Technical Meeting of the Institution

held at

The Institution of Electrical Engineers

Wednesday, November 15th, 1961

The President (Mr. F. G. HATHAWAY) in the chair

The minutes of Technical Meeting held on October 11th, 1961, were read and approved.

The **President** then requested Monsieur J. G. Walter of the French National Railways to read his paper entitled "Recent Developments in Electric Signalling on the French National Railways".

Messrs. A. W. Woodbridge, E. G. Brentnall, H. J. N. Riddle, H. W. Hadaway, A. N. McKillop, R. Dell and L. G. Smaldon took part in the discussion which followed.

Monsieur Walter having dealt with the points raised, the **President** proposed a very hearty vote of thanks which was carried.

The **President** stated that the next meeting in London would be on Wednesday, December 6th 1961, when Mr. F. W. Young would read a paper entitled "Planning and Progress of Signalling for 50 c/s Electrification".

The meeting then terminated.

Recent Developments in Electric Signalling on the French National Railways

by J. G. WALTER (Member)*

Introduction

During the last ten years, a contribution to the renewal of signalling in France has been characterised by the development of electrical installations and the introduction of electronic devices. (A number of mechanical boxes have also been put in service during this space of time but their features, though modern in some respects, do not result in great changes from conventional methods and call for no special comments in this paper).

The standard push-button signalbox, with its electric interlocking—now a standard type for the whole of the Railway system—represents an installation which has been produced for widespread use during that period. The operating methods and the chief devices used for that purpose need some explanatory notes and Section 1 of the paper deals with these.

Signalboxes of the push-button type are used for the control of the routes in a station. The centralised traffic control on a line of any distance calls for another sort of equipment, although the greater part of the operating methods and of the devices described for the signalboxes are still required. Electronics have been widely used for that purpose and the second part of this paper gives a brief description of the system employed.

The third section is devoted to new types of track circuits where electronics play a great part in the equipment. The possibilities of these are very wide and bring important changes to the conventional pattern of study usually associated with track circuits.

The fourth part concerns automatic signalling at level crossings, with the use of flashing signals and half-barriers.

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I—THE PUSH-BUTTON SIGNAL-BOX

French Railways have used route lever type installations for their signalboxes for a very long time. As soon as signals and points could be worked by motors (from the beginning of the century) French engineers displayed much imagination in order to find combinations which enabled the control of a route to be effected by actuating only one lever—or two in a certain type. An important number of such cabins are still in service and work satisfactorily. The oldest ones are now beginning to be replaced, however, some of them having been in service for more than 50 years. Later, the introduction of electrical interlockings between 1935 and 1938 has brought about a further step in the progress of development. With the disappearance of mechanical interlockings the locked levers have given way to buttons which can be worked at any time, the electrical interlocking covering all the conditions to be fulfilled.

After experimenting with different types of frames and diagrams a standard system has been evolved and adopted by the French Railways. It has now been employed for about ten years, a certain number of improvements having been introduced meantime which do not, however, change the principles of the installations. This development has been achieved in close co-operation with the signalling industry (from the technical point of view) and also with the Operating Department, so as to comply to the utmost with the desires of the latter. These desires concern on the one hand the general operation of the installation and on the other the rules to be observed by the signalmen, firstly when all works well, and secondly when some fault happens, as may always occur with the most elaborate devices. Since a maintenance specialist is not always present in the box, the signalman may have to decide for himself what action is to be taken to permit the running of trains until the fault has been rectified.

In 1951, we had just put into service the first push-button cabins of the post-war period: Les LAUMES, DIJON (PERRIGNY), MONTEREAU and GAGNY[1] It was just after that that the standard installation, the P.R.S.[2] as it is called, was adopted for our equipment. At present,

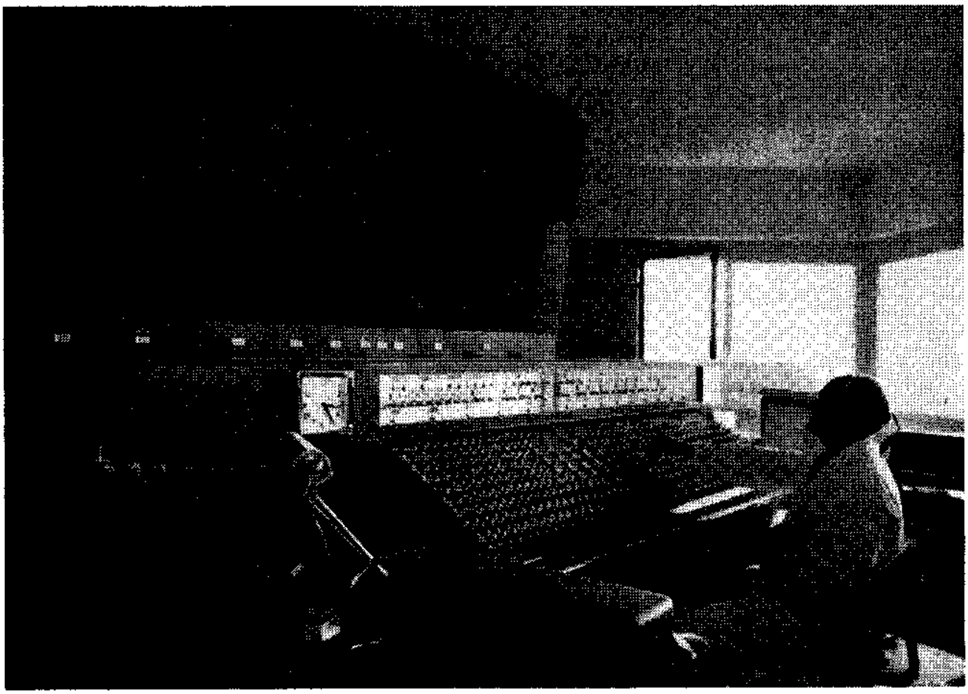


Fig. 1 P.R.S. Installation at PARIS-NORD

(1) See "Modern Signalling on the French National Railways," October 3rd, 1951
(2) Poste toute relais à transit souple

about a hundred cabins of that standard type are in service, 61 of them having only a small number of routes (less than 25) and the rest being cabins in which the number of routes vary from 25 to 500. Fig. 1 shows PARIS-NORD which has 480 routes and the next one to be installed, which will be the largest yet, will be PARIS-EST which will have 650 routes. The main characteristics of this kind of installation are that it is a standard device in which, for every function, standard electric diagrams and standard equipment are used. The principal wishes of the Operating Department that were taken into account when making this standardisation are as follows:

In order to give the greatest facilities for the control of routes to the signalman the method preferred by the Operating Department is a system where this control calls for only one movement of the finger, pushing—or pulling—the corresponding route button;

In order to give the greatest facilities for observation of the illuminated diagram by the signalman, the preferred method is to have this diagram distinct from the desk at which the signalman is sitting to work the buttons. (When the number of routes is very small this question is different and the disposition may vary, although this rule has been followed in most cases).

The efficiency of a signalbox is in relation to the time required for the setting up of new movements in the area concerned. For this reason, the following two devices have proved to be of great advantage and have been adopted in all new installations.

(1) The facility of pre-selecting routes, which means that, in addition to the route actually set up, it is possible to have the control for the following route held stored, that route being set up as soon as the first train clears the original route and cancels it by so doing.

(2) The use of sectional release locking, which permits a route to be changed just after a turnout has been cleared, without having to wait until the original route is wholly clear.

Another point calling for mention concerns the emergency devices used by the operating men when an incident occurs, facilities being given for allowing the movement of trains without having to wait until normal working is restored. (The first requirement is to have equipment as simple as possible, so as to reduce the risk of a failure; and next, in case of a failure, to allow the possibility of running the trains, though with all essential safety maintained, by the use of special devices such as cancellation of track circuits from the signalbox under certain conditions, working of point machines by hand according to certain rules, etc.). The operating and signalling regulations have been written anew so as to take into account these characteristics of the modern installations.

In conformity with this general programme, large signalboxes have replaced several mechanical frames in important stations, giving a greater efficiency to the equipment with a much reduced personnel.

On the other hand, in many small stations, a control panel for only a few routes, of the same standard design, has been put into service. Located generally in the stationmaster's office, the panel is about the size of a typewriter and the train movements operated from it do not take more than a few minutes now and again, contrasting with the previous mechanical box which required at least one man on permanent duty.

The improvements that are a feature of P.R.S. boxes have been brought about due to meeting the needs of the Operating Department. The pre-setting of one route, available in all cases, is acknowledged as a very valuable facility indeed. But other facilities may be called for according to the place and traffic. For example I can mention the following programmes that have now met with great favour on the French Railways.

Some junctions lead only to two directions, one of which is used much more than the other. A device introduced in many new boxes provides that, after a series of trains in the principal direction have passed, one route only in the other direction is pre-set, thereafter permitting a fresh series of trains on the first route.

It is possible also to pre-set a certain number of trains on one route followed by a series of trains on the other.

All this pre-setting of routes is carried out with conventional relays and circuits of a very simple design, and does not require the use of computers which may be necessary for the more complex programmes. (In fact, electronic solutions of several kinds are being studied or experimented with at present for such problems, but it is too early yet to mention their specifications, since these require long and careful tests in the laboratory and in service before being considered as efficient and reliable).

II—A NEW TYPE OF CENTRALISED TRAFFIC CONTROL

The standard push-button panel is the kind often found most suitable for use at small stations on lines having automatic block, the panel being installed in the stationmaster's office. Furthermore on such lines it may be of greater convenience to concentrate under one hand the controls for all the different stations. The equipment at each station will not be changed, but in addition to—or in lieu of the local operation of the routes, a centralised control will be set up in a certain place, and to this all stations will be connected.

On the French Railways this problem arose when they decided to electrify the section DOLE to VALLORBE, a part of the PARIS to LAUSANNE line. The greater part of the section was at that time double track line, equipped with a lock and block system of a very early design. The possibility of transforming the double track into a single track immediately presented itself, with its associated possibility of maintaining or even improving the amount of traffic on the line, this achievement being made possible by the modern signalling device proposed. The electric equipment, being now only for one track instead of two in the many tunnels existing on the section, was considerably simplified. The capacity of the single track was also improved by the new type of signalling installation.

The system of electrification being 25 kV. 50 cycles, the equipment had also to comply with the rules laid down by the Operating Department for that line.

The whole of the DOLE to VALLORBE section has been equipped with automatic block, electrical interlocking between successive stations ensuring the exclusive right of way for a specific direction of traffic Currents of different frequencies, within the band 1,000 to 2,000 cycles, with appropriate modulations, are normally transmitted. This gives at any moment the condition of the interlocking at any one station as compared with the others, in the most reliable way and free from interference.

In every station an electric interlocking device of the standard type has been installed. Using the push-button panels, it is possible to control the local routes in this way from one end of the line to the other. This was the first step in the new installation. Centralised traffic control was then proposed to take over the operation of the routes from the separate stations. The line has been divided into three parts: DOLE to MOUCHARD, MOUCHARD to FRASNE and FRASNE to VALLORBE. The middle part was the most convenient to control from a central point, according to the programme of the Operating Department; and that is why the section MOUCHARD to FRASNE was chosen for the experimental installation of the new electronic C.T.C.

From the technical point of view, the different stations and their all-relay boxes are connected to the central cabin at MOUCHARD. Their controls start from MOUCHARD and go to the various stations and all-relay boxes, while the indications of the position of points and signals and the progress of trains, transmitted from the stations, return to the central cabin at MOUCHARD. Such messages are composed of impulses produced by a frequency shift, the permanent frequencies of the transmission channel being modulated according to the message required .The duration of each impulse is 20 milliseconds.

One common frequency is used for the remote control of all the station units along the line, but the control transmissions are coded by groups of impulses conforming to the binary numerical system: a first code of five impulses selecting the destination unit and a second code of four impulses giving the order to be carried out at the corresponding station.

The transmission of the indications for points, signals, track circuits, etc., is effected by synchronous cyclic scanning continuously repeated, which in turn connects each point of origin to the corresponding indication device (an operation similar to the TV scanning of the spots of a picture). The message is formed of eight successive groups of five impulses, each one transmitting a different indication, i.e. forty distinct indications for each carrier frequency. As many frequen-

"Or" gates, diode matrixes, etc.

The currents at the various frequencies used by the system are transmitted through the conductors of a cable insulated with polyethylene. The central quad of this cable is used for the transmission of the frequencies necessary for the controls and indications of the C.T.C., one pair for each function. The distribution of electric power for the different installations of the line (signals, track circuits, etc.) uses the same central quad, by superimposition on the two pairs. A cable of this type offers a very cheap solution and has proved satisfactory since it was put into service in 1957.

It may be of some interest to give a few remarks concerning the studies carried out on this C.T.C and its programming unit to enable electronics to be introduced into signalling The great question in this field is the observation in such a new installation of all the safety rules that are compulsory with conventional methods, such as preventing a broken wire resulting in a dangerous condition and seeing that a battery in a low state of charge does not lead to an unsafe situation, and so on. Meeting such requirements calls for special care and a good deal of ingenuity.

The transistors in such installations have been used so as to comply with these rules and special circuit arrangements have been determined for the checking of any switching transistors employed in signalling. The condensers have had to be manufactured in a special way, with four taps instead of two, in order to eliminate the change of characteristics in the circuits resulting from the breakage of a conductor connected to the condenser. The very conception of the computers or programming units has been adapted to the requirements of railway signalling. The automatic checking of all apparatus included in safety circuits has become the general rule, which has necessitated important changes in any commercially available installations using electronics and designed for industry.

III—DIFFERENT TYPES OF ELECTRONIC TRACK CIRCUITS

The a.c. 25 kV. 50 cycles electrification has resulted in a considerable number of experiments and achievements in connection with track circuits and important developments in electronic track circuits have resulted from these studies.

From the outset d.c. fed track circuits have been used on double track lines, insulated in one rail only. This provides a cheap and simple installation. But we have not gone on with its use since it has some rather important drawbacks. From the signalling point of view, it does not automatically detect the breaking of a rail unless it is the insulated one. Consequently the rail used for the return current may be broken at one point—or even two—and the relay will remain energised. There is also another reason why such a track circuit is not favoured. Being insulated in one rail, only half the section of the rails is available for the passage of return currents.

A.C. electrification generates induced voltages in the conductors running alongside the line and the reduction of that induced voltage is a permanent preoccupation of all Electrification Railwaymen and of all Signalling Engineers. The use of both rails is far more favourable for that reduction, this being more effective since it works directly at the point of origin and on the cause of the phenomenon. These two considerations govern the reasons why preference must be given to track circuits with both rails insulated, where the return current runs symmetrically and by halves through one and the other. Indeed, these reasons are in the interest of signalling and telecommunication engineers themselves. If the induced voltages encountered are not reduced as much as possible by appropriate arrangement of the signalling, difficulties will be met with their own telecommunications devices and they will run the risk of having to face the necessity of finding complicated and costly ways of countering the effects of the induced voltage on circuits adjoining the railway line.

From a general point of view, the advantages of using alternating currents of various frequencies for the work of signalling devices as well as for telecommunication system must be stressed. When using d.c., it is necessary to bring the circuits of the cable without discontinuity to the apparatus, to relays for instance. This disposition compels the induced voltage to be limited to 60 volts, according to C.C.I.T.T., or to a value not much higher than 60 volts. When using a.c., however, a transformer can be placed before the connection to the apparatus and it is then possible, according to C.C.I.T.T. rules to raise the induced potential to 60 per cent of the disruptive voltage. This advantage is so important that in many cases it is worth replacing conventional equipments by quite new devices and the numerous possibilities offered by electronics offer a wide choice of solutions for such a replacement.

83⅓ track circuit

The first attempt to solve the question of interference in a.c. track circuits on 25 kV. electrified lines was to use in the rails a current sufficiently different to 50 cycles to prevent interference, but not too different from it, in order to retain the benefits of a long experience in the field of track circuits.

The 83⅓ cycles frequency was the nearest solution to conventional equipments. It provides very reliable installations, the service from which is quite satisfactory wherever they are employed. But in many cases such a solution is costly. Numerous signalling sub-stations are necessary for the generation of this current, while its distribution along the wayside requires special cables. If electrification at industrial frequencies simplifies the sub-stations and their feeding cables, it would seem desirable also to find for signalling a cheaper system.

It is this kind of pre-occupation that gave birth to a great variety of electronic track circuits, which have multiplied on the French 25 kV. lines.

All these track circuits have the following point in common: electronic devices, using either tubes or transistors, receive the 50 cycles current, either from the catenary, or from the general grid, or from an emergency supply, and then generate *in situ* the special currents to be sent to the track.

Electronic track circuit using tubes

At the beginning of our a.c. electrification, the semi-conductors were not at that time sufficiently perfect and reliable to be used for track circuit work. That is why electronic tubes were generally employed until recently. These electronic tubes had to be manufactured with special care for the service they had to give, but this result was achieved and the performances of our 3,200 track circuits equipped with these tubes are quite acceptable and give satisfaction. These investigations were carried out by the Compagnie de Signaux et d'Entreprises Electriques in close co-operation with the S.N.C.F.

The number of distinct frequencies to be used arises from the following condition. Insulated joints placed at both ends of a track circuit may fail and become short circuited: in that case, it could happen that the receiver of one track circuit comes into contact with the transmitter of the adjoining circuit. It is then necessary that the said receiver should not pick up or, even better, that it should de-energise when the current of the next track circuit reaches it. These requirements meant that it was impossible to use a single frequency for all cases and finally 4 types were adopted: 300 cycles and 850 for long track circuits and 1,500 and 2,000 for the shorter ones in the stations. The frequency of the first two are not transmitted continuously but are interrupted at 14 or 20 times per second. On the other hand there is no interruption to the frequencies transmitted at 1,500 and 2,000 cycles (fig. 3). A single electronic tube is included in each transmitter, working as an oscillator, while the same tube plays the part of an amplifier at the receiver for the 300 and 850 cycles units. (No amplifier is needed for the receiver of the short track circuits working at 1,500 and 2,000 cycles). The track relay is of a conventional type, being energised by the decoded and rectified current of the receiver. The equipment for these track circuits is not costly and their current consumption is remarkably low.

Transistorised track circuit requiring joints in the rails

Modern developments have made it possible to transistorise the audio frequency track circuit. This achievement has been made possible after a certain number of experiments and adaptations in our laboratory by the T.R.T. firm ("Télécommunications Radioélectriques et Téléphoniques"). The transistorised track circuit is not quite similar to the previous one that works with tubes. In the T.R.T. installation, the frequency is transmitted without discontinuity or modulation and the effective band is limited to a few cycles. All other frequencies are weakened, the more so as they are further away from the nominal

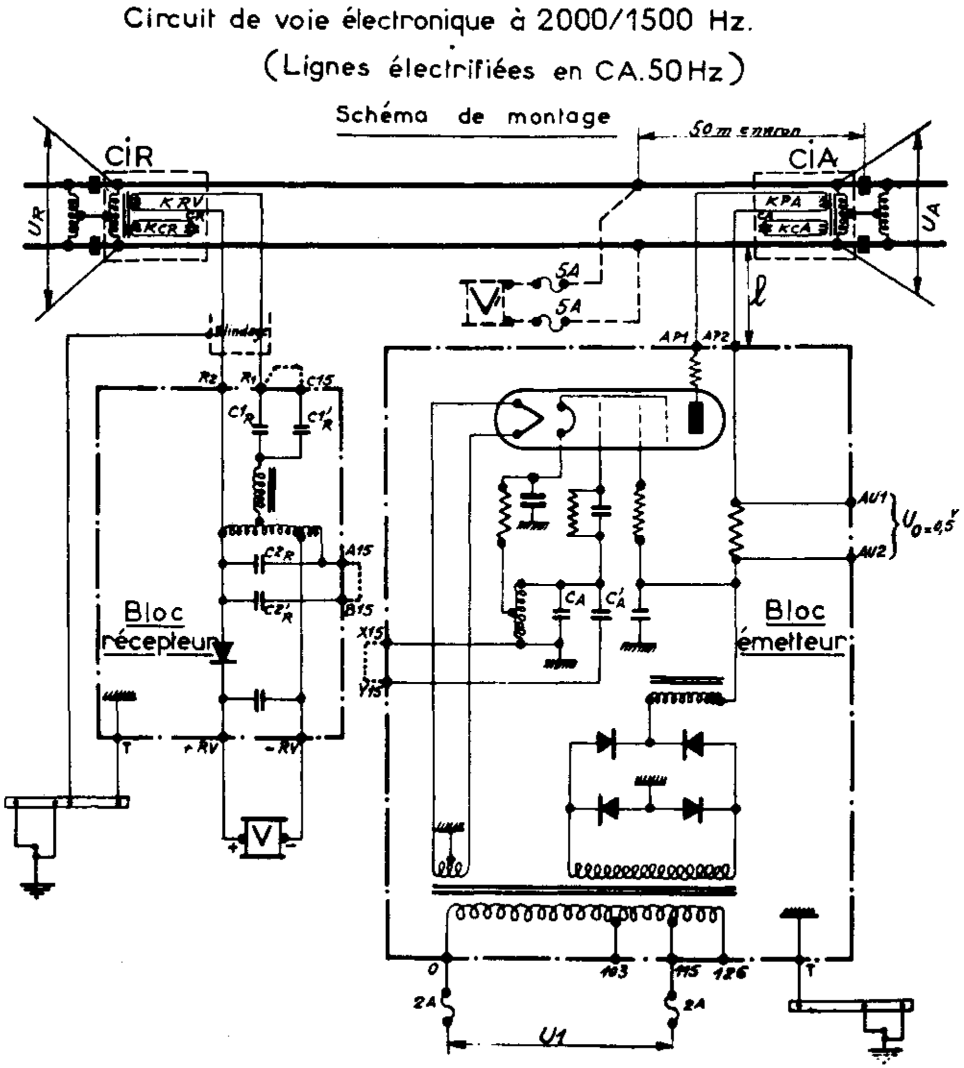


Fig. 3 1500 or 2000 cycles/sec. Electronic Track Circuit

Circuit de voie électronique=electronic track circuit; Ligne électrifiée en CA 50 Hz=Electrified line (single phase, 50 cycles); Schéma de montage=Circuit diagram; 50 m environ=about 50 metres; Bloc émetteur=transmitting set; Bloc récepteur=receiving set; UA=voltage at feed end; UR=voltage at relay end; V=track relay.

value of the track circuit frequency. This results in a very effective protection against all sorts of interference. The chosen values are 110, 180, 210, 275, 315 cycles. The three first are able to operate track circuits whose length is 2 kilometres as a *minimum*, and the last two track circuits of 1.5 kilometres length. Each track circuit is fed from the 8 volts battery supply at the signal and the consumption of the transmitter is about 20 watts, that for the receiver being 2½ watts. The transmitter (fig. 4) is composed of an oscillator having an excellent stability, followed by three symmetrical amplifiers. The last of these is coupled with the impedance bond, this coupling being made with an impedance sufficiently low to prevent any induction with the connecting cables. The receiver (fig. 5) has four parts: a filter working at the specified frequency with a band-pass range of only a few cycles; a sensitivity limit for the tension of the signal received, this limit resulting in the tension above which the track relay is energised and below which the relay does not pick up; a non-linear filter which passes the required frequency and stops all other frequencies or any other irrelevant signal; an amplifier which feeds the track relay through a detecting device.

The five specified frequencies provide a solution to all track circuit problems even in the most complicated stations.

Jointless track circuit

Other types of track circuits, of quite new design, have been used or installed experimentally during the last few years and seem to offer very interesting possibilities. They are track circuits that require no insulated rail joints and therefore can be installed in areas equipped with long welded rails without requiring the rails to be cut.

They have been developed according to two different formulæ that apply to two kinds of problems.

The first sort of track circuit without insulated joints was invented several years ago for use at level crossings equipped with automatic signalling (red flashing lights and automatic barriers). There is no need for the length of the track circuit to be longer than the width of the level crossing, since its only role is to check the presence of a train at that point. The solution has been found with the use of a frequency of about ten thousand cycles. Considering the characteristic impedance of the track and the longitudinal resistance of the rail at that frequency, the drop away of the track relay is achieved by the shunting effect of the axles over a length of 40 or 50 metres. The receiver is connected to the rails at a very short distance from the transmitter (fig. 6). When the wheels short circuit the rails, they de-energise the track relay a little before reaching the first of these connections and the track relay picks up again when the last wheel has passed a little beyond the second connection. Such track circuits, now transistorised, require only a small amount of energy, the total consumption from the battery being only a few watts. It may be superimposed on another track circuit working at a different frequency, for example a section of automatic block.

Another type of jointless track circuit has been more recently designed by the ASTER firm, which can be installed on main lines and become part of an automatic block installation. The length of such a track circuit is of course far greater than in the previous case being about half a mile. The frequencies used lie between 1,600 and 2,800 cycles. Each section of track is limited by a stopper circuit, where use is made of the inductance of a loop extending over a certain length of rail. Let us imagine a section of track limited at its end by a cable short-circuiting the rails (fig. 7: AB or A^1B^1), and including a condenser C (or C^1) connected between the rails at a given distance from the origin AB (or A^1B^1). We have thus an oscillatory circuit generating current at a certain frequency. At the other end of the same track circuit a similar loop is installed for the receiver.

In actual practice a slight change must be made in this arrangement, since a wheel standing on the connexion AB or A^1B^1 does not short circuit the installation and cannot de-energise the track relay. A change has been made to the first diagram (see fig. 8): it consists of placing A and B at some distance from each other. The cable that joins A and B is then connected at its middle to one rail through a condenser to go to the receiver and to the other rail through another condenser to go to the transmitter. The lengths O to A and O to B are such that, in association with the condensers, the desired frequencies F2 and F3 are generated in correspondence with each of the two track circuits. Although the tension is not delivered exactly between both rails, the difference is very slight, owing to the values of the impedances in the elements of the loop.

It is necessary to change frequency from one section to the next. In practice, three different frequencies are used, each loop being a short circuit for the next frequency. In addition, as a supplementary precaution, the group of three frequencies are different on one road and the other.

BLOC EMETTEUR POUR CDV. ELECTRONIQUE
à 110, 180, 210, 275 et 315 Hz (TRT)

Schéma de principe

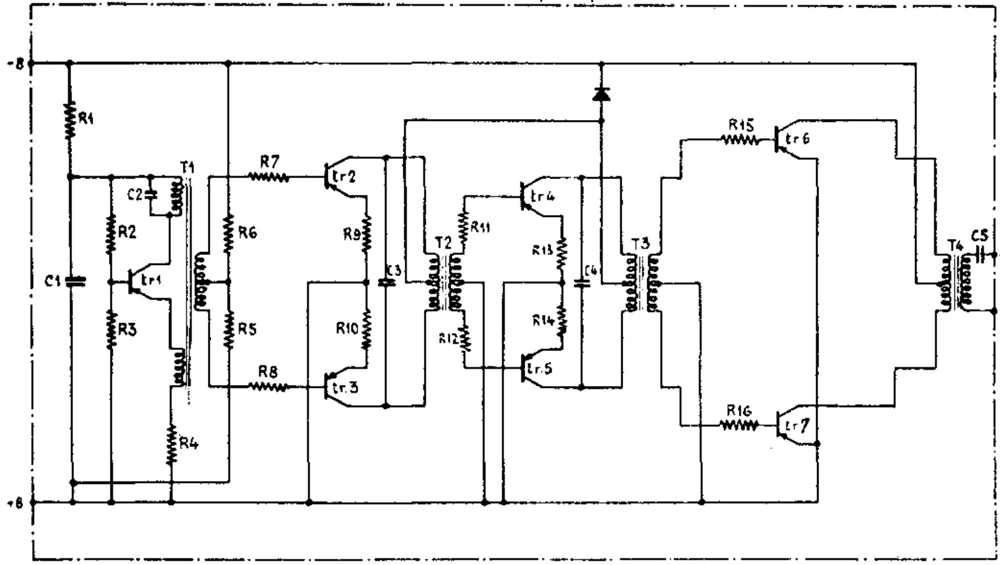


Fig. 4 Transmitter Unit for audio frequency track circuit

Bloc émetteur pour CDV électronique = transmitting set for an electronic track circuit; Schéma de principe = simplified diagram.

BLOC RÉCEPTEUR POUR CDV. ELECTRONIQUE
à 110, 180, 210, 275 et 315 Hz (TRT)

Schéma de principe

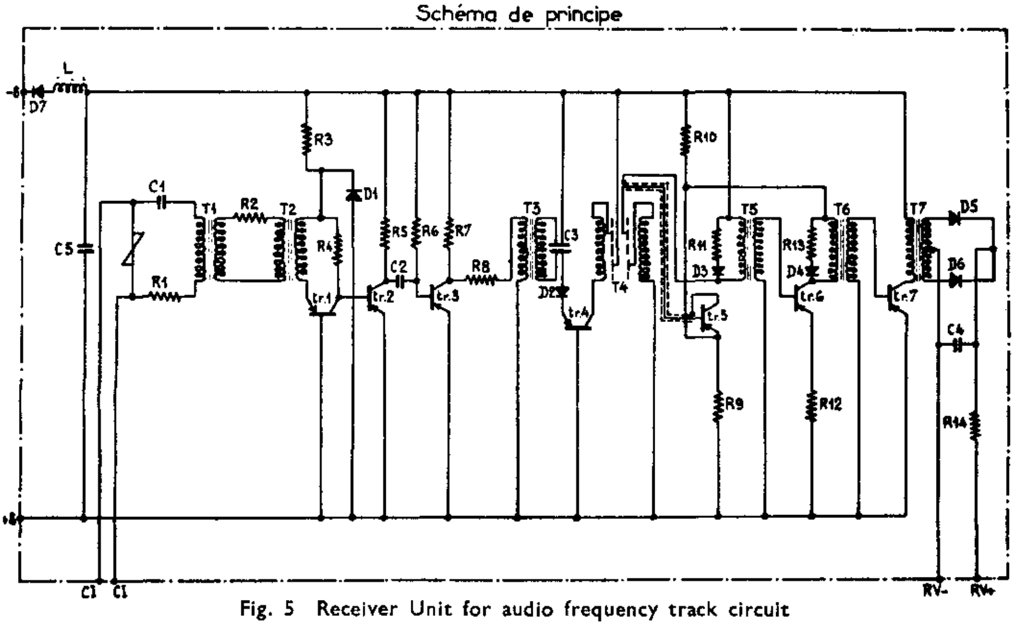


Fig. 5 Receiver Unit for audio frequency track circuit

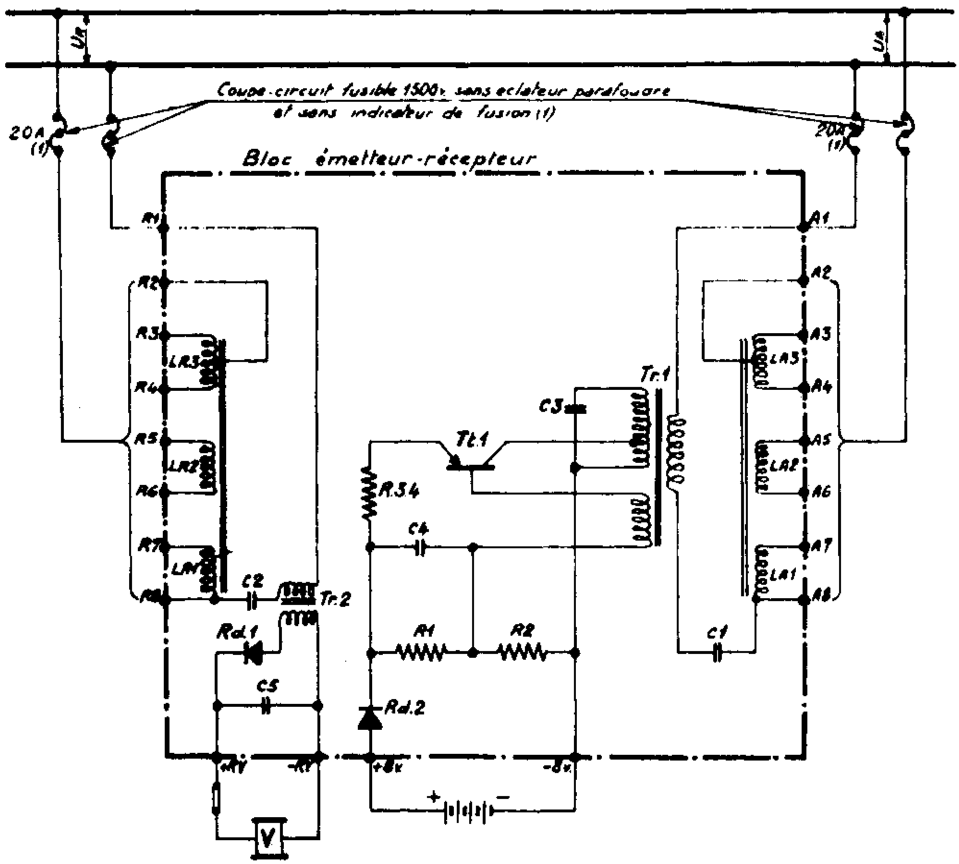
Bloc récepteur pour CDV électronique = receiving set for an electronic track circuit; Schéma de principe = simplified diagram.

CIRCUIT DE VOIE COURT SANS JOINTS

APPAREILLAGE C.S.E.E. A 8700 Hz

A TRANSISTRON

SCHÉMA DE MONTAGE



(1) Les coupe-circuits 1500 v ne sont à prévoir que sur les lignes électrifiées.

Fig. 6 Overlay Track Circuit

Circuit de voie court sans joints=jointless short track circuit; Appareillage C.S.E.E. à 8700 Hz à transistron= C.S.E.E. type of 8700 cycles transistorised track circuit.
Bloc emetteur récepteur=combined transmitting and receiving unit; Coupe-circuit fusible 1500= 1500 v. rated fuses (only necessary at 1500 v. when used on electrified lines).

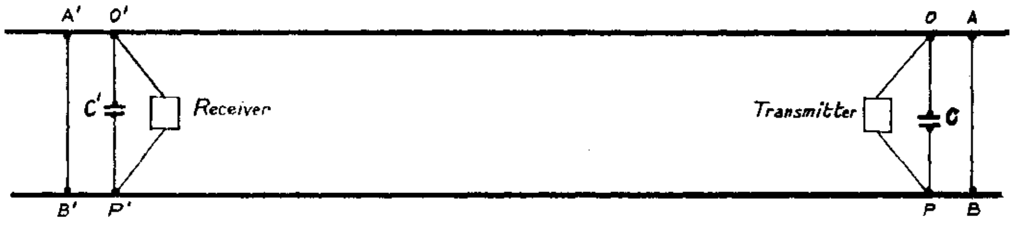


Fig. 7 Audio-frequency track circuit without insulated rail joints—basic principle

The shunting action of the wheels is effective within a variation of only a few metres at the point where the track relay de-energises. Thus, a short overlap appears, which is quite acceptable. Any rail break is detected by the dropping away of the track relay. Harmonics of traction current do not cause interference. Transmitters and receivers are fed by an 8 volts signalling battery and their consumption is 3 to 4 watts. The voltage on the track is 0.5 volt.

The maximum distance between a transmitter and its receiver being half a mile, it is necessary to equip longer sections by the use of two or more cut sections. The track relay is connected at the end of the last section and at the intermediate point no loop is necessary, since only a transformer associated with a condenser in series need be used. When no train is in its section, the receiver at the intermediate point receives a signal and the transmitter connected between the rails has its transistor biased and re-transmits.

Sufficient experiments have taken place in France with this jointless track circuit, either on d.c. or a.c. electrified lines, to prove that it works reliably and complies with the rules of signalling.

High voltage track circuit

In the classification of track circuits must be included the high voltage impulse type track circuit, which has been developed to a high degree in France, since more than 2,000 are in service at present. The impulses of this track circuit are delivered at a voltage of about 100 volts on the rails and at a frequency of 3 per second. These impulses are used to energise the track relay; a condenser is connected to its winding, while a valve (or a diode) gives passage only to current of the right polarity.

In the original type, the impulses were generated through a thyratron, which required a d.c. supply of about 1,500 volts to work the tube. The most recent arrangement, however, uses a silicon controlled rectifier instead of a thyratron (fig. 9). The whole transmitting unit requires no more room than a conventional relay and the maintenance is extremely simple.

Such impulses have the great advantage of enforcing the short circuiting of the rails by the wheels of a vehicle, whereas some irregularity may occur with other types of track circuits. These irregularities may happen in the case of rusty or dirty rails,

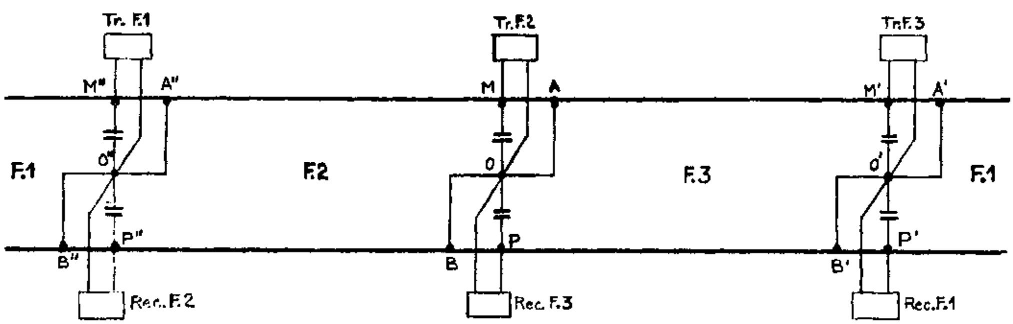


Fig 8 Audio-frequency track circuit without insulated rail joints—arrangements adopted in practice

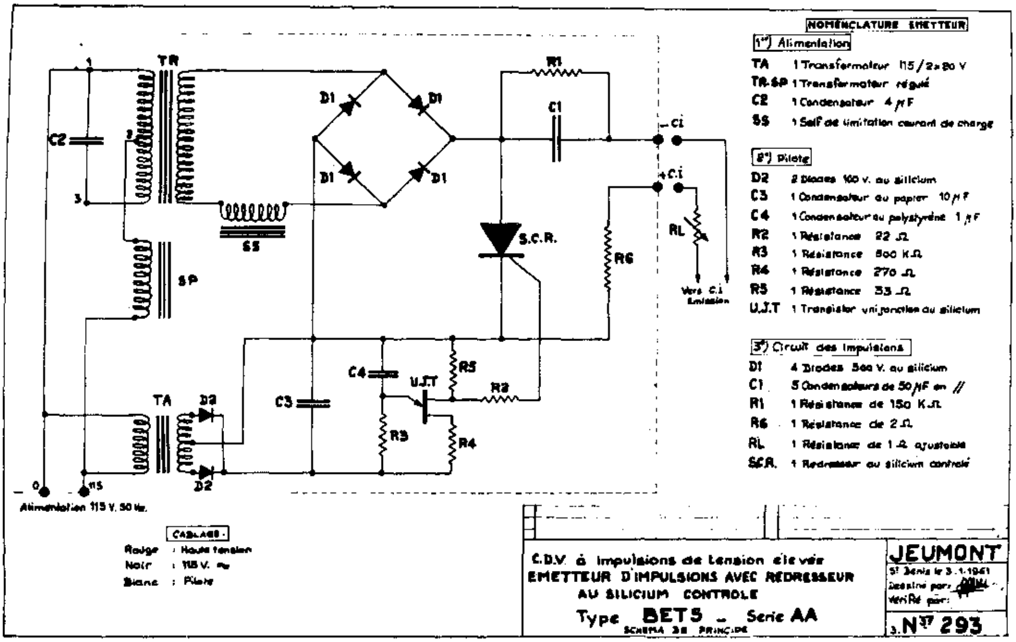


Fig 9 High voltage impulse-type track circuit transmitter unit

CDV à impulsions de tension élevée=track circuit working with high voltage impulses; Emetteur d'impulsions avec redresseur au silicium contrôlé=impulse transmitting unit incorporating a silicon controlled rectifier.

mostly when the train is composed of one or two light vehicles. The same thing may be observed on sanded track. A great deal of studies and experiments have been done in some of the Continental countries regarding the theory of track circuits in order to take these phenomena into account. It has been found that the conventional way of calculating track circuits, which does not take into account any isolating film that may cover the rail, does not give a complete explanation. The voltage necessary to break this thin coating on the rail has more importance than the shunting value, which is usually quoted as the only characteristic of quality for a track circuit. The contact between the wheel and the rail is either a semiconductor, or it belongs to the disruptive type. In all cases where the surfaces of the wheel and of the rail are not perfectly clean, the increase in voltage is a great help towards short-circuiting the track relay. Besides, the very short duration of the impulses have two advantages: they ensure a low consumption for the track circuit and they are of no danger whatsoever to the men working on the track.

This new track circuit has also been employed to solve the problem of sanding. By themselves, in fact, these impulses are not able to exert their disruptive effect through a thick sanding on the rails. But a heavy sanding is more a habit than an actual need for the engine drivers. When sanding is necessary, as in the case of starting a very heavy goods train, a certain quantity of sand is required. Experiments have been carried out in France in order to find out if the minimum quantity of sand required by engine drivers in these conditions can be dealt with by improved track circuits of the high voltage type. These experiments have shown that the possibility of a solution existed if the sanding from the engines was limited by the pipe and the delivery device while at the same time the track circuit had the characteristics mentioned above. The French Railways have adopted these conclusions and whereas a great number of incidents have occured in the past due to sanding on track circuits, these incidents have now disappeared thanks to the precautions taken both by the Traction and the Signalling Department.

cies are used as groups of forty indications are required, which in practice means one frequency for every half station.

The time for the transmission of a control code is 4/10 second and the period of cyclic repetition for all the indications in the diagram at MOUCHARD lasts for two seconds.

The shift of frequency is 30 cycles on either side of the carrier frequency.

These carrier frequencies are 120 cycles apart, according to the international rules for such transmissions.

The greater part of this equipment works by electronic means and makes much use of semi-conductors. However, at the receiving end, for both controls and indications, the final operation is carried out by means of standard signalling relays working in conjunction with the conventional part of the installation in the station.

We have seen that the storing of routes met with considerable favour on the French Railways. With the standard push-button panels, the possibility exists of pre-setting a route, which is stored so long as the route already set is required for a first train and then becomes effective as soon as the departure of this train cancels the preceding route.

At the C.T.C. installation at MOUCHARD the possibility has been given to the man in charge of the panel (fig. 2) of pre-selecting more than one route at a time, up to four routes. Thus, he can, in advance, knowing what will be arriving, decide in which station, for instance, a crossing will take place, or an overtaking. The controls he has stored are indicated in front of him by means of coloured light arrows, lit on a certain number of tiers—four when he uses his whole possibility of storage. Each train that passes causes the recorded arrows to move down one level. After preselection the operations proceed automatically, the passage of the trains being at all times visible on the illuminated diagram at MOUCHARD.

This registering and control of the successive routes are performed by a programming unit, or computer, the operation of which is carried entirely by electronic devices. The unit is made up of semi-conductor units, transistor equipped multivibrators, flip-flops, "And" gates,

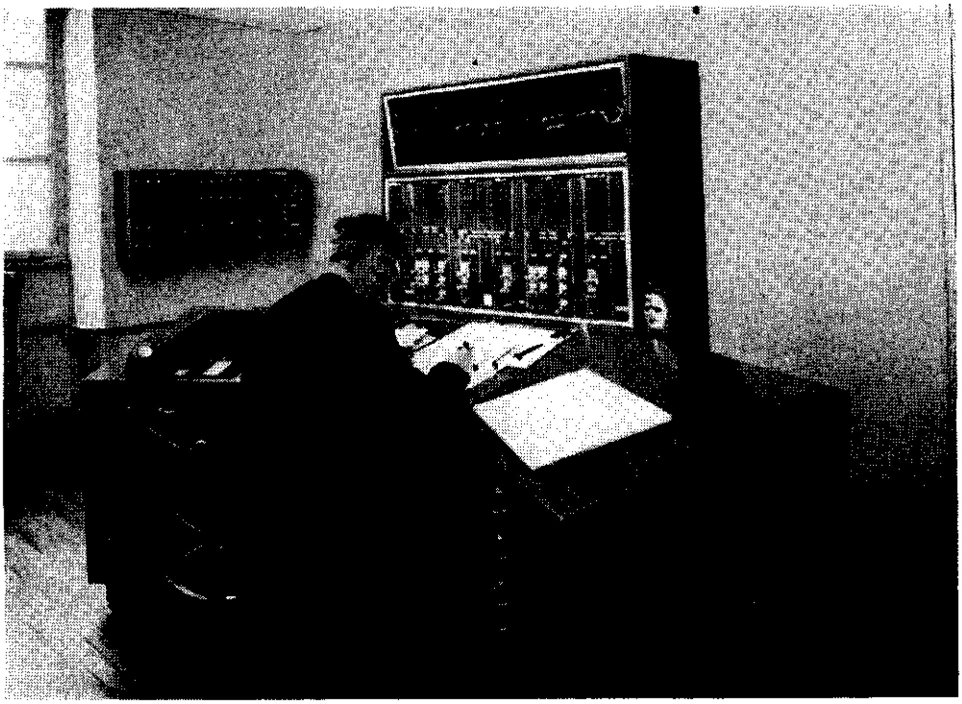


Fig. 2 Control Panel at Mouchard

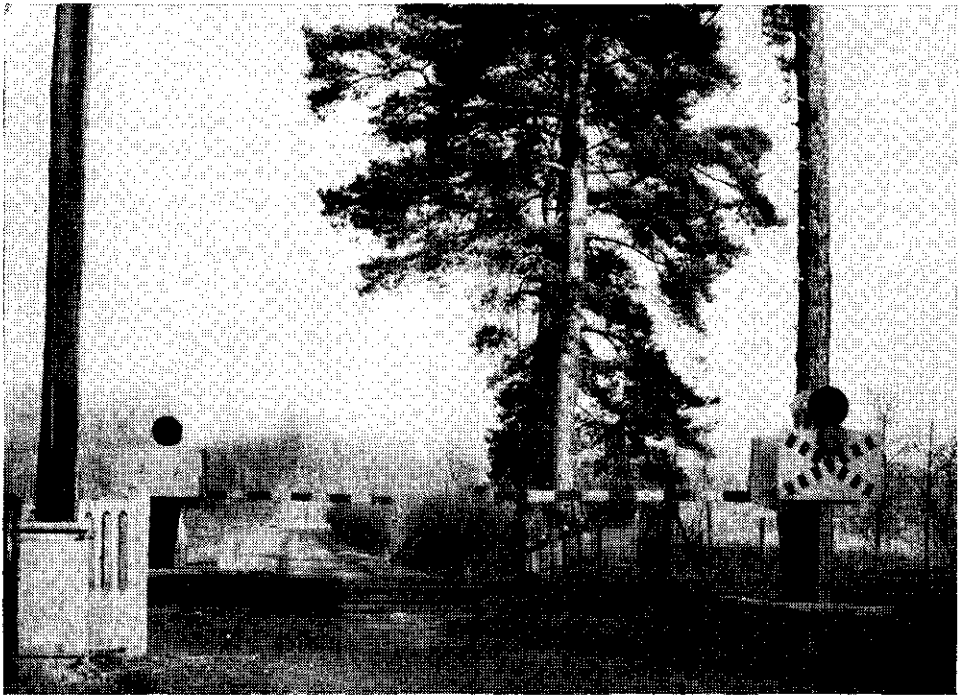


Fig. 10 Typical half-barrier installation

IV—AUTOMATIC SIGNALLING AT LEVEL CROSSINGS

A safety device that has been widely developed in France during the last years, is automatic signalling for level crossings.

After a first experimental installation consisting of red lights displayed together with boards ordering vehicles to stop, the standard device adopted has been the association of flashing red lights with a short barrier arm the length of which is only half the width of the road (fig. 10). This installation has been multiplied so many times that at present more than 1,300 level crossings are equipped with that type of automatic signalling. The Railway is authorised to put into service such a device only when a certain number of conditions are satisfied, these concerning the visibility of the track from the road and the importance of the traffic on both road and rail.

From the technical point of view, the control of the red lights and barriers is dependent upon treadles which bring the signals to danger when operated by the train. The clearing of the signals is effected after the train has passed the level crossing. This passage is detected by the simultaneous operation of a treadle and occupation of a short track circuit (the jointless track circuit additionally is to keep the signals "on" and the barriers down if a train happens to stop on the level crossing).

At present, the treadles are of an electro-mechanical type, a small lever being depressed by the wheels and closing or opening contacts. On single track lines, these treadles are arranged so that discrimination is made between the contacts actuated, according to the direction of the train. Such treadles give a satisfactory solution to the problem, although they require careful maintenance. Research has been carried out to find an electronic treadle able to work under the same conditions, but the question has not yet progressed much further than the laboratory stage.

An interesting experiment has been carried out at a level crossing where traffic is heavier than that authorised by the Ministry of Transport for the type of installation described above. In this installation there are four short barriers, the length of each being half the width of the road. When a train is proceeding in a direction approaching the level crossing, two of the short barriers begin to descend which stops traffic on the road.

A few seconds after, the other two small arms descend, thus allowing a small time interval for cars to clear the crossing. By the time the train arrives, all barriers bar the road completely on both sides of the railway line. In addition, the time during which the signals are "on," has been so regulated that it will provide about the same delay for slow trains and fast trains and also for trains whose speed varies as they approach the level crossing. This regulation of the time during which the signals are displayed is effected by the use of a combination of treadles that work in the control circuits of the various signals. This new equipment of level crossings with double half-barriers has caused considerable interest and its further development is contemplated for the future.

Conclusion

The installations and apparatus recently introduced by the S.N.C.F. are mostly based on specifically French data, since the signalling problems as well as the Operating Regulations are seldom similar on both sides of the Channel.

However, even if in some cases separate solutions cannot be avoided, any intellectual and technical exchange between British and French engineers may be of interest. The author of this paper wishes to pay a tribute to the Institution for many a valuable contribution found in their Proceedings in the later years.

He feels today that he has gained something in making the ideas expressed above clear to himself; his wishes will be gratified to the full if he has succeeded in making them not less clear to his readers.

DISCUSSION

Mr. A. W. Woodbridge. Mr. President, M. Walter, I would like to say how delighted I am to have the opportunity of opening this discussion, because so many of us in this country have had the opportunity of seeing the actual things which M. Walter has described tonight, and indeed in many respects we hold them in great admiration.

Now, I propose to keep my remarks fairly general so that I do not delve too much into technicalities, to which I am quite sure M. Walter could give us a very good answer. I will start by saying that I think M. Walter must be very lucky to belong to an organisation which, to judge from the newspapers, seems at least to have some continuity of form.

I am very interested to see that M. Walter has had the co-operation of his own Operating Department in the design of these new standard panels. At British Railways headquarters we feel envious of the fact that he has been able to achieve one standard; no doubt he had many headaches before he finally met the principal wishes of the Operating Department.

In the actual operation of route panels we do find ourselves with a certain amount of differences of opinion. We, on British Railways, have not really considered the question of pre-selecting routes as one which we ought to adopt. It has been tried, and it has been abandoned. So therefore we start with a fundamental change in attitude. I agree with M. Walter that some of the other things he has done are an essential, and are carried out on our own panels. M. Walter is, of course, a past master of the art in his own country, but referring to the top of page 184, right-hand column I am a bit puzzled where he talks about the cancellation of track circuits from the signalbox. No doubt he will enlarge upon it.

In connection with your small panels, M. Walter, you say they are located in the station master's Office and so on. I would like to know whether the station master himself operates the panel.

M. Walter. Yes he does.

Mr. Woodbridge. On the question of the selection of routes, programme machines have not been developed to any extent on the main lines of British

Railways, but of course we do consider that they are a thing worth studying. Mr. Dell on the Underground, as we all know, has a lot of these in service now, and they are giving exceedingly good service. But in the case of your simple junction I wonder whether you could not have done the job just as easily with train describer control. But perhaps you do not use train describers?

M. Walter. No.

Mr. Woodbridge. I, and no doubt many others of us, were most interested in your Mouchard C.T.C. control, which appears to be giving first class service. I think it is a most interesting conception of such a job to combine the programme machines with the actual operation. When I first went there I found that you had lightweight vehicles and I wondered if you have any difficulties in overcoming track circuit troubles with them, and how you have done it.

If you would be so kind as to send me, or submit in your reply to the Institution, a specification of your control cable, I think we would be very interested in it.

Another question is that there is no mention in your paper of the power and voltage which you transmit on your coding wires.

Another question in connection with your C.T.C. is that you mention the case preventing a broken wire resulting in a dangerous condition. Do I infer from that that the signals are put to danger, if you got a broken wire, or whether you lose your codes? Again do I understand that you have electronic devices in safety circuits, and if so would you let us know what they are?

One thing that M. Walter and I have crossed swords on many times before, is the question of broken rail protection. I do not know what the incidence is in France, but our own records of broken rails show that it is quite negligible. Consequently we do not put much effort towards solving the problem of making a track circuit detect a broken rail, even if it could.

I think if anything will go down in the history of signalling it is the pioneer work which M. Walter has carried out on track circuits. He has, as we have seen, introduced on to the French Railways many varieties of track circuits and in large numbers. We ourselves have been very pleased to follow his lead, and introduce some French track circuits into this country, where I am sure they will give us very good service. Our most recent importation from France, of course, has been the Aster J.E.S. jointless track circuit of which I have now had experience on non-electrified and D.C. traction roads and we are now going ahead to try it out in the 50 cycle areas. I was very glad to be reassured by M. Walter's Paper that he gets no troubles in France. I do not think we shall get any either.

Well gentlemen, I have briefly confined myself to generalities and I would like to congratulate M. Walter on behalf of the Institution and all of you present on his most interesting Paper, and the very 'cute' film.

M. Walter. Mr. President, gentlemen, I first thank Mr. Woodbridge for his very interesting remarks, and for his kind appreciation of what we have done on the S.N.C.F. First of all Mr. Woodbridge has spoken of the continuity of our plans and of our signalling. Well, we have changed our minds on some points. The comparison between 1951 and 1961 gives an example of these little changes in policies, passing, for example, from an extensive use of mechanical frames to a reduced use of such apparatus replaced in many cases by all-electric boxes.

Then the question of co-operation with the Operating Department. Of course this is a very difficult thing to achieve because their outlook is sometimes different from ours. We have at present—as we have had every year—many cases where they said they were not quite satisfied with what we did. On the other hand we, in reply, said we were not quite clear about what they wanted. On the cabins with push-button control panels however, after years of discussion, we have finalised a design with which they tell us that they are quite satisfied. The fact that we have put in more than 110 cabins of the standard type within 10 years is a measure of the favour in which the Operating Department regard these cabins. Without any suggestion from me the different regions have asked for them themselves, on behalf of their respective Operating Departments.

The pre-selection of the route is a thing that our Operating Department likes very much. They say that it saves time, because otherwise the lever-man, after having sent a train, is compelled to look at what happens, and immediately the train has cleared the points he has to send a control before the next route. On the other hand, with the pre-selection of the routes, it is done automatically. Our Operating Department thinks that this is a factor contributing to the efficiency of the different stations; that is why they have decided in several cases to remove some turn-outs that were not necessary, although the importance of the traffic was greater. For the Gare du Nord, in Paris, for example, we had at one time 140 turn-outs or junctions; we now have only 81 of them with P.R.S. These figures show the importance of the benefit derived from this form of interlocking.

Next comes the question of cancellation of track circuits. This is what it means: On our railways, the regions are asked not to have a man on permanent day and night maintenance service in the electric cabins. If there is something wrong, the operating man should be able to keep the trains running until the maintenance man arrives. He can be expected within one hour or half an hour, sometimes less. The Operating Department must have the facility of running trains, even though there is a track circuit failure, the track relay being dropped. Well, there is the man in the cabin to do that. I suppose that some of you have visited our cabins. There you may have seen both sides of an illuminated diagram little maps where you have the drawing of the track circuit, including, for instance, the points. Through the perforation of a coupon the lever-man pushes a button, and in doing so he picks up the repeater relay that gives him the possibility to change the position of the points. Of course, this must be done only with the taking of certain precautions. The lever-man must send a man to see that the track circuit is actually clear. This cancelling device is only available for one movement. This is what we mean by cancellation of track circuits.

Train describer. Well, until now our Operating Department did not accept train describers. They consider that simpler devices may give sufficient information to the lever-man.

For Mouchard, I wanted to tell you that this line, 101 kilometres long, has been divided into three sections; and after having made experiments with the electronic C.T.C. we are now preparing for its extension to the whole line from Dôle to Vallorbe. It will be worked from Dijon where the central panel will be. This extension has been asked for by the Operating Department who consider the experience obtained with Mouchard as very successful.

Then there is the question of light vehicles; this is very important. We have many light vehicles in France—diesel vehicles for passengers. The Operating people are not authorised to use the pre-selection of routes before the passage of these light vehicles, and in addition to these we have extremely light vehicles—40 tons—for the work of transporting sleepers and so on.

In all these light vehicles that run on lines equipped with automatic block, brushes are fitted—two pairs of brushes that give an additional shunt. This provides the protection on the track circuits; but for these special vehicles also it is forbidden to use the pre-selection. Until now we have never had difficulties, nor any cases of shifted points under these vehicles.

Mr. Woodbridge also asked if we have electronic devices in safety circuits. We have electronic devices in the track circuits. We have also electronic devices, which are safety devices, and provide interlocking on a single-track line from one station to another, in order to prevent the possibility of sending one train against the other. From the viewpoint of safety such circuits are specially important.

Regarding the control cable: I shall send Mr. Woodbridge the specification. It is without lead, and thus very economical. We have had to take precautions against interference, especially from the pantograph of the engine; but it has always been possible to eliminate these interferences by filters, and by choosing the frequencies and the voltage. I shall give you all the details.

We have another installation of C.T.C. I did not mention it in the paper because it is not yet in service but it is on the eastern part of the system, and uses the same type of cable. It is an interesting cable because it gives the possibility of using these high frequencies; it is not costly, because there is no lead or aluminium sheath.

Now a last word on the broken rail protection. In a double track the question is not quite so serious. I think it is mostly on single track. There it is very important, because you have not the possibility to reduce the risk which you have in double track where you can put connections between the return rail of both tracks, and by so doing of course you reduce the risk of having a broken rail between two connections. But on a single track you have not that possibility. I think it is important to use something very safe from that point of view.

Mr. E. G. Brentnall. Mr. President, M. Walter, gentlemen, I would like to add my congratulations to the author for the excellent paper he has given tonight. It has been my privilege for a number of years to see the developments on the French Railways and to see the similarities and differences between our own developments. We in this country, have many installations of what in fact are P.R.S. systems, with sectional release route locking. We originally had single units for operation, but now we have changed to switch buttons, with two per route, at the entrance and exit respectively. This method of operation has the advantage that in setting the route the signalman visualises very easily the actual movement of the train and does not have to translate his thoughts from one medium to another.

I sympathise with M. Walter for the necessity of using electro-mechanical installations for economy's sake. This has had to be done in Great Britain also.

Pre-selection

With regard to pre-selection, as described by M. Walter: it has not been considered necessary nor advantageous here, nor in our case is it felt that there would be any saving of time by pre-selection.

I would like to ask M. Walter how he guards against momentary energisation of a track circuit which in pre-selection would set the route up prematurely.

Emergency Arrangements

I was interested in the emergency arrangements mentioned by M. Walter. From the operating side here doubts were raised as to how relay interlockings would operate in the case of failures. We have gone into this in very great detail with the Traffic Department and for the purpose of keeping trains moving with safety we divide the methods under one or two headings:—

1. Before arrival of the Lineman, or the localisation of the fault, trains may be moved by the use of the individual point switches—with a maximum of two trains in one area. A train is authorised to pass a signal at danger if all point indications are in order. Points which cannot be moved by the point switch must be clamped. There is no clearance of signals.
2. After the arrival of the Lineman, but before localisation of the fault, the same arrangements hold until the Lineman wishes to test apparatus, when the faulty route must be disconnected and reminder appliances placed on conflicting route plungers. Trains may pass over the faulty route after points have been secured and the driver warned (handsignalmen).

Signals are cleared for routes *concerned* with the faulty route.

3. After localisation of fault, if it is a fault internal to the signalbox or relay room, all routes affected by the fault are disconnected and reminder appliances attached. Trains are moved over such routes after clipping of points and handsignalling to driver. There is no clearance of signals.

If the fault is at a point machine or detector, reminder appliances are attached to routes affected by the points concerned. If the detection circuit has failed, the points are operated and the detection circuit adjusted by the Lineman as necessary after the points have been placed in the required position.

If the points have failed, but the detection is in order, the points are clamped in the required position.

In either case normal route plungers are operated by lifting the reminder appliances and the signal is cleared if possible. Otherwise handsignalmen are used. The train is brought to a stand in case of defective points.

With regard to the track circuit release that M. Walter mentioned; many of you will recognise this as a form which is used on electro-mechanical installations in this country, but not on power installations. In special cases, such as permanent way alterations, we have, on the L.M. Region, a special site switch which is set up by the lineman, and which can cut out the track circuit. The switch would be operated, as required, by a responsible individual, after observations of physical clearance.

On page 184 the author mentions a device which provides that, after a series of trains in the principal direction have passed, one route only in the other direction is pre-set, thereafter, permitting a fresh series of trains on the first route. I am not quite clear what is meant in this case and perhaps M. Walter would enlarge on this point.

Remote Control

With regard to the question of remote control, I was very interested in the description of the signalling between Dôle and Vallorbe. I would like the author to state the number of trains that passed per day on the two lines in the past, and the number on the one single line with the new signalling.

I have had experience of centralised control on heavily-worked sections of four tracks with no attempt to use single line working.

I introduced an over-riding control which in the case of failure of the C.T.C. system allowed the four lines to work automatically.

I should be interested to know whether M. Walter has experience of any safety circuits using transistors. In my case, so far transistors are only used for control circuits, but from the wording of the author on page 187 that all safety rules for C.T.C. are compulsory, I wondered if that did hint that some of the safety circuits were operated by transistors.

Transmission of Currents

I am glad that M. Walter is sending a description of the cable used for the transmission of currents and I would like a copy. It seems that the central quad is used for the transmission of frequencies necessary for controls and indications of the C.T.C. and that the distribution of electric power for signals, track circuits, etc., use the same central quad by superimposition. Does this mean that the power for operating and lighting the signals, for feeding track circuits and for operating point machines is involved on this phantom circuit as it would seem that the power concerned would be very heavy for a quad with light conductors.

Life of Transistors

I wonder if M. Walter could give his experience in the life of transistors and also whether he found them susceptible to temperature variations.

Double Rail -*v*- Single Rail Track Circuits

I would like to join the controversy on broken rail protection. We had originally double rail track circuits, but we had rail connections for wires coupling the overhead structures, and also booster transformers, and with all these connections to the rails even concentrated at every third track circuit we could not guarantee broken rail protection. We are using D.C. single rail track circuits now.

I was interested in M. Walter's statement that the distribution of return current in double rail track circuits would reduce the inductive effects on cable runs. I think that is theoretically true, but may not apply always in practice as the position of the cable run does bring in other factors and generally the cable run is near to the rail and distant from the catenary. I did find in some cases that there was some over-compensation by the rail currents. A further disadvantage of the double rail track circuit is the cost of the impedance bonds.

Isolating Transformers

M. Walter's statement that with the use of isolating transformers the C.C.I.T.T. regulations permit the induced potential to be as high as 60% of the disruptive voltage, is most interesting, but I would like to stress that if that is done it must be on cables which are not brought into intermediate terminating points as, otherwise, the maintenance men may be subjected to dangerous voltages when carrying out tests.

Electronic Track Circuits

The electronic track circuits to which M. Walter refers are of two types—the valve type and the transistorised. I wonder why on the transistorised type the frequencies were much lower. Could not the lower frequencies be used on the valve type?

High Voltage Track Circuits

I was interested to hear M. Walter's experience with the high voltage track circuit. I have used such a track circuit with extremely good results—one case where the rail surface was so bad that an ordinary track circuit remained energised under three coaches.

Automatic Signalling at Level Crossings

Finally, with automatic signalling at level crossings, I can speak feelingly on that subject because I have managed, after many difficulties, to get two installations introduced in this country. I would mention that at some of the crossings where M. Walter introduced these automatic barriers, there was not very much protection before, but in our case we had swinging gates in all cases.

I note that as an experiment, double half barriers have been introduced. I am not clear why the double barriers should be considered more satisfactory than single. What is the minimum time allowed before the falling of the first two half barriers and the second half barriers, and the arrival of the train? In this country it is five seconds, after the single half barriers are lowered, but this does not seem to allow any scope for the second half barriers. There may be an advantage in case of failure however.

Could the author give further particulars about the regulations of the times to give the same period for slow and fast trains. How many speed ranges are covered and what are they? What safeguard is there to cover the rapid acceleration of, say, a multiple unit train (after its speed has been measured and the time for lowering the barriers set) which would give an earlier arrival at the crossing than anticipated, possibly before the barriers are lowered?

M. Walter. Thank you very much for your interesting remarks and questions. The first one is very important and concerns those track circuits where you always have the fear that for a short time the track relay picks up as a light vehicle is passing. This risk has been taken into consideration for the last 25 years, by what we term the 'flexible release'. In the chain of relays we have some that are slow picking up. The time-lag is between one and two seconds. But on the line from Mouchard to Frasne, on a single-track line, we have introduced still greater safety. To prevent a train leaving station A to go to B while another one should be leaving station B to go to A, we have put on a special track circuit working with impulses at about 100 volts, and we have used 5 seconds time lag for the relay picking up. In fact we have never had any case of incident due to that.

You mentioned a sentence that was not intelligible on page 184. "Some junctions lead only in two directions, one of which is used much more than the other . . ."

Well, it means that we have in many cases a junction where most trains, 9 out of 10, pass to the right; and then, from time to time, you have one train—maybe an engine coming to pick up another train —that passes to the left, but it is only one movement. In that case, without addition of any button or relay, we have the following possibility. You remember that we have two ways of controlling a route.

One is what may be called the control with block indication (or "permanent working"). Trains passing on the route controlled follow on another as if there were no points. The other way of controlling a route is the following:

In this case, the first train to enter the route puts the signal to danger and no other train can pass. Let us consider the case of trains coming from A to B followed by one train coming from A to C followed in turn by many trains from A to B. For the last train of the series of trains going from A to B the operator pushes the button of the second type concerning the route A to B, then he pushes the button A to C, and finally the button A to B for block system. When the last train on the series goes from A to B, he will put the signal to danger. As the route from A to C is pre-set, immediately after the train has left the track circuit of the points, these points will come to the position for A to C and the next train will go from A to C. Immediately after that train the route A to B will be set automatically for the next trains.

How many trains at Mouchard?

Well, it depends on the season. Something around 50 trains per day. C.T.C. has made it possible to replace double track by single track.

You ask if the scanning can jump a function. No, the light would not appear, and every two seconds it begins again. We have electronic devices to ensure synchronisation.

Regarding the life of transistors—

Well, we have had some difficulties at the beginning. The failures were due to excessive voltage, and especially with transistors normally fed through batteries through the general grid. When the general grid had peaks of voltage, transistors were destroyed. We have also had transistors that were destroyed due to lightning; but we have now put in extra transformers, and this trouble has not re-occurred.

You ask why we use different frequencies in track circuits with valves and with transistors:

With the system using valves the frequency was not of a very strict value, the range being great from one type of track circuit to the other. With the track circuits using non-modulated frequencies and transistors, special filters have been employed. This gives the possibility to have a greater number of types of track circuits, with frequencies having only slight differences of value, which is a very interesting improvement.

Why do we use double barriers? It is because we have had a certain number of accidents through people passing zig-zag. We were asked to find a solution, and what we did so far seems effective.

Then about the time devices, this is the device using treadles. The principle is to measure the time for a train to run from one treadle to another and compare it with the time of operation of a relay. It does not give equality of time for the signal to be displayed, but the differences in time are much reduced.

Mr. H. J. N. Riddle. Mr. President and gentlemen, I would like to add my congratulations to those of previous speakers to M. Walter's Paper which I find very interesting. On receiving it, I turned to the section on track circuits, because the 'old track circuit' is still one of the most interesting pieces of our signalling apparatus. I feel that M. Walter had summed up the position in one short sentence so very well on page 182, where he says "The possibilities of these are very wide and bring important changes to the conventional pattern of study usually associated with track circuits".

Automatically my mind went back over the 50 or 70 years of signal engineers who have visualised and perhaps had engaged themselves on the study of these track circuits late into the night. In the old days with the simple D.C. track circuits these 'students' would congratulate themselves on the knowledge which enabled them to understand what any combination of ballast leakage and rail resistance would do. They had no sooner got used to these practices than the A.C. track circuit came along and threw all their previous ideas into confusion, and made life much more complicated. Now having become accustomed to A.C. track circuits we are faced with the electronic track circuit. Over many years, is there any other piece of equipment that has suffered so many changes and progressed so much?

The diagrams and descriptions of the track circuits and other arrangements are so clear, and the descriptions are so good, that there is very little to add, but I rather wonder what is the object of two rectifiers in circuit number 5 where we see rectifier D7 immediately adjacent to the negative battery terminal. There is a similar one in another circuit, which had just the same position. I assume that it is merely there to prevent the transistors being destroyed in the event of the battery connection being applied the wrong way round.

Finally, the fall-off barriers. The object is to stop the zig-zagging of traffic across the barriers; but in a half-light, when the sun is setting with long shadows, the barriers may be seen as silhouettes and this rather leads me to wonder whether there have been any cases where the barriers which have come down first have been disregarded, the driver still seeing the other barrier raised into the sky and thereby crashing into the short one.

M. Walter. I quite agree with the remarks about the track circuits. We have tried to make the work of the maintenance man not more difficult, but perhaps easier than before. There is a special regulation of the track circuit, and he has simply from time to time to pick up some measurements of the working of the valve of the transmitter or receiver. According to the length of the track circuit and according to the value of the leakage resistance of the ballast, there is an adjustment to make, but he has not, as at the inception of the D.C. track circuit, a special adjustment to do by himself.

As for the fall-off barrier, so far they have always proved very satisfactory.

Mr. H. W. Hadaway. I would like to follow up Mr. President, if I may, a point which has been raised by the previous question, and that is on the question of the track circuit principle in controlled areas, with a complicated layout having a network of crossings. Whilst it is possible to arrange track circuits so that the frequencies change on adjacent track circuits on a through line, I am not clear as to the arrangement when track circuits adjoin through the crossings, for it must be quite impossible to oppose frequencies consistently.

The protection for route holding is also not clear in my mind. I can imagine that a track circuit commencing a route, and also for the release of a route, may be of the high-voltage type. But there may be a number of track circuits over the whole route, and presumably not all of them are of the high-voltage type. A short wheelbase vehicle on one of the intermediate tracks causing a track circuit "bob" could result in the release of the route.

M. Walter. I am not sure that I fully understand the information asked for, but I see two aspects of the question. First, in complicated layouts of stations you may have one track circuit which has several antennae and which is in contact with several track circuits. If you use four different frequencies you can solve all the problems. Sometimes we have to use different dispositions for the insulation of the track, according to the various cases, so as to have no place where an axle does not shunt the two rails. One may also have to reduce the length of the antennae at junctions. But we have always managed to find solutions with our your frequencies on our 3,000 electronic track circuits installed on the first lines equipped with 25 kV. Now, with the transistorised track circuits, we have five different frequencies available.

Regarding the other question, where you have a succession of different frequencies, of course if you have several insulated joints burnt at the same time the first frequency may arrive to a track relay that should not work with this transmitter. However, the level of the frequency is regulated so that after a certain impedance of a certain length of the track there is insufficient energy to pick up the relay at the other end. That is a question to which we have to give due consideration.

It is necessary also that the high-tension impulse track circuit could not send a current that might energise the other types of electronic track circuits. That is why, having a track circuit that complies with all the rules after all the tests are made, requires careful examination.

Mr. A. N. McKillop. As another to whom English is a foreign language, I would like to add my congratulations to M. Walter for his very interesting Paper.

There are two simple questions I would like to ask.

One I notice is that he does not have train describers. How does the signalman know what trains are coming up to him?

Secondly I notice that at Mouchard the signalman has the facility of pre-selecting up to four routes. M. Walter has said that there are something like 50 trains a day. As this equipment presumably costs quite a lot of money, I would like to ask what the signalman does with the time that is given to him after he has pre-selected the route?

M. Walter. We have no train describer, but the operator knows all the trains that run on the territory under his control. Not only on the Mouchard Line, but on all the lines in France he follows in trains by telephone. That is one of the things he has to do still even after he has sent his control for the route. Very often he has to telephone, or to receive orders by telephone. Besides, the whole section from Dôle to Vallorbe will be equipped with C.T.C. giving preselection of several routes. Train describers are very complicated and costly instruments. Our operating department has not found them necessary and is still intending to go on with information given by simpler means.

Mr. L. G. Smaldon. One point I am quite clear on. The Author says he has had to have frequencies for adjacent track circuits to prevent one track failing on another. It is comparatively simple in our Region. We just stagger adjacent track circuits so that if the blockjoint fails the next track would fail. There must be something more in it than meets the eye.

M. Walter. The idea is that if there are joints that are short circuited, the receiver picks up the current of the transmitter of the next track circuit; if it is not a frequency in accordance with its own frequency, the relay will fail. Considering the different uses that may occur in stations, we use four different frequencies—five when possible in some cases.

Mr. Dell. Mr. President, several speakers have described the difference in principle adopted on British Railways from those described by M. Walter, and I feel I must say how much the principles that we adopt on London Transport agree with those that M. Walter has described.

He set out several principles, for example the use of pushbuttons and one pushbutton operation to clear the route. That is the principle we employ. He set out the principle that for clearer observation of the diagram it should be separate from the pushbutton panel. That is the principle we employ.

Similarly, he describes the advantages of pre-selection, and we have adopted pre-selection for many years, and would regard it as an essential to the quick operation of the signalling. I cannot say that we have taken the pre-selection to several following movements. Our pre-selection has been generally confined to the next movement only. I think that had we not adopted programme machines, we should probab.y have gone to several stages of pre-selection, but the programme machine steps over that feature and takes us on to the whole programme being set for the day. That supersedes pre-selection.

I think M. Walter might be interested also to know that we have adopted the facing point lock which he has on the French Railways. We have now quite a number of them in use, and are employing that lock in preference to the old type for all our new installations.

Finally, I should like to say that I look forward with great interest to the time when the programme machines are adopted, as M. Walter described, to see whether they are anything like ours.

M. Walter. I am grateful to Mr. Dell for the very interesting information he has given, which show indeed a great similarity between many installations of the London Transport and those of the S.N.C.F.

The President. I am sure that everyone who went to France on this year's Convention will appreciate the amount of work M. Walter put in to make the visit the success it was.

He has now prepared a paper and answered the discussion in our language. I should like therefore to propose a very warm vote of thanks to him which I shall be glad if members will support in the usual manner.

M. Walter. Mr. President, gentlemen, I am grateful to you for that vote of thanks and for all the comments that were given by several of you tonight.

I must say that I have learned very much, because I did not know many of the studies and problems raised in this country, and mentioned by the different members. Even if the solutions are sometimes different, I think it is very useful to see how we have been at work on both sides. The comments have shown also the importance given here to these questions which concern a large part of signalling techniques, and I am very thankful to you for all the help you have given me tonight.

WRITTEN COMMUNICATION FROM MR. O. S. NOCK

I was one of those who had the pleasure of attending the Summer Convention in France, and later in the summer I had occasion to make a number of further journeys in France over routes equipped with signalling of the latest type; the experience of these journeys brought home to me one very big point. In the midst of the many technical problems that beset us from day to day I feel we are sometimes apt to overlook the point that after the provision of the utmost safety in travel the prime function of modern signalling is to provide a tool as powerful and effective as the motive power itself for running the train. In France today the train running is superb. After our visit to France last May I do not think that any of our party returned with any doubt that the signalling itself was most excellent. From the experience of everyday travel on some of the busiest main lines in that country it is evident that very effective use is being made of the installations that M. Walter and his staff have provided.

The extent to which fast and heavy traffic is run with an almost complete absence of signal checks is remarkable, and so far as density is concerned one has only to study the timetable of the South Eastern Region for example, for the period from 7 p.m. onwards leaving the Gare de Lyon in Paris, to realise what is achieved night after night, seven days a week.

I rather hoped that M. Walter would have said something in his paper about the use of C.T.C. on the main line between Les Laumes and Dijon where provision is made for reversible road working on the steeply graded section over Blaisy Bas summit. I would like to know to what extent the reversible road feature is used. In my own journeys over this particular route, all of which were made in the day time, it appeared that normal up and down road working was in progress, but I believe there are periods during the night when most of the traffic is in one direction only and that the timetable is arranged to avoid any trains running in the opposite direction during those periods of very heavy traffic. I would like to know how far this is actually carried out. It is of course very important to appreciate that with C.T.C., and with the controller constantly in possesion of the overall picture of the train running throughout the area, for changes to be quickly organised to meet a sudden, or special demands. Everything seems to move so smoothly and with such a total absence of check on the French main lines today that one begins to wonder if they do get situations in which rapid improvising is needed.

M. Walter replied as follows:

In my paper, I have not described our C.T.C. of Dijon - Blaisy, because it is not a recent installation, being more than ten years old.

The reversible road is used during the night and early morning. First the numerous trains leaving Paris in the evening take that road in the direction of Dijon. Some hours later, the trains due to arrive in Paris in the morning take that road in the direction of Paris. Besides, the reversible road on one track or the other gives great facilities for the maintenance of the track and of the overhead equipment, these facilities being very precious on a line where trains are numerous and fast.

Of course, the possibility of the reversible road are also of a great advantage when a difficulty occurs with a train that comes to stop on that section of line. This has happened several times since the C.T.C. was in service.