Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Thursday, October 28th, 1954

The President (Mr. J. H. FRASER) in the chair

After the minutes of the 41st Annual General Meeting held on April 14th, 1954, had been read and confirmed, the **President** welcomed Mr. R. N. Sen Gupta, Mr. S. A. H. Taylor, Mr. D. L. Hambley, and Mr. B. Hillier, who were present for the first time since their election to membership and Mr. D. F. F. Holdway, Spoorweg Sein Industrie, who was visiting this country from Holland.

The **President** announced that unfortunately Herr Reschuh was unable to be present to read his paper " Signal Engineering in Germany Today," but Mr. T. S. Lascelles had very kindly consented to do so on his behalf, and it gave him great pleasure to call upon him.

Signal Engineering in Germany Today

By G. RESCHUH (Member)

Diagrams—Inset Sheets Nos 21-24

Germany has a very extensive railway system, carrying a heavy traffic. There are 30,450 km. (18,921 miles) of route in Western Germany, operated by the Federal Railway (*Deutsche Bundesbahn*) and owned by the State, with 7,500 km. (4,660 miles) of private lines, lines operated by industrial and mining undertakings, and the rapid transit systems in various cities. Although no new lines are now likely to be opened, the traffic over the existing ones may be expected to increase, especially as a consequence of the trains being divided into a greater number of smaller units.

Signal engineering in Germany, as in some other countries, notably Great Britain and the United States, has a long tradition behind it, being almost as old as the railway itself, and has always been of a high standard, a result not only of the great development to which the railway system attained and the density of the traffic over it but of the very close co-operation between its technical officers and the engineers of the signalling industry. As in other countries the change from the old and well tried mechanical signalling equipment began to take place towards the end of last century. Up till then electrical operation had been confined to the block apparatus, used in and between stations, but the introduction of the power interlocking frame marked the extension of electrical working to the entire railway signalling field, paving the way for greater centralisation and the application of remote control and automatic signalling.

At about the same time (1896) as the first power frame was put into service, automatic signalling with light signals was introduced on the electrically operated suspended mono-railway between Barmen and Elberfeld, in the Wupper Valley.* This work was followed by automatic signalling installations on city rapid transit lines, equipment for the automatic operation of hump marshalling yards, automatic train control and level crossing warning apparatus, and axle counters. As far back as 1925 there was in operation in Germany a hump yard apparatus in which the levers, or handles, and indicating lamps were arranged on a track diagram panel or desk. The year 1929 saw the first power frame with all-electric interlocking on the Hamburg Elevated and Underground Railway and in 1932 appeared the first remote control installation.

The good results obtained with these showed that signalling could contribute to greatly improved and more economical traffic operation, both as regards running and shunting movements, as well as fulfilling its primary function of ensuring safety. With this dual purpose in mind a new line of development was entered on, with the close co-operation of the Federal Railway officers and the signalling industry, especially the firm of Siemens & Halske, themselves in touch with the leading authorities on the subject

*A detailed description of the very interesting circuits used in this pioneer installation, still in service with some improvements, operated on the intermittent contact principle, will be found in *The Railway Gazette* for October 18th, 1935.

in other countries, a development affecting every aspect of signal engineering. Its object was to obtain, by extending the application of automatic and centralised controls, a higher level of safety with increased flexibility and economy of working, unattainable with the type of equipment hitherto employed. The designs previously used, with the principles and rules adhered to in applying them to installations, were accordingly set aside in favour of new ones throughout, making use of every advance in engineering knowledge and practice that had occurred in the meantime. New methods of applying signalling to the actual practical control of traffic also were evolved.

Panel Apparatus with Track Diagram

The first and most important element in this new development is the track diagram panel apparatus. Available in satisfactory form since 1948, it has been applied at a number of stations, such as Cologne and Hanover, and has proved itself in service. It is purely a relay interlocking apparatus, all the controls of every kind being effected with the aid of relays and circuiting, while the greater part of its operation, with the detecting, proving, indicating, etc., takes place automatically. In the method of operation by the signalman and the manner in which the various movements are indicated to him, in the arrangements used for applying indicating and recording apparatus, in constructional details and circuiting arrangements, this equipment differs widely from previous designs. The manner of applying it to actual layouts differs also from the practice hitherto prevailing in Germany.

As a rule now only one signal box is provided at a station. The signalman controls the traffic on his own responsibility, operating the points and signals and setting up the routes, for both running and shunting movements, but very large stations have a special traffic supervising official, who has a controlling apparatus with which he directs the traffic movements. At such places the signalman himself deals with shunting movements from the desk panel, in association with the person in charge of them, but in the case of running movements his actions are under the control of the supervisor.

Previously in Germany, in the majority of cases, shunt movements were carried out without interlocked routes, all points being fitted with indicator lanterns showing their position, but it has been decided that in all large stations they shall be dealt with by means of shunt signals interlocked with the points in the ordinary way, essential to achieving the desired centralisation of the signal boxes. Wireless communication between signalman and shunting engines is also being applied. To obtain the maximum degree of flexibility in working it is customary not to set points as traps to shunting movements, neither is there any route locking, as there is in the case of running movements, only ordinary interlocking. There are no longer any point indicator lanterns at such stations.

In designing the circuits every advantage which electrical controls can offer for dealing with traffic movements is made use of. It becomes possible, practically without limitation, to utilise every route in a layout for both types of movement, with sectional setting and releasing, down to even a single pair of points, the smallest unit in a route. In this way maximum use of the lines is obtained.

At the smaller stations it is usual, for reasons of cost, to dispense with shunt signals interlocked with the points and many of the automatic features of the equipment. The points are operated individually and the routes made up by hand while it is usual to do without track circuiting—or its equivalent—in those parts of the station of which the signalman has a good view. The individual elements of this panel type equipment can be used for every kind of traffic condition met with in practice.

Details of the Panel

In the German panel installations all controlling and indicating elements are grouped together on a desk and located in geographical order on a diagram of the lines in the area concerned. Unlike the arrangement seen in some foreign designs, all items relating to the individual sets of points are placed next to them on the diagram. In spite of this it has proved possible, by making use of the latest manufacturing methods, to keep the dimensions such that even in the case of the largest stations the signalman can see the whole of the desk at a glance without difficulty and has every operating button within easy reach.

The unit form of construction is used. The face of the desk is made up of individual components measuring 63×38 mm.

($2\frac{1}{2} \times 1\frac{1}{2}$ in.) each having 15 places for lamps, over which are set cover plates, each of which bears an appropriate design, according to its particular position in the track diagram, such as a pair of points, a double slip, a length of plain track with a signal, and so on. These cover plates also carry the push buttons used to operate points and signals and set up the routes. In this way it is possible to make up at will any track layout and similarly to effect any alteration thereto.

The operating elements are simple push buttons. Their arrangement on the desk as well as that of the indicating lamps, is the result of the special operating conditions prevailing in Germany and the wish expressed by the railway authorities that the signalman's work should be rendered as simple as possible and everything on the panel be seen clearly without effort. A feature of the arrangement, adopted for safety reasons, is that operation is always two handed, that is to say that to produce any effect the signalman has invariably to depress two buttons simultaneously. Points can be actuated individually by operating a button located next to them on the diagram together with a so-called group button placed outside it, or they can be operated in complete routes. In the latter case only the two route buttons, located at each end of the route it is desired to establish, need to be depressed. If, however, it is desired also to clear the signal concerned then the signal button at the beginning of the route is depressed and not the route button, whether a running or a shunt signal is involved. By actuating various group buttons situated outside the diagram at the same time as one located within it, such as a points button, different electrical actions can be initiated, with a saving of buttons. When a route has been set up it becomes illuminated throughout in steady yellow light. Its electric locking is indicated by a special lamp and any portion occupied by a vehicle becomes lighted in red. Repeater lamps show the indications being given by the signals. This locating of all buttons and lamps referring to the individual sets of points on the track diagram offers many advantages. It makes it easy for the signalman to see exactly what the position is at any moment and so increases the safety of working, especially should any failure occur. Operation is facilitated when it becomes necessary to dispense with the automatic setting of all points in a route. The point buttons can be used individually to establish and release partial routes, or shunting routes, as required.

Relay Room Equipment and Wiring

In the design of the relay room equipment and wiring, extensive use was again made of the unit construction principle to facilitate planning, production and erection, and also maintenance afterwards. The smallest unit involved is the relay, next comes the relay group, and then the relay group assembly. In a relay group several relays are brought together to form what may be called a circuited unit, for example all relays referring to the operation of a pair of points or a signal, or associated with the setting up of a particular route and its locking. There are thus points, signal, block, route, etc., relay groups, distinct from one another, while groups of relays having like functions, as for example points relay groups, are in turn mounted together to form a points relay group assembly, route relay groups to form a route relay group assembly and so on. There are in addition certain group assemblies containing relays not necessarily circuited on a fixed plan, relays belonging to circuits meeting some special requirement at a particular station or location. All relays and relay groups have plug connectors so as to be readily replaced by others if necessary, without risk of alteration to the circuits concerned.

The design of the relay conforms to requirements now accepted internationally by signal engineers. The type used in telephone engineering was expressly not adopted for the work, an entirely new one being produced, making use of all available knowledge and progress gained in both the signal and telephone fields, not only as regards the materials to be used but also the process of manufacture. The new design was intended to combine the advantages possessed by the signalling relays of older type with the experience acquired in telephone practice. In view of the very great importance attaching to contact opening no circuit is ever interrupted once only but always at two places, on relay contacts in series. A silver bar makes contact, in the closed position, with two contact springs, moving away from both when the armature drops away or picks up, as the case may be, giving a break at each spring. An opening of the circuit is therefore ensured even should one spring have become bent or welded to the bar. All the bars are rigidly connected together by a fixed contact carrier piece, ensuring that either the upper or lower contacts are closed, and of course the opposite ones for the time being open. In order to obtain reliable electrical contact the surfaces concerned are arranged differently from the usual practice in this respect. Development work, extending over many years, has resulted in the production of an improved form of contact in which a silver bar of cylindrical section touches at right angles the apex line of a contact piece of triangular section with of course a certain amount of rubbing action. This design has proved to be very reliable and capable of dealing with a wide range of current and voltage values.

In other respects, however, the experience and knowledge available in telephone engineering, especially as regards manufacture, have been utilised as far as the conditions to be complied with in signal engineering would permit. For example, the old screw type terminal connections, always used hitherto, have been replaced by soldered ones, long familiar in telephone work. These have proved satisfactory. As the relays and relay groups have plug connectors it becomes hardly ever necessary to touch a soldered connection on apparatus in service. For safety reasons the distance between the soldered tags is made sufficiently great to ensure that there is no possibility of two becoming bridged when using the solder pistol or by any other means.

A relay particularly characteristic of signal work is the self latching type, used in all cases where no change in the position of the armature must result should a failure of power occur as, for example, in the case of relays controlling the holding of a route. These relays have two magnet cores and when the armature of one falls, it holds that of the other in the picked-up position, and the reverse.

In an installation in which all interlocking is effected electrically the design of the circuits themselves plays a very important part and calls for special attention. The safe working of the equipment, the way in which it fulfils its function of controlling the traffic, the cost of construction and maintenance, all depend in some measure on the manner in which the circuits are arranged. Practice has shown electrical interlocking methods to be in no way inferior to their mechanical predecessors. Since, however, with such equipment most of the operations are effected automatically, especially the setting up and releasing of routes, and no longer depend to the extent they formerly did on the signalman's action, more stringent requirements are laid down with respect to them than was the case with the older apparatus using mechanical interlocking. The higher standards called for in the specifications issued by the German Federal Railway cover more particularly the following :—proving of all relay armatures in the de-energised position ; all important contacts to be in duplicate as a protection against irregular contact between wires or extraneous current effects; protection against the release of a route or unlocking of a signal, or the operation of a pair of points by accidental lifting of a relay armature ; automatic indication of any fault developing.

The extensive use of fixed standardised circuit arrangements is as important for design and manufacture as it is from the safety point of view. Relay groups are pre-wired in the factory complete and there thoroughly tested in every particular. They are safer against the influence of extraneous current than ordinary wiring arrangements and in other respects also, since any group can be quickly and easily changed for a new one, testing being thoroughly and very simply effected with the aid of specially designed equipment.

Outdoor Equipment

The endeavour to get a greater degree of concentration in signalling installations led to changes in the equipment used out on the line. For both running and shunt movements light signals are now used instead of semaphores and discs, while track circuiting and axle counters are being widely applied. It is true that point machine motors can still be operated on 136 v.d.c. from batteries but it is more economical to use 3-phase motors and the 4-wire circuit designed by Siemens & Halske to carry both operating and detecting currents. A core diameter of 0·9 mm. (·035 in.) is sufficient up to a distance of 1,000 m. (1,094 yds.). Signals and track circuits are usually now also fed with a.c. and in most cases the signal lamps are 12 v., 10 or 20 w., the primary circuit being a 220 v. one. A second reserve filament becomes automatically switched in should the first one fail. Home and starting signals on through running lines are provided with a reserve red unit. At night the signal voltage is reduced to one half the normal.

Generally, the aspects given by the light signals are the same as those met with at night in the earlier type signals. A shunt signal at danger shows two red lights placed horizontally and indicates stop to all movements of whatever kind; when cleared it displays two white lights diagonally, upwards from left to right. Starting signals for running movements are combined with a shunt signal to form a unit showing for stop the two red lights just mentioned and for proceed for running movements either green or green over yellow. The clear aspect for a shunt movement is formed of the two diagonal white lights with one only of the two red stop lights still exhibited. No red light is seen in a running proceed indication.

Track Circuits and Axle Counters

Considerable changes also have been made of late years in the design of equipment for track circuiting. The new designs of track relays are remarkable for their reduced dimensions, high level of efficiency and small power consumption, this being 0·2 VA in the track, and 6·0 VA in the local winding. As a rule on steam lines a d.c. relay is used but on electrified lines a 2-phase motor type relay, the special feature of which is that it involves no gear mechanism. On d.c. traction lines the track circuit a.c. has a frequency of 50 but where the 15,000 v., 16⅔ cycles traction system is used this figure is 100. Very frequently in Germany the rails are laid on steel sleepers and to indicate whether a track section is occupied or not counters must be used to register the number of axles entering and leaving it and, when the two operations agree, to indicate that it is clear. By means of track devices resting on the principle of displacing a magnetic field, thus involving no mechanical contact with the passing wheels, a contact actuating device is operated and impulses transmitted from it to a counter in the relay room which, as each wheel passes, counts a step forward or back. A contact on this counter remains held open as long as the apparatus is not in the zero condition. This type of equipment operates at any speed, even the very lowest, down to no speed at all, in contrast to those types in which the track device is purely inductive. This is a great advantage of the German design, which is directional in action, thus excluding false counts.

Standard Signal Box Equipment

For small stations on both double and single lines where there are only one or two loop tracks a standard type of panel apparatus has been developed which, to an even greater extent than the other patterns, has all the wiring arranged on a fixed plan, with only very minor differences of detail corresponding to some small variations in the track layouts. More than fifty such installations are now in service on the Federal and certain privately owned lines and a considerable number in course of construction. They are cheaper in first cost than mechanical equipment and are being installed in the first instance at those places where the mechanical frames require renewal on account of age.

Supervisor's Panel Apparatus

As already mentioned, at large stations there is a traffic supervisor who directs all the train movements. He has his own form of panel or desk which, as with those in the signal boxes, has the indicating and operating items arranged geographically in such a way as to be easily seen and handled. In this case only the indications of importance to running movements are given and only the station tracks and the approach lines thereto, without any points, with the operating buttons in readily understood order located thereon. By actuating a button in one of the station lines together with one in one of the approach lines the supervisor instructs the signalman concerned to set up the route for the movement he desires to make. This is indicated on the signalman's panel by the route becoming lighted in flashing light, while on the supervisor's desk indications are given showing whether the order has been transmitted, whether it has been obeyed and whether the signal has been cleared. Other indications show when a train is ready to start, which lines in the station are occupied, when a train is approaching the area, and so on. There are also special illuminated indicators which show what movements are permissible as a consequence of the occupation of the station by others.

Train Number Indicators ; Train Time Recorders

At large stations the work of the signalmen and supervisor is assisted by the train number indicators or describers. Not only is the occupation of the various track sections shown on the panels, or other indicator boards, but also the actual time-table numbers of the trains concerned. These numbers consist of five numerals with a prefix letter denoting the class of train involved. The visual indication is produced on the panel by special optical equipment containing ten lamps for each digit position, each lamp being made to project a particular numeral through an object glass and condenser and each such projection appearing in the same place on the actual indicator screen. With the aid of this apparatus and chains of relays the complete train number is made to move from one indicating position to another, in accordance with the occupation of the various track sections and the particular routes that are for the time being set up.

This system of train description is found to be a great help to the supervisor in taking his decisions and it much facilitates the operation of the traffic. In the area covered by a large station and its approaches several places are arranged from which descriptions are transmitted. When a train arrives in the outermost part of the area its number appears on an indicator, at first merely in the order of approach, and with it is given in minutes any difference between its running and the actual booked timing. As soon as the train reaches the next, or inner, part of the area, beginning about 10 km. (6¼ miles) from the station itself, the number appears in its correct geographical position on the panel. The system is in operation at several large stations, such as Cologne and Hanover, with excellent results, and has functioned equally well in association with the centralised traffic control apparatus described below. It is supplemented by a train time printing recorder which automatically registers the time of each train with respect to some given position in the layout. For example, every movement into a station track and its departure therefrom is duly recorded, with the time when that occurred. There is no longer any need for a train register book, with consequent saving in staff, and a record is constantly available of the exact position regarding the condition, not only of the station tracks but of the approach lines leading thereto.

Remote Control

Relay interlocking installations can without difficulty be operated by remote control. By combining the new style signal engineering with what has been accomplished in other fields with remote controls the area with which a signalman, or equivalent official, can deal with can be extended at will. It then becomes possible to control stations of any size economically from one central signal box, or a number of stations located on the approaches to a main junction, while sections of route of considerable length can have all their points and signals and train working brought under the control of one central apparatus, with consequent savings in staff and better traffic operation.

Remotely controlled signalling has been in operation in Germany for many years. Siemens & Halske constructed the first there in 1932 at the Theodor mine near Bitterfeld. A considerable extension of the system took place on industrial and other privately owned railways. In the central lignite deposits region centralised control was put into service where the traffic was heavy, to great economic advantage, and since the war these mining railways have shown a lively interest in such operating methods and some large installations are in hand for the West German collieries. The former German State Railway (*Deutsche Reichsbahn*) also became interested in the question and had installed a few small remote control installations before the war at Porta in Hanover and in the Breslau area. The good results achieved with such equipment, at home and abroad, led the management of the Federal Railways to take up the problem again. Considerable difficulties remained to be overcome, both operating and technical, in order to arrive at a solution meeting German main line requirements, but the two installations made since the war between Regensburg and Nuremberg and Bebra and Cornberg have proved that this could be successfully effected.

The C.T.C. Equipment between Regensburg and Nuremberg

This section is about 100 km. (62 miles) long and formerly was worked by steam traction, with mechanical signalling and manual block system, but, when electrification was undertaken the signalling was converted to electrical working, using the latest equipment described above, with automatic signals and remote control, in order to test the value of this type of working for German main line conditions. All stations or other traffic operating locations are under the control of the central apparatus at Nuremberg. There are three stations where there is a considerable amount of shunting, seven where there is very little, three small wayside stations with locally operated points, and four halts with protecting home signals. There are also a number of automatic signalling locations and some attended level crossings.

Stations with an appreciable amount of shunting have a local signal box with panel and a signalman constantly on duty who operates the points and signals as required, the official at the central machine exercising control only over the arrival, departure and through running of trains. Those stations, however, where there is little shunting, which have a simple loop track for overtaking movements, are remotely controlled from the central apparatus, but have a local panel, while for the points there are control huts placed nearby from which they can be worked by the train crews when required. Should any failure occur to necessitate it an official can take up duty in the signal box and deal with the working on the spot. At the small wayside stations where there are locally worked points electrically locked ground levers are provided, released from the central apparatus.

This itself is located at Nuremberg in the telephone exchange building, where the telephone cable running through the section terminates. This serves to connect the locations along the route with the C.T.C. machine. The panel of the machine is built up from the same components as are used for ordinary signal box installations. It gives the person in charge a clear view of all train movements and the condition of the various points and signals. These indications are supplemented by the train number describers already mentioned. The method of operating the panel is the same as followed in an ordinary signal box. At the will of the operator the intermediate stations can be arranged for automatic through working, for remote control or local control. When remote control is in force the points, routes, and signals are dealt with by him, but when through working is established the routes are set for the direct through lines at a station and its signals then work automatically. When local operation is in force the points, routes and signals are withdrawn from the control of the central machine and worked by the person in charge of the station from the local panel. The same thing applies to the small wayside stations.

The automatic signals are not, as is usually the case in other countries, permissive but absolute stop signals and therefore have to be equipped, as do the signals worked from the stations, with remotely controlled subsidiaries, operated in emergencies from the central machine. The indications on the basis of which any use of these is made must, as also the actual control of the subsidiaries themselves, be transmitted in an absolutely reliable manner, as there is no local interlocking in this case.

Movements throughout the section are recorded by two train graph mechanisms, one for each direction of traffic, and these in conjunction with the other indications he receives enable the operator at the central machine to decide when to make use of any subsidiary signal.

All starting signals, or signals marking a division between block sections carry so-called running regulating signals, or signs, actuated from the central machine and used to advise drivers how to regulate their speed, making it easier to arrange for any overtaking movements required and eliminate any unnecessary stops. An illuminated arrow, point upwards, instructs the driver to run faster, and one showing point downwards denotes that he should run more slowly.

Special measures were necessary to protect passengers at places, such as halts with nobody on duty, where circumstances oblige them to cross the line, against through running trains, and to give adequate information to staff in charge of level crossings. The entire installation has given complete satisfaction since it was put into service and fulfilled all expectations.

The Bebra-Cornberg Installation

This installation was brought into use in the autumn of 1951, with very appreciable operating advantages. The C.T.C. machine is at Cornberg and there is reversible working on the 12 km. (7½ miles) of double line thence to Bebra. It was originally planned to provide a third track to enable ordinary stopping passenger trains and expresses to leave Bebra to time and travel through the section without hindrance from goods trains. To avoid the great cost involved it was decided to put in automatic signalling, with remotely controlled reversible working. About midway crossovers were laid in to enable trains to be passed from one track to the other. The up grade line was given automatic signalling for that direction only, but the other line was equipped for both directions, under remote control. An ordinary panel apparatus was installed at Cornberg, working in conjunction with that dealing with the reversible working. Goods trains ascending the gradient can be overtaken by another train arranged to run on the wrong line, either throughout the distance, or on the first or second portion of it. The panel controlling the section carries all necessary indications relating to the points and signals on the double line. There are special additional signals, or signs, displaying lights arranged in the shape of a snake, for advising the driver to be prepared to pass from one line to the other while all signals, automatic included, have the ordinary permissive subsidiaries and speed regulating signs already mentioned. This installation also has answered all expectations and trains are now able to leave Bebra punctually.

On working out the engineering details of this equipment it would, of course, have been possible to make use of experience gained in Germany and abroad, but it was felt necessary to follow new lines in order adequately to meet the high level of requirements which main line working in that country had shown to be desirable

The number of indications, etc., needing to be transmitted to do that is very large (some 30,000 are received and sent daily at the Nuremberg C.T.C. machine). This means that transmission time must be kept very short while, as already remarked, in most cases a very high degree of reliability in transmission is essential. In addition these German installations must be able to function on sections worked by 15,000 v., 16⅔ cycles, a.c. traction, and it is stipulated that the line circuits must be electrically separated from the apparatus itself by relaying equipment.

The remote control relay arrangements devised by Siemens & Halske operate by means of polarised induced impulses and have met all requirements. Transmission is especially reliable as all orders sent out and indications received are provided with a return acknowledgment, showing that the operation has been correctly performed. The apparatus can be used on electrified lines, requires few relays, and has short transmission times. In the two installations above mentioned two pairs of cores were required in the cable. The selection of the particular station to which an order is being sent is effected by coding but the return indications from the outside locations to the central machine are dealt with by synchronous rotary selector switches. The latest and more efficient arrangement, however, requires only one pair of cores, a code formed of induced polarised impulses being used for both functions.

The excellent results obtained with these installations have led the Federal Railway to decide to put others into service to control stations located near to main line junctions where several routes converge, junctions between stations, and other similar locations. In these cases the various orders and return indications must be transmitted in the shortest possible time. The arrangements so far devised to do this have been able to meet all requirements. On the other hand, simpler working is met with in certain cases as, for example, on single lines of secondary importance, or light railways, where as a rule no block signalling equipment is provided. No provision is made for the subsidiary signals mentioned above or any signals indicating increase or reduction of speed. Comparatively few orders and return indications need to be transmitted between the central apparatus and the stations. A simpler form of equipment, although of the same general type, is therefore used. In the present state of development there are five methods of applying remote control considered suitable for German conditions, namely :—

1—Centralised traffic control equipment for single or multiple track sections of route, with or without reversible working ;

2—Similar apparatus for lines of secondary importance ;

3—Remote control of small stations or junctions from nearby stations, as, for example, in the neighbourhood of an important junction ;

4—Traffic control for long sections of route, or in large station areas, using telephone equipment for directing the train movements ;

5—Remote control of relay rooms at outlying subsidiary locations, forming part of the working of a large signal box and under its direct control.

If there remains still in many circles a good deal of hesitation in applying centralised and remote control methods, an increasing number of railway officers are now becoming favourable to them, as a result of the excellent results obtained by their use.

Automatic Signalling

Although automatic signalling was applied many years ago on certain rapid transit city lines and on lines belonging to industrial concerns considerable difficulties were encountered in doing so in the case of main lines. Neither the former State

Railway nor the present Federal Railway management has seen its way clear to dispense with an absolute stop indication in the case of signals giving admission to a block section and agree to a train proceeding cautiously prepared to stop short of any obstruction. The application of automatic signals to such lines therefore did not begin until after the war, when a solution to the question acceptable to the railway authorities was arrived at. Under this arrangement every signal controlling admission to a block section carries a subsidiary operated in emergency from the station in rear. There are two wires between each signal and the station, serving to convey all the indications required. Should a failure occur, the signalman communicates by telegraph or telephone with the station in advance and makes sure that he is free to actuate the subsidiary. It is also possible to provide automatic signals, if necessary, with the speed regulating signals referred to above and control them over the same circuits.

With this equipment there is no difficulty in adding later a system of ordinary or centralised traffic control over the entire route. All that is required is to connect the central controlling point with the individual stations through which it becomes further connected to the automatic signals themselves.

In actual operation these subsidiary signals have been found to function extremely well, bringing the great advantage that lengthy runs under caution are avoided, something which, on sections where speeds are high and trains frequent, can react very badly on the working.

The equipment used for automatic signalling is of the same general design as that used in the latest signal boxes except that a 3-position instead of a 2-position 2-phase motor relay is used. All the stringent requirements laid down for the new style apparatus are fulfilled, including the proving at danger of each automatic signal in turn. Should any relay fail to operate it holds the signal immediately concerned at danger or the one in rear. The space taken up by the equipment has been considerably reduced in the new designs. The various items are grouped conveniently in apparatus cases, containing also the telephone for communicating with the neighbouring station in event of a signal failure.

A number of automatic signalling installations have been put into service of late years, as for example in the Cologne area, on heavily worked sections between Ludwigsburg and Bietigheim and Esslingen and Plochingen, with of course those already mentioned.

Automatic Signals in Station Limits

At the large stations a special form of automatic signalling is used to divide the platform lines into sections and protect trains standing in them. This enables several short length trains to run to the same platform under proper signal protection, greatly increasing the capacity of the station and making it easier for passengers to change trains.

Simplified Equipment for Secondary Lines

The Federal Railway has some 10,000 km. (6,214 miles) of single line secondary routes carrying light traffic and there is also an extensive network of privately owned lines of this kind. They are neverthless important as feeders to the main lines but can only be worked economically if operating costs are kept low. This means that every endeavour must be made to do with a minimum of staff. Modern equipment offers a way of doing this. At the moment the following possibilities are being considered :—

(*a*) Automatically returned loop points and protecting signals :

The two facing points at a station are arranged to remain at, or return automatically to, one position, the return spring having, however, a delayed action attachment preventing the points from returning between each pair of wheels. Protecting signals in rear prove the points properly closed for a train and when one is cleared the opposing one is held at stop.

(*b*) Electrically operated points with home signals, and starting signals, if circumstances so require.

The points and signals are operated either by local staff or the train crews, or automatically by the train itself acting on a magnetic device which transmits the necessary controls as the station is approached.

(*c*) Electrically operated points and signals under remote control from a central machine.

While the automatically returned points in (*a*) above suffice where traffic is very small the arrangements under (*b*) and (*c*) bring considerable savings in staff, even where traffic is heavy, and at small initial cost.

Hump Yard Installations

As mentioned, the panel arrangement applied to hump yard working in Germany from 1925 was the forerunner of the present signal box panel equipment. The point levers, or handles, and indicating lamps for points and track circuits were arranged in this earlier design on a desk in geographical form. This apparatus, supplemented by electric interlocking for actual train running movements, was provided for a large yard at Osterfeld South, but any general application of such methods was not thought acceptable by the then State Railway authorities.

Of recent years, using the latest designs described in this paper, the hump yard apparatus has been modernised, with an extensive use of automatic and centralised working. Standard parts are used to form the panel itself. The magazine equipment, for storing the point controls, formerly separate from the panel, is now combined with it. Following a request from the Federal Railway, the particulars referring to each cut in a train are indicated at the panel by an adaptation of the train number describer, giving the number of the track to which a cut is to run and the weight involved. The storage of the controls for a train is effected very simply by depressing the buttons in the tracks concerned. Corrections can be made at any time, if necessary.

Movements take place completely automatically. The retarders can be operated from the panel by buttons giving a four stage braking effect. The final form of this equipment provides for completely automatic braking, graduated exactly to the amount of run a vehicle requires to make, under the control of indicating apparatus on the panel which shows the extent to which each track is filled at any given moment, and therefore how far a vehicle is free to run. This apparatus has given excellent service. Speed of working in the yards has been noticeably increased and appreciable staff reductions effected.

Automatic Train Control

A considerable proportion of the more serious accidents of recent years have been attributable to failure to obey stop signal indications. This induced the German railways some considerable time ago to take up the problem of automatic train control. After extensive experiments with various systems, mechanical, optical and inductive, it was decided to adopt the inductive 3-frequency a.c. resonant system, and about 20 years ago to commence to install it on a large scale. By the time of the recent war almost all the main line sections run over by express trains had been fitted and more than 1,000 locomotives, railcars, etc. The advantages of this system are that there is no source of current nor any movable mechanism on the track and no mechanical contact between track apparatus and train. Maintenance costs therefore are low. The three effects are transmitted to the train by only one magnet on the track and one on the locomotive or other vehicle concerned. The efficiency of transmission is independent of the speed. Three frequencies are generated on the train, namely :—2,000 for the distant signal effect : 1,000 for the stop signal effect ; and 500 for checking the speed and enforcing a reduction between distant and stop signals.

When any of these effects is to be transmitted the track magnet is connected so as to be resonant, with the result that as the magnet on the train passes it the current flowing in the latter becomes reduced, which in turn causes a relay to drop away and act on the cab apparatus. This equipment has proved satisfactory in service for many years.

In recent years it has been redesigned from the electrical, constructional and manufacturing points of view and is now being applied in an improved, more compact and less expensive form. At the same time it has been made possible to provide a two-frequency system, adequate in the case of slow passenger and goods train locomotives, which can, however, be used without difficulty in conjunction with the older three-frequency arrangement.

In addition, Siemens & Halske have now in course of development a magnetic system which has, after some years of trial, been brought to a satisfactory form and is being at present applied on several lines such as, for example, the Hamburg Elevated Railway. There is a magnetic transmitter on the track acting on a similar receiver on the train, the air gap between being bridged by a magnetic field. This is independent of the speed and is set up by a permanent magnet. If no effect is to be produced on the train this field is neutralised by a counter electromagnetic one which consumes only a few watts. In special cases this effect can be given by turning the transmitter, thus altering the direction of the field. The receiver contains a small magnetic relay with a polarised armature, reversed under the influence of the field picked up from the transmitter. This operates a contact to complete a circuit acting on the braking or indicating apparatus, as required.

Transmitter and receiver are contained in aluminium alloy housings, made proof against the rough usage experienced in railway service by robust construction and shock absorbing mountings. The receiving relay also is constructed to be completely immune to shock of any kind.

With this magnetic type of automatic train control also it is possible to transmit several types of effect to the train and therefore several signal indications.

Protection of Level Crossings

The level crossing question is a specially important one for the German railways. In West Germany alone there are 40,000 crossings, of which about half have hand operated barriers. A few are protected by automatic flashing light installations. The cost of operating and maintaining the barriers is very high, so that a change to automatic working is as much to be desired as is an increased degree of safety at those crossings at present without any protection.

During the last 25 years a certain number of automatic installations have been put to work in which normally a white light is seen, flashing 45 times per minute, which changes to red and flashes twice as fast on the approach of a train. Recently, however, it has been decided to dispense with the normal white light. The use of the latest designs of equipment has made improved methods available, able to meet all traffic conditions, and it is intended to apply them on a larger scale. It is also intended to use the so-called half-barriers and also barriers electrically operated from a distance on request. These latter are used on roads where traffic is light and are normally closed across them. When a person wishes to go over the line he advises the signalman concerned, who may be several kilometres away, by two-way telephone equipment and, if conditions permit, the barriers are raised for him. Controlling and proving are effected over the existing telephone wires along the line. These devices also are a means of introducing a greater degree of rationalisation into the working.

Conclusion

The signal engineer's task is a very responsible one and while an important objective in all these new developments is to construct apparatus which will raise both the operating and economic efficiency of the railways, nevertheless his primary endeavour must ever remain that of securing the highest possible standard of safety. It is gratifying to know that he can serve effectually both these aims. The German railways, and especially the leading officers of the Federal system of lines, have, as remarked at the beginning of this paper, co-operated fully to this end with the result that the work has been carried to a conclusion in complete accord with the requirements of railway operation today. The correctness of the course pursued has been proved by everyday experience and the new signal engineering technology can be said to have stood the test in numerous installations, both at home and abroad. Let us hope that the railways in turn may be able to derive the fullest benefit from it in their endeavours to render their working constantly more efficient and adapted to the needs of the time.

DISCUSSION

Mr. E. G. Brentall, in opening the discussion, said that he had been privileged to see a number of modern German signalling installations and they reflected credit on all concerned. In that country, design and application had been allowed full scope, and the results were quite remarkable. There were differences in principle and application of signalling, between the United Kingdom and Germany, and contrasts and comparisons could be made.

With regard to the relay interlocking installation, it was interesting to note that the signalman was now allowed to control the trains. In the past, the station master had been all important, as in many other countries on the Continent, and the signalman, to some extent, secondary.

He was of the opinion that the provision of a separate panel for the traffic supervisor was an unnecessary complication, and there seemed to be far more button pressing than we had in really busy or very large stations in Britain.

In Germany there was no route locking for shunting movements ; that was different from the principle in Britain and was, he believed, the residue of long standing practice in Germany, as until recently, no shunt signals had been provided, only point indications. Another difference was that track circuiting was not provided where trains could be easily seen by the signalman.

The construction of the panels in the form of units was very interesting and permitted of extensions and changes being readily made to the layout.

He was particularly interested in the relay arrangement whereby the circuit was broken in two places due to the two contacts and the small bar which moved between them. Soldered connections were much favoured in Germany and he had asked various signal engineers about them. He could not obtain much information as to what effect the soldered connection had in making changes, whether more difficulty was experienced than with terminal arrangement. He asked for further information regarding the statement that pre-wired relay groups were safer against extraneous current than the ordinary wiring arrangement.

He noted that most of the colour-light signals were provided with double filament lamps, and asked if there was any proving of the lamps. With double filament lamps, why should a reserve unit be required for home and starting signals ? The train number indicators had to be seen to be believed and were useful on long sections. The two C.T.C. installations described were most interesting, as they were on two very different types of line. With regard to automatic signalling, it was interesting to note that the German railway authorities did not agree to dispensing with the absolute stop indication and used an extra signal, if the automatic signal was showing a red aspect, to permit the train to pass.

He asked for more information on the simplified equipment for secondary lines. How did they automatically set the points reverse, in the first place, and how were they kept reverse until the train arrived.

In one installation he had seen, arrangements had been made in the relay interlocking, in the case of failure or emergency, to bridge out some of the functions to permit route operation of the rest. He would like to know if that was common practice or whether it applied only to that particular station.

Mr. J. C. Kubale said that the paper showed how, on the German railways, the signalling was being used as a means of helping the operation of the railway. It had been used as an operating tool, instead of being looked upon, as signalling did sometimes appear to be, as a disadvantage to operating.

It was noted that the signalman's panel was designed as a two-handed system, to be operated by two push buttons, but he felt that was something of a disadvantage and wondered why it could not have been arranged for a one-handed operation.

In the paper, it was mentioned that the relays were designed to conform to the requirements now accepted internationally by signal engineers, but he knew of no international standard for relay design. Considering what was demanded of manufacturers in the United Kingdom, who were bound to manufacture to British standards or Association of American Raliroads standards, he felt that the German equipment would be vastly different, if the Germans had to work to any such specification. The use of C.T.C. was an instance where the German railways seemed to be able to justify its installation ; whereas, British railways seemed to have the utmost difficulty in justifying these modern devices. One wondered if there was not something out of balance somewhere.

The details disclosed in the paper were a credit to the energy and courage of the German railways and a credit also to the enterprise of the concern which Herr Reschuh represented, Messrs. Siemens & Halske. Mr. Kubale concluded by recording his thanks to Mr. Lascelles for translating and reading the paper.

Mr. B. F. Wagenrieder enquired how many trains per day passed on the German main lines to warrant the installation of the very extravagant signalling schemes shown in the slides.

Mr. R. Dell commented that, from the illustrations, it did not appear that carbon contacts were used on the relays. It was known that metal to metal contacts would weld, and although in the paper it was stated that having two contacts in series would prevent any untoward happening, he personally would be rather worried about the position. The relay illustrated left him rather concerned about how the pivots were constructed to ensure safety of operation.

Referring to the statement that the signalling installations provided for the proving of all relays down, that was a highly commendable arrangement, and he would be glad to have particulars of the way in which it was done.

Mr. T. J. Aldridge, referring to Mr. Kubale's comment on the two-handed operation of the panel, said that the paper did stress that this was done for safety reasons. It had been explained to him that one reason for doing it was not a technical one, but to avoid the possibility of an accident, if anything dropped on one button ; the chances of something dropping on two buttons were remote.

He would like to know how, in the hump yard installations, the indication was given on the control desk of the extent to which each track was filled at a given moment. Was it given by a number indicating the number of vehicles that had entered a specific track ? Or was it indicated by a figure representing distance ? If the latter, such a distance could be measured by high frequency currents, but in that case, how did they overcome the problem of showing a vehicle that was still moving along the track and had not yet reached its stationary position ?

Mr. W. G. Wheable enquired how frequently had information to be passed to a train number indicator ? And how were the numbers of the trains observed ? When things did break down, the operating people found difficulty in reducing delays, and this might be one of the things to add to their difficulties, especially in bad weather.

The **President** observed that it was his own impression that it was the working time-table number that was used. Generally, one knew what train it was, even if it were foggy.

Continuing, the **President** thought that there should be some way of protecting the public at unattended halts on the main line. The controlling and proving of level crossing barriers effected over the telephone wires alongside the line was a new feature. The dividing up of platform tracks into automatic signalling sections sounded quite simple, but was not so easy when one began to consider the different lengths of trains. He also noticed that there was no " Stop and Proceed " rule in Germany, but that they had subsidiary signals which avoided trains running at caution when the normal signalling was out of order. In like circumstances in Britain, we intended the trains to proceed cautiously.

In conclusion, the **President** said all members would be very grateful to Herr Reschuh for preparing the paper and giving an insight into what they were doing in Germany. With that vote of thanks, he coupled the name of Mr. T. S. Lascelles, who had been responsible for translating the paper and for getting the slides though the Customs, in addition to reading the paper.

This was carried with acclamation.

Mr. T. S. Lascelles said that a report of the discussion would be sent to the Author who would no doubt reply to the various questions and these would appear in the Journal of Proceedings for 1954.

Mr. G. Reschuh's reply to the discussion on his paper.

Formerly it was the practice in Germany to make a clear distinction between the supervising official (*Fahrdienstleiter*) and the signalman (*Stellwerkswärter*). The latter handled the shunting movements and set the points whereas the former controlled all running movements and had the duty of operating the signals for them. Today, with the new panel type signal boxes, there is usually only one signalman at all the small or medium sized stations, to deal with all movements, of whatever kind, and he combines in himself the two offices previously kept separated. Only in the case of very large stations, such as Cologne and Hanover, is a supervisor found, but he no longer, as previously, works the signals himself but confines himself to supervising the traffic and, from his own desk, he gives orders regarding running movements to the various signalmen stationed at their respective panels. This arrangement has proved perfectly satisfactory. It divides the work and allows of each man concentrating on his particular task. This is illustrated in figs. 1 and 2 in the paper. Fig. 1 shows the ordinary operating panel at Hanover, with the signalman at work, and fig 2, on the other hand, the supervisor seated at his own special panel. On this only those indications which are of importance for regulating the movements are given and particularly of course the train number descriptions.

As regards route locking for shunting movements, Mr. Brentnall was under a misapprehension in thinking that there was no such locking in Germany. This was only the case with the first panel installations. In all the newer ones, such as for example, Hanover, all shunting movements are made with locked routes and individual shunt signals. This locking, it is true, is not as rigid as in the case of running movements. For the latter there was really a double locking effect which could only be released by hand by resorting to a special auxiliary release button provided with a counter, so that it could always be seen whether it had been used.

The locking for shunting movements is simpler and can be released by the signalman with the aid of a plain push button. This new method of dealing with shunting has proved most satisfactory at several large stations in Germany and other countries. It is now the custom in Germany to work without locking for shunting only in the case of very small stations, where very little needs to be dealt with.

The soldered joints in the modern type equipment have proved to be satisfactory in practice and offer no difficulties when making alterations. The tags are at a specially large distance apart so that connections to them could be disconnected without fear of trouble, while the equipment was functioning. Maintenance staff find they can work very much more safely with the solder gun than they did formerly with screwdrivers or other tools.

Complete relay groups are tested in the works by means of special automatic equipment so that each wire can be tested individually for a break or cross-connection. All wires are carefully placed in position in the factory and are better protected against damage when in a group assembly than those outside it, or which connect individual relay assemblies together. For this reason such assemblies give greater protection against interference from extraneous current, as this usually comes from irregular cross-connections.

Double filament lamps have been used in Germany and several other countries for over twenty years and have given satisfaction generally. The main filament is of course burning normally and if it fails the reserve one is automatically switched in circuit. If, nevertheless, in the case of home signals and certain starting signals, a so-called stand-by red has been provided that is not because of any mistrust in the double filament lamp itself but because it was feared that the wires used for the two filaments in common might themselves become interrupted. It has to be remembered that in Germany the signal lamps are normally fed from the main supply, but should that fail then from a converter set. Were the converter not to start for some reason, on a power failure occurring, say, from some defect in itself, the lamps would be without current. In such a case the reserve red lamp becomes lighted from the signal box battery. No doubt these arrangements have involved carrying safety precautions somewhat far, but this could be done without much concern being felt, as little extra cost was involved and the wiring serving the green light was used for the stand-by red.

Particulars of the simplified arrangements used for secondary lines can be found in the article by Dr. H. W. Sasse in issue No. 2 for 1954 of the journal *Signal und Draht*, but it may be remarked here that the automatic operation of the points is effected under the control of track circuits or treadle rail contacts. The possibility of operating them automatically directly from approaching trains also has been considered. A movable permanent magnet is in that case mounted on the train and acts upon a receiving arrangement on the track.

Various forms of failure and emergency conditions are provided for in all signal boxes for dealing with faults, should one occur. For example, should a point machine develop a fault but the cable connections to it are still in order a special device is coupled to the cables at the points. This is actuated by a key which also serves to lock a key lock at the points. The points are then operated to the required position by hand crank and the key interlocking ensures that they remain safely connected to the route locking and signal controls. This means that trains can continue to be signalled as usual. In addition so called " substitute " (a form of subsidiary) signals are provided for use when a signal cannot be cleared, in consequence of some failure in the route locking controls. Similar emergency arrangements are provided for dealing with the failures of track circuits which lock points.

Operating the equipment " two-handed," under which every operation necessitates the actuation of two buttons, offers several advantages. In the first place accidental operation of a single button can have no effect. It is possible, for example, for some object to be placed or dropped in a button unintentionally. Secondly, the setting up of a route takes place in such a manner that a " departure " and " arrival "—or " commencement " and " termination "—button must both be actuated together. This makes the arrangement of the buttons on the panel particularly clear and their functions come naturally to the mind. The signalman can find the right buttons without having to read any indicating labels or other inscriptions. Thirdly, there is the further advantage that fewer buttons are required. For example, there is only one button at each pair of points. If this is depressed simultaneously with the common group points button the points will reverse. If this button is used, however, at the same time as the common points release button then the locking on the points becomes released. To work with a single movement only—that is " one-handed "—two buttons would be needed at each pair of points on the panel, or else a very complicated arrangement of buttons. The buttons on the Siemens & Halske type panels never have more than one making contact.

When speaking of internationally accepted requirements regarding relays the Author meant on the one hand those laid down by the International Union of Railways, that was to say, U.I.C. Codex I, 1st edition of January 1st, 1954, and on the other hand the requirements of the Association of American Railroads and the British Standards Institution, and finally the opinions held and conditions laid down by most signal engineers in all countries with respect to relays. The specifications of the International Union of Railways are met completely by the Siemens & Halske type relays and almost all the points contained in the recommendations of the Association of American Railroads and British Standards Institution also were complied with. Contrary to the view expressed by Mr. Kubale, the Author considers that the German relays would not look appreciably different if all the requirements of these two bodies were to be taken into account. Dimensions would need to be somewhat greater, that is all, and this would apply specially to the distances between current carrying parts and the leakage paths lying between. It must be remembered, however, that the American and British Standards dated back some years now and that with the present quality of insulating materials and manufacturing processes such dimensions are no longer necessary as were thought to be so in earlier days. It could be taken as established that several hundred thousand of the new Siemens & Halske relays were in service and so far had not given rise to the least complaint or criticism, either in Germany or elsewhere, in Europe or Overseas. In addition to the specific requirements just mentioned the Author had in mind also the opinions he has heard expressed, in the course of many years experience in the conversations which he has had with numerous signal engineers at home and abroad. He believed that the design of the latest Siemens and Halske relay, as explained in the paper, met these requirements and opinions, particularly as regards the points which distinguish them from telephone type relays.

These relays were so constructed that all contacts were forced to operate in unison. Should any contact become fused by excessive current the relay becomes held in this position and is incapable of actuating the opposite set of contacts. No circuit can become set up unless the conflicting contacts have previously become broken. The electrical exclusion of a number of circuits is basically a mechanical action, as the contacts are rigidly connected together.

It is not very easy to see the contact bar in fig. 6, but the silver pin can be seen which serves to connect two contact springs. The spring supports are strong enough to prevent all movement should fusing of contacts occur, while the double break, which the silver pin gives, also serves to guarantee safe working.

The rigid coupling of the contacts has the additional advantage that every relay can be proved for drop away, that is to say that in the de-energised position a contact becomes closed which serves to determine whether some other operation, such as, say, the clearing of a signal, shall take place. Should the relay armature not fall on account of some mechanical seizure then such operation becomes prevented. This proving, however, obviously possesses value only when, with the closing of the proving contact, all other contacts are shown to have changed their position. Back contacts are now very frequently used in the circuiting and it is always endeavoured to make use of them for this drop-away proving. In the latest circuit designs, however, this is successfully effected with very little additional outlay. Relays which do not possess this coupling between contacts, such as telephone relays, are only used for purely indicating purposes, that is in circuits on which the safety of the working does not depend. In special cases, for example for track relays, carbon-silver contacts are provided which of course cannot become fused together. Formerly these were used only where the relays were connected to open line wires, not met with today, and carbon-silver contacts are provided now only in apparatus supplied to foreign railways.

On many sections of line the traffic is very heavy and is constantly increasing. On the double line bridge at Cologne between the Central Station and Deutz the peak figure is 700 trains daily. On the three track section between Ludwigsburg and Bietigheim, on which there is reversible working on the centre track, the peak figure in 1952 was 385 trains daily. Similar conditions obtain on many parts of the German Federal Railway system.

The installation at Gremberg yard which indicates the amount of free space in each siding, works with the aid of track circuits fed at a frequency of about 1,000. At this frequency the resistance of the rails becomes so high in comparison with the ballast resistance that the variations of the latter are scarcely noticeable. The inductivity of the rail loop is measured up to the nearest axle in advance and shown on the measuring instrument which is calibrated in metres. Naturally this indication is varying as long as a wagon continues to move, but this has not been found to offer any disadvantage and the yard control staff find the apparatus of great assistance to them. Equipment for counting axles was intended to be used at Gremberg but has not in fact been fitted, as the siding free space measuring apparatus has been found to meet the requirements.

The train number describers exhibit the numbers by which the trains concerned are designated in the working time-table. When a train enters a signal box or remote control area the description is passed into the magazine equipment by a signalman or other official and its indication then moves forward on the track diagram with the progress of the train. This indication is optically projected on the diagram, or sometimes on a special describing panel, and so clearly that there is no difficulty whatever in reading it. There is no noise with it and the transmission is very reliable, while mistakes in hearing what is said over a telephone can no longer arise and produce difficulties. This system of train description has given excellent results at the large German stations, such as Cologne and Hanover, and proved of the greatest assistance to the traffic controllers and supervisors.

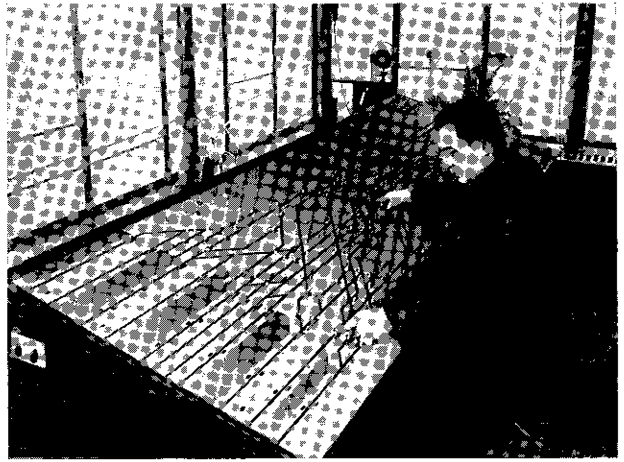

Fig. 1. Signalman's panel, Hanover East Cabin

Fig. 2. Supervisor's panel, Hanover Station

Fig. 3. Panel at Essen Station Signal Cabin

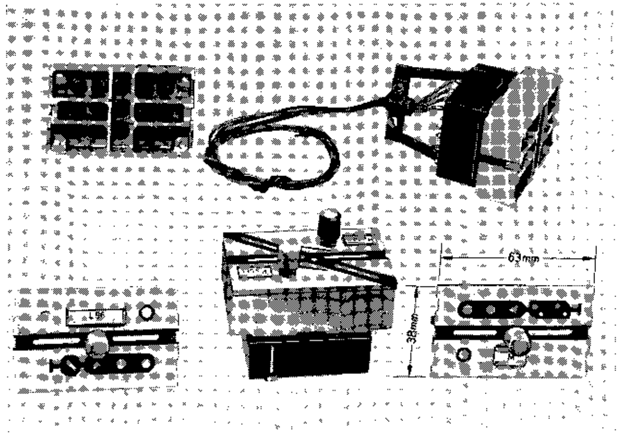

Fig. 4. Unit components of panel

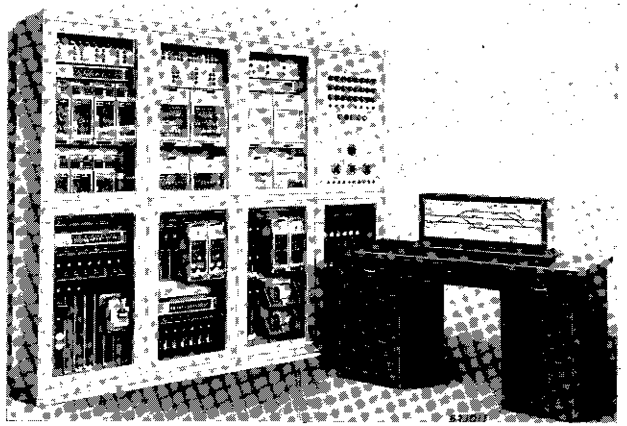

Fig. 5. Standard type of relay equipment and panel

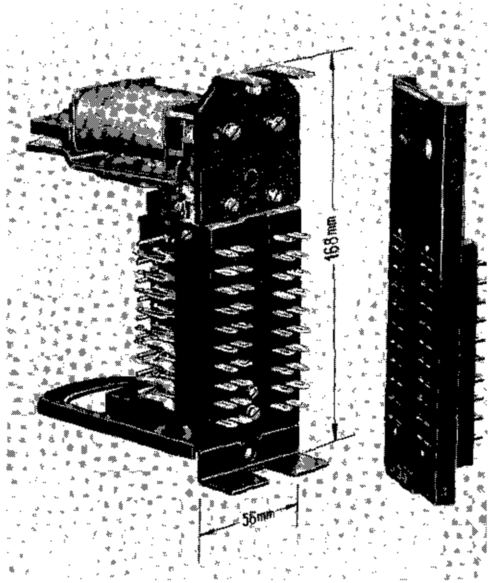

Fig. 6. Plug-in type signal relay

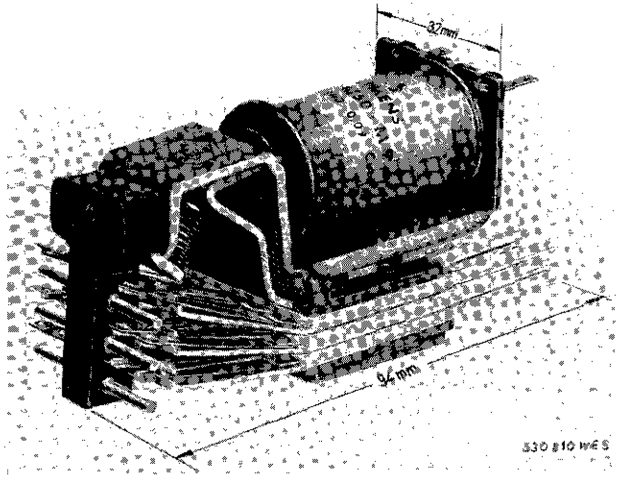

Fig. 7. Signal relay

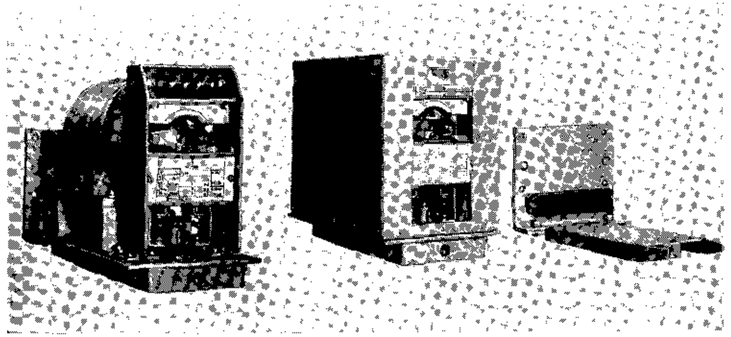

Fig. 8. Two-phase motor type relay

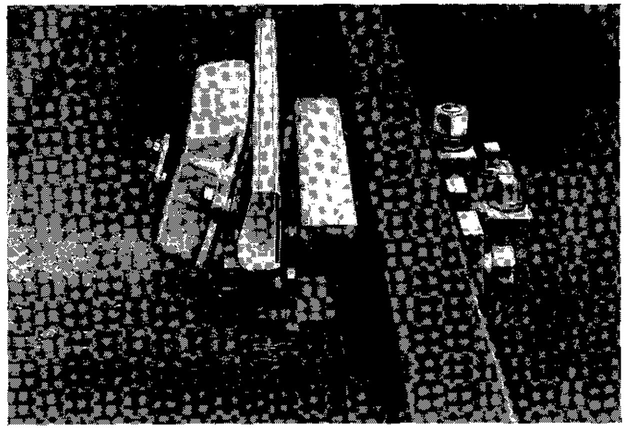

Fig. 9. Magnetic axle counting impulse transmitter

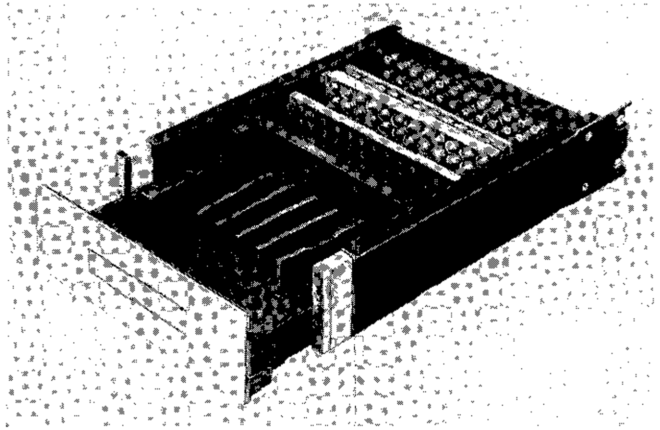

Fig. 10. Optical projection component

Proceedings 1954
Inset Sheet No. 23

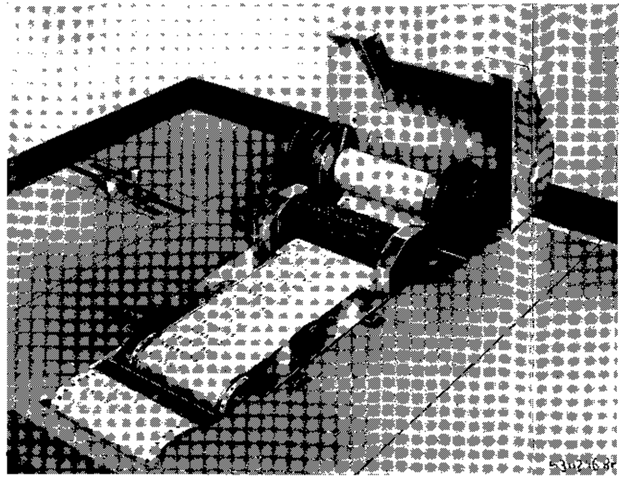

Fig. 11. Train time recorder

Fig. 12. C.T.C. Machine—Regensburg—Nuremberg line

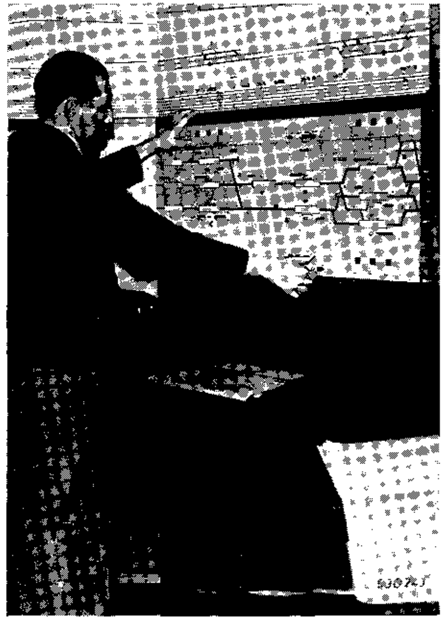

Fig. 13. Portion of panel shown in fig. 12

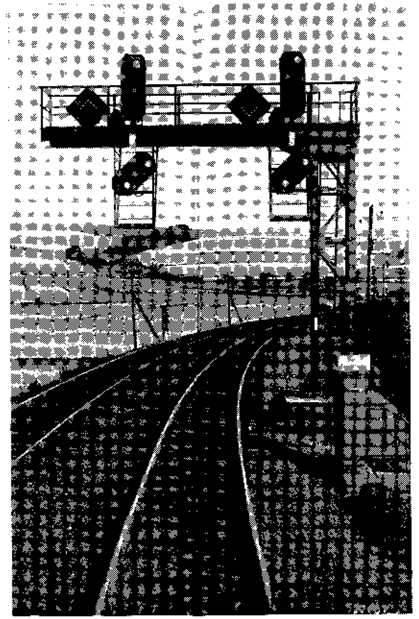

Fig. 14. Track circuit controlled signals—Bebra-Cornberg line

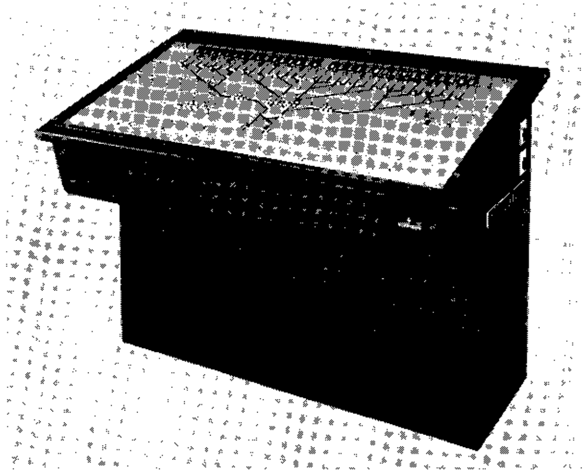

Fig. 15. Desk panel—Gremberg Hump Yard

Fig. 16. Small panel operated by train guard

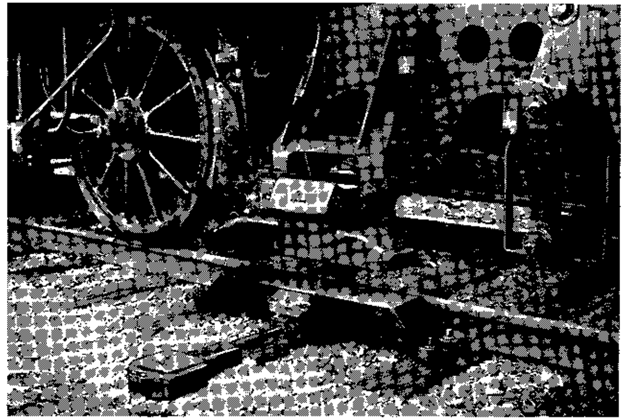

Fig. 17. Automatic train control equipment

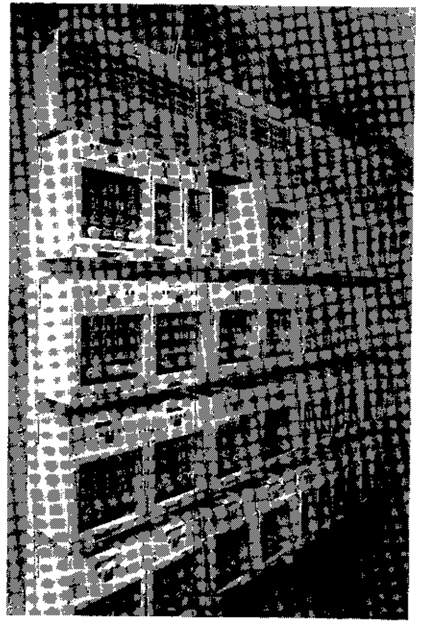

Fig. 18. Relay room arrangement—latest type