Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Thursday, December 18th, 1958

The President (Mr. J. F. H. TYLER) in the chair

After the minutes of the Technical Meeting held on Thursday, November 20th, had been read and confirmed, the **President** introduced Mr. F. A. Workman (Associate Member), Mr. H. J. Baldwin and Mr. G. R. Thomson (Associates), and Messrs. D. Hamer, A. S. Little, R. A. Mobley and M. F. Wilkins (Students) who were present for the first time since their election to membership.

The **President** then invited Mr. H. A. Codd (Member) to read his paper, entitled " Geographical Circuit Technique."

Geographical Circuit Technique

By H. A. CODD (Member)

Introduction

The term " geographical circuitry " is closely linked with the related term commonly used in this country, viz., "packaged relays." It should be remembered that relays have been grouped in packaged sets with plug-in terminals almost as soon as relay interlocking was introduced. At that time relays working in set groups or relays fulfilling a special function were housed under a common cover to assist fault detection and maintenance, and to minimise sources of failure when cable trees were prepared between relays.

These ideas were not solely linked with the signalling technique on the European continent and one can regard tokenless single and double line lock and block instruments as packaged relay sets (see fig. 1). After the German designed a.c. block the more simple all-relay d.c. block was developed and brought with it as a consequence the idea of housing these relays under one cover and incidentally provide them with the facilities of interchangeability.

Early Attempts to Package Relays

Tokenless block working has always relied on track circuits, which made the use of this apparatus difficult on railway lines laid on concrete or steel sleepers. Various methods were evolved to overcome these difficulties, one of them being the axle counter. The principles of axle counting call for a large number of relays for storing the counted axles at the entrance and exit points. It was a feasible proposition to recommend the use of packaged sets with plug-in connections. These relay sets were easily interchangeable and having introduced the idea of easy exchange the problem of finding highly qualified linemen was temporarily overcome. The lineman's job was to pinpoint the fault, then replace the set and send the faulty unit to a central depot for servicing.

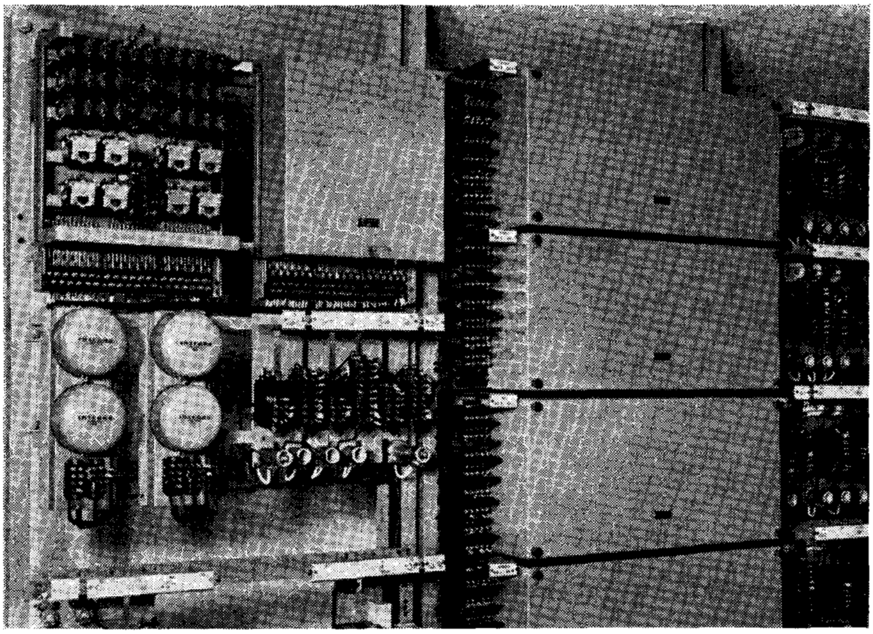

Fig. 1 Relay room showing axle counting relay set

The problem of higher technical training for linemen is one that is becoming increasingly important, especially when considering the use of complicated relay circuits, electronic equipment, etc. Although the examples mentioned above were typical of the early attempts they do not in any way represent the necessity for the plug-in relay sets required by the geographical circuit technique, where it is essential to have relays grouped according to the functions they fulfil and designed on the principle that they can be used as a unit, grouped in position according to the geographical layout of the track they are intended to control.

Miniaturisation a Necessity for Packaged Relay Sets

The principles of the geographical circuit technique were first developed on the continent of Europe. To enable the signal engineer to house a relatively large number of relays in comfort it is essential that he has at his command relays with small physical dimensions and with a basic design that can give him all the varieties of contact arrangements required by a packaged all-relay interlocking system. As a result of the foregoing the continental signal engineer found it a more simple task to start with this new system because from the very first designs of circuits used standard relays which would be regarded in the British Isles even today as miniaturised equipment.

For the British Signal Engineer and Signal Engineers of countries which were influenced by signalling development in the United Kingdom the first step must be to understand and appreciate the main features of these relays before the circuit technique itself can be considered.

It is extremely important to note that miniaturisation does not only affect relay designs but also control panels, the outdoor installations and to a lesser extent the cabling itself.

When comparing the contactor type miniature relays (fig. 2) with their British counterparts one finds that in many cases contact sizes, contact rating and leakage paths are almost identical. The main differences are shown in the principles of design, such as guided contact operation, which in itself makes the use of silver to silver contacts possible while still maintaining the very high standards and adhering to the very tight Specifications used for railway signalling equipment.

As has been mentioned earlier it is important that relays with various contact

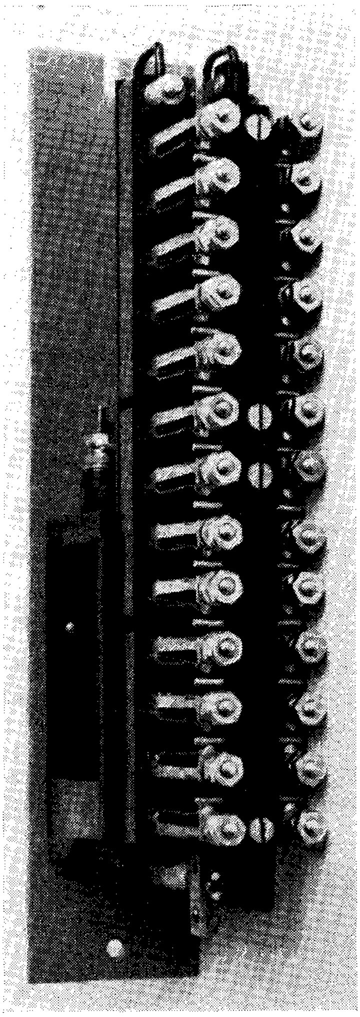

Fig. 2 Relay type TTd 113

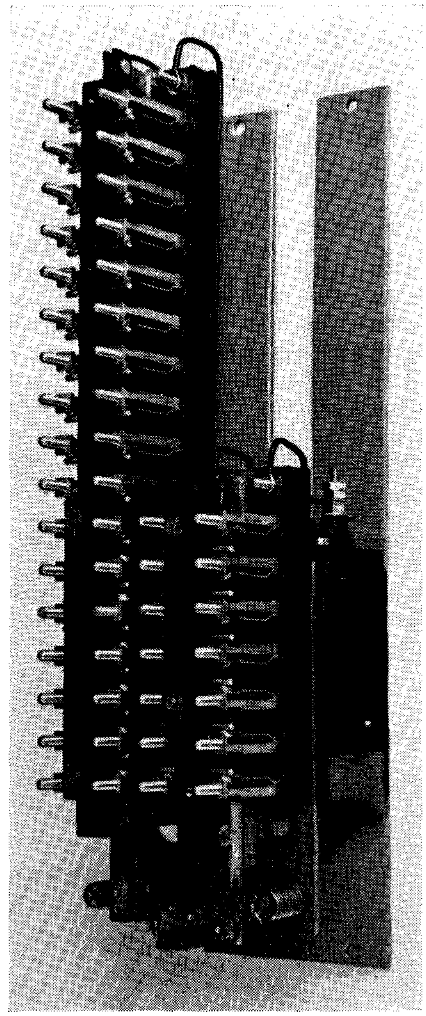

Fig. 3 Latched relay left side TTd 117, right side TTd 107

assemblies can be treated as simple alternatives of a main standard design (see fig. 3). When a technique has to rely upon a large number of relays the fact must be accepted that they must have the design features of mass production, providing a large number of relay varieties by simply altering the positioning of contacts and by making it possible to exchange coils with various electrical characteristics.

Relay Designs

The majority of we signal engineers still shudder at the thought of using relays with 20 to 40 contacts. If we were to ask advice from the relay designers their first reaction could well be: "An impossible task!" The difficulties inherent in such an arrangement were overcome in a manner which enabled the circuit designer to link a number of standard relays into one composite unit, allowing the relay design engineer to present to the signal engineer a unit that provided a physical link equal in principle and quality of workmanship to a relay specially designed with a large number of contacts.

All new techniques must also be considered from a point of view of economics and it would be ridiculous to offer a system which would require a power supply installation similar in size to a medium size power station. It is important to remember this because the need for a large variety of independent relays is eliminated through the facility of being able to combine in one relay a considerable variety of contacts, ranging from normal-duty contacts to special contacts of different kinds and even heavy-duty contacts where necessary (see fig. 3). These heavy duty contacts in combination with others make it possible to use a single relay to control point machine control circuits simultaneously with interlocking relay circuits.

The plug-in relay set overcame the difficulties of special protection being required for high voltage circuits because the wiring could be preformed, and as they were all under a special protecting cover (the cover of the plug-in relay set) unauthorised interference or accidents were eliminated.

The ideas leading to the construction of packaged relay units were transferred to other main items of the signalling installation and resulted in the design of signal lamp units which could be grouped according to the number of aspects and according to the types of signals. The idea of unit construction having been introduced to the design of signals manufacturing costs were also cut, as all the varieties of signals such as main line, subsidiary, shunt, level crossing protection, etc., could be assembled from the same units.

We should consider the point machine as a main item of the geographical circuit technique and if we do so, will immediately find that the advantages of the system can only be fully realised if an accidental bursting open of a point will not render the whole system or a considerable part of it inoperative. This means that trailable point machines are essential (see figs. 4 and 5). It is not the purpose of this paper to delve too deeply into the advantages and disadvantages of the various designs of these, especially when considering that they were so excellently covered in a discussion led by Mr. J. F. H. Tyler, our present President.

Principles of Geographical Circuit Technique

Railway signalling has always been regarded as a specialised mechanical and electrical engineering technique, every layout being designed to suit the individual requirements specified for each signal installation. This made it necessary to employ a large signal engineering staff to design equipment and circuitry for each

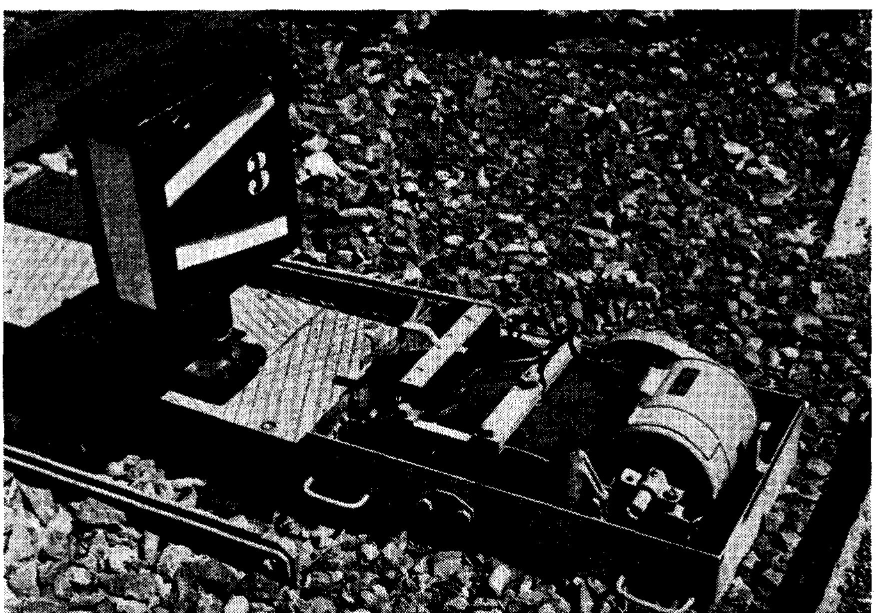

Fig. 4 Close-up of Integra point machine

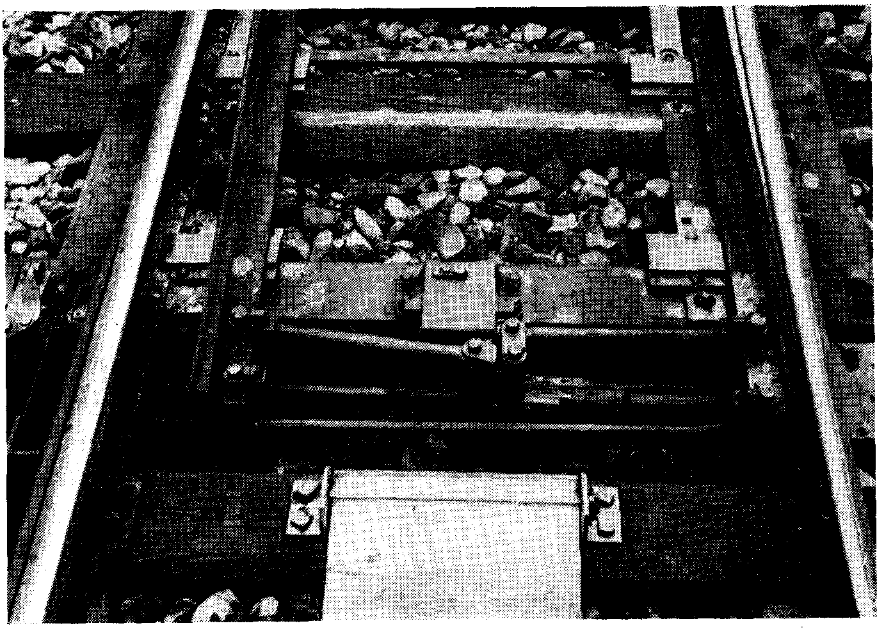

Fig. 5 Close-up of toggle lock

individual problem. The sequential operating requirements were laid down in the form of a locking chart, this taking into account established operating principles and special local requirements.

The cardinal principle of the geographical circuit technique is that it should be applicable to any track layout and in principle to any design of outdoor equipment.

Telecommunications engineers have worked closely with signal engineers in the past and as much as signal engineers refuse to accept the idea, they have influenced our way of thinking, and I am convinced that when the first all-relay packaged interlocking system was brought into operation many salient features could be traced back

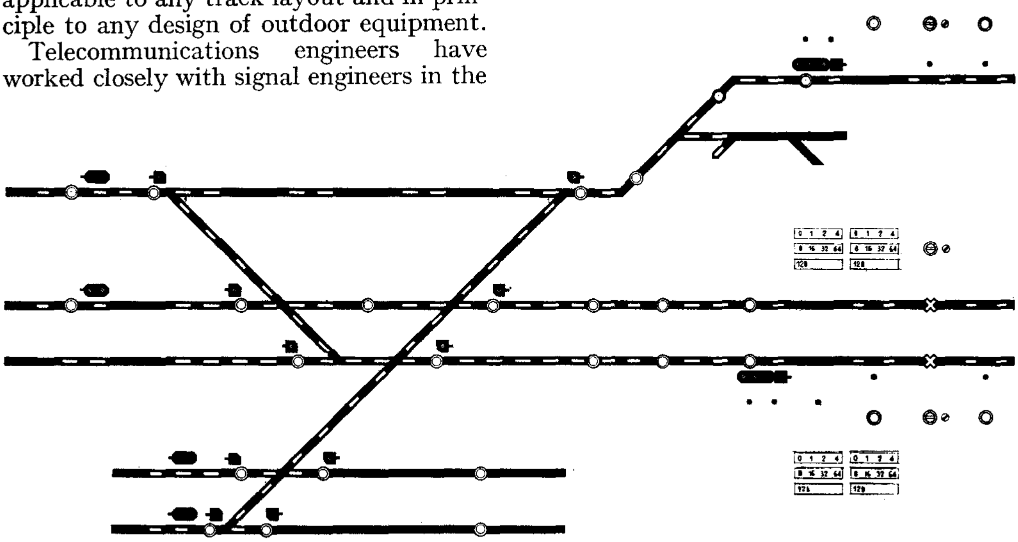

Fig. 6 A section of the Domino control panel drawing for Spiez

to principles already established in telecommunications networks.

The name "geographical circuit technique" is possibly a most lucid term but it should be remembered that other similar systems are in existence carrying the name of "unit construction system," "track layout system," etc., dependent on the country of origin.

Starting circuit to clear shunting signals

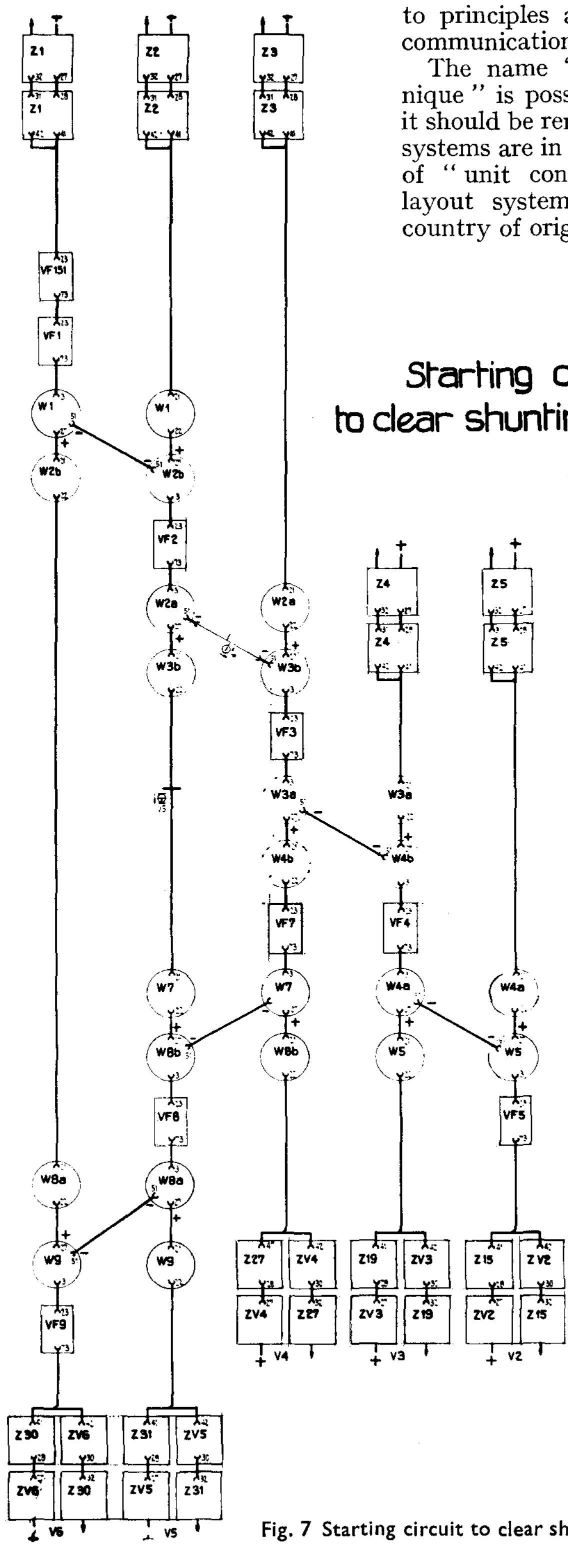

Fig. 7 Starting circuit to clear shunting signals for Spiez

The main principles involved remain still the same: to guide a train from a starting point to a terminating point without the problem of having to worry about the sequential setting of points, routes and signals. To enable us to package relays it is necessary to establish the main groups of functions to give us the chance to link these groups in the order as they appear when looking at the layout plan (see fig. 6).

These functions are as follows:—

1. Command to points.
2. Acknowledgment of the command.
3. Storage of the command to set up the desired route dependent on the direction of traffic (a " should " route).
4. Transmitting of orders to the shunt signals. (See fig. 7).

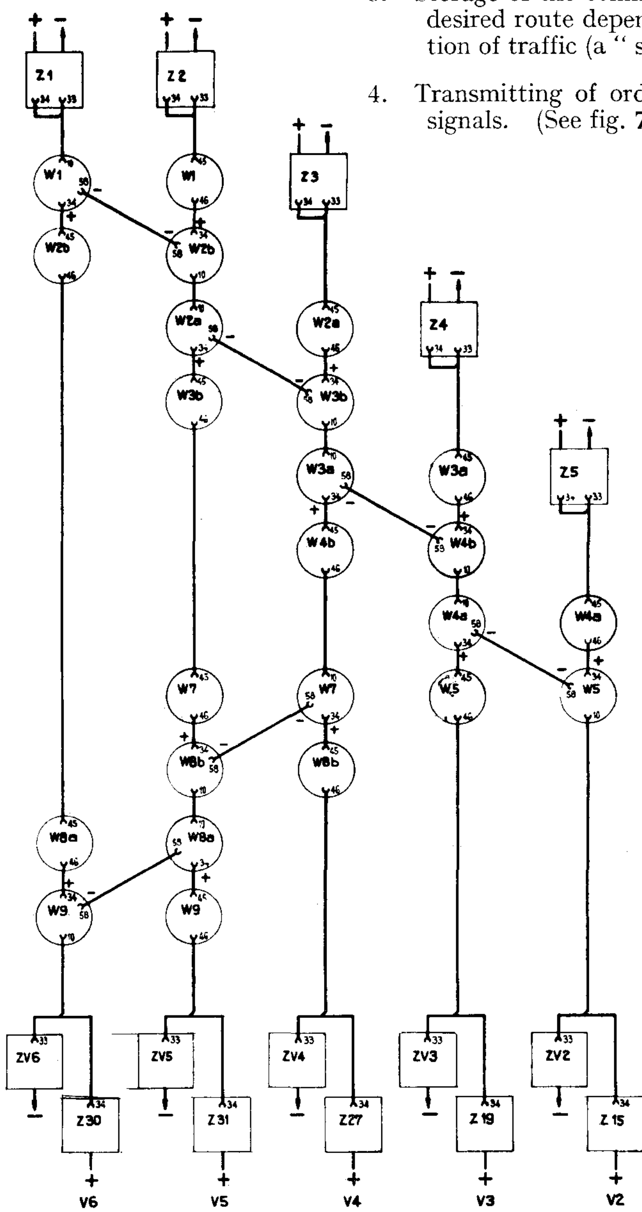

Fig. 8 Checking of the correct position of points for Spiez

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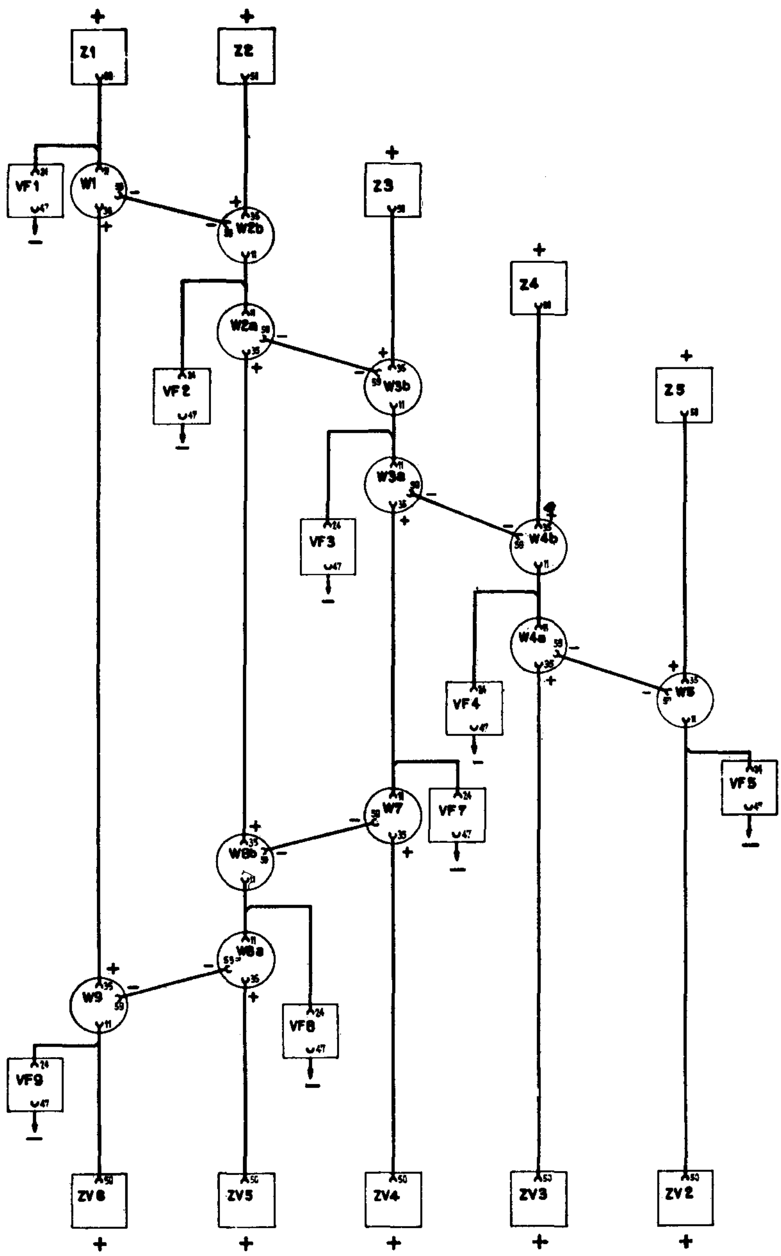


Fig. 9 Operation of the point locking relays for Spiez

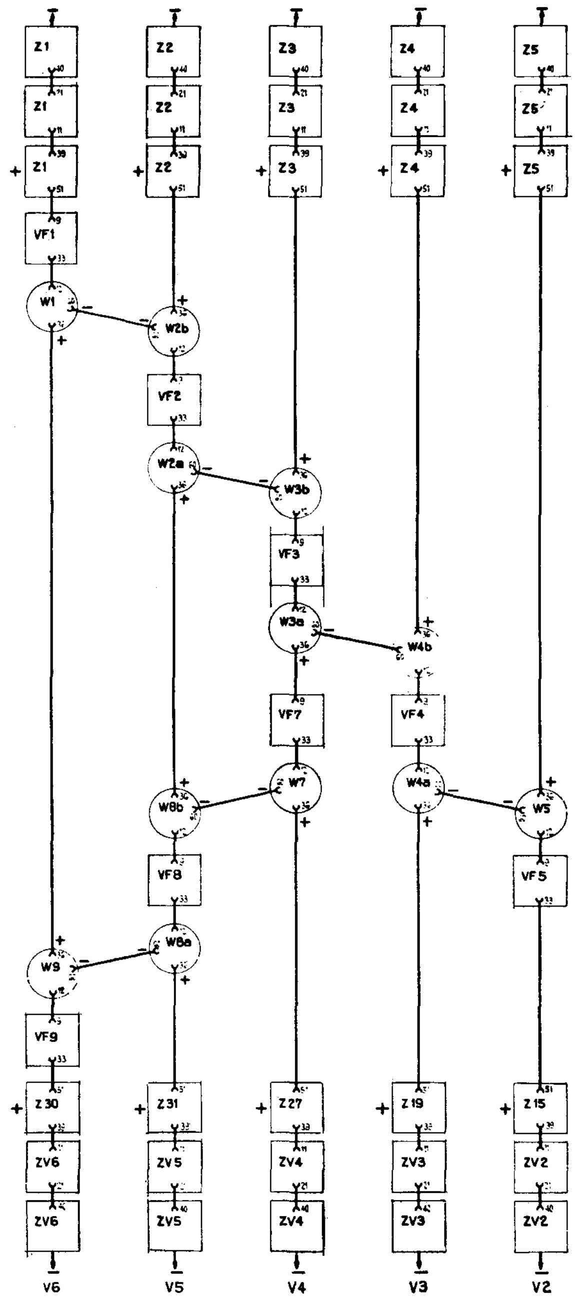


Fig. 10 Clearing circuit for shunting signals for Spiez

5. Storage of these transmitted orders.
6. Proving the final position of the points (an " is " route). (See fig. 8).
7. Control of point locking (see fig. 9).
8. Proving of point locking.
9. Commanding the shunt signals into the OFF position (see fig. 10).
10. Transmitting the command to the main signal.
11. Proving the shunt routes have been established.
12. Locking the shunt routes.
13. Commanding the main signal into the off position as a result of the foregoing.
14. The auxiliary function of cancelling a shunt route.
15. The auxiliary function of returning main signals to danger.
16. Cancelling main routes.

The functions listed above will depend on the track being free or occupied. It would be illogical to complete the sequence before this fact has been taken into consideration, and it has been incorporated between functions 9 and 10 before the control of the main signals is completed. Further it would be time-wasting to lock certain points when others incorporated in the route could not take up their required position owing to mechanical or electrical defects. This has resulted in the introduction of the *command perdu* (lost command) which will automatically cancel the chain reaction if the " is route " cannot be established.

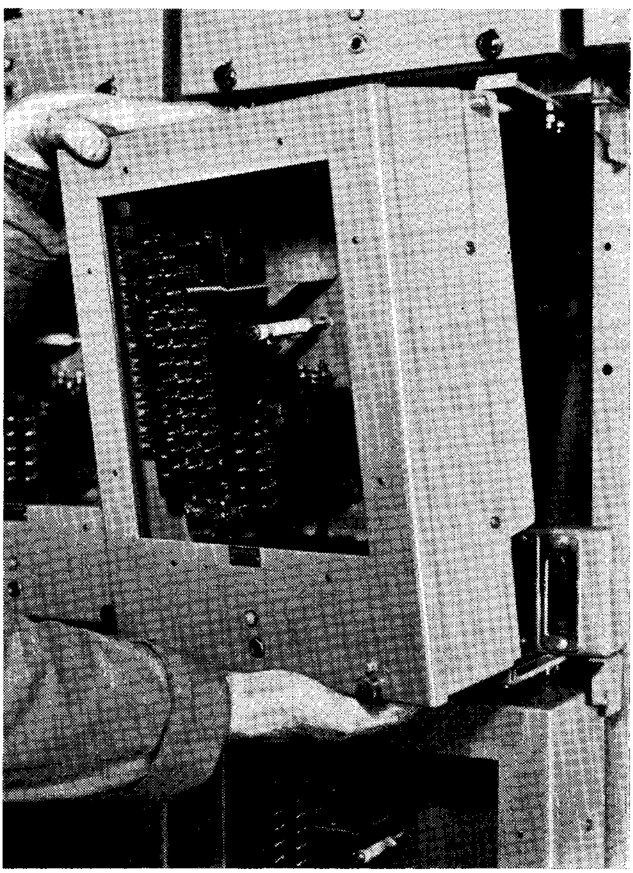
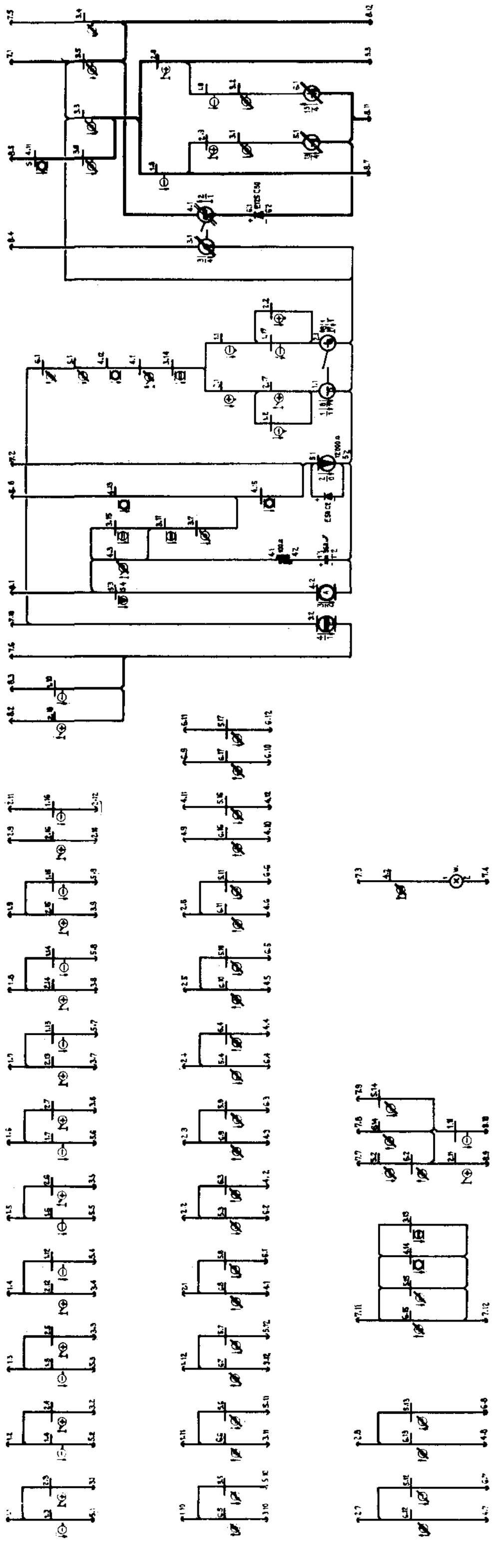


Fig. 11 Close-up of plug-in relay set being exchanged

The problem now is to link the listed functions in the correct order and as this linkage is obviously dependent on the track layout, we have taken this layout plan as our main guide. This will now explain why geography is mentioned and why the system has been named geographical circuit technique. The position of equipment constituting the main parts of the track and the outdoor signalling equipment provide us with a map and it is this map we will follow, giving us the impression that when moving from a starting point to a terminating point we are passing certain landmarks. Our landmarks are not brooks and bridges, churches and woods, but signals, parts of the track and points.

The functions listed can now be replaced by relay sets (see fig. 11) and if these sets are linked in the same sequential order but remembering the programme of order of the landmarks, we have reached the point where we can state that the basic foundations of the geographical circuit technique are now well and truly laid. For the sake of good order we



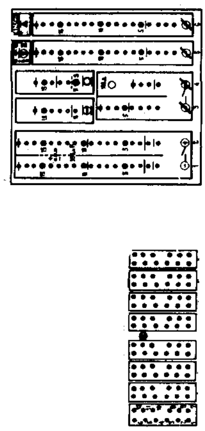


Fig. 12 Internal wiring diagram for point control relay set

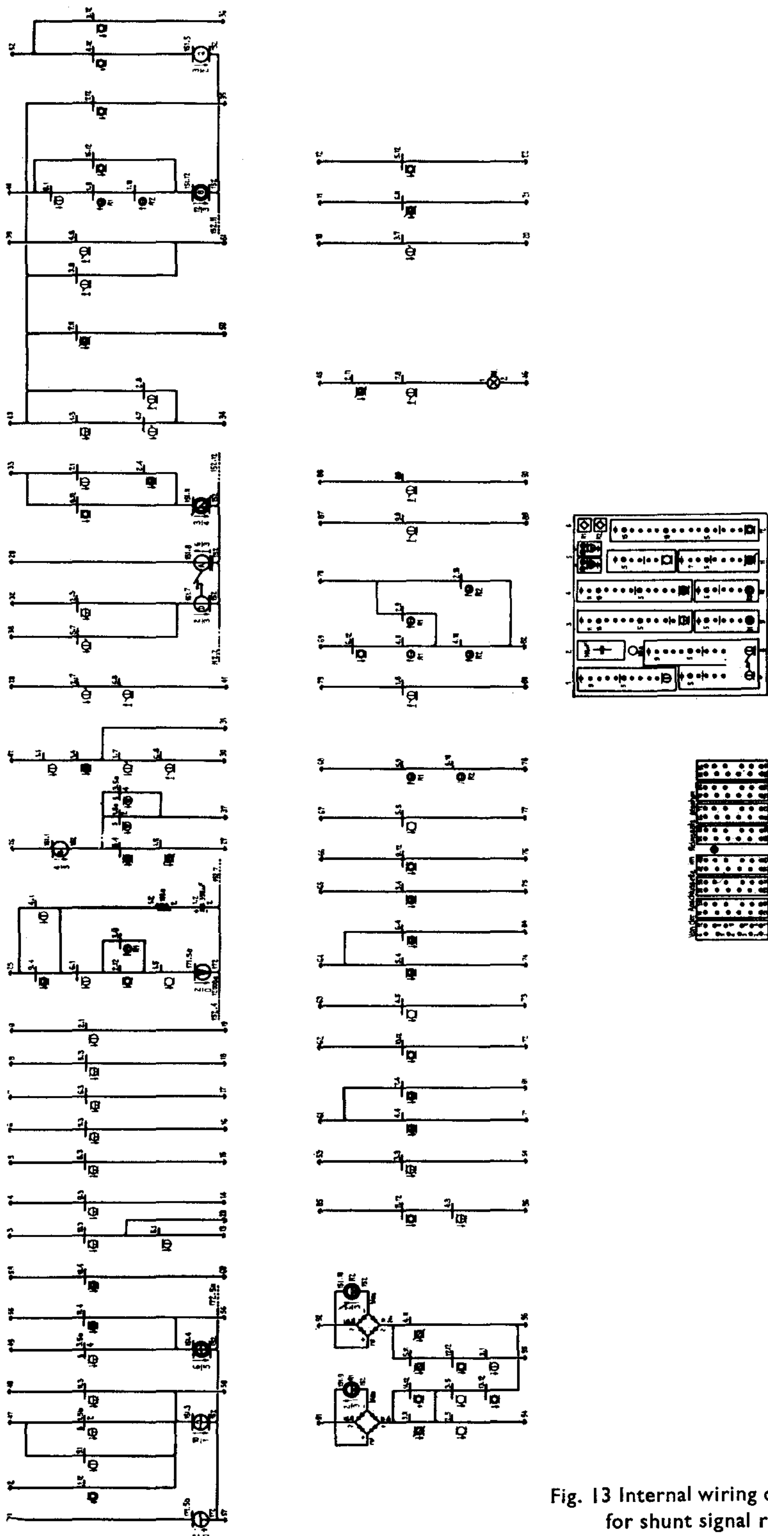


Fig. 13 Internal wiring diagram
for shunt signal relay set

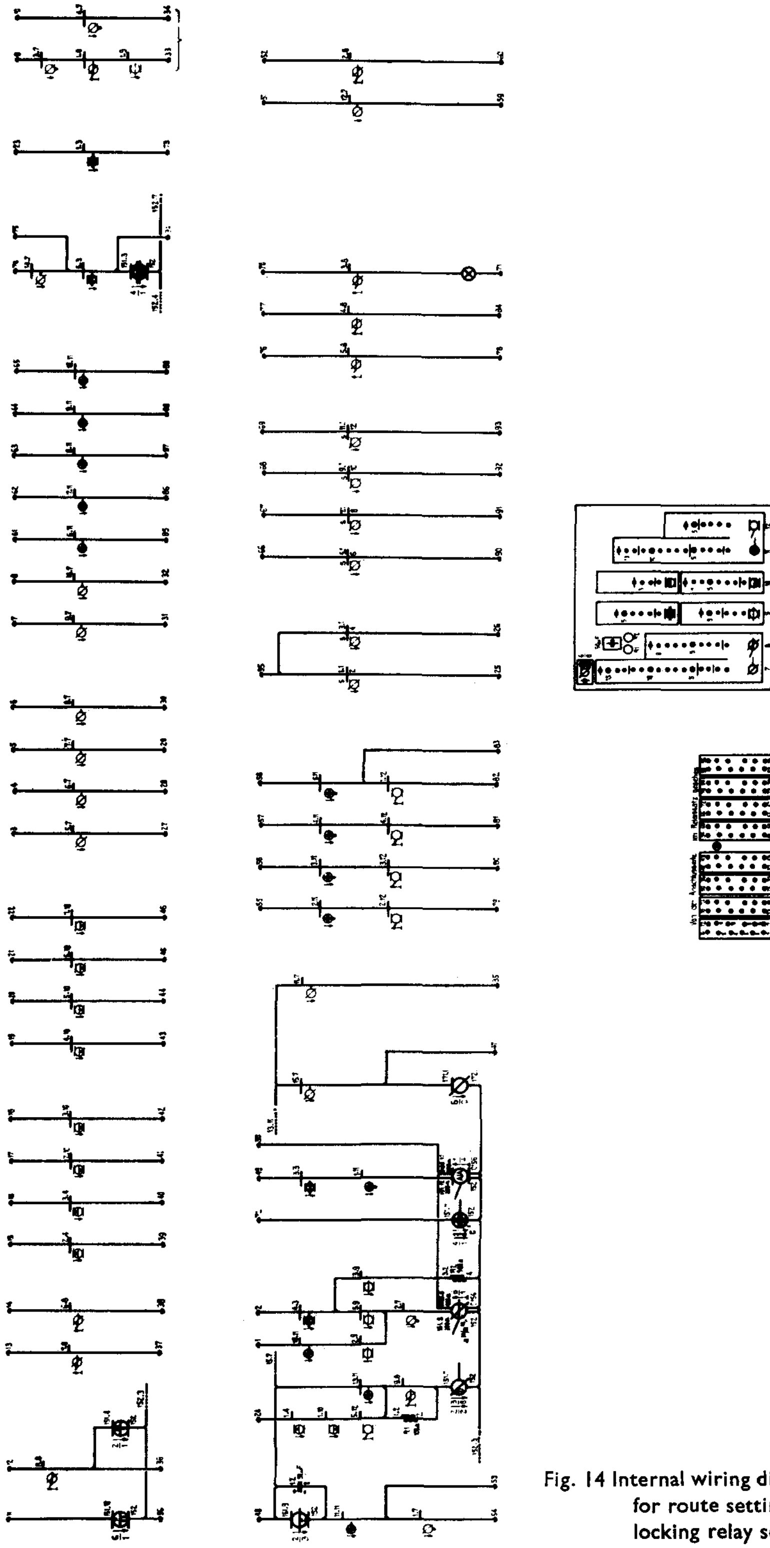
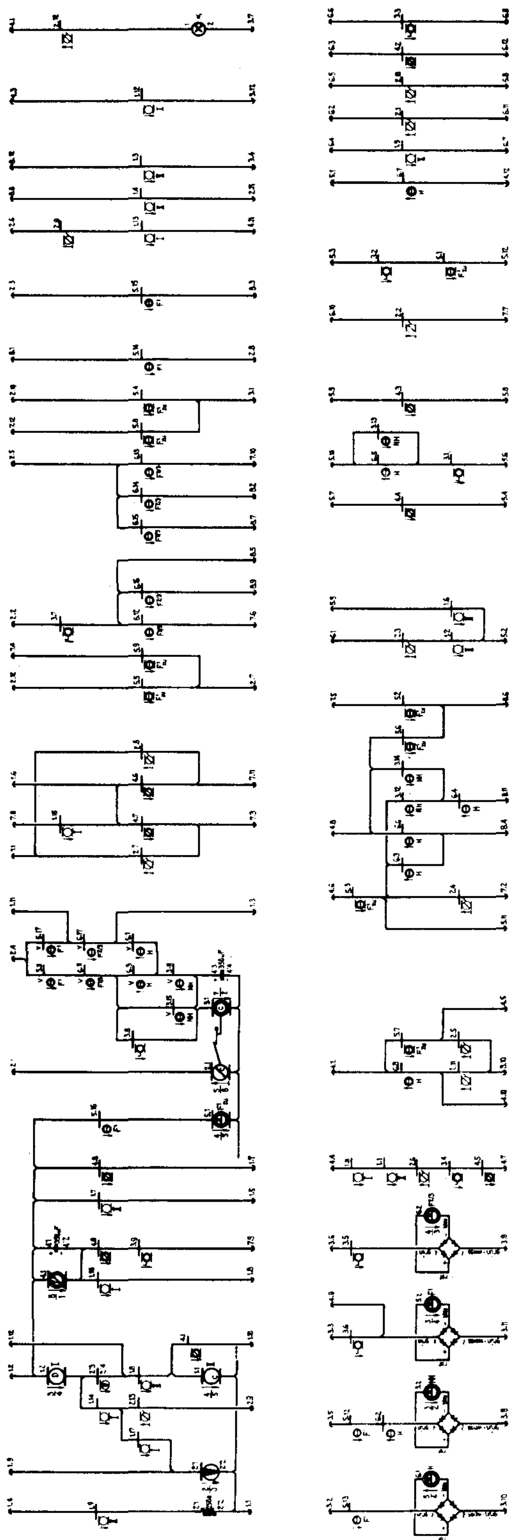


Fig. 14 Internal wiring diagram for route setting and locking relay set



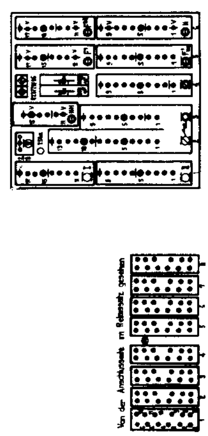


Fig. 15 Internal wiring diagram for main signal relay set

will now list the relay sets which when completed, will be identical to the table of the main functions:—

1. Point control relay set. (See fig. 12).
2. Shunt signal relay set. (See fig. 13).
3. Dummy shunt signal relay set.
4. Point locking relay set. (See fig. 14).
5. Main signal relay set. (See fig. 15).
6. Cancelling relay set.

If, as mentioned in the foregoing, we group these sets side by side in accordance with the layout plan we will find that our typical circuit diagrams will look identical to track layout plans except that the connecting links are now cables and not rails (see figs. 6 and 7). This will clearly emphasise the advantages of the geographical circuit technique as it will cut drawing office work and manufacturing preparatory work. The works can keep a steady flow of plug-in relay sets coming off the assembly lines and whenever an installation is to be executed standard sets will be available from the stores.

You will notice that 16 main functions are covered by 6 main types of plug-in relay sets. The functions link the sets at various stages of the operation and these stages are so clearly determined that they virtually separate the relay sets into sub-sections. Each sub-section is complete in itself and every time a function is completed the result is passed on to the next sub-section. We term these sub-sections levels and we name them according to the functions they fulfil. As a result our circuit diagrams, following the shape of the layout plan, will be as many in numbers as the functions, and each being an easily identifiable part of the system can readily be checked and tested.

Means had to be found to transmit the orders to the relay equipment and it seemed a logical conclusion that these should be grouped following the principles of unit construction and in accordance with the geography of our system (see figs. 16 and 17). The result was a mosaic type control panel where points, sections of the track and the various signals could be displayed, combined with the means to control them. As the system is a fully automatic one it had to incorporate the principles of sectional route release. This has resulted

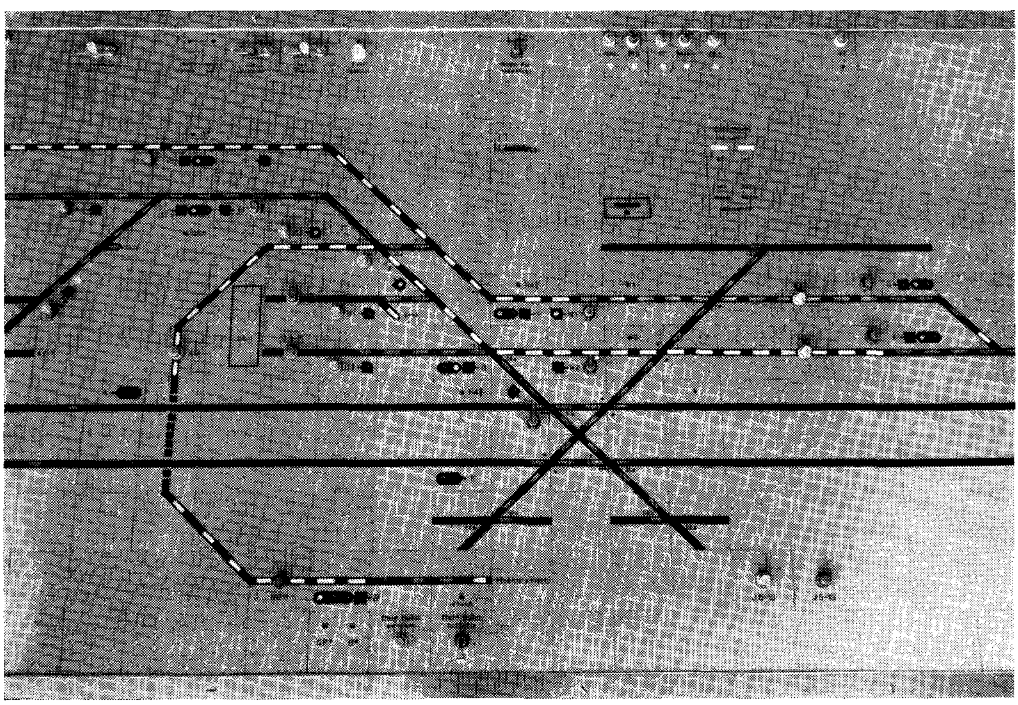


Fig. 16 Close-up of Bern-Weissenbuehl Domino panel

Fig. 17 Domino panel at Lyss

in the choice of the pushbutton as the main controlling element. Rotary switches will also be found but only for secondary purposes such as controlling intensity of panel lighting, the control of fire extinguishers, etc. It should be noted, however, that the latest trend is to eliminate rotary switches even for these purposes and to utilise a pushbutton controlling a cascade circuit arrangement.

The operating principles of the system can be listed as follows:—

1. The simultaneous pressing of two pushbuttons causes the points route and direction to be determined.
2. The instructions transmitted to the relay apparatus by means of the pressing of pushbuttons should then be carried out automatically.
3. The storing up of the instructions should only take place if it is possible for the selected signal to be cleared.
4. The carrying out of the instructions (setting of points and the clearance of signals) should only be possible when both pushbuttons have been released.
5. The stored-up instructions are to be automatically cancelled in the event of a technical fault in the apparatus, for instance, points not arriving in their final position, or point locking relays not operating (*command perdu*).
6. The locking of all points in a signalled point route should only be possible when all points concerned have taken up their final position.
7. The controlling items shall fulfil their functions only in their corresponding "geographical" position and nowhere else.
8. The unintentional energising of one single relay must not result in the build-up of a circuit level.
9. The main circuits should be free from the effects of stray currents and earthing.
10. The pressing of one single pushbutton must not result in the build-up of a circuit level.

Referring to Item No. 4 the principles behind this are that in the event of a push-button remaining in its pressed-down position the pressing of a further push-button should not result in the clearing of a signal.

Item No. 7 means that relays controlling points, signals, etc., can be housed in relay sets which can be pre-manufactured independent of the actual track layout plan.

We can find a plug-in unit for the control of each main item, which means that if every portion of the track can be represented in the form of a unit, any modifications, replacements, additions, etc., can be done without any difficulty and without the trouble of having to seriously interrupt the operation of the entire installation while these modifications are being carried out (see figs. 18 and 19). Remembering that the principles of unit construction were introduced into the design of control panels as well, we shall not even have the problem of having to remodel or even to remanufacture the control panel itself.

Special Considerations

In spite of the fact that I have pointed out the advantages of trailable point machines, units of relay sets can be designed to control any makes of points or signals, still maintaining the principles of the circuit build-up.

The principles of the geographical circuit technique have followed the basic ideas of continental signalling. This will explain why the sequence of the functions first cover the setting and clearing of shunt routes followed by the setting and clearing of main routes. Shunt routes are divisions of main routes and main routes are formed by the clearance of these individual shunt route sections which, when completed, are linked to form the main route. In British signalling practice this would not be a prerequisite and shunt routes would be treated as independent routes, with the only difference that track occupancy would not be a requirement for clearing the signals.

When a circuit technique is designed special requirements have also to be considered. I have not mentioned in the foregoing flank protection, approach locking, or the problem of overlaps. They can be made an integral part of the system, and flank protection would be covered by the first in the list of functions, that is to say by the command to the points, which in turn will be the result of a search impulse being sent out to all points affected. This search impulse will check the position of

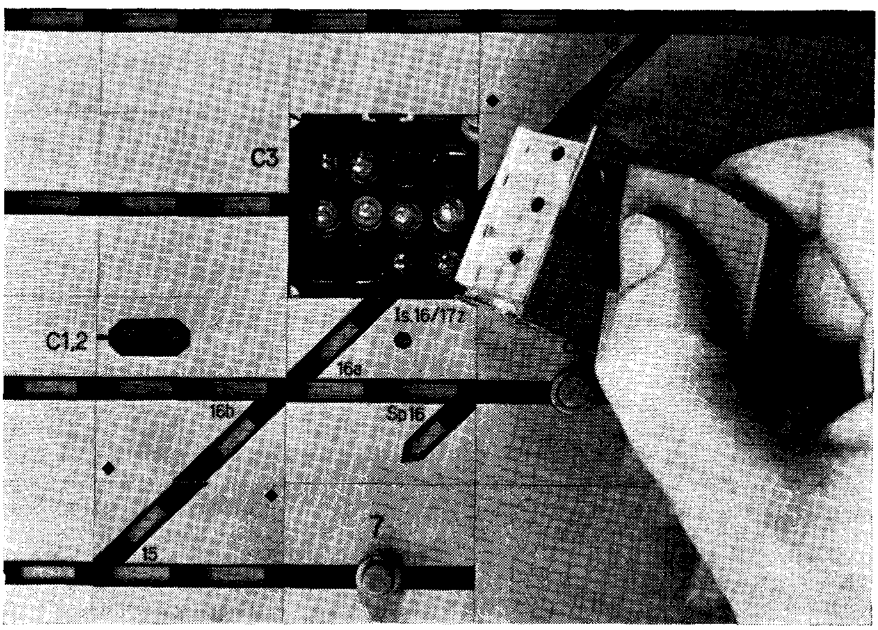


Fig. 18 Close-up of Domino panel showing withdrawal of top cover

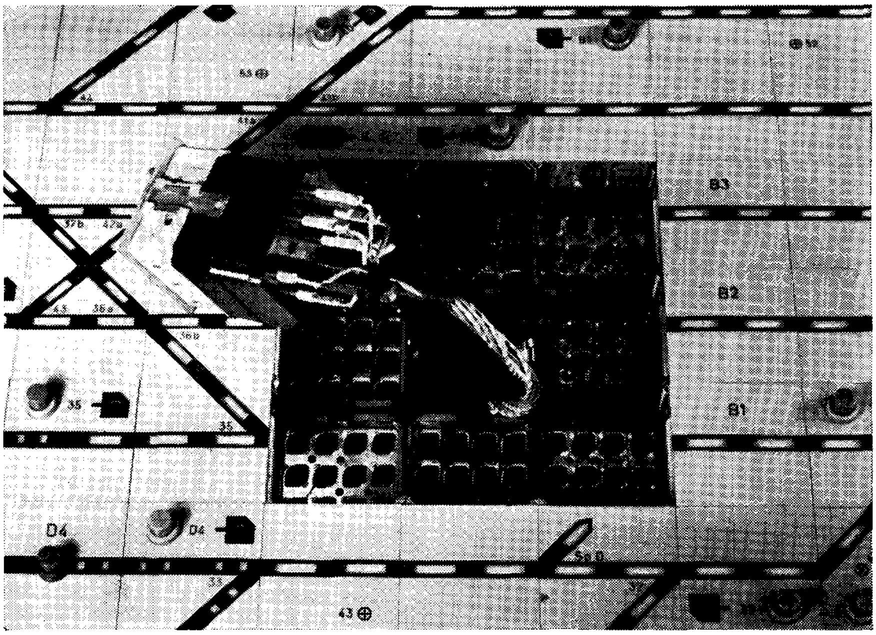


Fig. 19 Close-up of Domino panel showing withdrawal of complete Domino unit

all facing points from the starting point, which will enable us to control points providing us with flank protection in spite of the fact that they will not form a part of the required route. Substitute flank protection can be catered for in the event of one or two main protecting points not being operative because of other prevailing conditions. It is possible to introduce shunt signals or subsidiary signals as an alternative means of protection, although this might complicate the system to an extent not desired by the signal engineer. Many systems claim that no further use is made of the locking chart. In my mind, however, a certain percentage of the equipment controlling a specific installation must still be regarded as characteristic of that installation only and will, as a result, introduce a certain number of relays which cannot be housed in plug-in relay sets (see fig. 20). When considering the typical circuits the presence of these special relays will become emphasised and will hence cause the signal engineer to pay special attention to them when checking and testing.

Free Circuitry

The parts of the relay equipment covering special requirements are termed " free circuitry." Dependent on the design of the layout they can represent from 5 to 15% of the equipment housed on relay racks.

Any system that is based on the principle of standard relay sets must by its very nature be a symmetrical circuit arangement. The term symmetrical means in this case that control sets must be used whenever a turnout occurs in the layout. From a signalling point of view this is not always necessary and it is for this reason that a special plug-in set was designed, termed a " dummy shunt signal set." This set is positioned in the circuitry whenever and wherever a shunt signal should occur on the route. The relays in this set are identical to the ones in the shunt signal relay set with the only difference that no signal control relays or signal proving relays are used. In so many words it means that we imagine a signal being located there without the signal being actually installed.

Under the heading of flank protection I have mentioned search impulses. These search impulses are initiated at the route starting pushbutton and they automatically affect all facing points. Whenever they reach a facing point the search impulse will be divided and one impulse will con-

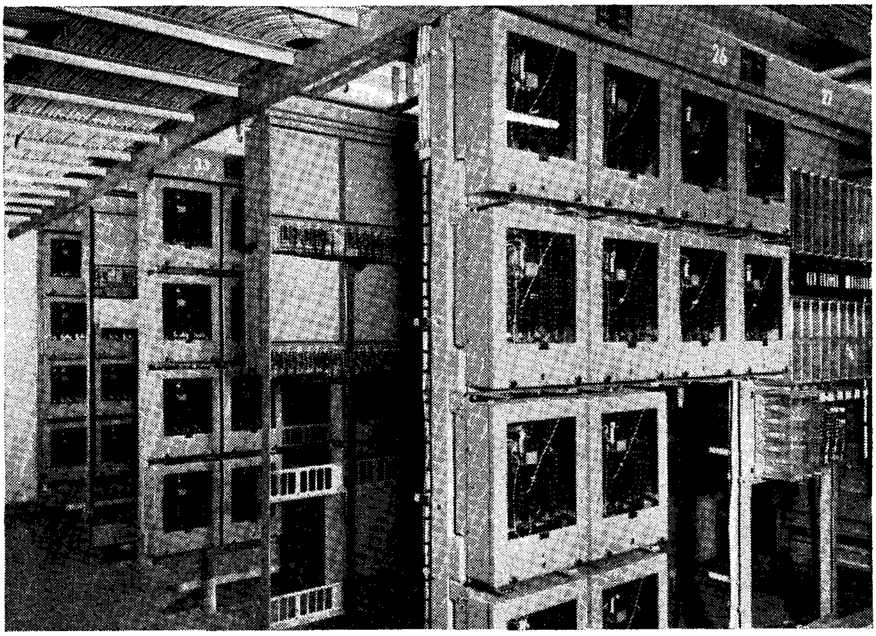


Fig. 20 Part of relay room at Lyss

tinue along each leg of the turnout. This means that by pressing the route starting pushbutton the selection of any route obtainable from that starting point will be quite automatic, providing, of course, that no other conflicting movement or track occupancy is prohibiting it. The selection of the desired route (" should " route) from this large variety of routes will be made by pressing the route terminating button. The first search impulse mentioned has laid the way open for a checking impulse to be returned in the opposite direction to the desired movement of traffic and these two impulses when meeting at the affected points will provide us with the means to command these points into their required position.

I have explained that shunt routes are considered as divisions of the main route, which means that when a main route is set these divisional shunt routes are all automatically cleared. This principle enables us to set adjoining shunt routes by simply pressing the starting pushbutton of the first section and the terminating button of the last one. This will avoid the necessity of having to set shunt routes individually when shunt movements are required covering more than one shunt route.

Track layouts very often present us with a choice of routes between the starting and terminating points. It is possible to make the system work on an automatic principle, searching for the most desired route and changing over to an alternative solution if this desired route is not available. It must be quite clear that any arrangement of this nature will require additional relay equipment, and as a result our solution to this problem would be as follows:

The simultaneous pressing of a starting and terminating button will endeavour to set up the most desired route. If this is not available we can try to select the alternative route by pressing the starting pushbutton, pressing an intermediate pushbutton which would determine the direction, and then releasing this second button and pressing the terminating button of our desired route. The simultaneous release of the starting and final terminating button will then set our route over the alternative layout.

Individual point operation will be executed by the pressing of the individual point operating pushbutton and a common point pushbutton placed at certain vantage points on the panel. Point lock indications will be given adjacent to these buttons, reminding the operator that his point is not individually operative either because the point is included in a set route (white light) or because it is occupied (red light).

Some railway administrations require the additional feature of locking the point layout in one of its two final positions, rendering it inoperative to route settings requiring the points in the opposite position to which they have been locked.

The last three functions in our table cover the facility of cancelling shunt and main routes and putting the signal to danger. Under normal operating conditions the routes will be cancelled automatically under sectional route release. It is sometimes necessary, however, to cancel a set route owing to a change in timetables or when a route has been set in error. Shunt routes which do not depend on clear track circuits can be cancelled at any time by pressing the route starting button and a common shunt route cancelling button. The same principle does not apply to main routes and the following two solutions are available:—

(*a*) A main signal can always be returned to danger by pressing the route starting button and a common "signal to danger" button.
Once this has been done the re-pressing of the route starting button and the pressing of a sealed main route cancelling button will cancel the main route entirely.

(*b*) By pressing the route starting button and a sealed main route cancelling button the signal will be returned to danger, and the route will then be cancelled as a sequel to the signal going " on."

Standard British practice of route cancelling based on a time lapse can easily be catered for, but of course specially designed typical circuits will be necessary. The same applies to making allowances for approach locking.

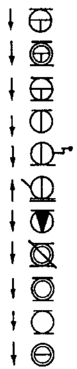
Terms and Symbols

I would like to take the opportunity of mentioning the various methods of circuit drawing. British standard railway signalling symbols do not allow for the large varieties of signalling relays, and asterisk upon asterisk would be required, with special remarks to enable a circuit engineer to follow the operational sequences. The method of indicating front and back contacts is also not ideal for this type of circuit design and perhaps it would not be out of place to recommend a new approach to this problem (see fig. 21). It is most interesting to study continental methods where symbols are used to a very large extent combined with letter and number designations. There are many groups of engineers using various symbols for relays, relay contacts, etc., in the railway signalling field and also in mining and telecommunications, and they all go to the trouble to devise their own symbols to make it more difficult for any outsider to read their own circuit designs.

I have drawn special attention to the problem of relay and circuit symbols and methods of circuit drawing. It is necessary to introduce a new vocabulary as well to explain in short terms various intermediary functions without having to go to lengthy explanations. The main terms which we frequently use when discussing geographical circuit technique are as follows:—

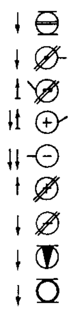
Geographical Circuitry	The operating mechanisms grouped according to the track layout plan enabling the use of the " unit construction principle."
" Should " Route	The desired route, including proving the position of the point control relays but not the point detecting relays.
" Is " Route	The completed route, including all the necessary proving, especially for the point detecting relays.
Point Route	The train route, but including only the points.

DWARF SIGNAL RELAY SET



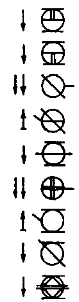
- PUSH BUTTON RELAY
- ROUTE STARTING PUSH BUTTON RELAY
- ROUTE TERMINATING PUSH BUTTON RELAY
- ROUTE STARTING RELAY
- ROUTE TERMINATING RELAY
- ROUTE TERMINATING LOCKING RELAY
- TIME RELAY
- 1ST SIGNAL CONTROL RELAY
- 2ND SIGNAL CONTROL RELAY
- SIGNAL OFF RELAY
- SIGNAL REPEATING RELAY

2 POINT CONTROL RELAY SET



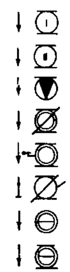
- POINT CONTROL PROVING RELAY
- POLARITY CHANGER
- RELEASE RELAY OF POLARITY CHANGER
- 'NORMAL' CONTROL RELAY
- 'REVERSE' CONTROL RELAY
- 'NORMAL' PROVING RELAY
- 'REVERSE' PROVING RELAY
- TIME RELAY
- MOTOR CURRENT CONTROL RELAY

3 ROUTE SETTING AND LOCKING RELAY SET



- POINT SETTING AUXILIARY RELAY
- POINT SETTING RELAY
- LOCKING RELAY
- RELEASE RELAY OF LOCKING RELAY
- SIGNAL ON CONTROL RELAY
- ROUTE SETTING RELAY
- RELEASE RELAY OF ROUTE SETTING RELAY
- LOCKING INDICATION RELAY
- TRACK PROVING RELAY

4 MAIN SIGNAL RELAY SET



- INITIATING RELAY I
- INITIATING RELAY II
- TIME RELAY
- 1ST SIGNAL CONTROL RELAY
- 2ND SIGNAL CONTROL RELAY
- SIGNAL STICK
- SIGNAL REPEATING RELAY
- REPEATER OF SIGNAL REPEATING RELAY

Fig. 21 Table showing relay symbols and names of relays

Train Route	The selected route, including proving of the points, track circuits, shunt signals, flank protection and overlap.
Circuit Level	One stage in the sequence of controls, including also the control of points.

It would be possible to spend hours on the details of the geographical circuit technique but I hope that this short introduction has made it possible to appreciate its advantages and by presenting some of the problems involved, to give all of us an added incentive to further develop this very specialised branch of engineering to the advantage of the user and manufacturer.

Summary

1. A system logical in its entire build-up, manufactured from units and utilising preprinted internal circuit diagrams.
2. Saving in designing and preparation time.
3. Saving in manufacturing time.
4. Assisting maintenance and overhaul.
5. Alterations and modifications can be made without undue interference to the day to day operation.
6. Reliability of components, well tested over many years of operation.
7. Control panel of a mosaic design with all the advantages of a unit construction: clear indications and straightforward operation.

DISCUSSION

In opening the discussion, **Mr. A. W. Woodbridge** said that as far as papers read before the Institution were concerned, Mr. Codd had presented a new conception of circuitry, one which appeared to have considerable merit and possibilities in practice.

Mr. Woodbridge had been privileged to see a number of both Swiss and German installations. Probably the interior of relays which Mr. Codd had demonstrated might differ in some detail from the continental ones, but they were comparable. He was going to repeat what he had said in his Presidential address nearly two years ago. There were elements there which signal engineers in this country must examine and examine very seriously. There was, first of all, the point that one could see on the Continent so regularly, the fact that they were putting in nothing but that type of installation; they were putting them in at a very much quicker rate than we were, and at a much lower figure. A quotation for what was probably the biggest installation in Europe, if not in the world, amounted to 17 million Deutsche marks which, converted to pounds, was roughly £1¼ million. One had only to compare Frankfort with any of the big installations in this country and to put the prices against them. That same subject was the most serious one the signal engineers had to face.

Mr. Woodbridge had had the view for many years, and he was glad to say that he did not think that he was alone in it, that their equipment was far too big, far too costly, and out of date in its conception; and he was very pleased that Mr. Codd had given, so ably, a lecture on the equipment he had demonstrated.

Mr. Woodbridge preferred to judge an installation, first of all, on its sound engineering conception. He then judged it on the results achieved; and there was no question, in his mind, that those circuit techniques were achieving what they set out to achieve. He thought that they might, in the future, see some very considerable developments along those lines. There was, of course, in the Institution a committee which was studying the problem, with a view to seeing what could be done in this country. Some people were even going ahead of that committee to try to obtain some practical experience of the equipment.

Mr. J. P. Coley: The miniaturisation of relays was an important factor in permitting the possibility of the packaging of relays into units. One of the most important single factors which permitted relays to be miniaturised was the use of considerably increased power in the operating windings, and progress on miniature relays employing this principle had been rapid in this country in the last year or two. Another factor which helped in the miniaturisation of relays was the use of metal-to-metal contacts, but it must be understood that the use of such contacts introduced very special circuit requirements, and also special design features in relays employing such contacts. Thus the circuits must be arranged so that when a relay is supposed to release it is proved to have released. Similarly, the relays must be so designed that if one back contact is used for this proving, then it must inherently prove that all front contacts are open. Consequently, the relay must be so designed that if one of the front contacts becomes welded in the closed position, then all the others will open when the relay is de-energised, but the back proving contact will not be closed.

The paper states that the use of relay sets overcame the difficulty of special protection for high voltage circuits. The speaker was not in agreement with this, since in the case, for example, of point machine circuits, there would still be connections from the supply to the relay units and from the relay units to the points themselves at high voltages.

On the question of the use of symbols for designating the different types of relay used in such systems Mr. Coley deprecated the possible introduction of the continental type system, but felt that the present B.S.I. symbols should be adapted and extended to cover this type of circuit work.

The author appeared to argue that because it was a good practice to have package units, it was equally good practice to build the control desk also in small unit packages. The speaker was in agreement with the idea of package units for two reasons. The first of these was that it enabled a great deal more of the installation wiring to be carried out in workshops under good conditions and to standardised wiring diagrams. The second advantage was that the maintenance of an installation would be eased by the use of package units. In the event of a failure, maintenance staff have only to seek out one of a relatively small number of package units instead of, in the case of an individual relay system, having to seek out one relay out of a very large number of relays. Such arguments do not apply to the control desk itself, and the speaker felt that it might well be more economical to have appreciably larger mosaic elements than those employed by Mr. Codd. There is some advantage in breaking up a large panel to a certain extent to facilitate changes to the track layout which may have to be made at some date subsequent to the initial installation.

Finally, Mr. Coley suggested that operationally it would be just as satisfactory, and from the circuit point of view, a considerable simplification, if the push buttons were held down for the two or three seconds required to set up the route.

Mr. H. W. Hadaway agreed with the author's plea for standardisation of symbols and terms, and frankly, he confessed that he was somewhat puzzled by precisely what was meant by "flank protection." Did it mean suitable electric locking and track circuit control of a conflicting route? Or was it a track circuit signal control of an over-running train from some other conflicting route?

Was the interlocking wiring included in what had been termed "free circuitry," which had been mentioned as 5% to 15%? Because if this type of wiring, together with other non-standard circuitry, was to be included, it seemed to Mr. Hadaway that the value of 15% would be exceeded in covering such circuitry.

The question of breaking down the analysis of the layout was of interest to him, because on London Transport, with the application of programme machines, they had come, very largely, to similar sort of thinking, which enabled the breakdown of equipment into a set of points and its associated components; but there were one or two things which had to be faced after that. It was not clear to Mr. Hadaway how the equipment described in the paper covered the remaining matters.

The two-button method of controlling a layout was a very simple way of controlling perhaps, a very long section of line and setting up a large number of points in one movement; but coming to the question of close headway working, did it, in fact, largely destroy itself in the fact that one had to operate a number of pushes at intermediate positions, to the extent that, from the two buttons one started with originally, one might ultimately have a number approximating the number of sets of points on the route controlled?

Mr. A. Brown had had an opportunity of studying, to some extent, that sort of system in Germany more than in Switzerland.

He felt that perhaps a little more emphasis might be placed on the point that, in introducing miniature relays of the type they had been discussing, and in particular with metal to metal contacts, the whole theory had to be considered on the basis of circuit security, that no matter what went wrong with any one relay or any one element in the circuit at all, things were still safe. At least two things had to go wrong together to cause a wrong-side failure and that, whichever went wrong first, must advertise itself in some way. If one pushed the argument, one could say that three things had to go wrong, before the circuit was in trouble.

It had been mentioned that there was still need for some circuitry apart from the standardised circuits in the various relay sets. He understood from his friends in Germany that, in recent years, they had been endeavouring to concentrate very much on reducing the free circuitry to a minimum. He was rather surprised to hear that the circuits they had seen that evening might have only 5% of free circuitry, but he understood that the German engineers took the view that, to obtain a real saving from their standard type of equipment, one must push the principle of standardisation to the limit and cut the free circuitry to a minimum. One might not get rid of it completely, but perhaps could cut it down to 5%.

The author had shown them some typical examples of a set of symbols which were used by Swiss engineers and it seemed that they had gone very far in the direction of hieroglyphics. In other words, they were trying to use a different picture for every individual relay in the group. He was sure the Germans had not got so far; they had symbols representing the type of relay. The symbol told the essential things one needed to know, but did not go so far as to tell what job the relay was there for. Letters were used, as we use them ourselves, to indicate the function of each relay.

Mr. E. G. Brentnall was interested in Mr. Woodbridge's mention of the cost of the Frankfort installation, bearing in mind that it is the largest installation in Europe.

The question of the size of British relays would have to be considered. He attended a Continental Committee dealing with relays which drew up a fairly wide specification for all kinds of countries. The clearances and tolerances were much less than in the British standard relays. A year later, when the specification came up for revision, the Germans asked for much less clearance than they had in the first case. He admitted that other factors entered into it—Mr. Brown had mentioned circuit design—but he was sure that they would have to come to much smaller relays.

One great advantage of the "geographical" system was the ease in the preparation of diagrams; that was a very great point. One of the biggest difficulties today on British Railways was the shortage of the required number of technical assistants.

In preparing wiring diagrams for large relay interlockings, it would help if some simple symbols could be adopted. Signal engineers, in the past, had gone from graphic symbols to written circuits; now the system mentioned in the paper seemed to go back to the graphic type of symbol. Something easier and simpler would help.

Mr. J. Boura, referring to the axle counting devices, knew that that was not the main feature of the paper, but it did strike him that there was an opportunity there to use cold cathode counting devices or rotary selectors. He would be interested to know whether these devices had been tried, and if so, would they compare favourably from a flexibility point of view.

He noted that, on one of the relays, there was a visual indicator on the front of the panel, which informed the lineman when he could take the relay out. Perhaps the next step was to actually lock up the panel whilst in a dangerous position—just one more thing to add to make it absolutely foolproof.

Mr. J. C. Kubale said they had all witnessed the author's enthusiasm for what he called geographical circuitry, and with that he would agree, but thought that he was being less than fair in not having mentioned the work of some of the early inventors of the geographical circuitry system, of which the equipment shown by the author was an example. Continental practice to a large extent at the present time, is a development of the geographical circuitry which was invented in the early nineteen-thirties by S. N. Wight of the G.R.S. Company, U.S.A., who, incidentally, also invented the first C.T.C. for railways. He felt quite sure that the German and the Swiss inventors were well aware of Mr. Wight's patents, which had now come to us in a form which many people considered very new. He thought that, in a way, it was characteristic of this country that we were the first in some things, then, for some reason or other, we let them drift. This country was the first in the world to install the geographical signalling called the " NX " system. It was brought into service at Brunswick near Liverpool in February, 1937. Since then there had been a large number of installations all over the world. Perhaps, if not for the war, there would have been more here. Stratford was one of the examples which, due to the war, was delayed. Now, twenty years or more after the first installation, people were thinking of it as something very new. Germany was enthusiastic over it. The signal engineers of this country should decide amongst themselves, or individually, whether something like it would suit their requirements. When they saw somebody else using it, they would probably be convinced, but they could have been the leaders in this field. Historically, they had had it in their hands for over 20 years.

Packaged units had been used for such things as C.T.C. for a very long time, and there were several examples to be seen in this country. Mr. Dell had shown quite a number that he was using on the L.T.E., when he read his paper a few weeks ago.

People who used geographical circuitry endeavoured to simplify requirements and that was why, in his opinion, on the Continent, their signalling systems were less costly than in this country. An expensive item was what the author called "free circuitry." It was not " free " by any means.

Mr. Kubale did not like the idea of having to draw pictures, instead of having a set of symbols which could be easily read.

He had always been in favour of a geographical panel and one as small as possible. If a mosaic panel to show all the information requested could be made at the same cost as alternative types, there are good reasons for using it.

Mr. F. G. Hathaway asked whether the author would agree that, on the Continent, the signalling of traffic moves were not the same as in England. Their conception of signalling shunt moves was a good deal different from ours. The very fact that they used trailable point machines meant that they did not signal every shunt movement, as we did. All the added interlocking and protection cost money. That was one of the things they had to take into account regarding the cost of some of the large installations. If many of the signalled moves could be cut out, it would simplify things and cut down the cost.

Mr. M. E. Leach said that, on the question of the relay stopping in its half-cocked position when one of the front contacts was welded, this was rather a difficult business to achieve. It probably depended on the contact load and one or two other things, but as far as the relay was concerned which the author had shown on the screen—the small relay with a large number of contacts on it—Mr. Leach had carried out some experiments. He had been successful in welding one front contact by a " little bit of butchery," but nevertheless, it was done. In the course of this experiment, the springs on which the contact elements were fixed were subjected, by the fault current to a form of heat treatment, causing loss of temper, and the back contacts definitely closed, with the front contacts welded. Under that condition, he did not know whether it could really be said that the relay was completely immune —that is to say, if the front contact was welded, the back contacts would never close.

Referring to the geographical circuit technique, Mr. Leach mentioned the pressing of the entrance button and then the intermediate button, which determined which of two alternative or more routes was wanted; but supposing that intermediate button also occurred in the geographical track of another route, did the intermediate button have to be pressed, if that route was wanted?

Mr. Codd replied that the route could be selected. So far as that was concerned, it was not necessary to press that button for another route where that particular button could occur.

Mr. M. E. Leach said that if a signalman had to select an alternative route, he would press one button, would come to the intermediate button and would press that, and then go to the exit button. In the one case, he had an intermediate button to operate, but not necessarily in the other case.

Mr. Codd explained that that was the point for another shunt somewhere; it was not a special button.

Continuing, **Mr. M. E. Leach** sought information with regard to alternative flank protection. In the event of the machine or circuitry seeking flank protection, and the points which it would normally set for flank protection were engaged, the machine then going on to seek further until coming up to some points which could form an alternative for the route in question, if the first pair of points became free, did the circuitry automatically revert the flank protection to the first points? Or did it remain set in the way in which it was at the time of initiating the route?

He still thought that overlaps were a very difficult thing to work into the geographical circuit technique, because there were so many conditions that had to be allowed for. In setting a route, the overlap was dictated by the facing points in it. Proving was required, if one wished to move the facing points by hand, to make sure that the overlap to which one was switching was a free one; in other words, not occupied or taken up by some conflicting route.

Mr. P. A. Langley wondered whether it would be worthwhile applying the geographical circuit technique to relay interlocking in this country. Taking the example illustrated by Mr. Codd for one connection between two lines crossing three other running lines, it was necessary to split the crossing into four separate crossover roads employing mythical facing points and shunt signals. The equipment for these connections had to take the form of packaged units as obviously it would be out of the question to do this with conventional relays. It was only the fact that miniaturisation enabled it to be done. It seems therefore, that miniaturisation is a first requirement of such a system.

It must also be borne in mind that in this country a high standard of protection is laid down by the Ministry of Transport Requirements, for example: the overlap control must be added whereas this is not used on the Continent. In addition, track locking, flank locking and approach locking have to be provided and after that free circuitry is necessary. He felt that it would be quite some time before our draughtsmen could produce the circuits at anything like the speed at which Mr. Codd had indicated.

Finally, he asked whether the draughtsmen prepared the circuits from conventional sheets.

Mr. V. K. Openshaw enquired whether the packaged circuitry technique was adopted for working two sets of points, as for instance on a crossover road, with one set of control relays, or whether it was found easier to work them with an individual control set for each end of the crossover, and then provide flank protection?

The President stated that with regard to the type of relay demonstrated that evening, he had heard that, if welding conditions occurred, only one side of the bar contacts would weld. Was that so?

Mr. H. A. Codd: *Replying to the President.* The fact that welded contacts should only occur on one side of the bar was not a prerequisite of the relay. It was possible for both sides to weld.

Replying to Mr. Leach. With regard to metal to metal contacts, what he termed "a guided contact operation" was a requirement of the relay. The fact that Mr. Leach had succeeded in producing a relay which was contrary to that statement was partly covered by the term he used, which he said was "butchery." The author knew of this particular case as the relay was one of his firm's. In his opinion the condition under which that relay failed was not one which he could foresee would occur under normal operating conditions, and he could not remember a similar occurrence in practice.

Replying to Mr. Coley regarding precautions when handling high voltage circuits—which are meshed in with low voltage circuits—it could easily be done and under complete protection if handled the right way. Special protecting covers appropriately labelled should prove to be adequate. As far as symbols were concerned the author did not advocate the introduction of the types used on the Continent. He felt, however, that additional symbols should be introduced to cover the variety of relays but they should be contemporary and simple in their design. With regard to fault finding the author could not agree with Mr. Coley. If Mr. Coley could find a fault on one contact of one relay quicker than the author could find in a plug-in relay set, Mr. Codd would challenge him to a competition!

As to packaged relays that had been used already for other parts of railway signalling, like C.T.C., he heartily agreed. C.T.C. was, in many respects, related to telecommunications.

The interlocking was still left to the locking apparatus and it was that which they were trying to cover by the geographical circuit technique, and not to lengthen the arm of the signalman. However, if he had created the impression that he was trying to advocate a system which his firm happened to produce, after all, it was right from a business angle, but it was not right to believe that was his intention. He was fully aware of the early attempts of geographical circuit technique.

Dealing with Mr. Coley's remarks regarding the type of panel, the limit to miniaturisation was the standard size of the signalman's fingers. If he could operate a panel conveniently from a small type of equipment, it could only be to the advantage of users and manufacturers.

Flanking protection meant safeguards against rolling stock, propelled or otherwise, infringing on the clearing of points.

The interlocking was covered by the relay sets themselves but it was still necessary to follow a locking chart. The author also emphasised the difficulty in fully explaining a technique in a technical paper because when a system is being developed it is sometimes necessary to retract from some of the points made if actual life tests had proved the opposite.

Did not their German colleagues advocate an even further reduction of the free circuitry?

Plug-in relay sets were now in such a form as to cover almost 100% especially when one considers that a large proportion of the free circuitry could be housed in plug-in relay sets, but these special sets would be characteristic to the specific layout only and would not necessarily be interchangeable with sets used for other installations.

Mr. Kubale had asked how it was free circuitry, when it cost a lot of money and it had been suggested that the geographical technique was perhaps more applicable to the type of layout on the Continent. Mr. Codd would like to disagree with that, because he had seen installations on the Continent anything but simple and still covered by the circuitry technique. The advantages of a system could not be explained in the form of a lecture. The only way was to give him a chance and he would show whether it could be done for the same price or not.

With regard to Mr. Boura's reference to the axle counting device and cold cathode tubes, many parts of the circuitry could be made workable by using cold cathode tubes or other types of electronic equipment. The element which the designer used was largely dependent on what the customer was willing to accept. It was no good designing a beautiful signalling circuit if nobody wanted to buy it.

The axle counting relay mechanism had been in service for over 15 years. When cold cathode tubes became available and the circuit designers did consider it suitable for axle counting circuits, a special method of circuit meshing would be necessary if cold cathode tubes were to be used in safety circuits.

There was a set of tables which were prepared in advance and which were very similar to the control table, but he would like to say that it was not a table of controls. It was nearer to the locking chart, because the table of control was automatically included in the system.

Mr. Codd disagreed with some of the remarks on overlaps. When he said that he disagreed, he very humbly did so. They had managed already to overcome 70% of the possible problems that could occur. He would not like to say how long it would take to cover the remaining 30%, but he was convinced that before the M.O.T. could decide on what the final miniaturisation would be, he would know the answer.

The **President** proposed a hearty vote of thanks to Mr. Codd for his excellent paper, and this was carried with acclamation.