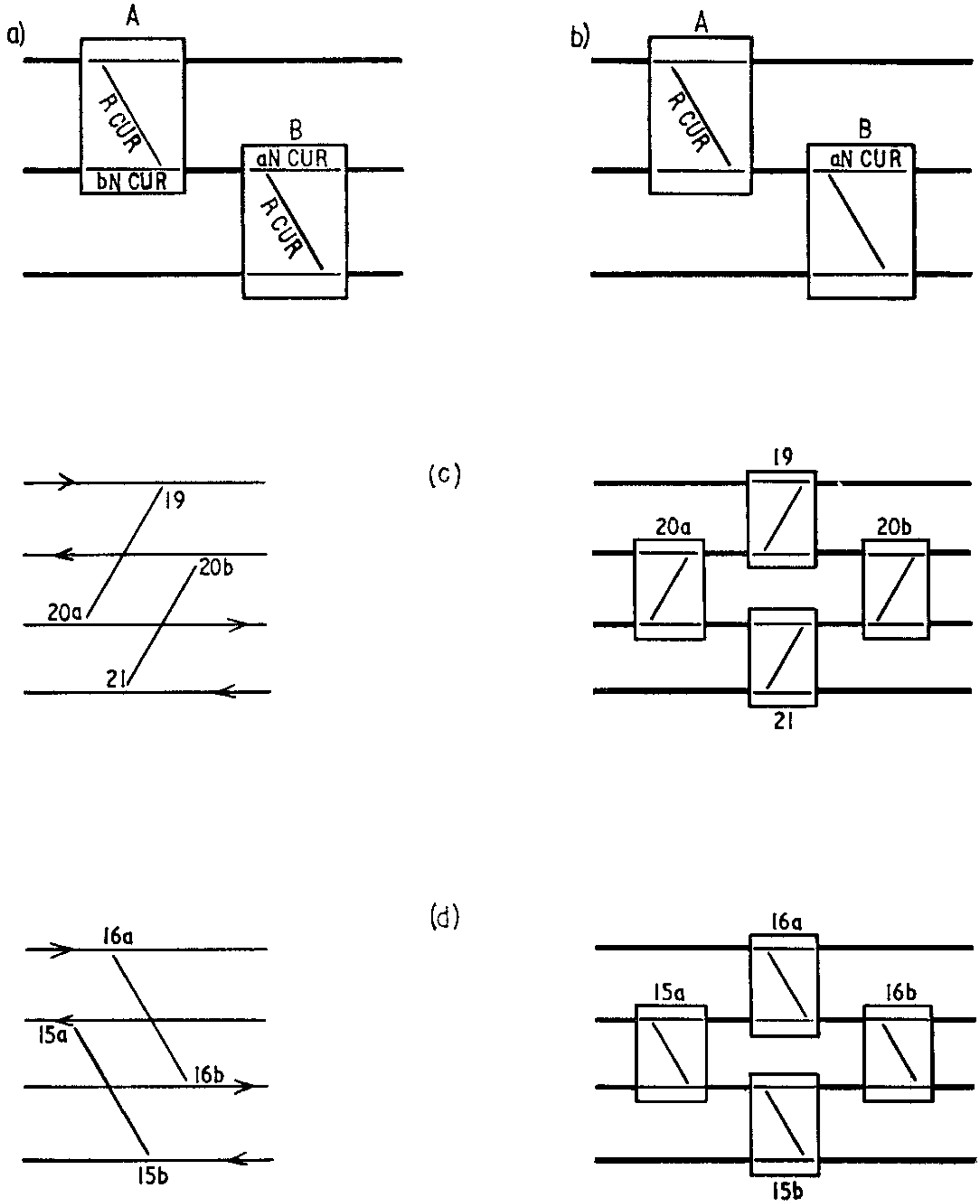

Fig. 7. Special Track Formations.

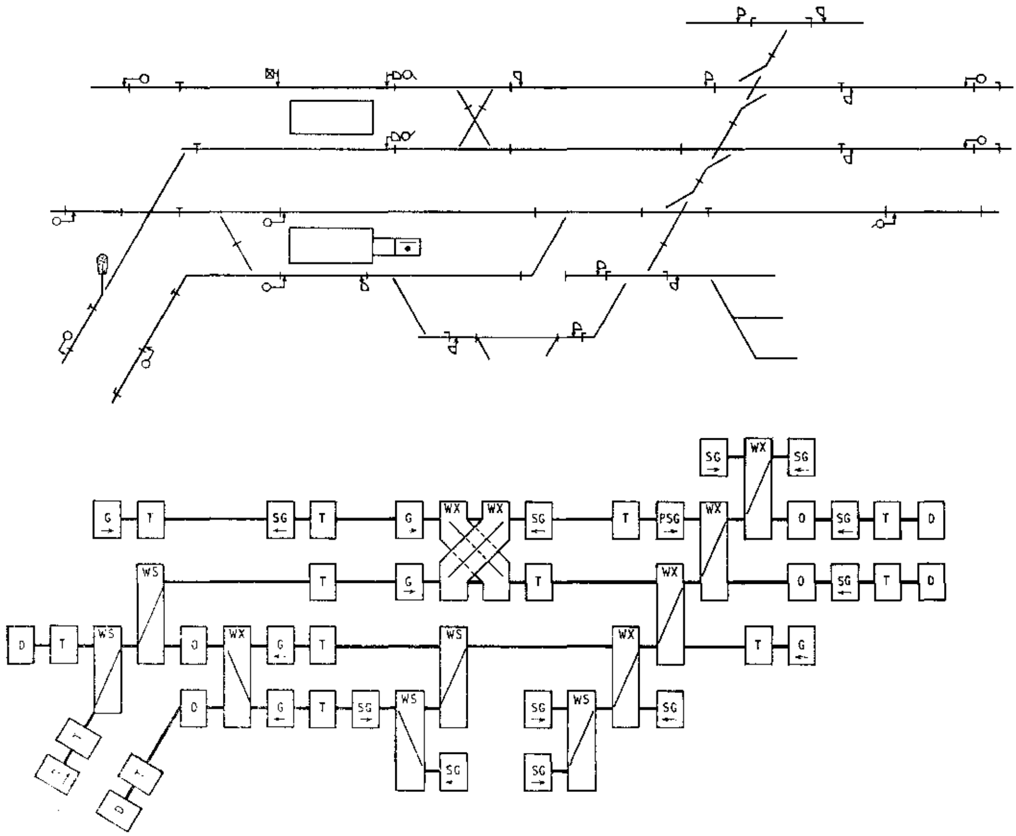

Fig. 8. Typical Geographical Unit Network.

5. GEOGRAPHICAL SYSTEM CONSTRUCTION

To achieve the advantages of easier production, and handling of relay units on site, the smaller types of relays can be used ; and for the unit interconnections multicore cables are of advantage when terminated in plug coupling devices for simplicity of connection. Additional security, too, can be provided by prevention of interference with relay and circuit equipment, from the time of manufacture onwards, by enclosing units in sealed cases, and such a system of " fully packaged and sealed " relay units would possess the features required for the ' pure ' system envisaged.

The degree of unit enclosure greatly influences the variety of unit types to be supplied and also the means of making circuit selections, and linkages between units, as in section 4. With sealed systems the greater amount of deliberation is necessary in determining the minimum number of relay unit types, consistent with full provision for all facilities demanded.

The basic conception behind the system taken for illustration is that for each complete trackside function there shall be a corresponding single totally-enclosed relay unit, and that the succession of such single units shall be interconnected, apart from servicing supplies and so on, by one geographic multicore cable carrying all the necessary operational circuit networks. Only one size of geographical cable is used suitable for use between any pair of units, all of which accept the full number of cores and can therefore be connected in any logical order. All units are completely sealed to provide the maximum security against interference. Also by having one unit to one function, and one constant size of geographic cable throughout the system, the basic planning necessary for an installation is reduced to that of drawing up a geographic network of the form of Fig. 8.

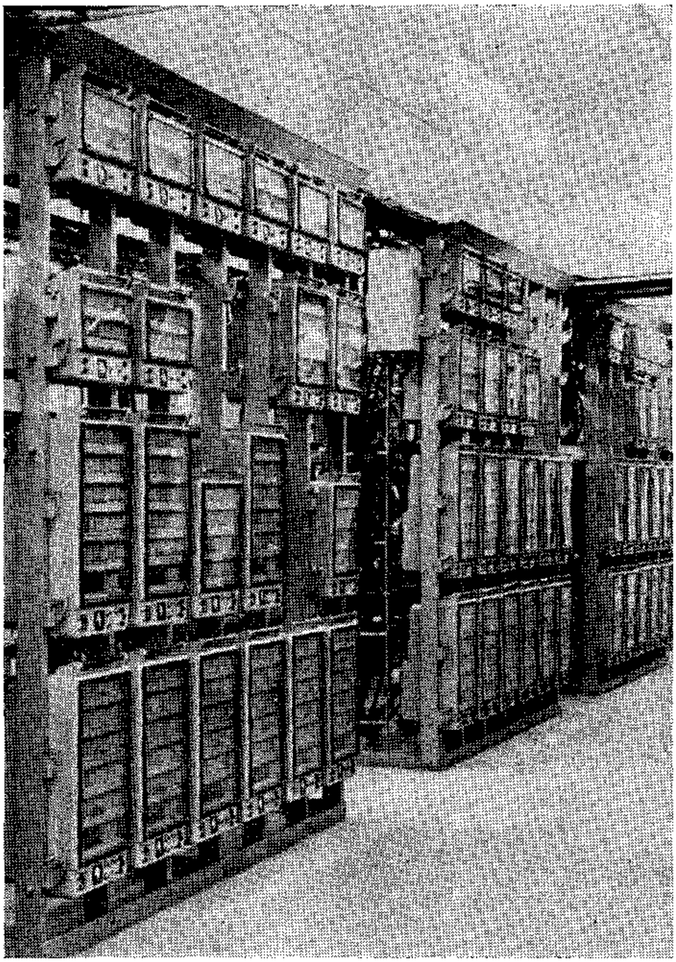

Fig. 9. W. B. & S. Co. " Westpac " Geographical Relay Units.

Illustrations of this equipment are given in Figs. 9 and 10, the first showing relay units of various sizes mounted on racks, and the second showing multicore cables running to the unit plug couplers which are interlocked to prevent misarrangement. The larger cables are the geographic connections, (four paths for a crossover unit) and the others convey controls and indications to the desk, external controls, push button interlocking, power supply, and so on.

In any system, access points and selection means are required in unit wiring, to a greater or lesser extent, to enable variations to be effected economically. Here, with separate plug couplers, a ' locality ' coupler contains adjustable link elements so as to ' programme ' the relevant unit as required, and also, if necessary, to provide the entry for additional controls as mentioned elsewhere. It is to be noted that such ' locality ' heads, or the equivalent, form part of the rack equipment at particular positions, so that upon a unit being changed the fresh one, from stock or from another position where its programme was set differently, will immediately take up the new programme and the changed additional controls.

As an example of programming and additional controls, Fig. 11 shows a simple variation to give the diamond crossing and single slip results of Fig. 7a and b. The route setting network is again shown,

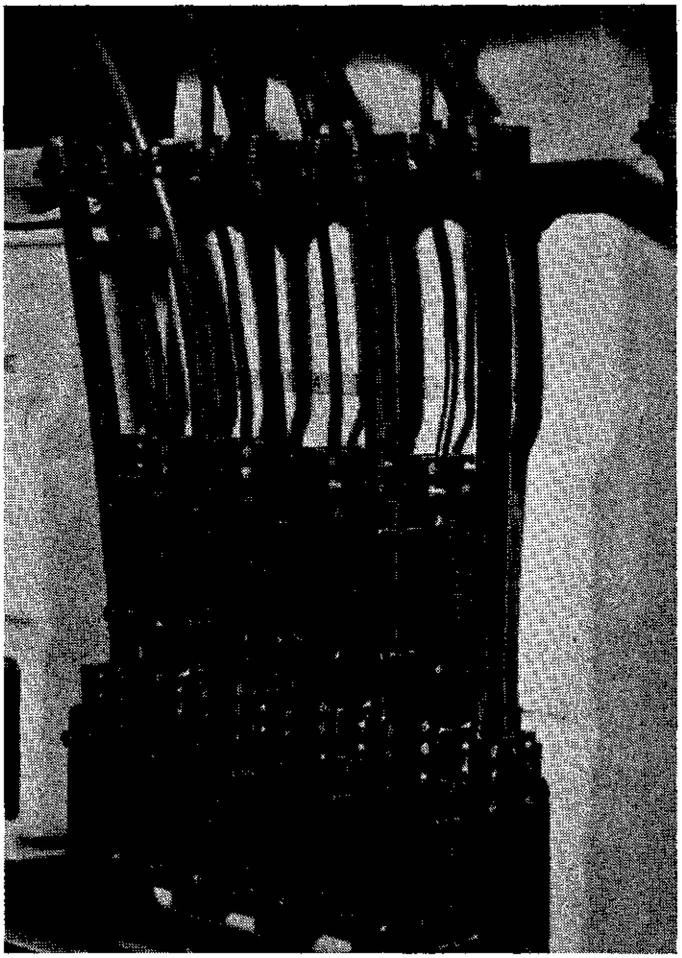

Fig. 10. W. B. & S. Co. " Westpac " Cable connections to units.

and with the links present the result for two crossovers or a double slip is obtained. However, with link u removed a route setting feed through 'A' R CUR can now only proceed via the second line of the cable between the units, and thence on only through 'B' R CUR; only a feed along line L1 can set B crossover to normal or reverse. The action of the diode ensures the correctness of the setting current path during the cascading process, though for safety the cross-locking between CURs is applied at x and y as additional controls. For a diamond crossing, as in Fig. 7a, link v is removed in addition to u, and then as the normal and reverse setting paths are independent no additional controls are required.

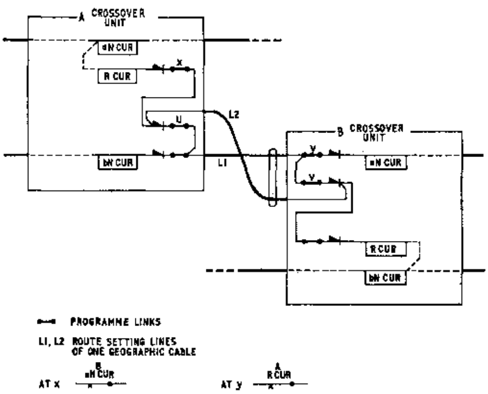

Fig. 11. Use of Programme Plug-Coupler.

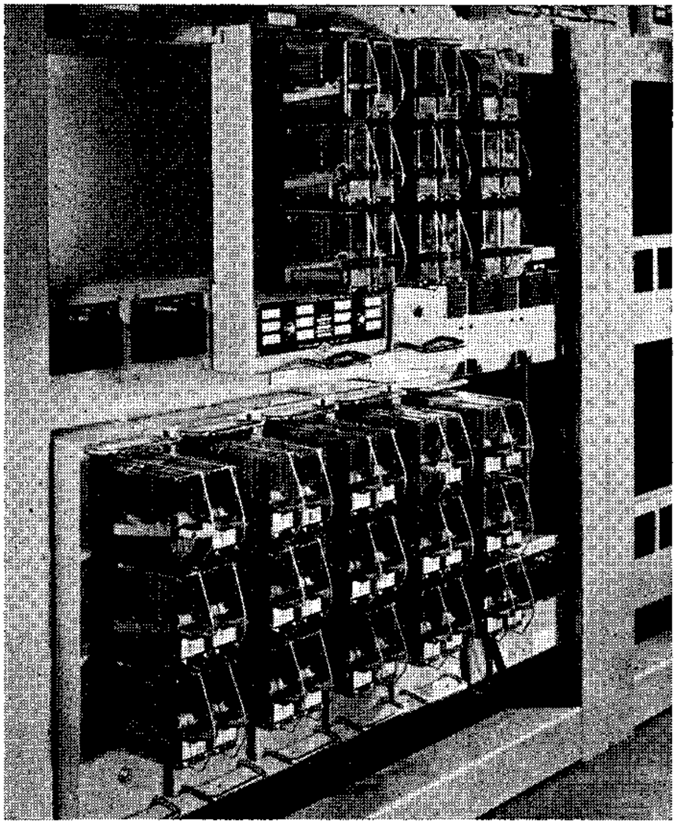

Fig. 12. S.G.E. Signals. Geographical Relay Units.

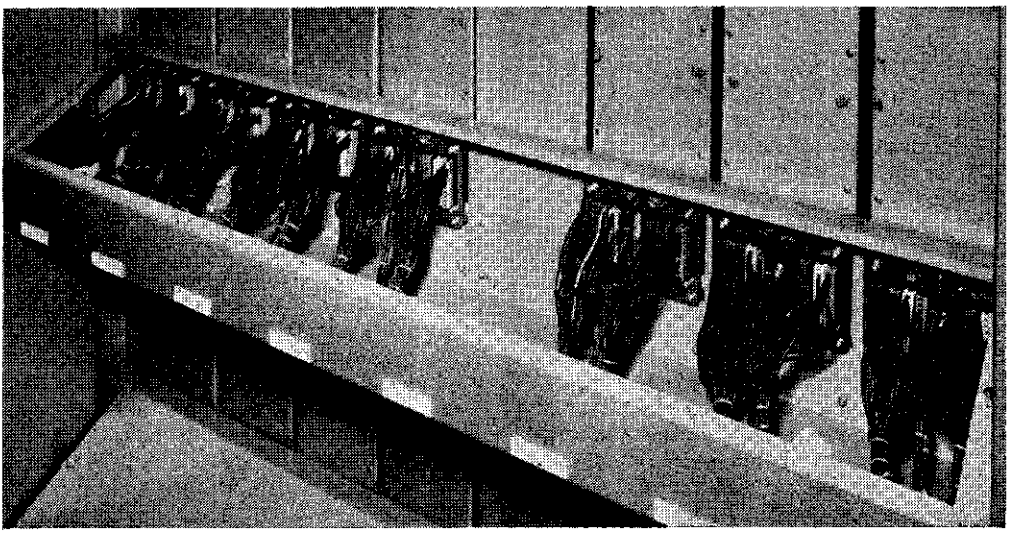

Fig. 13. S.G.E. Signals. Cable connections to units.

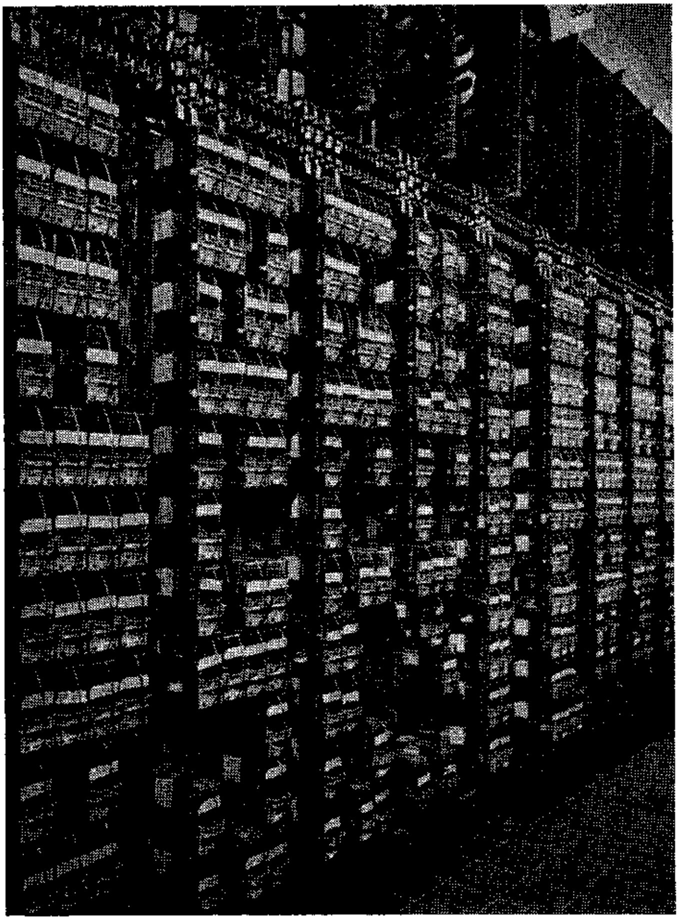

Fig. 14. A.E.I.—G.R.S. Geographical Relay Units.

The number of access connections depends largely on the number of unit circuits which could require variation; but the amount of additional circuitry or 'free wiring' to be expected depends only partly on the system in question. With larger one-piece units, economics dictate that a greater degree of variation must be catered for by external adjustment to minimise the number of unit types without restricting the facilities. However, a large proportion of this 'free wiring' results from the numerous cases of special signalling functions being demanded at present, so that the amount for basic facility extensions, such as point-to-point locking and the examples illustrated is not great. In any case, the deterring thought of numbers of single wires detracting from the ease of using multicore cables can be dispelled by suitable organisation as shown, with any special relay functions housed in a prewired 'locality cubicle.'

A rather different conception of geographical technique forms the basis of another system, which moves away from the 'one unit one cable' principle. In this case the equipment for trackside functions is built up with smaller separate relay units and the geographic connections with corresponding separate cables; and upon the basic geographic network, containing a primary unit per function, can be imagined a number of further layers or partial layers of circuit networks and units dealing with different stages or classes of operation. These layers extend only over those areas where their particular function is required, so that, for any particular track function, its controls, and so on, are obtained by linking together, to form a group, those units which appertain to it in the various layers.

The basic layer and units cover geographic route control, and another governs signal control, whilst others for, say, overlap control and trap setting only appear where required; thus the number of cables varies between groups which themselves vary in make up, and are drawn from a greater number of different unit types.

Whilst these variables in cables and units require further planning work for an installation, and changes in track layout would cause more disturbance, acceptance of varying numbers of cables and the greater number of unit types does permit of unit accommodation for a greater number of the special conditions and facilities demanded.

Figs. 12 and 13 show equipment of this system. The front view of the units show B.R.B. miniature relays being used externally on the unit face; some of these can be omitted if not required for a particular application. The other view shows the termination of the various multicore cables into the unit connector, and it is here that selections and other special wiring can be effected.

The wiring of the units of this system is sealed for security, as shown, but an open wiring system can be used. Units incorporating this open arrangement are shown in Fig. 14. In such a case there is not the improvement in security over conventional installations, but such units are readily adapted if required and the advantages of easier planning, etc., remain.

6. NON-GEOGRAPHICAL FUNCTIONS

The functions considered so far in route and signal operation have all been straightforward in the line of route. All the controls and detection of these items have therefore been in units along the selected route 'Channel,' and thus have been immediately accessible to the setting and proving circuits. Whilst these are often ingenious and worthy of attention, the purpose of the paper would be better served by mention of an important group of functions which lie off to one side of the route and is therefore 'non-geographic.' Within this group is an item which, because it has been so widely discussed, has almost formed a subject of its own—namely 'Flank Protection.'

6.1. Flank Protection

This is a term which seems to have grown up solely with the advent of geographical circuitry, although the protection referred to has always been taken into consideration. It may well be that the earlier Continental systems required an involved process for flank protection, and that, in consequence the term has been imported as an adjunct to the principle of geographical circuits; in Great Britain, of course, 'trapping' is commonplace.

Continental systems have normally treated all point ends as individual units, so that from every point in the route 'trapping' type of protection is sought and operated by searches along the divergent paths to seek available trailing points. The designers decided that since this flank-search process was to become necessary for every point set, the equipment to carry it out would always be

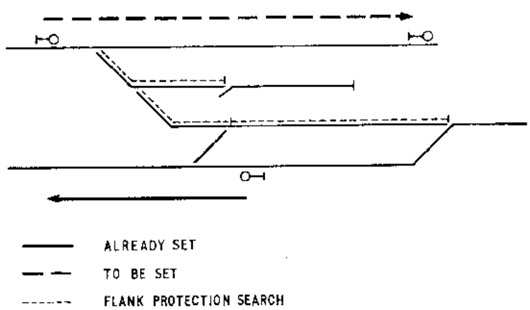

Fig. 15a. Track layout using single point ends and showing extent of flank protection.

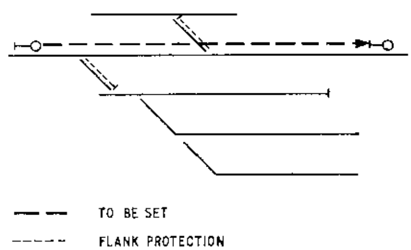

Fig. 15b. Track layout using crossovers. Flank protection greatly reduced.

necessary and should therefore form part of the point relay unit. The action operates along the geographic connection to search for, set, and lock the flank points ; to return detection to the route, and later give the release, thus providing the " automatic flank protection " often referred to.

In this country even before thoughts of geographical circuitry, this flank protection has never loomed as a large subject in the minds of signal engineers because of the much more widespread use here of crossovers for line connections. Such crossovers, bearing a single number and operating from one control, change the whole magnitude of flank protection, as is apparent from Fig. 15. Purely from the track layout viewpoint, main routes frequently pass through one end of these crossovers in the normal position, so that since the regular detection proves the other end is normal also, all necessary flank protection at this point is immediately, and inherently, provided.

This has a considerable bearing on design now that geographical circuits are being applied to British systems of signalling. If it were considered that exclusive use of single end point units were appropriate in Great Britain then probably a system of " automatic flank protection," similar to that on the Continent, would also be appropriate. However, with the widespread use of crossovers and with the economies derived from combining certain units, the use of crossover relay units alters the position.

With such a unit any interlocking which is holding one end of the crossover in a non-trapping position is also directly locking the geographical route network of the other end ; so that it is not until the trapping end of the crossover is free that a route over the other end can be set. Then once set and cleared, the flank protection is shown to be provided at this locality through the normal crossover detection, without the need for having any special circuits, relay chains or geographical cable lines for the purpose. By this means these units will automatically provide a high proportion of the required total quantity of straightforward flank protection.

The remaining flank protection has of course to be provided ; but immediately the question of economics demands that careful consideration be given to whether or not the wired-in "automatic operation" of this residual can be justified. The approach to this varies according to the basis of the system. Where it is the principle to have a single and fixed size of geographic cable it could well be worth having the standard addition of relays and circuit networks to give 100 per cent coverage if this residual protection were generally of the simple trailing point type.

However, in current work, it is being noted that to give greater flexibility and to cater for the intense service of a busy junction area 80 per cent of this residual protection has, in fact, to be of special and varying design which cannot, economically, be added to the already comprehensive units. Any wired-in provision of the Continental type would therefore be called into use for only 20 per cent of the residual, so that in consequence of this low utility, and of the fact that the special protection requires individual treatment in any case, it is preferable to provide for the individual treatment of all remaining flank protection. There is then complete freedom to insert any form of special or normal protection as desired.

A different approach is made when the make-up of a group of units appertaining to a track function can be varied, and likewise the cable connections between groups. In this case the flank protection remaining after coverage by the crossovers is dealt with as a whole, in that both the straight-forward protection and the various special forms of flank and ' run-by ' protection are accommodated in a further set of units, or part units. These, together with their interlinking multicore cable, form a flank protection network providing for the functions of setting, detecting, releasing and so on, and this is linked into the geographical network. The units are associated with whichever unit groups are to initiate or provide flank protection.

6.2. *Overlap Control*

To the signalman, most noticeably, the overlap is non-geographic, as it is beyond the area between the two control buttons that he uses for the route. These he operates geographically, like the train movement, ' signal to signal.' No one

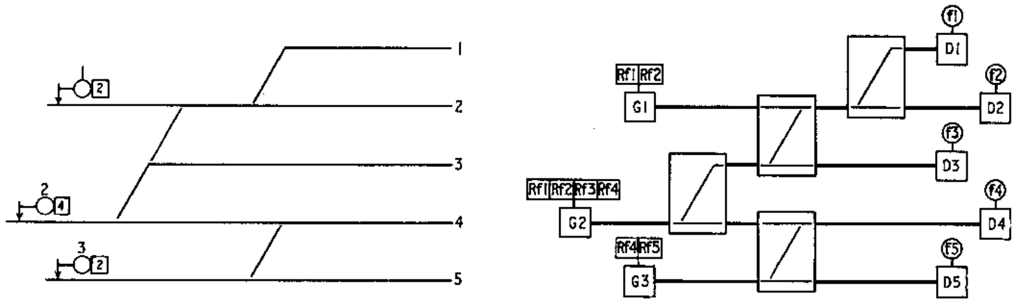

Fig. 16. A form of Route Indicator Control.

suggests that overlap ends should constitute the route terminal button position just because it is the limit of the interlocking action; the perpetual zig-zag panel operation would be intolerable.

Instead, if more than a simple track circuit overlap is required, the operation of a signal unit as a destination is transferred forward, along the geographic connection to the required terminal point of the locking, where an 'overlap unit' then acts as the route termination. The route is then set and locked the whole way through, although provision is usually made for the locking of the overlap section to be time-released if not required.

The existence of facing points in the overlap means splitting of the information passed forward to overlap units, and programming of the facing points units provides a means of determining which of the alternative overlaps will be obtained. Should one direction lead into a siding then overlap operation of the points is arranged to set along the main. For a move destined for the siding however, the points will subsequently be reset by the inner signal whenever they are free.

If both alternatives are practical ones it can be arranged that the overlap takes the direction in which the points happen to lie; but without doubt the signalman will, at some time, wish to make the choice himself to suit other traffic. It is therefore usual in this case to provide overlap selection buttons at the overlap ends, and although this is at times criticised, it has not been found that the number of additional buttons on a panel is such as to confuse the usual control of routes. These buttons are associated with the overlap units, which will be there anyway; and the signalman's actions then remain entirely geographic, thus: operation of the start button, destination and then the chosen overlap button, with no necessity for making a check on the existing position of the hinge points. If subsequently necessary, this chosen overlap can be changed, under suitable traffic conditions, by the geographic action of operating the destination button and the alternative overlap button, or by the usual procedure for setting of the route ahead.

Change of overlap could be initiated by use of the independent thumbswitch of the hinge points, but its use here is illogical. While all other setting action is push-push, use of the thumb switch would give a setting action which is not only rotational but involves only a single device.

6.3. *Route Indicator Control*

This may seem mis-placed under non-geographic functions, but in fact most forms of indicator control circuit can only work non-geographically due to the 'blindness' of a signal unit preventing it knowing from where it is receiving the signal clearing feed. A signal HR circuit fan can be envisaged over the signal's route area converging onto the signal unit. Such a fan, dividing over the various points, might provide an ideal indicator control network, but for the fact that the HR current-flow commences at a destination and passes in towards the HR leaving the required information, non-geographically, still at the destination.

However, Fig. 16 illustrates a possible method of arranging for the HR current flow in the converging fan to carry also

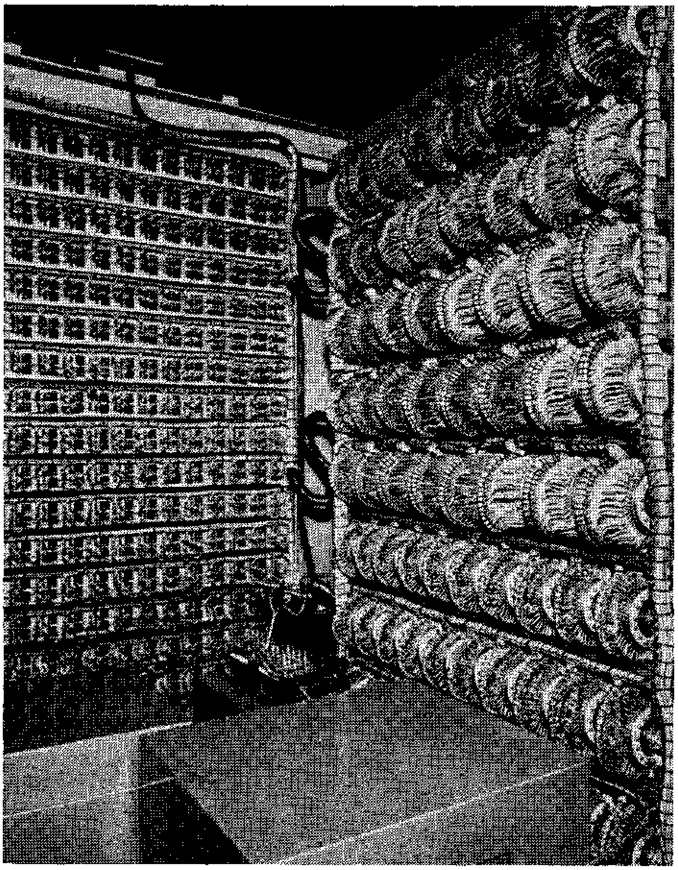

Fig. 17. Routiner Testing Machine.

identification of its source. The necessary route destination equipments have associated with them small audio-frequency generators, which superimpose their oscillations on to the HR circuit feed; different frequencies are allocated to each destination. A signal unit receiving this combination feed will operate its HR and, through tuned receivers, identify the destination to operate the appropriate indicator control.

An entirely different form of control makes use of the fact that within one signalman's area of operation, only one route can be initiated at a time. A group of code bus lines are run through all those relay units in this area which can act as destinations for routes requiring indications, and the signal units governing these routes contain route identification relays, one per indication.

At the time of route initiation the identification relays interrogate the code lines, and when the destination unit is established this unit puts on to the code lines one of a limited number of codes such as to operate the appropriate identification relay for the route indications required at the signal. This done, the code lines are released for subsequent use during the next route initiation.

The number of codes required is not large, being generally confined to the greatest number of indications at any one signal, since for signals reading over differing lines the codes can be repeated. In Fig. 16 for instance, frequency f5 could well be, say, f3 in which case signal G2 receiving f3 identifies destination D3, whereas signal G3 receiving f3 will identify destination D5.

7. TESTING

Since a great part of the object of using geographical circuitry is to save time, that time which can be saved in site testing, as compared with a conventional installation, strengthens the case considerably. As the relay equipment is manufactured in unit form, pre-wired to a certain range of standards, the units should be delivered to the site guaranteed correct to these standards. Mass production methods have to be used for the units if costs are to be kept down ; thus ' mass ' testing is also called for, though regular consistency in testing is required rather than speed. Machine or routiner testing is therefore required, so as to overcome monotony and human lapses ; and the degree of elaboration of this equipment depends on the degree to which the units are enclosed. If the relays of a unit are exposed and are individually detachable then these would be separately tested in the conventional manner, and only the unit wiring would remain to be routiner tested.

If, however, the units are of the totally enclosed type, then these units must be tested as a whole to ensure 100 per cent working order on delivery. Such units must be closed before the routiner test is carried out, so as to ensure there is no subsequent interference ; and they must therefore be tested, entirely from the outside, to cover all factors to full signalling safety standard. This is essential because this test constitutes the normal circuit operation tests of a conventional installation. The routiner elaboration required for this equipment is considerable, as can be seen in the view of such a machine in Figs. 17 and 18.

Upon plug-connecting a relay unit to the machine, in the same way as on a rack, it is sufficient to record here that routiner operation is entirely automatic, being controlled from a punched tape, one of which is required for each type of

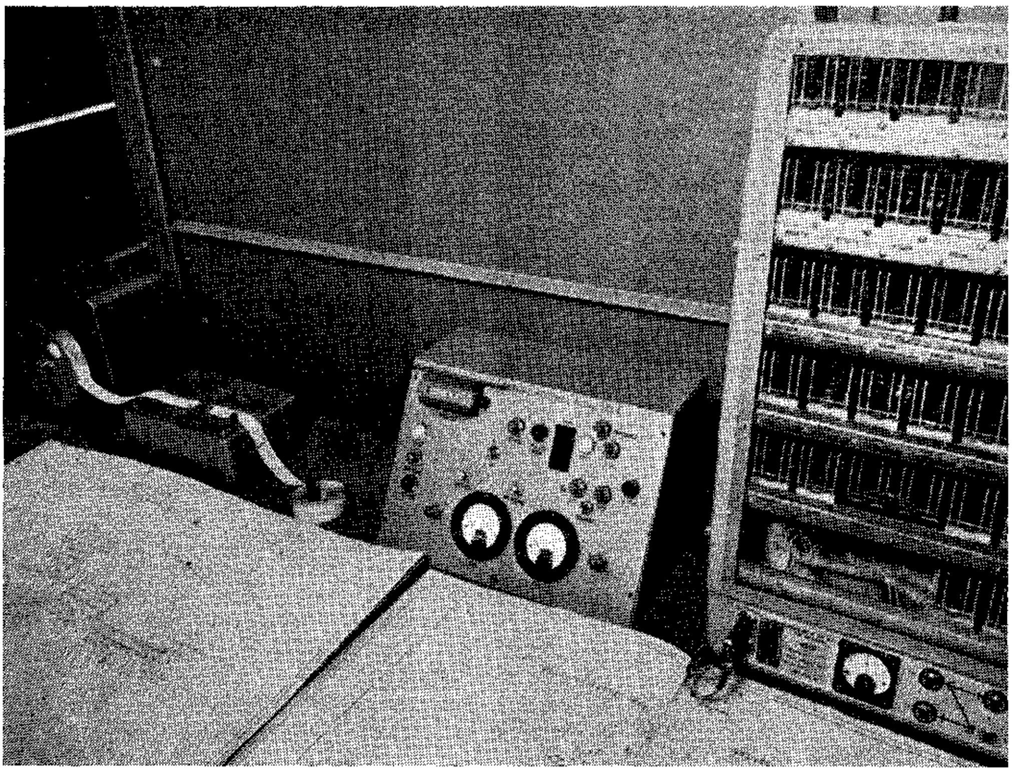

Fig. 18. Routiner Test Bench.

unit to be tested. Full circuit and relay operation tests are made throughout, and also each outlet is proved isolated from every other circuit and outlet.

The small indication panel permits visual supervision of the tests, but in any case upon a fault being detected further operation is prevented, and illuminated alarm lamps, together with the test number shown on the counter, enable the faulty circuit to be identified by reference to the test schedule.

On completion of a fault-free run the unit must be sealed to preserve the security against interference. However, in systems where sealing is omitted to permit on-site access to the wiring for unit variation, then the validity of any works tests is not ensured and the conventional form of relay room testing would be resorted to.

The multicore cables have to be run and terminated on site, but testing the terminations to the plug-connectors can be quite rapid especially with the use of a portable cable test routiner appliance. This constitutes practically the whole of the circuit testing required in the signal cabin. Any pre-wiring has, of course, to be treated separately, but by utilising pre-wired cubicles, if warranted, and by making other suitable arrangements, testing of this can be kept to a minimum. The only remaining test is then the overall functional acceptance test conducted by the railway's engineers and with geographical circuitry it is being found that the total signal box testing time is reduced by half or more.

8. OPERATIONAL FAULT LOCATION

In the case of Geographical Circuit systems of the open type a knowledge of the new mode of operation has to be acquired, but methods of fault finding will change very little. However, such conventional methods are applicable only occasionally to those systems incorporating relay units with enclosed and sealed wiring, so that some assistance for the maintenance staff is desirable, not because of new circuit design, as this could be followed from diagrams, but in view of the considerable reduction of available test points. The form of this assistance will vary with the actual system in question, as will the procedures to be followed; the

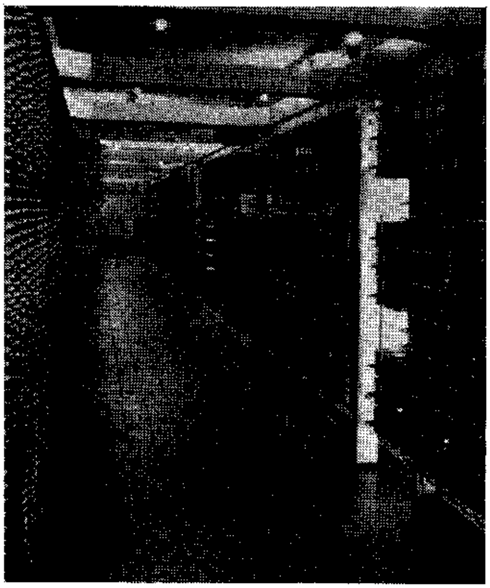

Fig. 19. S.G.E. Relay Room.

latter will depend particularly upon whether or not the individual relays are separately removable.

Instructions are required to emphasise useful leads to fault diagnosis which can be obtained from critical observations of conditions. All relays are observable, and a good appreciation of operation sequences can rapidly localise the search for a fault. Again, it cannot be emphasised too strongly to maintenance staff that intelligent assessment of information from the control panel where so many functions, inside and outside, are indicated can provide invaluable assistance. The cause of non-clearance of a signal due to track or detection failure will be obvious from the panel; less obvious however, would be the whereabouts of a fault in a route setting network. In this latter case, utilising the knowledge that routes along the same paths use the same circuits and equipment it might well be possible to localise the failure by observing which routes in the area do remain in working order.

However, it is inevitable that some faults will require further assistance for their location, and in one system an indicator is mounted in the relay room, as can be seen in Fig. 19. This is operated from the route setting stages of those relay units under the control of one signalman, and for each route being set up the progress achieved is displayed. Should the action stop at some mid-stage then, armed also with knowledge of the limits of the route being set, the maintainer can quickly identify the chain of circuits in which the mal-function lies.

In the case of the route setting system described earlier it was shown that before any route setting action could take place the interlocking controls for the whole route had first to be complete. Thus, should an inadvertent break occur somewhere in the route setting network, its position will not be evident from observations of relay operation, as there will be none. On the front of the relay units in Fig. 9 can be seen push buttons which are associated with the geographical connections and with the test meter. These provide the facility of ' looking in ' on the network to seek ' voltage available '

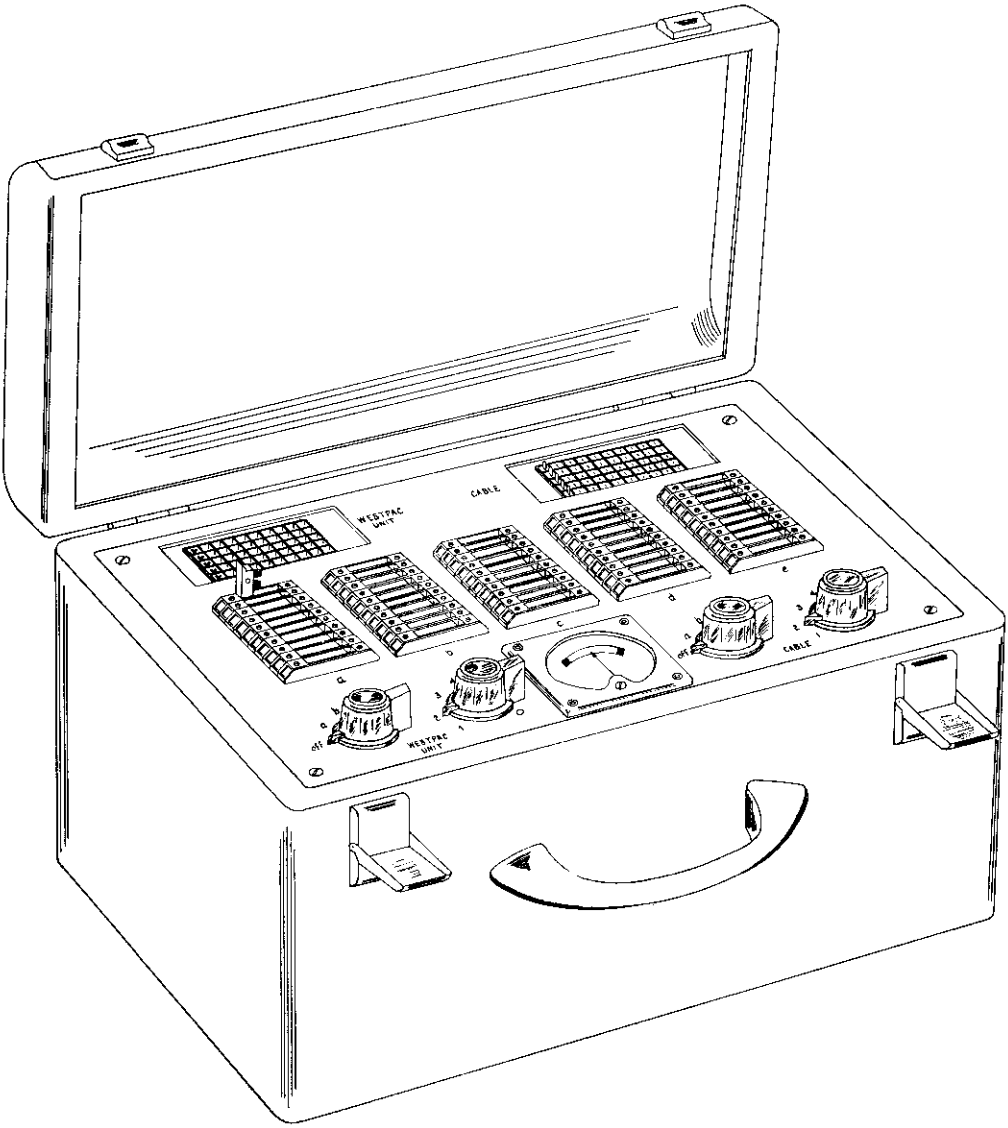

Fig. 20. W. B. & S. Co. Lineman's Test Unit.

along the sequence of units and connections of the route. If, on a unit, voltage is present at the entering position but not at the leaving position then any relevant special connections, programme links, and so on, must be examined together with the unit itself.

For other circuits, after guidance from observations, and meter readings at such connection points as are available, it may be necessary to break into a cabled circuit for voltage or other measurements, and a Lineman's Test Unit, such as shown in Fig. 20 may be used. By means of jumper cables to the multi-way sockets shown, the test unit can be inserted into any cable to a relay unit, and through selector switches any voltage readings may be taken. Also, should it be necessary individual lines can be broken by links for current measurements etc.

It may be thought by some that fault finding in the more enclosed and sealed systems of geographical circuitry is bound to present difficulties, and to absorb time to such an extent as to constitute a distinct disadvantage as compared with any open system of relay interlocking. However, this should definitely not be so after allowing a little time for the staff to become acquainted with the equipment, and with the different methods necessary. Certainly some instruction is required on the use of the various testing facilities made available, and there is a need to appreciate the order of connection of the units in the geographical network. This however, is not dissimilar to gaining an understanding of the operation of a new conventional system, with its associated advantageous methods of fault finding.

For such faults as do occur in the relay room correction tends to be more rapid with the use of enclosed relay units. A detailed search for an actual faulty wire or contact, for example, becomes unnecessary ; a change of relay or relay unit is all that is necessary to meet the case.

9. CONCLUSION

The aim of this paper has been to illustrate some of the methods by which geographical circuitry is being applied to British Railways, and to show some of the principles which systems are incorporating, to enable the best advantages to be derived.

Summarising, the ideal advantages to be gained from the use of geographical circuitry can be listed as :—

(a) Saving in scheme preparation. Production of a relay unit connection plan following the track layout.
(b) Economy in production. Standard circuits regularly employed for production and testing of relay units.
(c) Economy in installation. Laying of multicore cables and plug-connecting relay units.
(d) Reduction of testing. Site testing confined to functional test.
(e) Faulty wire or equipment not repaired *in situ* but units replaced and corrected subsequently.
(f) Simplicity of effecting changes. Rapid re-arrangement of relay units and multicore cables.

However, by comparison with the use of geographical techniques abroad, where the above are exploited to the full, the benefits of the application to British Railways are at present not so great as some had expected, due basically to heavier traffic in this country with some dense and interlaced traffic patterns. Complex signalling arrangements have been developed with differing conditions frequently being imposed to cover all manner of traffic situations as these have arisen. Hitherto these variations in, for example, signal replacement, overlaps, approach release, and so on, have provided traffic conveniences and niceties of signalling technique. As such they have been considered worthwhile, related to individually-wired equipment ; but related to the primary object of geographical circuitry they are awkward and expensive. It is not the complexity of signalling as much as accommodation of these variations which is hampering attainment of the goal.

With further development of the Modernisation Plan of British Railways, main through-passenger and ' liner ' trains will be directed along the main routes whilst freight sundries traffic will be curtailed and directed to a greatly reduced number of depots. Thus the main lines will not have to cater for all possible stopping, passing and sorting moves, and station area layouts can become simpler. Those operational moves which remain can be formed to a standard. This, then, provides an opportunity to make a fresh approach to the customary refinements and variations, by the railway departments in concerted action, and for a critical examination to determine whether some variations can be disp:nsed with, or the same overall result obtained by other means, such as resiting equipment or revising operating procedure. The opportunity, emphatically, should not be missed as a regularised, even if not a simple, form of signalling will enable geographical circuit systems to begin to provide the widespread economies that are desired.

Further system improvements, too, can be encouraged by a continuity of new installations. Possibly the incorporation of Solid State Switching of a suitable form may provide faster operation and greater reliability, and would approach computer action as envisaged by Mr. Hix in his recent paper.

The author hopes that the brief references it has been possible to make to some aspects of what is a large subject will be enough to provide interest and to encourage expression of views in discussion on system and railway requirements.

ACKNOWLEDGEMENTS

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DISCUSSION

Mr. A. W. Woodbridge, opening the discussion, said that it was with great interest that he had listened to the paper, because for one thing he had been named and presumably would " go down for ever as the ' bloke ' who inflicted all this stuff on British Railways." The sole concept of geographical circuitry was to make the job logical ; to make it easier and, of course, to build into it all the necessary things like reliability and safety, as was done with the ordinary individual relay systems. It seemed to him that the stage had been reached where another look at geographical circuitry was needed. He thought it could be said that the state had been reached where geographical circuitry was feasable and covered, or could be made to cover, all their peculiar requirements. Mr. Hawkes, quite rightly had talked about things being expensive. As he understood it, it was expensive because they of British Railways asked for a lot of refinements. He thought that was a fair statement of the position.

It was now up to them on British Railways to get rid of the superfluities that surrounded their practice, and which was built into their locking tables and control tables by tradition rather than by logic. Most of his generation of Signal Engineers, having been brought up with mechanical signalling, found that a locking table was never a logical thing. Why it was never logical he could not understand ; it should be. And there should not be a call to allow for something which was done at one place, and which has never repeated over 50 or 100 years, as happened in some cases. They must, therefore, get logic into their thinking. He thought Mr. Rogers might follow him with more detail, and give some ideas as to what their thinking now came to.

He would like the manufacturers of this country to make proposals to him as a representative of British Railways, as to how this sort of system could be simplified and could be reduced in price. They had now to compete overseas with at least three or four forms of geographical circuitry which might be refined and simplified a lot more than their own systems had been so far. Mr. Hawkes had quite definitely shown that they were on the way. They had been on the way in a very short time, and he thought all credit devolved on the heads of the people who had really got down to this and produced something worthwhile.

He would like someone, at some time or other, to try to quantify the savings