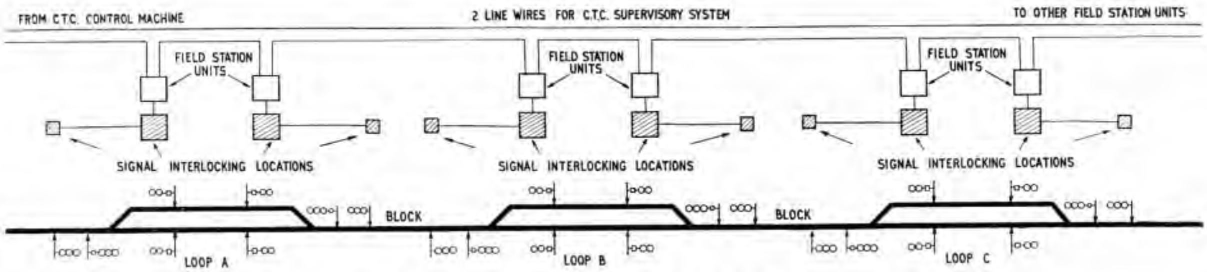

Fig. 1—Basic elements of a typical C.T.C. installation.

CENTRALISED TRAFFIC CONTROL

A new system using improved coding technique whereby all impulses are generated at the Control Point

By

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Centralised Traffic Control, or C.T.C. is a modern system for controlling the movement of trains by signal indication. It is usually applied to long stretches of single track with crossing loops, but may also be applied to sections having two or more tracks and wherever central control is required over long distances.

The basic elements may be considered in two parts :—

(*a*) Signals alongside the track, together with interlocking and all safety protective means, in accordance with accepted signalling principles. This interlocking is effected locally over the usual form of signalling relays.

(*b*) Supervisory equipment, comprising a control machine connected by a line pair to field-station units at local interlocking points alongside the track throughout the section, i.e. at stations and loops.

Fig. 1 illustrates diagrammatically a typical application of these basic elements.

Friday, September 28th 1951, saw the official inauguration of the first system in Africa, when the Prime Minister of Southern Rhodesia, Sir Godfrey Huggins, C.H., K.C.M.G., turned the switch on the C.T.C. panel in Bulawayo to authorise *No. 7 Down* train to proceed on its journey from Heany Junction some 16½ miles away At that time a stretch of 50 miles of track was brought into use but more recently this installation has been extended to control 93½ miles of track, the most distant point of which is some 110 miles from Bulawayo where the control machine is located. Fig. 2 is a plan of this installation showing stations and crossing loops with relation to the control point at Bulawayo. The country over this section of line is at an altitude of about 4000 feet—it is comparatively undeveloped and sparsely populated with a few European settlers in addition to some native habitations. This rail link however, forms part of the very important artery between Bulawayo and Salisbury, a link on which much of the country's development depends.

Before C.T.C. was introduced on this section trains were operated on the Telegraph Order

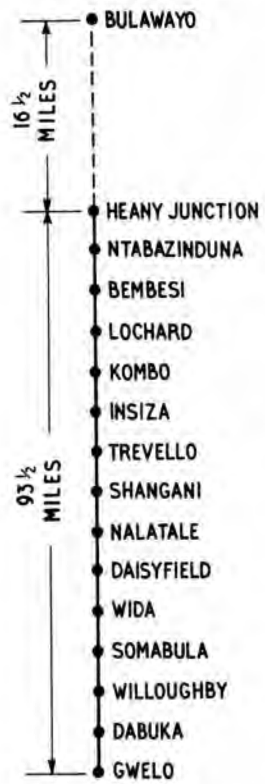


Fig. 2.—Station and siding plan of C.T.C. installation on Rhodesia Railways.

system, in which the movement of each train is planned ahead by authorised staff located at the more important stations. A paper order is given to the driver to authorise his progress and this order instructs him where he must cross trains in the conflicting direction, or be passed by others travelling in the same direction. Since an order is made out in advance and may provide for a distance of say 50 miles of track and many of the stations and crossing points are unmanned, it is inevitable that delays occur and that when one train is late others are affected, resulting in a general loss of time.

C.T.C. has been introduced with the object of removing these delays by keeping the waiting time at crossing points to a minimum and it is expected that it will be possible to handle a very much larger volume of traffic. To have provided this extra train capacity with other methods would have involved the provision of staff at many crossing sidings now unmanned, a very difficult and costly procedure. The use of C.T.C. has therefore avoided the necessity of meeting this problem of securing extra operating staff, whilst at the same time providing a more efficient solution to the problem. Another important factor is that the provision of fixed signals alongside the track, with electrical track circuits, makes for increased safety Further, operational experience of this C.T.C. installation has shown that the speeding-up of traffic movements has brought about a large saving in engine hours, which has a substantial economic value, particularly in a country where the watering of engines alone is a difficult and costly problem.

Before the description of this installation, a few general notes on the more important features of signalling are necessary

An electrical track circuit is used to determine whether a section of track is occupied or clear Fig. 3A illustrates the simple DC track circuit which is used on this installation. The two running rails are insulated from each other by the use of wood sleepers and the ends of the track circuit are insulated from the rest of the track with insulated rail joints. An electrical supply of about 0.6 volts, obtained from a primary cell, is connected across the rails at one end and a relay is connected across the rails at the distant end. In this way the relay is energised so long as the track circuit is clear.

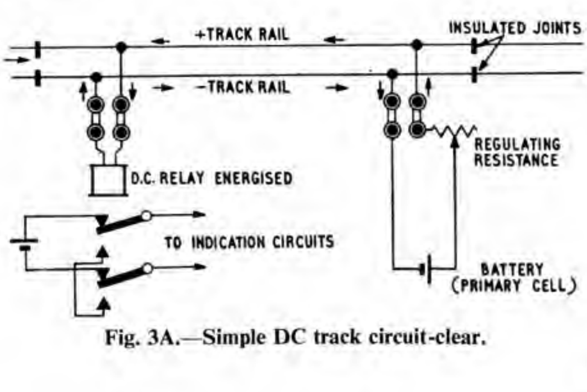


Fig. 3A.—Simple DC track circuit-clear.

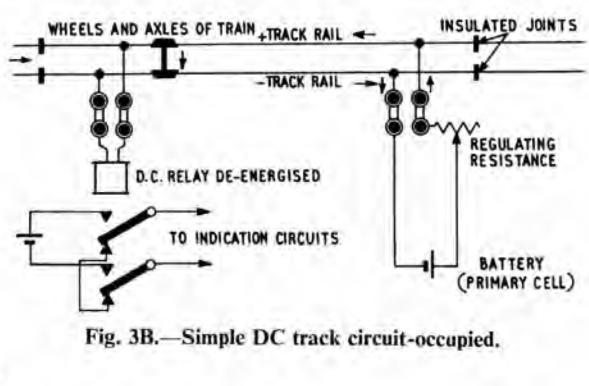


Fig. 3B.—Simple DC track circuit-occupied.

Fig. 3B shows the circuit condition when a train is on the track. The rails are now short-circuited through the wheels and axles of the train and this causes the relay to fall away and so indicate that the track is occupied. This form of track circuit will operate for a length of 1000 yards or more. Contacts from the track relay are connected in protective and interlocking circuits to provide the necessary signalling protection, e.g. before a signal can be released for a train to proceed, all track relays for the required distance ahead of the train are proved to be operated, indicating that the section is clear

A further essential is to prove that the track is correctly set. As general practice therefore, the tongues of all facing points are detected to ensure that they are in the correct position and points which are facing train movements are also locked, the bolt plunger being detected to prove that it is in the fully-locked position.

It is a basic requirement also that interlocking be provided to prevent signals being released for conflicting movements.

On this installation proving and interlocking is effected over relays housed alongside the track, a main location hut being provided near to points and signals at the ends of each loop and also at the Home signal some 630 yards out from the ends of the loop. Fig. 5 illustrates the interior of a typical main location hut which includes a field station unit alongside the interlocking relays. In

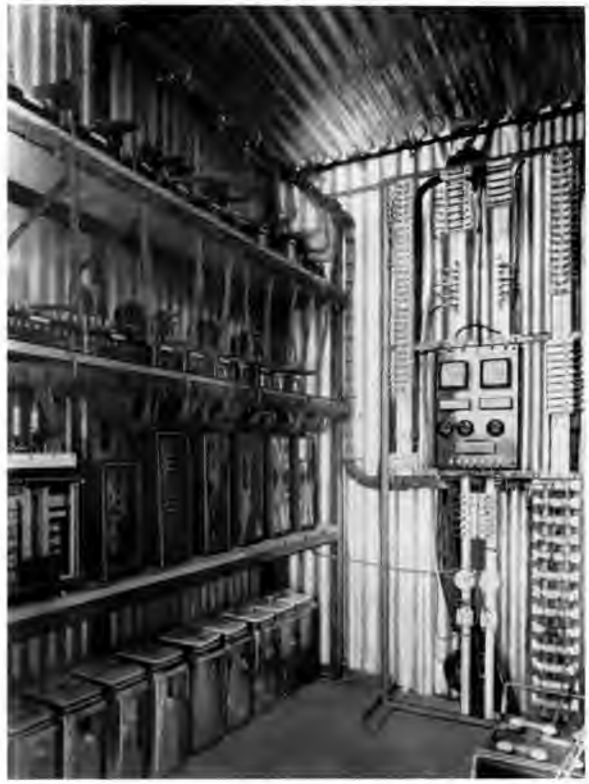


Fig. 5.—Interior of typical main location hut, showing field station unit and signal interlocking relays etc.

addition to these location housings, track feed cut sections are provided along the block track because its length is greater than the maximum length of one electrical track circuit, i.e. the block section may be as long as 10 miles and thus track circuits are sited with a relay and battery feed at about every 1000 yds.

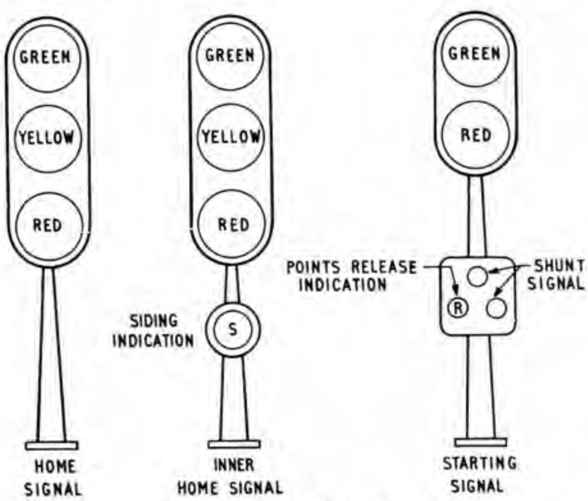


Fig. 4.—Types of signals.

It is a special feature of this installation that the block track is fed directionally, i.e. to travel from A to B, the C.T.C. supervisory connects a battery feed across the rails at B and a relay at A, and if the relay is then energised the block section is proved to be clear If travelling from B to A, a battery feed is connected across the rails at A and a relay at B. This use of directional track circuits introduces an economy of line wires.

Signals for Drivers

Fig. 4 illustrates the signals used, the main aspects of which are of the Colourlight type, a powerful colourlight beam being projected from a 24-watt lamp through a doublet lens combination, the indication being so powerful that it can readily be seen in bright sunlight. The signals are approach lighted, i.e. they are normally out and only light up when a train is approaching—this control is effected over the track-circuit relays.

Fig. 6 illustrates the layout of signals alongside the track at a standard station or crossing siding, an approaching train passing in turn a warning board, home signal and an inner home signal before reaching the starting signal for the next block section.

Proceed Through on Main Line.

Fig. 7A, shows the signals to instruct a driver to pass straight through on the main line , signals 1, 3 and 5A will all be at green.

Stop at Station on Main Line.

Fig. 7B. If a train is to stop at the station on the main line, signal 1 will be at green, signal 3 at yellow (warning the driver to stop at the next signal) and signal 5A at red.

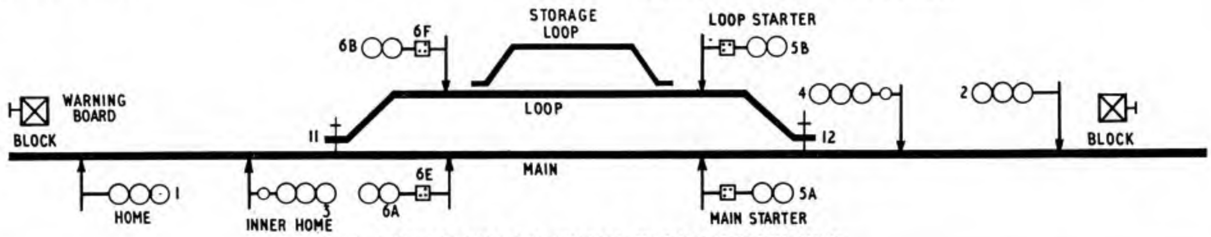


FIG 6 LAYOUT OF SIGNALS AT STANDARD STATION OR CROSSING SIDING

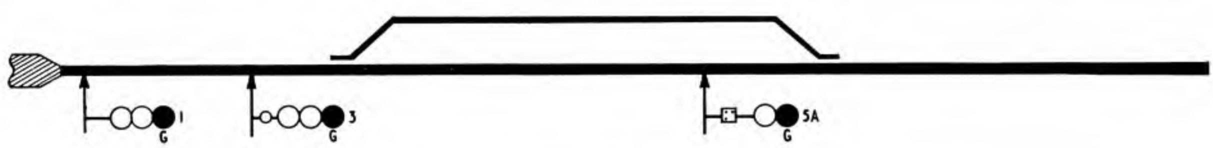


FIG 7(A) PROCEED THROUGH ON MAIN LINE

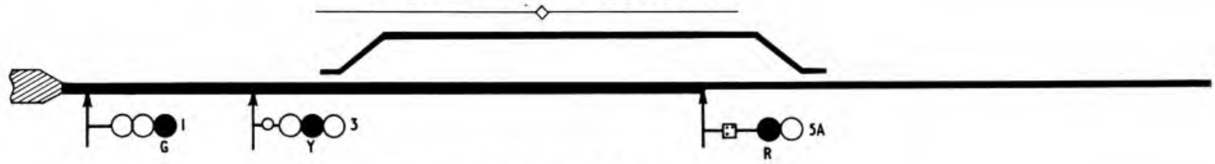


FIG 7(B) STOP AT STATION ON MAIN LINE

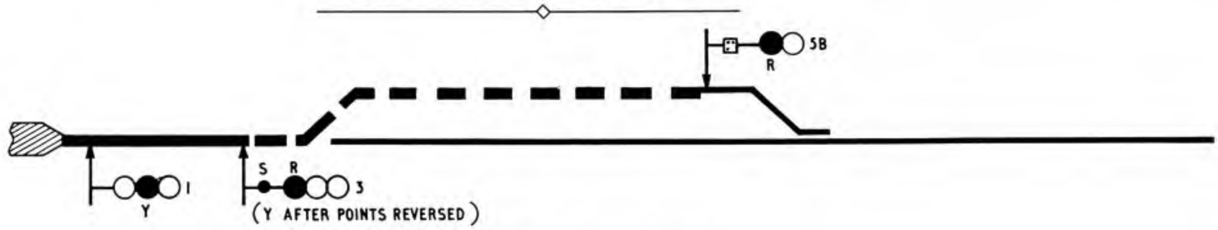


FIG 7(C) STOP AT STATION ON LOOP LINE

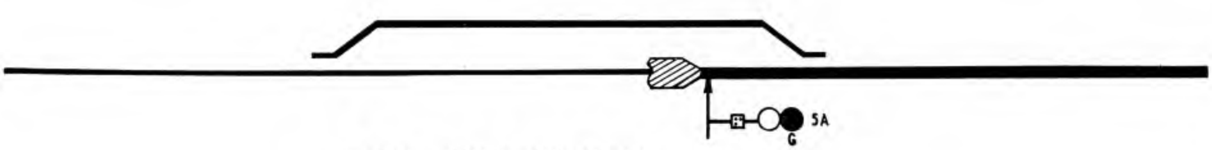


FIG 7 (D) STARTING FROM MAIN LINE.

Stop at Station on Loop Line.

Fig. 7C shows the signals for a train to take the loop. Signal 1 will be at yellow and signal 3 at red with an *S* sign illuminated below This tells the driver that he is to take the siding, that the points are released and that his fireman must get down from the engine and reverse the points by operating the hand lever When this operation has been completed signal 3 will change to yellow and the train may proceed into the loop. After the train has moved completely into the loop the guard will re-set the points for the main line. Under normal conditions important trains carrying mail and passengers use the main line, the inferior trains being diverted into the loop , thus little delay due to hand operation of the points occurs to the more important trains except perhaps when they cross each other The system can readily provide for the power operation of points, but for economy provision was not made for this facility

Starting from Main Line.

Fig. 7D shows the starting signal *Off* for a train to leave from the main line through the block to the next siding.

Starting from Loop Line.

For starting from the loop line into the block, the driver first sees an *R* sign in the corner of the shunt signal, below red on the loop starting signal, indicating that the points are released , his fireman then goes forward and reverses the points, Fig. 8. The *R* sign is then extinguished and the signal changes from red to green which permits the train to proceed into the block section.

Shunting Moves.

Shunting movements from the main and loop lines are controlled by shunt signals of the position light type. These are signals which give the *Off* indication by showing two white lights diagonally, an arrangement considered safer than using a small green light which might be confused with a main aspect. When a shunt move is to be made it is necessary to obtain a release of the points ahead from the controller, the procedure being for the trainman to ask for the release over the telephone, advising the movements to be made and the expected time required. If the release is given it is indicated by an *R* aspect appearing in the

Fig. 8.—Operation of main-line points at end of loop.

corner of the shunt signal. Fig. 9 illustrates a locomotive proceeding forward for a shunt move from the main line to the storage loop off the loop line.

Supervisory Equipment

The C.T.C. Supervisory Equipment is a recent development and is based on many years experience with supervisory control systems. It is a fully comprehensive system using an improved coding technique whereby all impulses are generated at the control machine, a feature which makes for consistently good impulsing, as well as maintaining economy in battery requirements.

Control Machine

Fig. 10 shows the C.T.C. Control Machine in operation at Bulawayo , a controller and an assistant checking controller are seen operating the panel.

A miniature diagram of the whole length of track controlled from the machine is mounted at the top of its front face and is divided into sections to repeat each track circuit. A luminous indication bearing the appropriate track reference is caused

Fig. 9.—Locomotive moving forward for a shunt move from the main line.

to glow whenever a track circuit is occupied, and in this way the controller can readily see the position of all trains in the section at any time.

Below this diagram are mounted small key switches for operating signals and for releasing points at the ends of the loops. Adjacent to these switches are luminous indications which show the actual condition of the functions as repeated back from the trackside. Train movements to and from the end of each particular loop on the diagram are controlled by the switches mounted immediately below, control operations being made effective by first setting the switches to the required position and then depressing the *start* key at the bottom of the panel. This sends the required code of electrical impulses to the appropriate field station.

Fig. 10.—Control machine in operation at Bulawayo.

Fig. 11 shows a close-up view of part of the operating panel , the points-release key with its indications is at the top of each panel section, and two signal keys for main and shunt movements are mounted below

The main signal switches combine the functions of setting direction as well as operating a signal , they are turned to the left for *Up* direction movements and to the right for *Down* direction movements. Considering the signal switch for the left-hand end of a loop, when turned to the left the main or loop starting signal for the block is released, depending upon the setting of the points, and when turned to the right the home and inner home signals are released , that is, *request* releases are sent to the field station unit which will only result in the signal showing *proceed* if the signal interlocking permits.

Indications are repeated back from the track automatically as changes occur, so that the controller can always see the conditions of track circuits, points and signals throughout the section. It is also a facility that depression of a *start* key at any time will effect a check of indications on its associated panel. Points have *normal* and *reverse* indications. A central *replacement light* is also provided which glows when the points have been reversed and restored , the key on the panel should then be replaced to normal.

A common *red* indication is provided over the centre of each main signal switch and when this glows it indicates that all the signals at the loop end are at *stop*. A *green* indication is provided each side of the key, one for each direction of movement, and when the key is turned for a particular direction of operation and the *start* key depressed, the lighting up of the *green* lamp indicates that the signal is off.

For shunt signals a common *red* indication only is provided.

The control machine illustrated has sufficient capacity to operate 35 field-station units, each of which contains 8 control and 10 indication functions , the system however, can accommodate a larger capacity These functions are applied to the requirements of the layout concerned and may be used individually or collectively

Fig. 11.—Close up of part of control-machine operating panel at Bulawayo.

SCHEDULE (a) CONTROL AND INDICATIONS CODED BETWEEN CONTROL MACHINE AND FIELD STATIONS

Control No.	Function	Indication No.	Function
1	*Up* direction	1	*Up* block Track occupied
2	*Down* direction	2	A track ,,
3	1/3/6 signal	3	B track ,,
4	6E signal	4	C track ,,
5	6F signal	5	1/3/6/ signal *On*
6	Points release	6	6 A/B Signal reversed
		7	1/3 Signal reversed
		8	6E/F Normal
		9	11 Points normal
		10	11 Points reversed

Schedule (a) on the previous page shows the application of typical control and indication functions, and schedule (b) (page 15) the key operations made for typical traffic movements. Fig. 6 shows the signal numbers to which reference is made.

Control Machine Construction.

To keep the reach required of the operator to a minimum the machine is constructed with a central bay and side wings, a desk shelf is included for the convenience of operation.

Control relays, other than for line impulsing, are of the British Post Office 3000 type and are mounted on standard plug-in plates, all of which are housed in the control machine. They are plugged-in from the rear of the machine and hinged gates give access to the rear of the keys and lamps on the panel. Fig. 12 illustrates a rear view of the machine.

Train Graph

It is the duty of the checking controller to plot the progress of all trains, as they proceed from siding to siding, on a train graph. This makes for efficient handling of train movements as it enables the controller to estimate the progress of trains relative to each other It also serves as a record and reference in case of failure when emergency train orders may be necessary

As an adjunct to this hand-made graph, an automatic train graph recorder is provided for check and record purposes. Fig. 13 illustrates the unit with its cover removed. Two pens are provided for each siding and whenever a train enters or leaves a siding the appropriate pen is caused to deflect. The chart moves at a regular rate in accordance with a clockwork time base and by joining up indentations made by the pens as each loop is passed by a train an effective time/distance graph is obtained.

Field-Station Units

The supervisory link between the control machine and the signal equipment along the track side comprises a pilot line pair connected to field-station units which are housed in the main signal locations throughout the section.

Instructions are sent from the control machine to the track side and indications of local conditions are sent back from the track side to the control machine via these field-station units.

Fig. 14 illustrates a typical field-station unit, which consists of an assembly of relays in a case fitted with a detachable top on which are mounted terminals suitable for connexions to the signalling equipment. Each field-station unit has its own particular identifying code, and it is a feature that the code of each individual unit is determined by link-strapping on the top plate of the unit, this strapping forming part of the permanent wiring. Since the assembly of relays in its case is

Fig. 12.—Rear view of control machine at Bulawayo.

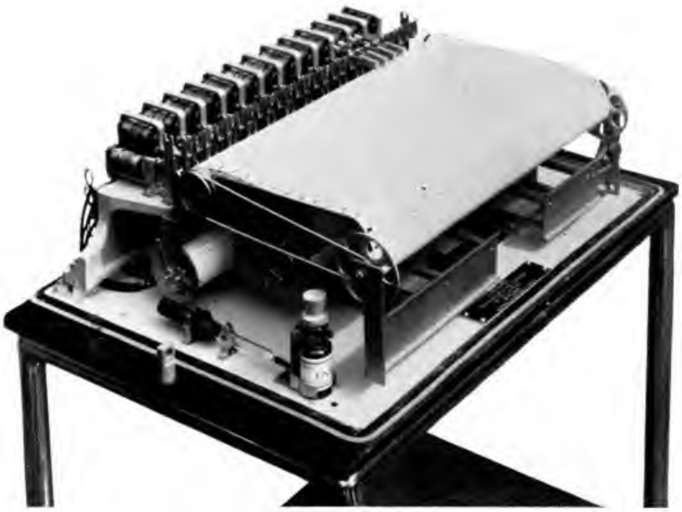


Fig. 13.—Automatic train graph recorder with cover removed.

readily detachable from this top plate, the relay assembly is common for all field-station units. This facility permits a unit to be replaced in a few seconds, an important feature should a unit have to be removed for normal service overhaul or become faulty

System of Coding

Field stations are selected and identified, and control and indication functions selected by the use of coded impulses, a different code being used for each condition.

The system employs a form of polarised impulsing, a fixed number of forward impulses being used, which are each separated by either an open period or a reverse impulse, specific codes being distinguished by the position of these open periods and reverse impulses. Considering the selection of field stations, with eight forward impulses, five reverse impulses and three open periods, thirty-five different identifying codes are obtained. Thus, from one control machine employing this particular form of coding up to 35 field stations can be operated.

Two code cycles are used (Fig. 15) one for controls from the control machine to field stations and the other for indications from field stations to the control machine. The control cycle first selects the field station required and then the

Fig. 14.—Typical field-station unit.

functions to be operated. For the indication cycle the field station is first identified and then the condition of functions being indicated.

It is a unique and patented feature of the system that the field stations do not generate any impluses for coding to the control machine, each field station registering its codes and indications by modulating the impulse form as sent out from the control machine.

The advantage of this arrangement is that supply for line impulsing has only to be provided at the control machine , further the characteristics of the impulsing are determined at this point. The supply required for each field station is 24 volts DC, which provides for the operation of the local relays in the unit.

Line Wires between Control Machine and Field Stations, etc.

A limited number of line wires run alongside the track for communication purposes and two of these wires have been made available throughout the section as a line pair for the C.T.C. Supervisory, i.e. this pair runs from the control machine and is looped in series connexion to polarised relays in each field-station unit.

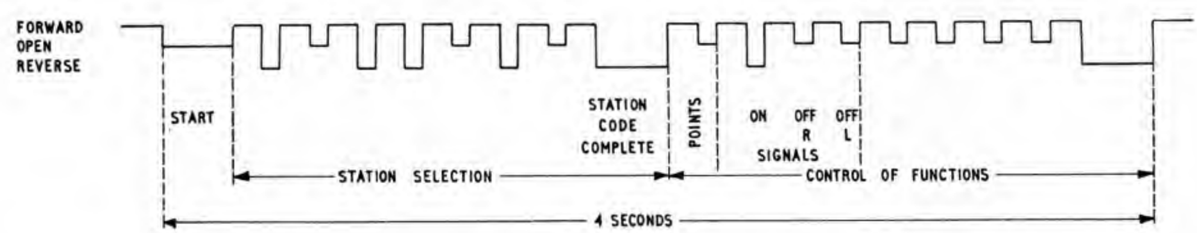
A special feature of the installation is that automatic sectionalising of lines is provided at selected sidings. Should a line become disconnected then it will be automatically sectionalised on the control machine side of the fault and the system will operate up to this point.

Telephones are provided at the ends of each loop and adjacent to each home signal. Should a driver receive a *red* signal for an undue length of time then he can communicate with control over one of these telephones. A separate line-wire pair is allocated for this purpose so that should a fault occur on the supervisory lines this means of communication would still be available. Regulations permit a procedure which allows a special train order authority to be issued by the controller to authorise the driver to pass a signal at danger should this be necessary under fault conditions. The procedure to issue this authority is specified in detail and is rigidly observed, in order to avoid any misunderstanding.

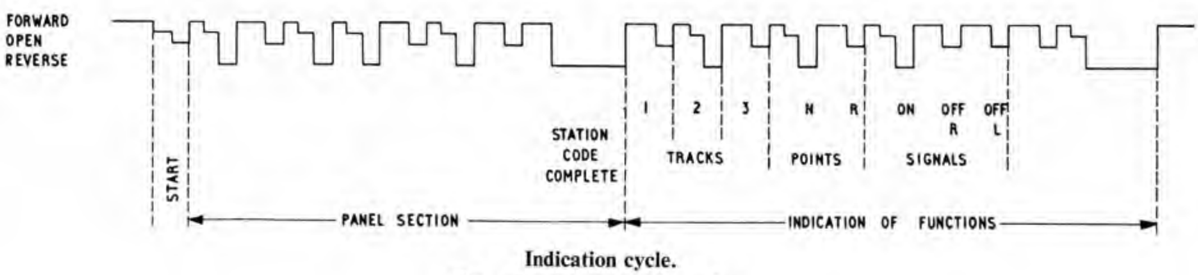
Test Equipment

A special test unit, as illustrated in Fig. 16, is located at the control point near to the control machine.

Field-station units brought in from the track side may be plugged into this unit and all functions checked.



Control cycle.



Indication cycle.

Fig. 15.—Typical code cycles.

Relay sets from the control machine may also be plugged into the test unit and each function checked step-by-step.

A further facility is that the test unit may be connected directly to the C.T.C. lines and arranged to operate specific field-station units, i.e. by setting up the appropriate field-station code and then checking through the controls etc.

The Siemens and General Electric Railway Signal Company Limited, who are the associated G.E.C. Company specialising in all Railway and Road Signalling business, are the principals dealing with C.T.C. Equipment. The supervisory part of the system was developed and manufactured at Coventry to S.G.E. requirements.

Fig. 16.—Special universal test unit.

SCHEDULE (b) CONTROL MACHINE OPERATIONS FOR TRAFFIC MOVEMENTS

MOVEMENT	SIGNAL AND POINTS REQUIRED	CONTROL MACHINE SWITCH OPERATION	CONTROLS SENT
Up—from main track to block	Starting signal 6A *off* with points 11 normal	Signal switch turned to left, points key normal. Push *start* key	1 + 3
Up—from loop track to block	Starting signal 6B *off* with points 11 reversed.	Signal switch turned to left, points key reversed. Push *start* key	1 + 3 + 6
(Signal off after points reversed by hand.)			
Down—from block to main track	Home and inner home signals *off* with points 11 normal.	Signal switch turned to right, points key normal. Push *start* key	2 + 3
Down—from block to loop track	Home and inner home signals *off* with points 11 reversed.	Signal switch turned to right, points key reversed. Push *start* key	2 + 3 + 6
(Inner home signal *off* after points reversed by hand).			