Technical Meeting of the Institution

held at

The Institution of Electrical Engineers
Wednesday, October 21st, 1953

The President (Mr. T. AUSTIN) in the chair

After the minutes of the 40th Annual General Meeting held on April 8th, 1953, had been read and confirmed, the **President** welcomed Dr. Karl Oehler and Messrs. C. W. Pitt, F. E. Ralph, L. G. Barnden, J. A. Kadwell, A. J. Hawkett, and H. A. W. Hardwick who were present for the first time since their election to membership.

The **President** said that he was privileged to call upon Dr. Karl Oehler, who had come from Switzerland to read a paper on modern signalling developments in that country. For some years the Institution had endeavoured to invite eminent engineers from continental countries, one in each session, to give a talk on their own signalling practice, and he was sure that it was of great interest and value for members to know how problems were solved and objects were achieved in different countries.

Dr. Karl Oehler said he considered it a great honour to be invited to prepare and read a paper before the Institution, and possibly the pictures he was going to show might encourage some to visit Switzerland and obtain more direct information.

Dr. Oehler's reading of the paper was preceded by a demonstration of various types of signals used on the Swiss Railways, the models having been made by Mr. H. A. Codd of Messrs. Tyer & Co., Ltd. Numerous lantern slides were also shown.

Dr. Oehler concluded by thanking Mr. T. S. Lascelles for his excellent translation of the paper into English, as it exactly conveyed the ideas the author wished it to do.

Modern Signalling Developments on the Swiss Railways

By KARL OEHLER (Member)

Diagrams Inset Sheets Nos. 11-14

The change from mechanical to electrical methods of signalling, which became so noticeable after the first world war, has been marked by a constantly increasing rate of development. This has had noteworthy results on the Swiss railways and in certain more or less clearly defined stages, varying in length, has made itself felt in many directions. For obvious reasons the Swiss Federal Railways, as carrying the bulk of the traffic in the country, have been principally concerned in this, although the privately owned lines cannot be said to be behindhand. The Federal Railways system comprises a mileage of about 2,852 km. (1,772 miles) of standard gauge line and 74 km. (46 miles) of narrow gauge and forms about half the total mileage in the country. Omitting cable railways and tramways there are 1,636 km. (1,017 miles) of privately owned narrow gauge and rack-rail lines, and 770 km. (478 miles) of standard gauge, or a total of 2,406 km. (1,495 miles).

The starting points of modern signalling developments in Switzerland can be considered to be the introduction of the colour-light signal and the adoption of the power locking frame with all-electric locking. These were not introduced together, as of course light signals can function with signalling apparatus of other types. Colour-lights appeared in 1929, but electrically locked frames were not seen until 1940.

Signals

The development of light signals necessarily had to follow from the practice already being observed with the mechanical signals, especially as regards the aspects to be displayed. As it is impossible to change all the mechanical signals into light signals at one stroke, many years must pass during which the two types will be required to function side by side. Admitting the principle that for each signalling meaning there shall be but one signal aspect, the new light signals must be made to correspond with those exhibited by the mechanical signals during hours of darkness, any variation being permissible only in so far as it does not conflict with any existing aspect.

As in earlier years the signal equipment came principally from Germany, the signal system met with in Switzerland corresponds with that seen in that country. Home, starting or other stop signals are of semaphore type, with either one or two arms. When the signal is at danger the arm—or upper arm if there are two—is horizontal and points to the right,* its lamp showing a red light.

* The trains take the left-hand track, however, as in Great Britain.

The lower arm stands closed up vertically in line with the post and its lamp is covered by a blinder.

In accordance with the old regulations in use until 1947 the clear signal is given in one or other of the following ways. If the train is to proceed on the direct route the upper arm is set at 45 deg. in the upper quadrant, with one green light at night. If the diverging route is to be taken then the lower arm also is inclined in this manner and shows a yellow light directly below the green one of the upper arm.

As this latter aspect is not capable of distinguishing between several different diverging routes its meaning has been corrected in the present-day regulations to signify " proceed over points set for a diverging movement," which means that the aspect partakes more of a speed than a route character. Which route is in fact set up the driver learns not from the signal itself but from the aspects shown by the point indicators. This is possible since he must have reduced speed to 40 km.p.h. (25 m.p.h.). To do so, however, requires a very close knowledge of local conditions, which cannot always be assumed when the driver is entering one of the larger stations.

With the increasing use in recent years of special designs of points able to be taken at higher speeds (60 to 80 km.p.h. (37 to 50 m.p.h.) when set for diverging, the need became felt for a special signal aspect which would distinguish between such a route and one involving the normal type of points. For this purpose the aspect of green over green was selected. As this cannot be applied by simple alteration to an existing mechanical signal, while it would be difficult to arrange for a satisfactory day indication, it has been laid down that this double green aspect shall be given invariably by a colour-light signal. It was possible to take this decision all the more readily in that no new mechanical type signals were constructed after 1938, and the tendency is to replace such as still exist by colour-lights.

The chief reason for turning to light signals, however, came from the necessity to improve the signalling in order to cater for the higher speeds which the Federal Railways were able to introduce following the electrification undertaken after the 1914 war. This, of course, affected principally the distant signals, of great importance to drivers, as they instruct them what to do, the stop signal in advance indicating the point where such order has to be carried out. The higher speeds, and resulting increased braking distances, made it necessary to place the distant signals on most of the main line sections at 1,095 m. (621 yd.) in rear of their stop signals. As the distant signals are in the same double-wire transmission that operates the relevant stop signal, so that the two signals change aspect together, it becomes rather difficult to work them at such a distance from the lever and it was accordingly decided to change to colour-lights.

The mechanical distant signals, when at caution, show a round yellow disc and at night two yellow lights placed horizontally, but if the stop signal ahead is at clear— whether for a direct or a diverging route—the disc is turned horizontally on edge and the lights become green. These signals are therefore 2-aspect ; they do not indicate what kind of proceed aspect the stop signal is showing.

In changing to colour-lights the opportunity was taken to make the distant signals indicate when a diverging route was set in advance, the new aspects being arranged, as follows :—

Aspect	*Lights*
1—Caution	two yellow, horizontally ;
2—Proceed	two green, horizontally (position of points not signalled) ;
3—Proceed, direct route ...	two green, diagonally ;
4—Proceed, diverging route	one yellow and one green diagonally.

When aspect 4 is shown the stop signal ahead shows green over yellow vertically (two arms at 45 deg.). These four aspects allow of being used in association with the existing mechanical semaphores, and Nos. 1 and 2 correspond exactly with those of the old disc pattern distant signals ; the first step in the introduction of colour-lights was to apply them in this manner, after which the following additional aspect was created :—

Aspect	*Lights*
5—Proceed over diverging route (large radius)	Two green, diagonally, with yellow above, forming a triangle of lights.

These signal aspects, both distant and stop, are not merely colour-light indications but a combination of colour and position, from which it follows that each light unit displays one colour only and the searchlight type of signal—called on the Continent a " relay " signal—cannot be employed. The optical units are therefore plain Fresnel lenses of only 170 mm. ($6\frac{11}{16}$-in.) diameter, the lamps being fed at 40 volts with a 20 watt rating, and allowing of the use of comparatively long horizontally placed filaments. A relatively good spread of about 3 deg. is obtained, without special deflecting prisms, but in the great majority of cases these have to be used, as even on the sections in the plains the Swiss railways retain a markedly mountainous character, as the following details show.

On the Federal lines, which have a relatively higher proportion of fairly level track than others, 15 per cent of the routes are on curves of less than 500 m.(25 ch.) radius and 1·56 per cent on curves of less than 300 m. (15 ch.). Only 77 per cent of the route mileage is level or on gradients of less than 1 in 100. Gradients from 1 in 100 to 1 in 66 account for 11 per cent, from 1 in 66 to 1 in 40 for 9 per cent, and from 1 in 40 to 1 in 20, 3 per cent. The maximum gradient on narrow gauge sections is 1 in 14·4. A wide spread on the signal lights of course shortens the range of visibility. but it is always sufficient for the limited view obtained on the curves.

It is of interest to mention that an arrangement has been devised for controlling light signals over two wires only by using different types of circuit for the different aspects, the changes in the circuits of the lamps themselves being effected by relays at the signal. In this way the wires originally provided in connection with the electric lighting of the old discs have been made to serve for the new distant signals and the running of cables has been avoided, of considerable economic importance for their introduction. It was also found possible, using these same two wires, to make the signals give the additional aspect indicating that the stop signal in advance is at clear for a diverging route over large radius points without having to add complicated equipment to them.

Stop signals serve as either home or starting signals. In the former case they are placed about 200 m. (219 yd.) in rear of the first pair of points, while starting signals are situated in advance of the last group of points at a station or in a layout. Strictly speaking each departure track ought to have its own starting signal and there should be a corresponding section signal for each line at the outlet of a station, where there are more than one. Generally, however, for economic reasons this is not done, a single starting signal being regarded as sufficient, it being considered that at the small stations any mistake is practically impossible, but at the larger stations separate starting signals are provided. Where this is not practicable route indicators are installed, so that when the actual starting signal is cleared a number indicates from which track the movement is to take place. The signal itself indicates the maximum permissible speed for it unless there happens to be an overall speed limit for the station area of 40 km.p.h. (25 m.p.h.), in which case, again for economic reasons, all routes, direct or diverging, are signalled with a single green light.

As already mentioned, in Switzerland it is considered important that distant signals should always stand at the prescribed distance in rear of the stop signal to which they refer, so that the driver knows not only what to do but exactly where he must do it. An exception is made, however, in the case of the inner distant signals—known as the " through running " signals—repeating the starting signals, usually carried on the same posts as the home signals. This is permissible because the driver knows, even by night, where the station ends, which is where he must be in position to obey a warning given by the inner distant. A difficulty arises, however, in the case of automatic signal locations situated at not more than braking distance apart, in which case 3-aspect signals have been applied showing red for stop, green for clear, and for caution (next signal at red) two yellow lights placed horizontally.

This signal has four lamp units, but arranged differently from those in the distant signals. The 3-aspect type of signal showing single red, yellow or green, seen in other countries, was not adopted, for the following reasons :—(1) to avoid introducing another aspect for the caution indication ; (2) because in all aspects used hitherto a yellow light is never seen singly but always in combination with another, yellow or green. As in Switzerland the yellow lenses are very dark and the red very light, there would be a possibility of confusion between yellow and red were a yellow light permitted to appear alone. As, however, red is seen only in a stop signal indication, and invariably by itself, no such confusion can arise.

It may be of interest here to point out that the stop and distant signals do not have to be observed by shunting movements ; they are running signals only. Shunting movements are controlled by special signals which themselves—with one exception—have no meaning for running movements. Practically speaking, the only mechanical type shunting signal is the so-called " shunting prohibiter," with two arms displayed as a diagonal cross when indicating that no shunting may take place. To denote that this prohibition is removed the two arms are brought vertically in line with each other. This signal is also now seen as a light signal, showing two rows of 5 white lights crosswise, or one row standing vertically. Certain other light type signals also have been introduced. One is the shunt ahead signal, which at "stop" shows a white vertical cross, and for " shunt ahead " 5 white lights arranged diagonally.

While a "shunting prohibition" signal can apply to a group of tracks the signal just mentioned applies to one track only and can govern light engine movements. This signal does not merely give permission to shunt, it constitutes an actual instruction to do so, thus bringing shunt movements under the direct control of the signal box, a change from the practice previously prevailing on the Swiss railways.

Quite recently another type of signal has been brought into use, a position-light dwarf signal, with two white lights for each indication, placed horizontally for " stop," diagonally for " proceed : next shunt signal at stop," and vertically for " proceed." As the " stop " aspect of this signal corresponds to that of an earlier mechanical one used to hold all movements, shunt or running—the only instance of a signal having such authority—these new dwarf signals are cleared when a running movement has to take place, so that they may be regarded as being something more than shunt signals. With their aid shunt movements can be effected over locked routes—not possible previously in Swiss installations—and the signals replace the earlier point indicator lanterns, representing a fundamental change of outlook compared with that hitherto obtaining.

Interlocking Installations

The development of interlocking apparatus can be divided similarly into certain well defined stages. Up to 1939 a certain number of electric power frames, using mechanical locking, were installed, concurrently with mechanical frames of the Bruchsal and Jüdel types. The first power frame to be installed—actually electro-pneumatic, the only example in Switzerland—was that supplied in 1914 by the firms of Stahmer and Siemens for Spiez station on the Lötschberg line. No other was put into service until

1922 when the A.E.G. Co. supplied one for Göschenen, followed up to 1929 by four more of the Siemens pattern. In that year the firm of Orenstein and Koppel was invited to tender and provided an installation at Chiasso station. Between then and 1940 seven more were supplied by it, and altogether from 1929 until 1944, during the war, 35 additional stations were equipped with Siemens frames. At four of them, Zurich, Neuchâtel, Berne and Basle, these were of the so-called " 4-row " pattern.

These frames can be described as electric in the sense that they control electric point machines and part of the interlocking controls are affected electrically. The operating levers or handles are interlocked by mechanical mechanism which, in its form of working, and partly in its design, corresponds to that seen in mechanical frames, the arrangement of the handles* being also the same. It is only in the frames put in of recent years that handles of a combined type have been seen, enabling the total number to be reduced. The possibilities offered by electrical apparatus of this kind of simplifying the working parts, reducing first cost and economising space were not then taken advantage of. Not until 1939, when dealing with the arrival lines at Lucerne, coming in from Berne and Olten, was a decisive step forward made by the Swiss signalling industry, in that mechanical locking was dispensed with.

In this layout it was a question of remotely controlling points and signals at an appreciable distance, 2 to 3 km. ($1\frac{1}{4}$ to 2miles) from the station. As there was no mechanical locking, and also no shunting over these particular points to be reckoned with, an arrangement was designed in which the points themselves had no operating handles but were actuated directly by the signal handles—known as " route-signal handles " in Switzerland—giving a form of "*levier d'itinéraire*" or " route lever." It may be mentioned that this installation rendered unnecessary the construction of a second tunnel, which would have cost 25 times as much.

Shortly afterwards the Federal Railways requested that equipment be developed to suit the stations on their Brünig line, capable of being fixed against a wall or let into it, which led to the production of the Swiss pattern of " single row " frame, of which

* As in most cases in the Swiss power frames miniature levers, as seen in Great Britain, are not used but rotary handles, the expression "handles" will be used hereafter throughout this paper.

250 have been constructed since 1941. From the commencement with this design the possibility offered by all-electric locking of reducing the working parts was taken advantage of, in that for each track leading to or from a station only one signal handle was provided, the direction in which it was turned indicating the direction of movement, that is for arrival or departure. The particular track in the station to or from which the movement was to take place was selected by depressing a button at the same time as the handle was turned, which meant that the parts of the frame to be used by the operating official corresponded with the train movement he had to deal with, (1) the direction of running and the line outside the station being denoted by the signal handle, and (2) the track in the station by the button, the combined actuation of the two defining the actual route. This arrangement makes it possible not only practically to exclude mistakes in the working, but enables any official to feel quickly at home with it, although not always doing duty at the station in question.

A particularly instructive example of the degree of simplification that can be attained is given by comparing the old crank-handle type mechanical frame at Schaffhausen, which had 37 handles and was about 7 m.(23-ft.) long with the electric frame which replaced it, which has only 10 handles and is 1·6 m. (5-ft. 3-in.) long. This can control 70 routes and could deal with appreciably more if the remaining mechanical signal boxes would allow of it. It must be emphasised that in accordance with an official regulation, applying to all Swiss railways, only the leading official in a station may operate signals for running movements, so as to place responsibility for their safety in a single hand.

In the larger stations it is not possible to place the frame out on the platform, and since the supervising official has many other duties to attend to, it is out of the question to trouble him with having to deal with shunting movements, which he can do at the small stations. It becomes necessary to install a number of signal boxes manned by subordinates and provide him with a so-called " order frame," or central control frame, from which he can release the signal handles in the boxes or, to the extent that his own apparatus contains such, operate signals under releases received from them. In any case such releases have to be provided between the various frames as each individual signal box area cannot be delimitated by separate running signals. That would be possible only by using signals applicable to both running and shunt movements, such as the dwarf type signals described earlier in this paper. These arrangements have, however, the disadvantage that every signal box must be manned when a running movement requires to take place, unless it can be effected without having to operate any points. This, of course, can only occur at through running stations when no shunting is in progress, as for example at night or at holiday times.

The more recently constructed types of apparatus permit in this respect of a degree of freedom not available with the old mechanically locked frames. The point handles are no longer as large as the signal handles but are simple thumb switches, actuating the point machines through relays. This makes it feasible to use the route lever principle, so that when a subsidiary signal box is closed the points ordinarily worked therefrom can be operated direct from the station supervisor's apparatus. This arrangement was applied this year to a subsidiary signal box at Burgdorf, which needs to be manned only during shunting.

In all these cases, however, the signal handles are equipped with electric locks, a feature which the Swiss railways have so far been unwilling to dispense with. They serve merely to attract the operating official's attention, should he endeavour to signal some movement not permissible at the moment, and prevent him from proceeding to set up, without noticing it, some control which cannot become effective. As by far the greater number of stations are small ones, with relatively little local traffic, there is usually only one official on duty, with at times an assistant, who has to deal with all the work, operating the frame being only one among the tasks he has to perform when he can, amidst the claims of other duties. Experience shows that there is considerable risk of his not taking time to observe that an operation he intends to effect has in fact been completed, so that in certain circumstances delays may result. The locking on the signal handles takes care of that, although not necessary from the purely safety point of view.

In the large stations special staff are on duty in the signal boxes, concerned solely with directing the various movements, and such locking can be dispensed with. They can, of course, be required to see that any operation they initiate has been duly completed. Such an installation is found at Geneva, its working differing from that of earlier ones in that shunting movements are carried out by signal over locked routes. As, however, they call for relatively short signalling sections the number of routes is very large, about 280. Shunting movements are formed of several such partial routes, each protected by its own dwarf signal. The signal box apparatus is of desk pattern, with track diagram upon it and thumb switches located to mark the beginning and end of each route, each being used in connection with either of the routes coming together at that point.

A route is set up by depressing the two turn switches marking its beginning and end, which brings all the points involved into the required position and locks it. The direction of movement is given by turning the switch at the beginning of the route in the corresponding sense, and this clears the relevant dwarf signal. The route is released by first putting the switch back to normal, which restores the signal to danger, and again depressing the two switches. Automatic restoration of the signal has not been adopted because a large part of the station is not track circuited, not having wooden sleepers, while in the case of propelled shunting movements time is saved by at least some of the signals along a route remaining at clear. Automatic route releasing also has not been provided, because for such movements only that part of the route should be released as requires to be set differently to permit the next group of vehicles to be dealt with, the rest remaining held.

The two main running tracks through the station, signalled by colour-lights, are dealt with similarly, and, by leaving the turn switches in position for clear aspects to be shown, automatic working of the signals for these routes is obtained.

It may be of interest to say something at this point about the type of relay used for interlocking, controls, etc., with this equipment, representing an advance on the contactor type used with the Siemens installations. The tractive power of the relay, the armature bearings, and certain parts of the contact arrangements have been greatly improved. As a relay is built up of individual elements, always in the same forms, it can be provided with from 1 to 17 contacts, in any number required up to 9 back-contacts per relay, and two can be coupled together to form a double relay, while by using a special toggle arrangement a self-latching or interlocking type can be obtained. The magnetic qualities are so good that these relays can be used for track circuits up to 300 m. (984-ft.) long, but a heavier sealed relay is used for longer lengths and in automatic signalling. These can, when required, be made as polar relays. The contactor type relays are, however, not sealed but mounted in open condition, but there is a tendency to make them now in sealed form, or to provide at least some kind of cover protection owing to the important part they play in the interlocking.

The use of telephone type relays for actual signalling circuits is not admitted by the Swiss railways. They are allowed only for repeating and indicating purposes; they are never included in safety circuits, unless it proves possible to arrange to prove the correct working of all contacts at each operation and for technical reasons it is not possible to use any other kind of relay.

The tendency now is to use smaller forms of relay in place of the earlier contactor type but having the same safety characteristics, the screw terminal connections hitherto employed being replaced by soldered ones. It is also the intention to alter the circuit arrangements in such a manner as to make it possible to assemble groups of relays, already connected up, such groups being provided with plug connectors, and readily changed, if necessary, when testing, making alterations, etc. The question of whether to provide individual relays with plug connectors has yet to be decided.

The cross sectional area of the wire connections is small, 0·75 sq. mm. (about No. 19 gauge) in agreement with the size of the relay. All relay apparatus rooms or cases are, with the exception of the power supply portions, wired with this wire, and special relay assemblies—for example, those used in connection with block working—can have even smaller wire, as the current never exceeds 0·5 amp. It will be clear from this that with the help of these small units relatively large installations can be housed in a very small space. It is possible, for instance, in a normal type signal box to house all the control, proving and interlocking relays behind the frame itself—or equivalent equipment—in a special casing.

Block Working

What type of block working* to use is of special interest and importance to the Swiss railways as the majority of routes are

* The expression "block working" (*Streckenblock*, literally 'section block'), when used in Switzerland, means apparatus having some amount of interlocking between it and the outdoor signals. The space interval has been obligatory for all passenger carrying lines since July 1, 1892, following the fatal accident of August 17, 1891, at Zollikofen station, by which 18 lives were lost. If, however, this is given effect to by using the telegraph or telephone, without actual positive control over the signals, such working is not officially described as "block working."

single line. Moreover the distances between stations are very short and the traffic on most of the single line sections is very heavy. The following figures give an idea of the position. Of the 2,926 km. (1,818 miles) of route of the Federal lines, 58 per cent are single line and of the 2,406 km. (1,495 miles) of privately owned lines, 90 per cent. On the standard gauge sections of the Federal lines the average distance between stations is about 3·5 km. ($2\frac{1}{8}$ miles). On their narrow gauge section, 74 km. (46 miles) long, and on the standard gauge sections of privately owned lines, which total 770 km. (478 miles), this distance is 2·2 km. ($1\frac{1}{3}$ miles). Both on the Federal and privately owned single lines there are up to 70 trains daily, and up to 80 or more on special occasions. This traffic can only be handled satisfactorily because the stations are close together and provide a great number of crossing places. It will be clear from this how much responsibility rests on the station officials, especially at junctions, if there is no block apparatus and it is very surprising that only in recent years has this been installed to any great extent.

Up to 1945 the only block apparatus known on the Federal lines was the Siemens a.c. pattern, which had all along rendered excellent service. The fact that it could be worked not only by means of the magneto generator provided with each set of equipment but by a.c. at $16\frac{2}{3}$ cycles taken from the traction supply afforded the advantage that a transformer could be used to relieve the official from the necessity of working the magneto, but this in turn possessed an appreciable disadvantage, in that the block could be affected by false current coming from the traction circuit. It was found that when a traction short-circuit occurred such high voltages were created between the ends of a block section that the mechanism became operated irregularly.

This led to the adoption of d.c. in place of a.c. and opportunity was taken also to arrange the circuits so that even should foreign d.c. be received in the block circuit in the correct operating order no dangerous condition would be set up. At the same time a certain amount of beneficial simplification in the actual working of the block was introduced.

In the first place, matters were so arranged that there was no necessity for the official at the next station to co-operate in order to effect a change in the direction of traffic. As already mentioned, the person in charge at the small stations has many other duties to attend to besides carrying out the signalling operations. If, say, at station A, a crossing between two trains is to take place and therefore the direction of traffic between A and B has to be changed on the arrival of the oncoming train, ordinarily this would mean the official at B having to interrupt his work in order to give permission for it. For this reason the d.c. block now being used is so constructed that he does not need to do so, although of course all safety requirements governing such a change of direction must be properly complied with. The person in charge at B nevertheless has the power to prevent the change if he has any reason for wishing that no train shall be sent towards him from A.

A further improvement compared with the older equipment is that the setting of the block to " train on line " on the departure of a train is no longer effected by hand by a separate operation but automatically by the clearing of the starting signal. This feature of the new apparatus has been taken advantage of to give notice at the station in advance that the starting signal in rear has been cleared but the train has not yet left there. Its departure is signalled at the correct moment in addition, which is of special advantage to the station official in the case of the running of an extra train, or when one is out of course.

The means by which the block is operated usually forms part of the signal frame itself and consists of three push-buttons, in the case of single line working. The first serves to clear back to the station in rear and restore the apparatus to normal after a train arrives and all the conditions required by that are fulfilled, one of which is that the home signal shall have been put back to danger. A small lamp above the button marked " clearing back permissible " indicates that this is the case. The official himself, of course, has to see that the train is carrying the tail lamp.

Of the two remaining buttons the first serves to obtain possession of the section for a train after the arrival of another from the opposite direction, and as soon as all requisite safety conditions are met the necessary permission is received automatically from the station in advance. This is indicated by the illuminated arrow in the section on the track diagram, showing the oncoming movement, being extinguished and another, referring to the opposite direction of traffic, becoming lighted. The third button serves to retain possession of a given direction of traffic, for which purpose it must be depressed and turned to secure it. When this is done it is impossible for the other station to reverse the direction of movement by operating its " asking " button, which means that its starting signal is held locked by the depressed " holding " button at the adjacent station. Should the other station, however, transmit a request for permission to use the section a lamp becomes lighted under the " holding " button to indicate to which section the audible warning, which sounds at the same time, applies. Only when a change of direction is required is it necessary to ask for possession of a section. Once a station has received permission to use a section it can do so for as many trains as it desires ; it is not necessary to request permission to send each one. This corresponds to the situation which applies when the block is automatic, or with the Swiss manual block on double lines.

In the new double line block the " asking " and " holding " buttons are not provided. There is only one, for clearing back behind an arriving train, with its indicating lamp, as of course there is no question of change of traffic direction. It should be mentioned, however, that recently, in nearly all cases of new frames being provided for double line stations, means of changing temporarily to single line working has been asked for. This changeover switching arrangement makes it possible, while retaining every safety feature, to operate one track as a single line while permanent way or other works are in progress on the other. This means not only providing the necessary route and signal controls for movements to and from the, for the time being, single line, but also the additional block controls called for by the change. An " asking " button becomes once again necessary, but instead of the "holding" button above described, there is an "accepting" one, possession of the section in this case not being obtained automatically. The reason for this is that the single line working is something exceptional and the co-operation of the official at the far end of a section is required before any train passes into it.

In the newer signal frames this changeover is effected by means of a special turn button located in each block section on the track diagram. The station from which " wrong line " movements are to take place initiates the process by depressing and turning the relevant button. The other station, notified of this by a visual and audible warning, performs a similar operation to cover the incoming movements and directly that has been done all the apparatus concerned at the two stations becomes correctly switched over. These operations and all block operations, with any proving associated with them, are effected over two wires in the cables. Similarly the ordinary single line block requires but two wires between stations.

Gotthard Line Installations

In 1947 an intermediate signalling location, with small panel type signal box, not normally staffed, having two crossovers and the necessary signals, was brought into service in the middle of the Gotthard tunnel (about 9¼ miles long) which allows of one half being changed over at will to single line working with the aid of suitable switching arrangements at the stations at each end. Since then similar work has been installed on the northern approach incline to the tunnel. The stations are fitted for alternative working on each track, and between stations there are intermediate signal locations to enable a more frequent service to be run. It is intended to apply the same methods on the southern approach lines. Both in the tunnel and on the northern incline the clearing of the sections is effected entirely automatically; there is no button for clearing back behind a train. As the lengths of the sections, the damp conditions in the tunnel, and the presence of steel sleepers outside it, preclude the use of track circuiting, axle counting has been put in to control the working of each section. The axles of a train are counted into a section and then out of it again, and if the two operations agree the clearance is given and another movement may take place.

As the Swiss lines, as already mentioned, abound in small radius curves, steel sleepers are widely used and consequently axle counters are employed to protect a large number of heavily worked block sections. These installations consist of impulse transmitters at each end of a section and a counter apparatus. The impulse transmitters are permanent magnets provided with windings, and as each wheel passes an impulse is generated by induction and acts on the counter through a relay: the counter itself consists of a group of 16 relays for each end of the section, capable of counting 255 axles in and out and comparing the results. On account of the speed of counting—in the case of the smallest wheelbase at maximum speed two axles can follow each other at 1/50th sec. interval—certain of these relays are of special construction, the remainder being of telephone pattern. The very important clearing circuit, which compares the results of the two counting operations, is arranged to prove itself, so that in the event of any defect no danger side failure can occur. It may be mentioned that the problem of making an automatic signalling system controlled by axle counters cannot as yet be regarded as completely solved on account of the relatively complicated operations involved. Efforts are therefore being turned to developing some direct form of detecting the passage of the last vehicle of a train, but by using something entirely different. since the magnetic devices, such as the attaching of a permanent magnet to the last vehicle, already tried in earlier attempts in Germany, had not proved reliable. It appears, however, as if trials now being made in this connection in conjunction with the Swiss railways will lead to a satisfactory result.

Remote Control

The remote control of the location in the middle of the Gotthard tunnel and of points and signals near Lucerne was effected over cables which contained the necessary number of cores. The necessity was felt, however, for something of the kind that could be worked over two wires only. Of interest in this connection is the control of the passing loop at Altmatt from Bieberbrugg station, effected by telephone type selectors and relays. Although the telephone type relay is used the arrangement is such that it does not merely operate as a kind of long arm of the controlling official, that is to say that a fault occurring in the transmission portion of the equipment must remain unnoticed. In addition, an endeavour has been made to construct a remote control that can form part of the safety circuits of the installation. This has been accomplished by proving that synchronism obtains at each step as the movements take place, so that the actual length of any impulse is of no consequence. Nothing therefore depends on intervals of time being maintained, intervals which might alter gradually and lead to a loss of synchronism. Each relay operation is obliged to take place in the correct order, so that if anything does fail to occur as it should it is at once indicated and cannot lead to a false control being transmitted. The control at Altmatt is so arranged that the station is normally switched out, the home signals standing at clear and the starting signals working automatically in accordance with the condition of the block section ahead. The points are set and route-locked for the direct track, in each direction, and the person in charge at Bieberbrugg has ordinarily nothing to do in connection with movements running through Altmatt. It is only when trains have to cross there that he switches in the apparatus and operates the signals, etc., from his panel, located in the station buildings, just as if he were controlling a normal type station, fitted with the ordinary kind of frame. The savings realised by using this equipment allow of the capital cost being redeemed in a very short time. Another such installation is being put into service now and a third is under construction. Whether the Swiss railways will adopt C.T.C., properly so called, in which a number of stations along a route are all controlled from one central point, is somewhat doubtful. At the moment the operating conditions favourable to such working do not obtain and the remote control of single installations will probably remain the preferred course, at least in the immediate future.

Automatic Train Control

The question of how to transmit signals between the track and the train itself now may be regarded as satisfactorily solved. In the '20's trials of apparatus for this purpose were undertaken and after a serious accident near Lucerne, caused by signals being disregarded, the Federal Railways decided, after making thorough trials of various systems, to adopt the Metrum type of equipment for all their locomotives, motor coaches and railcars. This programme was carried through in the '30's, giving an intermittent inductive transmission of the caution indication at the distant signals. With this system there is no source of power along the track ; that is provided on the locomotive, or vehicle concerned, and can be proved continuously to be in proper order. There are two pairs of inductors—one pair on the train and the other on the track—so that the impulse is transmitted over a total air gap of 160 mm. ($6\frac{5}{16}$-in.). Transmission is effective from a speed of 5 km.p.h. (3·1 m.p.h.) up to the highest speeds run and the simplicity and robust construction of the equipment are such that excellent results have been obtained for several years past.

Another accident in the '40's due to a driver ignoring an adverse starting signal led to the decision to equip the inner distant signals and starting signals, and this second stage in the work was concluded by the close of 1952, when about 590 locomotives, motor coaches and driving trailers, with some 3,500 signals had been fitted. As at present installed the apparatus functions in such a manner as to prove that the driver is paying attention to his duty of observing the signal indications, obliging him, as he passes an adverse distant signal, to allow it to begin to operate and then to return it to its normal condition by depressing a so-called vigilance button. Thus the apparatus only comes into complete action if the driver fails in his duty and does not actuate the button. In that case the current collecting pantograph is lowered automatically and the brakes set in action, the distance between distant and stop signals being sufficient to allow of the train being brought to a stand at the latter.

Such failures as occurred were found to be due, practically exclusively, to having to use, in consequence of the war, materials that were not quite up to the high standard needed. Maintenance can be carried out in the same way as with any ordinary item of electrical equipment. The wisdom of the policy adopted is shown by the fact that no accident has taken place due to non-observance of signals anywhere on the 2,684 km. (1,668 miles) of route where A.T.C. is in operation, except one collision where the driver acknowledged the warning with the vigilance button and then failed to act on it. On the privately owned lines where up to now there is no A.T.C., several collisions have occurred which could have been avoided had it been in use.

Notwithstanding the good results obtained the apparatus has been in process of continuous development in three directions :—(1) the system is extraordinarily simple and has no special detecting or proving circuits of the kind usually provided with signalling equipment ; the first thing to be accomplished therefore was to provide some proving for the circuits in the track equipment and the receiving relay circuit on the train ; (2) in its present form the apparatus provides for only one indication, that of caution at the distant signal* ; the clear signal is not transmitted to the train and therefore positive action is only looked for when danger is to be apprehended. The inventor set himself to improve the design so as to transmit more indications, at least up to four, viz. :—at the distant signal, "clear," "caution," "attention" (for example in the case of having to take a diverging route) and at the stop signal "absolute stop," "caution," "attention" and "clear" ; (3) the possibility of a driver who often has to pass distant signals at caution becoming so accustomed to operating the vigilance button that he does so and then

*The same indication is given at starting signals as at distant signals.

takes no further action was realised before the 1951 accident occurred, so that it merely confirmed misgivings already felt. Development is now proceeding in the direction of doing away with the vigilance button and replacing it by some form of speed detection, that is to say of proving that the driver really obeys the instruction given him by the distant signal and of applying the brakes if he does not. When, however, the speed becomes reduced to some prescribed minimum then this control ceases to operate.

The Federal Railways have not as yet manifested any particular interest in the developments mentioned under (1) and (2) above, although several foreign railways have done so. They consider that experience shows their periodical inspection of the track apparatus and testing of the train equipment, each time a locomotive, or other fitted vehicle, leaves the sheds, to be sufficient. The management has, however, decided to undertake trials with apparatus that carries out the requirements set out under (3). This is being constructed and will be in service on a locomotive during the present year.

Summing up, it may be said that the Swiss railways have played a very effective part in the development of signal engineering, both in stating clearly the problems to be solved and by modifying their operating practice to suit new conditions and the impact of new ideas. As regards colour-light signals, their development may be considered as having been completed, except in the case of the newer dwarf signals, which are perhaps susceptible of being added to and improved. Some years must elapse however before the most up-to-date practice can be applied to the running signals everywhere.

With regard to interlocking frames and panels, a standard design suited to the conditions at any small or medium sized station has been arrived at, but this cannot be said about the apparatus to be used at the larger ones. Experiments in this direction are continuing and improved circuit arrangements are being worked out, together with designs for improved methods of grouping relays in sets and constructing their individual parts. While automatic signalling methods may be expected to continue to advance, the manual block apparatus of the Swiss railways can be said now to have attained its final form. In the case of remote control and automatic train control the position is not quite so clearly defined. With the former it is chiefly a matter of the operating department adapting itself to, and taking full advantage of, the possibilities offered by the latest progress in this field, thus enabling an idea of the types of apparatus most suitable for use to be arrived at, always essential in work of this class.

DISCUSSION

Mr. T. S. Lascelles said that although they had had a number of addresses on foreign signalling by gentlemen visiting this country he could not remember any previous occasion when signalling in Switzerland had been the subject and it was very appropriate to have this paper from one who occupied a very high and distinguished position in the signalling industry of that country. The Swiss people were in the front rank of engineering of every kind. In Switzerland, one saw the finest civil engineering works, water works, magnificent tunnels and railway buildings, and Swiss industry was engaged on the very finest mechanical work possible. So it had not come as a surprise to hear that in railway signalling they were not behind in any way. There was much to admire in the installations shown by means of the lantern slides, and he congratulated Dr. Oehler and his railway colleagues on what they had accomplished. Great skill had been shown in adapting the latest ideas to the peculiar conditions which obtained in Switzerland where, for example, winter conditions made it very difficult for the operation of mechanical signalling, and the bold step had been taken of installing power signalling at even the very smallest country stations.

He thought the introduction of shunting signals was a noticeable step forward. Where they had trailable points and point indicators, originally they had no proper shunting signals ; if they ran through a pair of points, it did no damage. It was only a question of time before the general use of shunting signals was made, at any rate, in larger stations; but probably at the smaller stations, the older arrangement would be found quite sufficient.

Continuing, Mr. Lascelles said that he was very interested in axle counting and would like to know whether the Zaugg axle counter in the Hauenstein Tunnel was still in use, or whether it had been superseded by more modern apparatus.

It was suggested, at one time, that the Institution should hold one of its summer meetings in Switzerland. The idea was not proceeded with, but some of them hoped that it would prove practicable before very long. If they did go, they would certainly see some very fine engineering work and would receive a warm welcome from their distinguished speaker.

Replying, **Dr. Karl Oehler** thanked Mr. Lascelles for his remarks.

The Zaugg axle counter was no longer in use, having been replaced many years ago by the system described in the paper. It had not been easy to develop an axle counter which was really reliable with high speed trains. It should work in a manner so that the railway officials could forget it, and that condition was a little hard to meet.

Mr. J. H. Fraser asked whether the author could give any more information regarding the possibility of failures with the A.T.C. apparatus and say what proportion of such were of a kind where the warning was not given when it ought to have been? Could he also give a few more details of the proposals to modify the equipment under item 3 in his paper, Mr. Fraser assumed that these included some arrangement for cancelling the speed control on nearing a home signal if the latter should be indicating "clear." Compulsory reduction of speed after a warning had been received would appear likely to reduce track capacity severely in places where headway was close and where a driver frequently could observe the stop signal ahead go to "clear" after he had received a "caution" indication at the distant signal.

Mr. J. E. Mott enquired whether Dr. Oehler could give a rough idea of the number of axle counting equipments now in service. It would appear that counting was effected by the cutting of magnetic lines and if that was so it would not be possible to count at very low speeds and probably not directionally. Was that the reason why the reference to axle counting dealt with its application to block sections only? From the illustrations it would appear that the impulse transmitter was mounted above rail level. In Great Britain and in some overseas countries any projection above rail level when close to the rails was in danger of being fouled. Did that ever occur in Switzerland? Could platelayers working on the line cause false operation of the axle counting by inserting any metallic implement in the transmitting air gap? Finally, it would be interesting to know the form of safety check imposed to ensure that counting was in fact effected for every train passing into the section.

Referring to that part of the paper dealing with remote control where Dr. Oehler said " an endeavour has been made to construct a remote control that can form part of the safety circuits of the installation " and suggested—if Mr. Mott had understood him correctly—that interlocking might be effected over coding. Usually it was considered the best practice to confine coding to supervisory controls and have all the safety interlocking at the local control locations, since no matter what proving was used for the coding it could never be so positive as continuous circuiting. He would be grateful therefore to Dr. Oehler if he would offer some further comment on this point.

Dr. Oehler, in reply to *Mr. Fraser,* said that from February 16th, 1952, to February 15th, 1953, 758 irregularities were reported, of which 10 were wrong side failures. Of those latter, three were attributable to defects in the connections to the track apparatus, two to faults in those connecting the receiving magnet to the equipment itself, and five resulted from unexplained causes. Failures of the classes covered by the first five would not occur again as the new circuit arrangements provided for the wiring being proved continuously. There were two possible explanations of the remainder. Either the apparatus did not in fact for the moment act as it should have done, or there was some misunderstanding on the part of the staff reporting the supposed fault, that was to say the man believed the equipment should have functioned when such was not the case. How far such faults, if real, could be attributed to this or that possible cause was of course a matter for investigation.

The right side failures were attributable partly to external circumstances, partly to internal faults in the apparatus. In certain cases again the causes could not be definitely established. As regards external circumstances, which caused 393 failures, the following were involved :—frozen signal contacts, magnetised masses of metal alongside the line, inductive effects produced by men working on cables or carrying out welding operations, mechanical signals remaining in a doubtful position, external inductive action, faults in the apparatus at a station, or short circuits on the locomotives giving rise to inductive influences. These troubles could not be called failures of the A.T.C. equipment, in the proper sense of the term, as it was actually functioning correctly and had revealed the defects which had developed. The same must be said of the external wiring faults, of which 54 related to the track equipment, attributable to defects in the wiring between the signals and the track magnets and 65 to something wrong in the locomotive apparatus—say in the leads to it—to incorrectly adjusted relays, mechanical defects in the exciting magnet or the cabling running to it, battery out of order, something in the fitting of the equipment, or a short circuit in the relay assembly or the driver's vigilance button. Insufficiently explained causes of untimely actuation covered 70 cases at the moment of acceleration of the engine, possibly the effects of vibration. There were 14 failures due to unexplained blowing of fuses, while for 152 other cases no cause could be put forward. In the last there were no doubt misunderstandings on the part of the railway staff, but how many could not be arrived at.

Against these fault report figures had to be set the fact that there were about 40 million cases of a signal being passed by a locomotive at about one-third of which the " caution " indication would be showing, or about 5 wrong side failures in about 13 million operations, these being of a type as not to have been avoided by the improved design of equipment and the cause of which has remained unexplained.

Mr. Fraser's second question referred to the speed control feature which operated up to 40 km.p.h. (25 m.p.h.), and below that speed automatically restored things to normal. This control could also, by the use of additional track actuating positions, likewise be cancelled out at higher speeds, should the signal ahead have gone to " clear " in the meantime, but the time lost by a temporary speed limitation of 40 km.p.h. did not seem serious enough to the Swiss railway authorities to justify the expenditure involved. If a speed of 100 km.p.h. (62.5 m.p.h.) was assumed and a braking deceleration of 0·8 m. to 3·5 m. per sec., per sec. or an acceleration of 0·5 m. per sec. per sec., they got a difference of 36 sec. between a train which ran without restriction and one which was braked down to 40 km.p.h. and then, because the signal became cleared in the interim, was again accelerated up to 100 km.p.h. It was to be assumed that where traffic was very dense a 4-aspect signal system would be used as a matter of course, in conjunction with two distant speed indications. In such a case also the release at the higher speed would be possible earlier and the same argument applied.

Referring to Mr. Mott's questions, Dr. Oehler said there were now some 20 single line and 30 double line axle counter block sections, some counting each actual section. There were 7 block sections on single and 24 on two or more track lines worked by track circuiting, so that the axle counter sections formed a considerable majority of the automatic signalling sections. As Mr. Mott supposed, the Integra axle counting was not directional and needed a minimum speed of about 3 km.p.h. (1·87 m.p.h.). This was not, however, the reason why the equipment was only a paying proposition on complete block sections. On short lengths the price worked out too high and it was cheaper to install wooden sleepers in the stations.

The impulse magnets were, it was true, mounted in Switzerland with their tops above rail level, which was permissible there, and a special design was worked out for use in England which had not this characteristic. Damage caused by hanging equipment was very seldom experienced. Generally a defective or derailed vehicle was the cause. Normally the impulse magnets were out of circuit and only switched in when the relative home or starting signal was cleared and also, in addition the length of insulated rail, about 24 m. (79-ft.) long, in the centre of which the magnets were located, was occupied. It was therefore practically impossible for masses of iron other than the wheels to cause counting to occur.

Proof that counting had actually taken place was given by a so-called repetition locking relay, which became de-energised when the signal was cleared and was itself proved over the lamp circuit. This relay prevented the signal from being cleared a second time unless this relay became once more picked up but this could not occur unless the counter itself had moved from the zero position. This ensured that a counter which was out of action could in no case lead to a false clear signal indication.

It was true that outside Switzerland remote control circuits had not as yet been used to obtain actual interlocking, or safety circuit, effects. The equipment used there, however was so constructed that the synchronous action of all parts was continuously proved, step by step. The carrying into effect of any control sent out could only take place after this synchronous proving was completely effected. With such an arrangement it was possible to entrust the apparatus with both controls and return indications for single line reversibility, proving sections unoccupied and block working movements, and these functions at least, which otherwise would require further conductors allocated to them in the cabling, could be allowed to be performed by remote control action. Of course, all interlocking effects were, so far as that proved possible, carried out at the outlying location in the usual manner. The Swiss Federal Railways were well aware that they were going further in this matter than had been done elsewhere, but the technical requirements prescribed in connection with the equipment involved were set at a correspondingly high level.

The **President** congratulated Dr. Oehler on his excellent paper and proposed a very cordial vote of thanks, which was carried with acclamation.

He announced that the next meeting would be held on November 18th, 1953, when an informal discussion on "The Economic Aspect of Railway Signalling Cables" would be introduced by Mr. N. W. Russell.

Modern Signalling Developments on the Swiss Railways

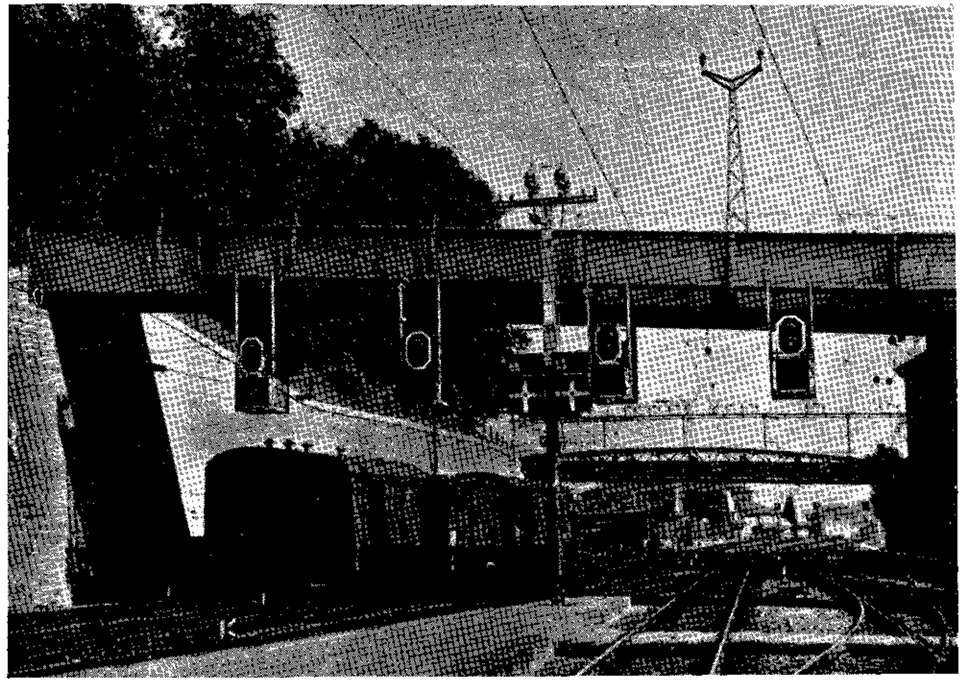
(Karl Oehler)

Fig. 1

Home signal, with inner distant signal below, on Lötschberg line

Fig. 2

Group starting signals with route indicators at Berne station. In the centre shunt ahead signals



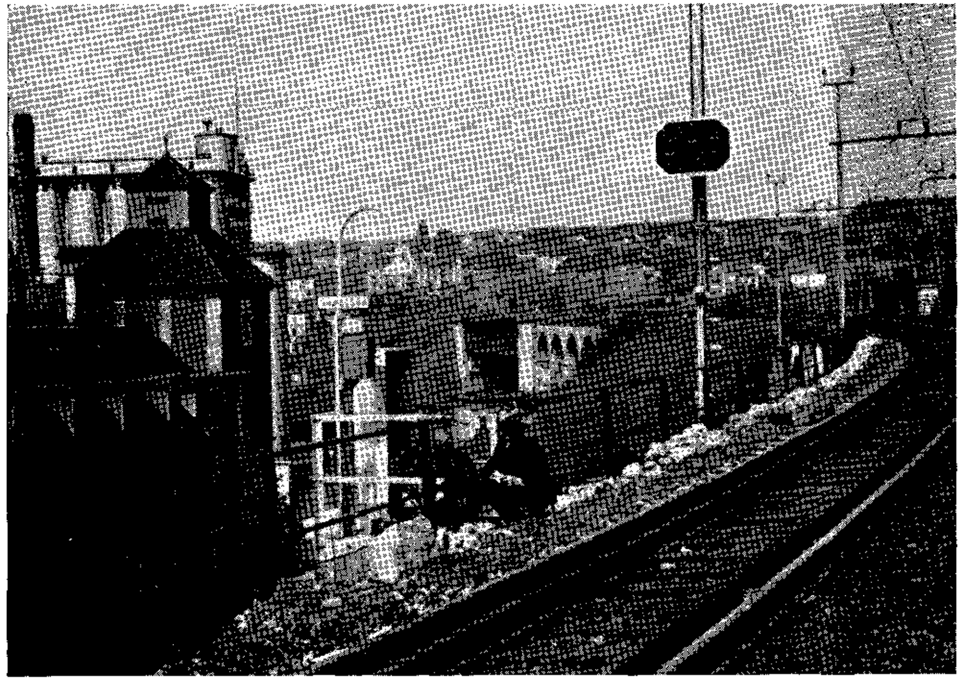


Fig. 3. Three-aspect Automatic Signal, showing " stop," " caution " or " proceed," near Zurich

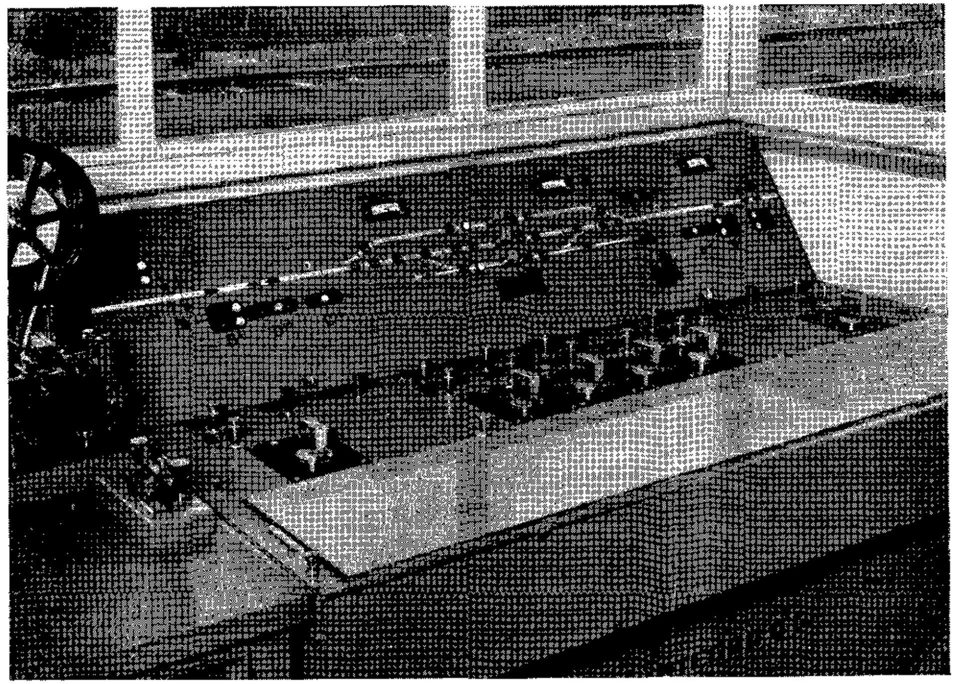


Fig. 4. Normal type power frame, desk pattern. In the centre the route signal handles for the two single line sections and on the track diagram the route selector buttons

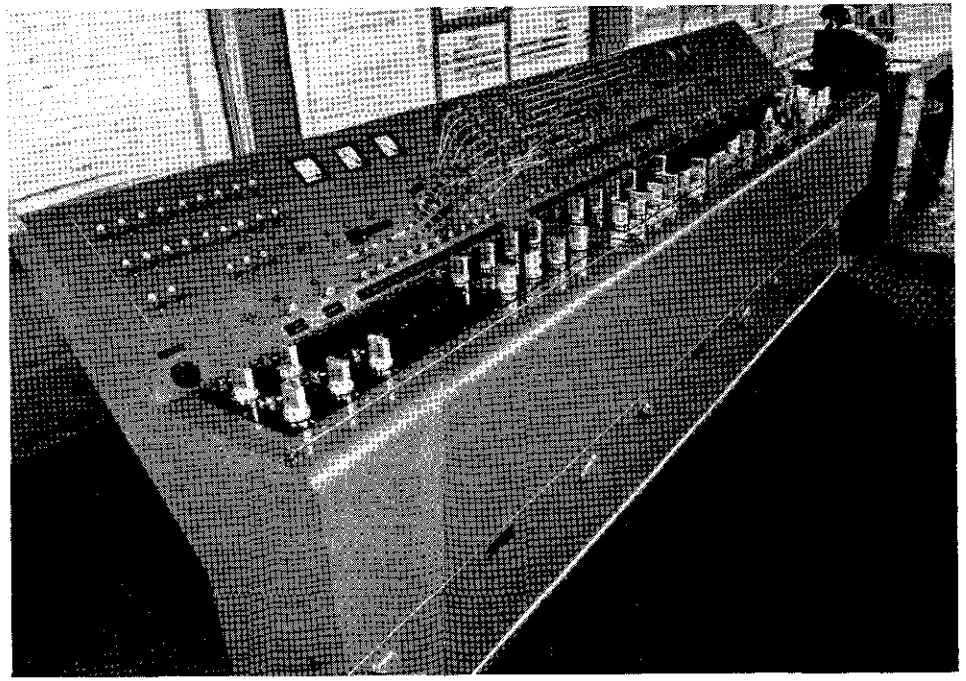


Fig. 5. Double row power frame for medium sized station in subsidiary signal box at Langnau

Modern Signalling Developments on the Swiss Railways (*Karl Oehler*)

Fig. 6

Supervisor's control apparatus at Zug, with buttons for sending releases to signal boxes

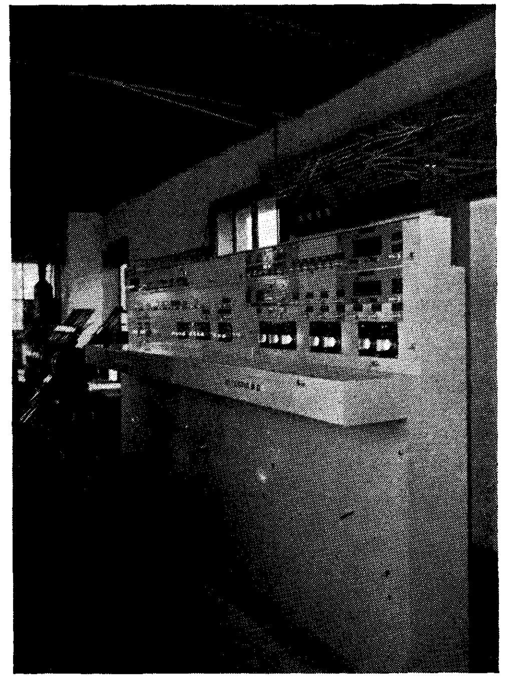


Fig. 7

Subsidiary signal box at Zug working with apparatus seen in fig. 6. At far end of power frame are the small point control switches

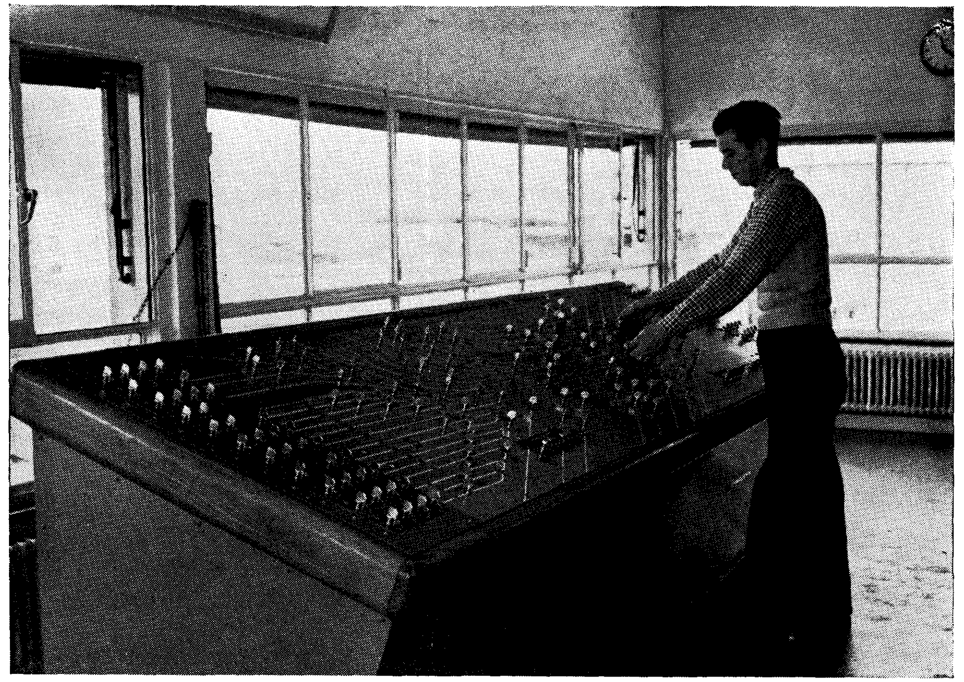


Fig. 8

Desk type panel apparatus at Geneva with buttons on track diagram for setting up routes

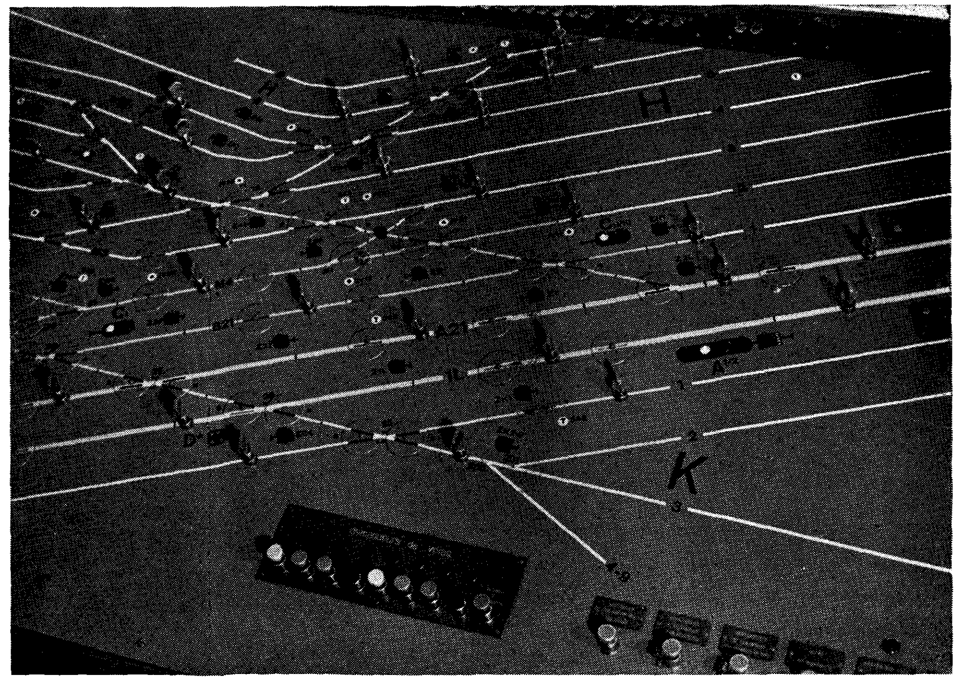


Fig. 9

Close-up view of part of the Geneva desk panel, showing buttons, indicators, etc.

Fig. 10

Interior of relay room under operating room, Geneva panel installation

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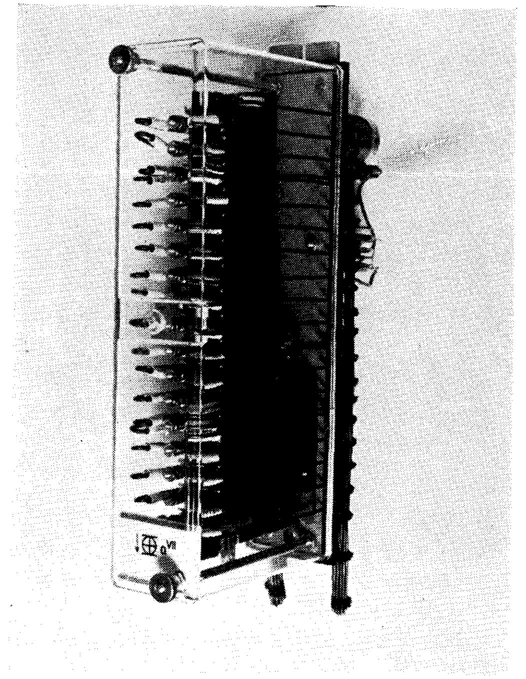

Fig. 11.

Relay of the type seen in fig. 10, Geneva relay room, but with sealed cover. Maximum number of contacts 17

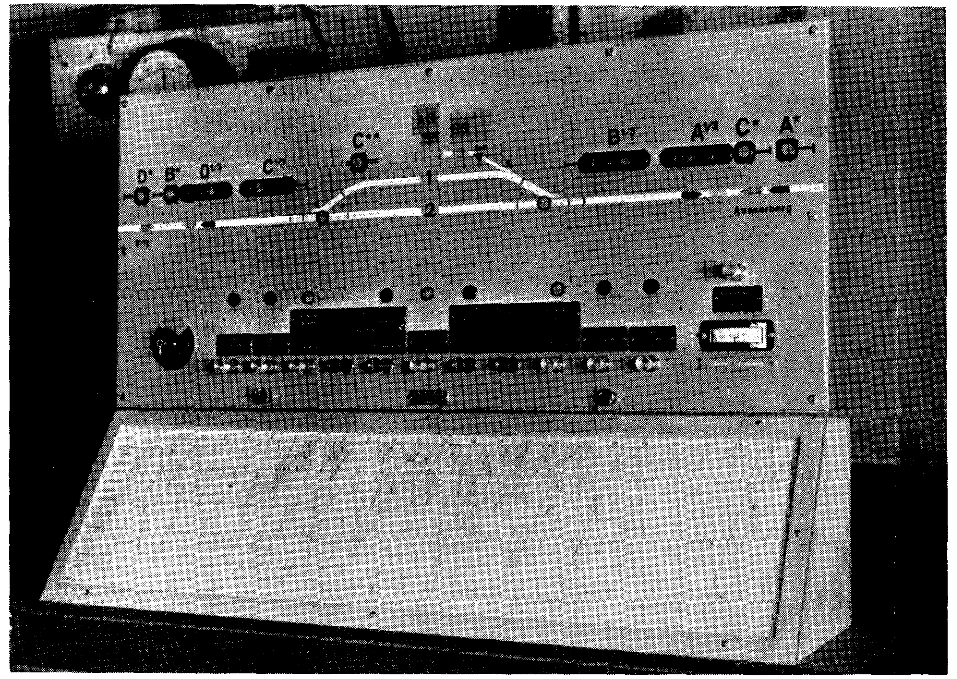

Fig. 12. Single line interlocked block apparatus working in conjunction with a mechanical frame

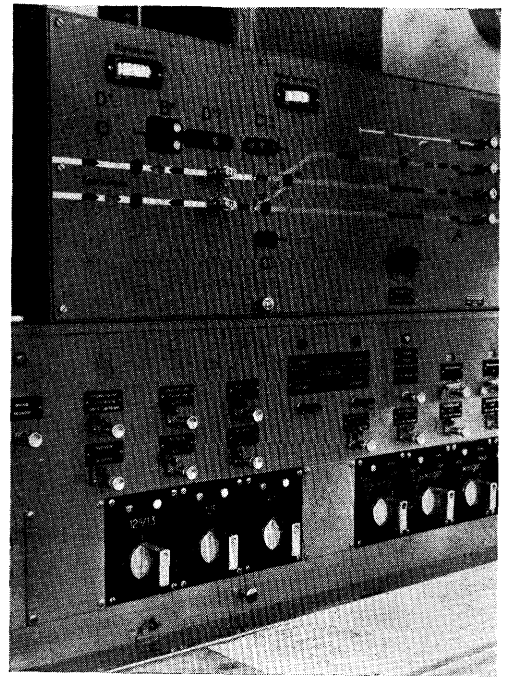

Fig. 13

Part of frame showing route signal handles, route selector and block control buttons and equipment for setting up single line working on either track

Fig. 14. Automatic intermediate signal location at Eggwald on the Gotthard line, showing axle counting impulse magnets on track

Modern Signalling Developments on the Swiss Railways

(*Karl Oehler*)

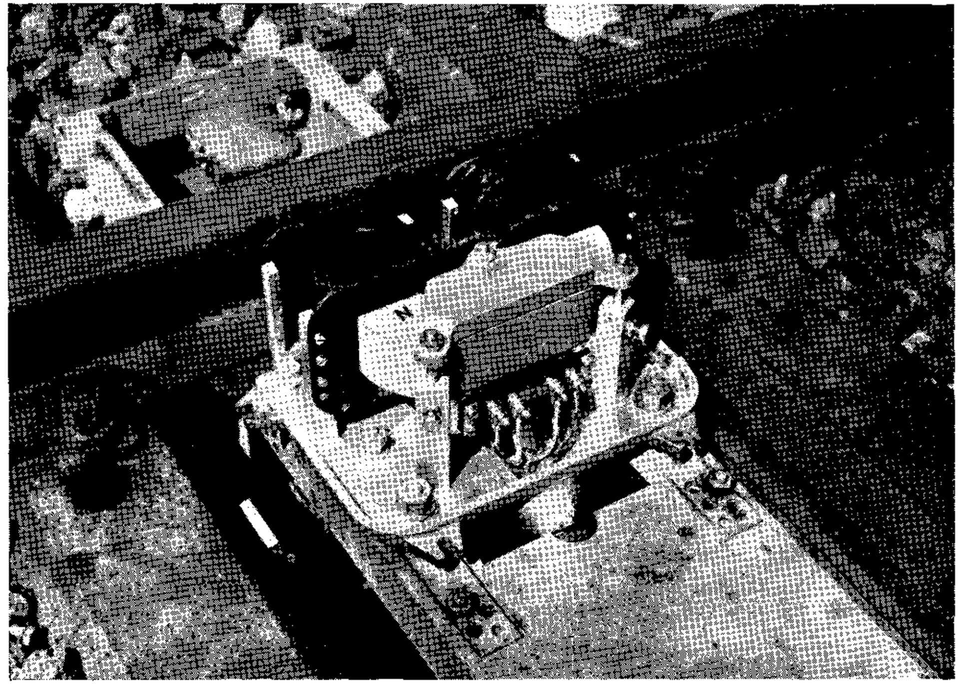

Fig. 15.

Axle counting impulse magnet on track, cover removed

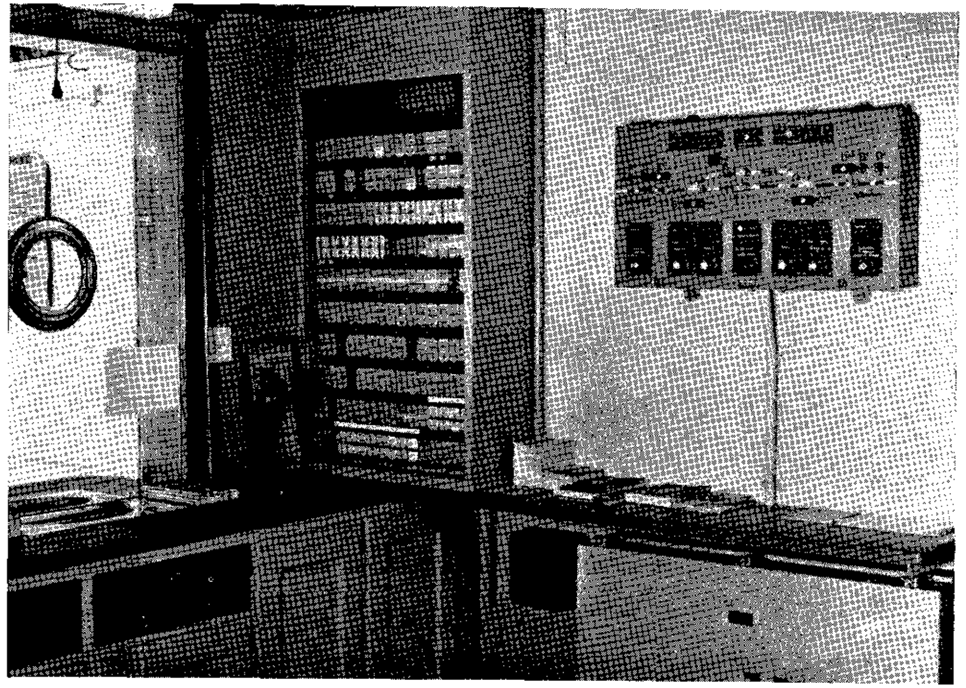

Fig. 16.

Small panel in station office at Bieberbrugg for the remote control of points and signals at Altmatt station

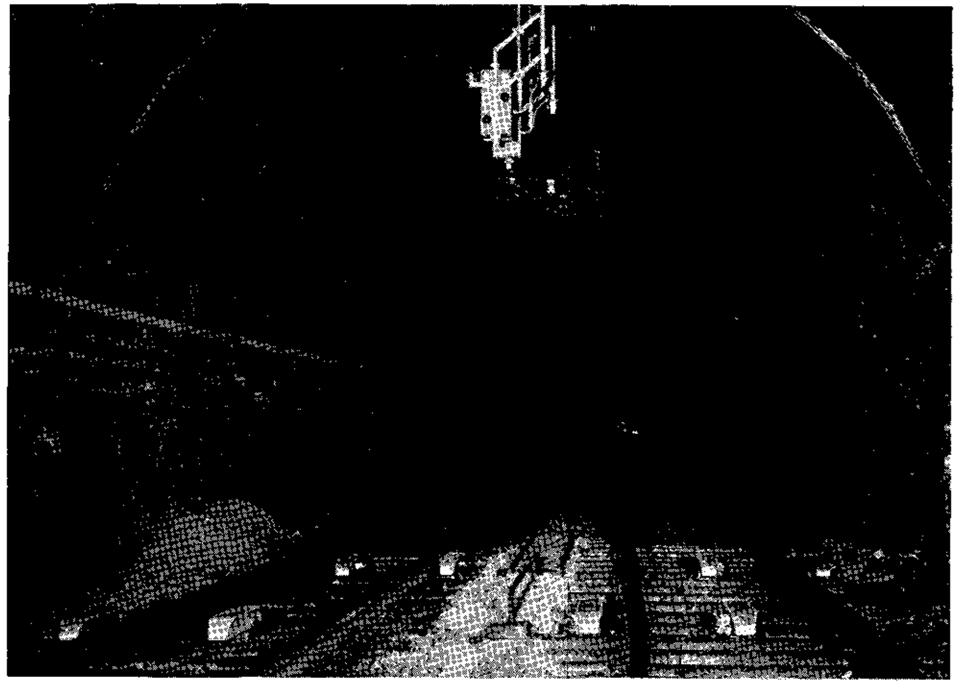

Fig. 17.

Intermediate stop and distant signal location in centre of Gotthard tunnel ($9\frac{1}{4}$ miles long) showing A.T.C. track inductors for reversible working

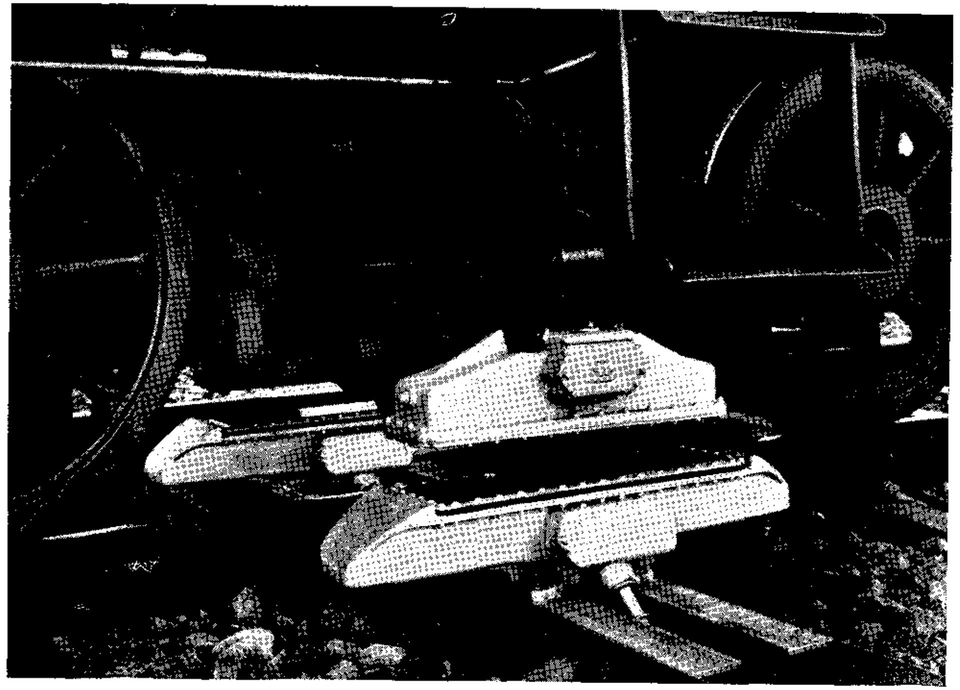

Fig. 18.

Automatic train control inductors, on track and locomotive, at the moment of transmitting the impulse