British Rail

Chief Signal and Telecommunications Engineers Department

N Wilson Northallerton

BASIC ELECTRICAL SIGNALLING COURSE

Training School YORK

Eastern Region

British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools,
York & Ilford.

Ref. B.E.S./1.1
- 1 JAN 1983

Course. Basic Electrical Signalling

Subject. The Need for A Signalling System

WHY SIGNALLING is NECESSARY

Signalling may be broadly defined as the whole of the methods and means by which traffic movements are controlled, encompassing not only points and signals, but also the block system, interlocking and all other associated equipment.

The essential purposes of a railway signalling system are:

a) To maintain a safe distance between following trains on the same track.
b) To safeguard the movement of trains at junctions, and when crossing a path which could be taken by another.
c) To regulate the passage of trains according to the service density and speed required.

It is also a fundamental requirement that in the event of equipment failure, the safety of trains must be ensured.

In other words, SIGNALLING IS NECESSARY FOR THE SAFE AND EFFICIENT WORKING OF TRAFFIC

It can now be appreciated that TRAFFIC SPEED AND DENSITY ARE THE FACTORS WHICH RENDER A SIGNALLING SYSTEM NECESSARY AND DETERMINE ITS SALIENT FEATURES
This is emphasized because, in order to obtain a clear conception of the actual means required to control traffic movements, it is essential to bear in mind the traffic conditions obtaining. This makes it clear why the signalling arrangements say, at a busy London terminal like Kings Cross, are so much more elaborate than those required, say, on a branch line.

There are four links in the signalling system, viz., the driver, the signal, the signalman, and the equipment which ensures the integrity of signalling - (the block system and interlocking). Signals are provided to be obeyed by the driver and they convey to him the instructions of the signalman. The block and interlocking system ensures the safe application of the signalmans decisions.

THE DEVELOPMENT OF RAILWAY SIGNALLING

British Railways are generally acknowledged to have one of the most modern and well equipped signalling systems in the world. However, in order to appreciate the present system, it is necessary to understand its evolution from its early beginnings in the mid nineteenth century.

In the early days of railways, signalling was non existant, in fact it was not until well after the opening of the Liverpool and Manchester Railway in 1830 that any attempt was made to provide fixed form of signals to govern the movement of traffic.

The gradual increase in the number of trains however, and the building of branch lines, made some better form of control essential in order to protect trains standing at stations and to regulate their movement at junctions. Further, the "time interval" system of working then coming into use, necessitated some positive indication being given to the driver of a train of the time that had elapsed since the train ahead of him had left.

The signals were given by "policemen", each policeman having two signal flags, one red and the other white, the white flag being displayed when the train could proceed.

Fig. 1 shows a print of a policemen. It is interesting to note that, even today signalmen are still sometimes called "Bobby", the name being derived from the policemen of the early railways.

Fig. 2 shows a print of a train being stopped by "policemen" because of an obstruction on the line. (Obviously before Section M of the rule book was introduced).

About 1837, Edward Woods, the engineer of the Liverpool and Manchester Railway introduced a form of signal. It consisted of a target fixed to the top of a post, which could be turned parallel to the track when the line was clear and across the track when it was blocked.
Fig. 3 shows a print of this early signal.

In 1841, a development of the utmost importance occurred. The engineer of the London and Croydon Railway, C.H. Greory, erected the first railway semaphore signal.
Fig. 4 shows a print of a railway semaphore signal.

While fixed signals met, to a limited extent, the requirements for ordinary running movements, the increase in the number of points and crossings and the increase in speed and density of traffic led eventually to the development of the interlocking frame, where levers controlling points and signals were interlocked to ensure safe working.

Accidents of a serious nature, arising from points being moved while trains were passing over them, led to the development of the Facing Point Lock Bar and Plunger. The bar, long enough to bridge the longest wheelbase, had to be thrown over from one position to the other before the points could be moved. If a wheel was over the bar, it prevented the bar from being thrown. The application of these devices made facing points safe, thus greatly improving traffic working.

The development of points and signals continued, first by the use of Electro-Pneumatic systems, and later, with improvements in electric motors, all electric motor machines were used.

The Block System evolved from the telegraph instruments patented by Cooke and Wheatstone in 1837.

The system was founded on the idea of Maintaining an Interval of 'Space' Between Following Trains instead of merely an interval of 'Time'. Many accidents had occurred due to the inadequacy of the 'time interval' system to cope with increasing speed and density of traffic.

The Block Section is the distance between one signalbox's last stop signal and the advance signalbox's first stop signal. The Absolute Block System only allows one train in the block section at any one time.

Another innovation which had important consequences for railway signalling was the 'Track Circuit', whereby rails could be used for signalling purposes by the provision of insulated joints electrically isolating the length concerned. The first really practical application of the track circuit in England was at Kings Cross in 1893/94.

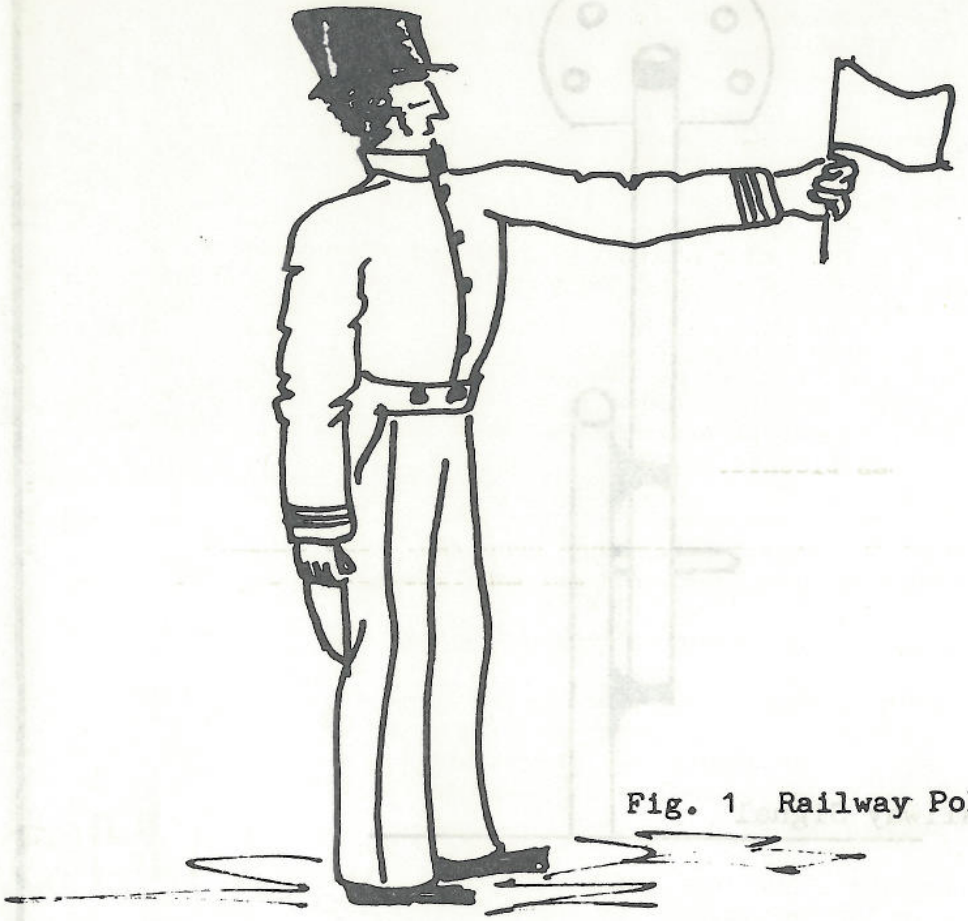

Fig. 1 Railway Policeman

Fig. 2 Obstruction On The Line

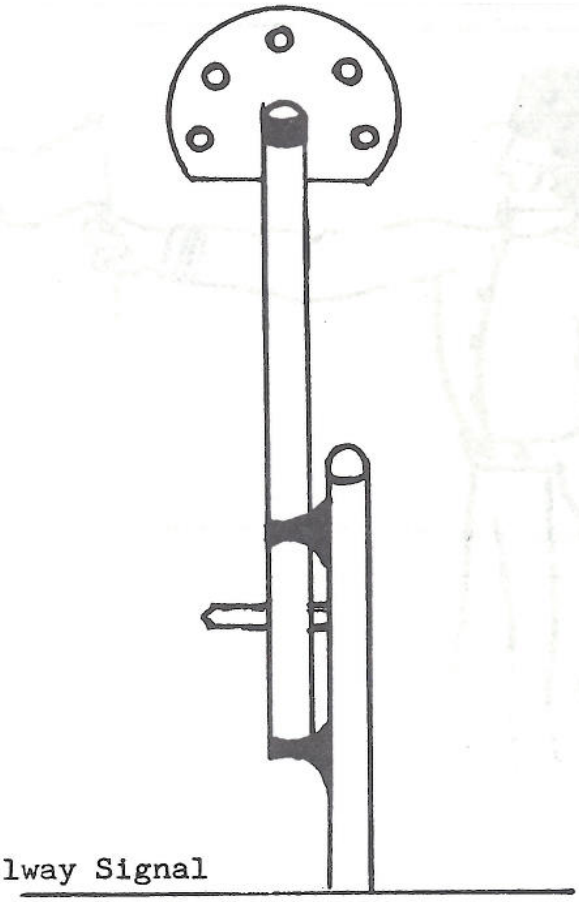

Fig. 3 First Railway Signal

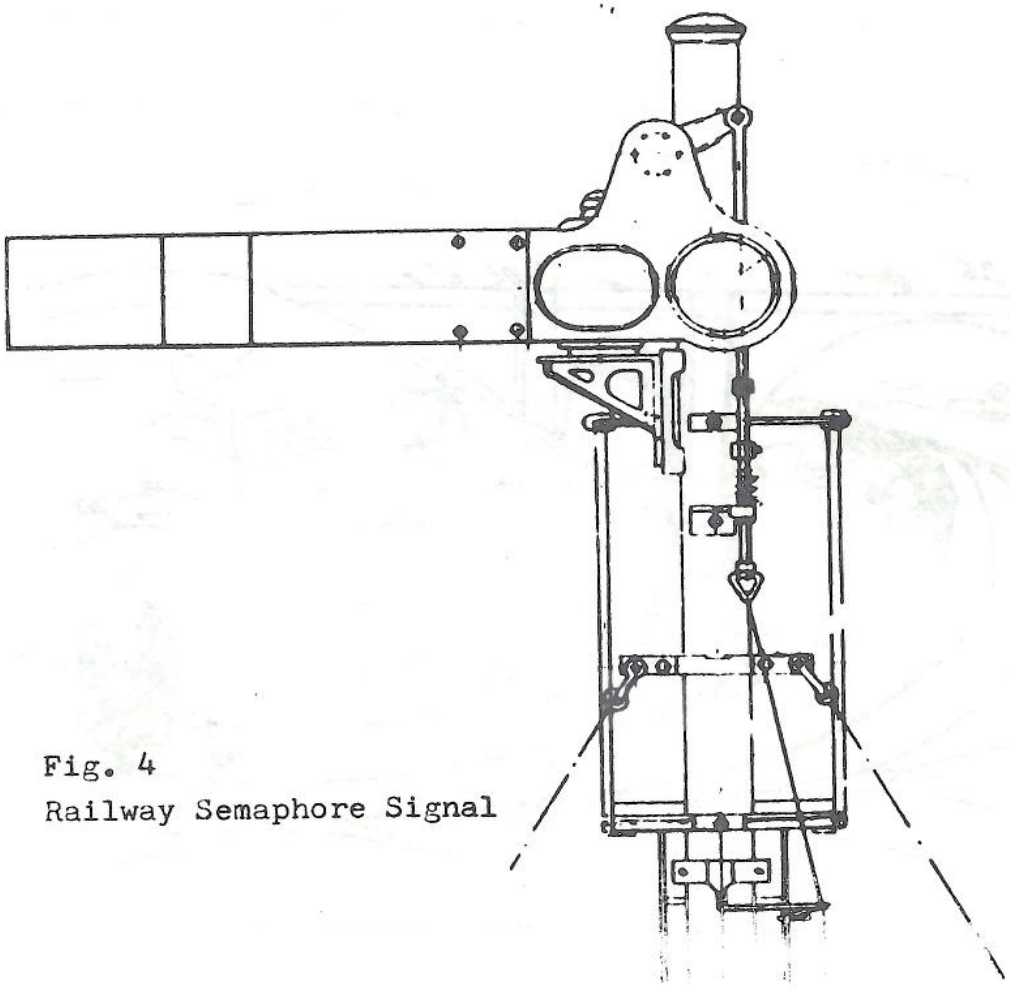

Fig. 4
Railway Semaphore Signal

With the development of the power operated (semaphore) signal and the track circuit, the way was clear for the general introduction of fully automatic signalling.

The development of precision-filament electric lamps promoted the use of colour light signals. Colour Lights are more efficient than semaphore signals, particularly in conditions of poor visibility. They are also very flexible in application, being essential where multiple aspects are required, since each signal, when not showing 'Red', can be made to give an indication of the aspect of the signal (or signals) ahead.

It can now be appreciated that the present railway signalling system has evolved as a result of a number of factors:

1) The growing complexity of the railway network
2) The increasing speed and density of traffic
3) The continual search for technological innovation
4) The demand for the efficient control of traffic
5) The underlying necessity for safety and for 'fail safe' equipment.

SIGNALLING TODAY

From its inception, the main function of signalling has been to safeguard traffic movements, and practically every development and improvement in the apparatus employed has had this object in view. It is becoming increasingly apparent however, that with the aid of modern equipment and techniques, signalling can now be arranged to function in other directions in addition to that of safe working.

The signalling system can materially assist in effecting economies in operating costs and also in increasing the carrying, and therefore the earning capacity of the railway. What might at first sight appear strange is that signalling schemes designed to increase operating efficiency and thus reduce costs, usually afford greater security than the system displaced. The functions of modern signalling are to safeguard traffic movements and also to keep Traffic Moving.

Let us now look at some of the aspects of signalling today.

THE BLOCK SECTION AND SIGNALLING

When discussing the Absolute Block System, it will be noted that only one train could approach a signal box on each pair of rails, thus the number of signalboxes was dependent upon the number of block sections required. It can be seen that such a signalling system does not function to the best advantage.

The old system of block working is rapidly being replaced by Multiple Aspect Colour Light Signalling (M.A.S.), with associated Track Circuit Block. It is a very simple system so far as the driver is concerned, and has been found capable of coping successfully with the wide range of speeds, varying braking rates and headway between following trains.

Fig. 5 shows the elements of the system which may be 2-, 3- or 4- aspect according to traffic needs.

AUTOMATIC WARNING SYSTEM (A.W.S.)

Associated with the lineside signalling is an automatic warning system termed A.W.S. which supervises the drivers reaction to caution aspects and indicates to him the passing of a clear aspect. It is advisory and leaves the regulation of the train speed in the hands of the driver for the most part, but causes a brake application to be made automatically if he fails to react when approaching a restrictive aspect.

A.W.S. functions by inductive action between magnetic inductors in the track and a pick-up on the locomotive, giving the driver an audible and visual indication of the state of the signals.

INTERLOCKING

Mechanical interlocking frames have considerable limitations, the capacity of the installation being limited not only by physical size, but also by the time taken by the signalman in making the necessary movements, these restraints have led to the development of Relay Interlockings where the levers have been replaced by switches and push buttons which are generally incorporated in the signalling console itself, having the same relative positions thereon as the functions have on the actual layout.

The switches and push buttons control relays which are electrically interlocked and are the real controllers of the working and take the place of the lever from an engineering point of view.

It will readily be appreciated that relay interlocking enables a considerable reduction in the time of operation and thus increases the efficiency of the installation.

The type of relay interlocking now generally adopted by British Railways is the N.X. system. The setting up of a route is accomplished by pushing a button at the entrance of the route and then pressing a button at the exit of the route. The apparatus itself then automatically performs all the necessary operations to set up the route and clear the relevant signal. This results in considerable simplification of the panel and its operation from the signalman's point of view. The designation "N.X." given to the equipment is derived from the two words eNtrance - eXit.

TRAIN DESCRIBERS

With relay interlocking installations, high class train describer equipment is essential. The indications displayed move across the panel with the progress of the train concerned, so enabling the signalman to follow it from signal to signal in the area of his control. The display is automatically transmitted from signal box to signal box as the train proceeds along the line.

REMOTE CONTROL OF INTERLOCKING

A method of controlling geographically remote interlockings by conventional means, such as by standard lineside cable, would make the costs of many installations prohibitive.

The majority of remote control systems are used as non-vital links between a signalmans console and remote interlockings.

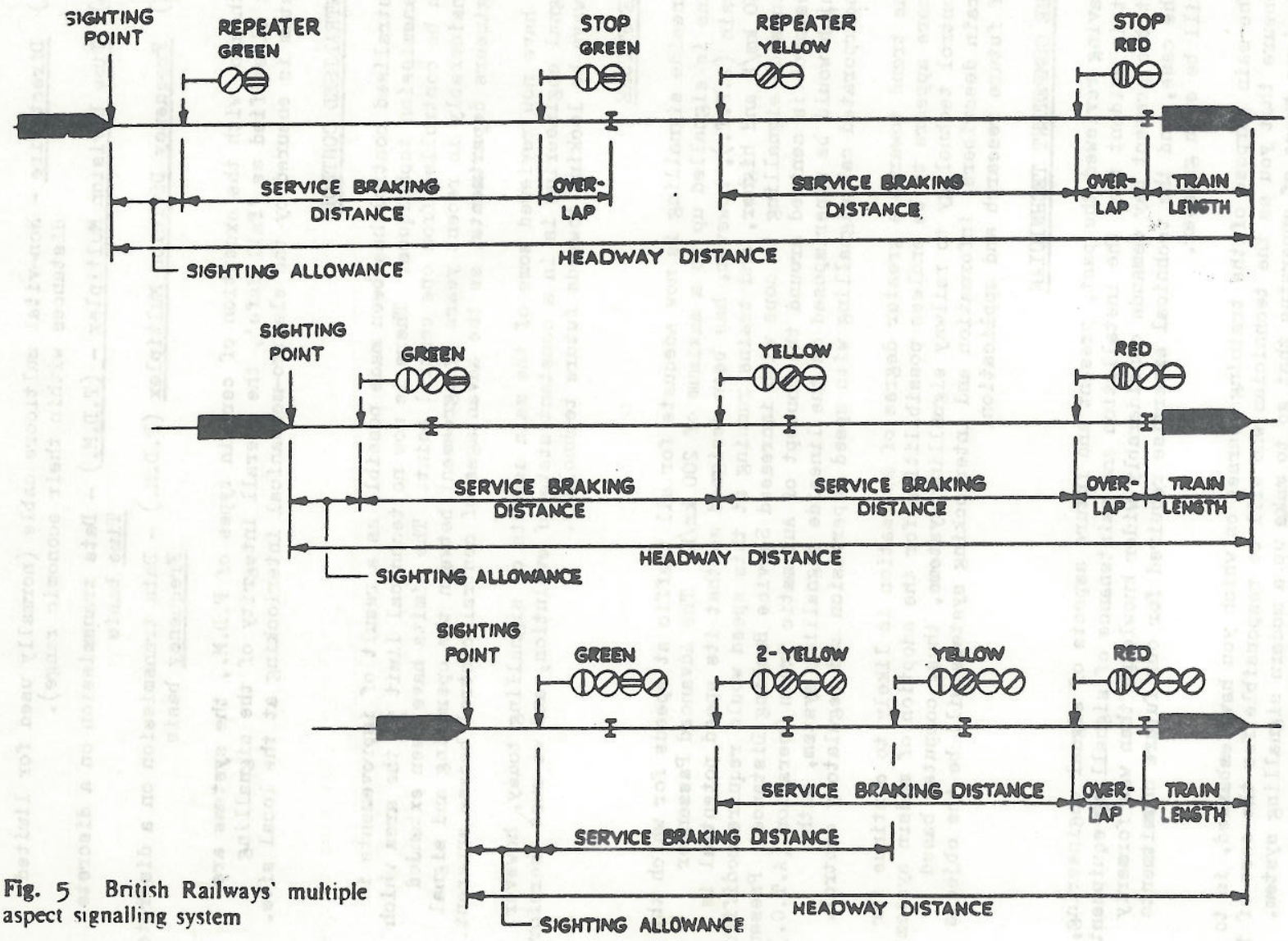

Fig. 5 British Railways' multiple aspect signalling system

There are three categories into which remote control systems fall, each being used for a particular set of circumstances. These are:

a) Direct Wire - Non-vital multicore cable (normally used for limited distances within their economic range).

b) Time Division Multiplex - (T.D.M.) - Data transmission on a discrete Time basis

c) Frequency Division Multiplex (F.D.M.) - Data transmission on a discrete Frequency basis

Although, with the exception of certain types of F.D.M., the systems are not classified as 'Fail Safe', the overall integrity of the signalling system is ensured by the electro-mechanical interlocking at the local site.

CENTRALISED CONTROL

Centralised control has been made possible as a result of improvements in transmission techniques. There is now no technical limit to the area which can be controlled from one central point. The limits have been extended considerably in recent years by agreement between the operating and signal engineers departments, as the advantages of central control became apparent.

We have now reviewed some of the main aspects of signalling today, however, signal engineering is in a constant state of evolution, and we must therefore always be looking towards future technology.

THE FUTURE

Lineside signalling is now adequate for all traffic at speeds for which the line is signalled up to a maximum of 200 km/h. The Advanced Passenger Train (A.P.T.), however, has been designed so that its speed potential is 250 km/h and higher, and trains running at this speed would require modified lineside signalling to cope with increased Service Braking Distance. Present research is centred around the concept of Automatic Train Operation (A.T.O.), which would be superimposed on the lineside signalling system, with incorporated cab signalling with speed supervision and regulatory control.

The trend towards a greater degree of automation is likely to continue for there appears to be endless possibilities for the adoption of modern system control technology to railway signalling systems, thus, computer based train describers, information and interlocking systems will be the objects of future research and application.

THE COMPETENT TECHNICIAN

Having reviewed the past, present and future aspects of signal engineering, it is evident that the installation and maintenance of signalling equipment at the present day demands considerably wider knowledge than was formerly the case, and the technical expertise required for our future commitments will be even greater.

The main purpose of the training courses on which you have embarked, is to ensure that you as the technician who will be responsible for the care of the various types of apparatus that go to make up a modern signalling system, possess a sound understanding of the principles underlying your work. OF THE TECHNICIAN'S RESPONSIBILITIES, THE MOST IMPORTANT IS TO MAINTAIN THE EQUIPMENT IN SUCH A STATE THAT IT MAY BE RELIED UPON TO FUNCTION SAFELY AND CORRECTLY AT ALL TIMES.

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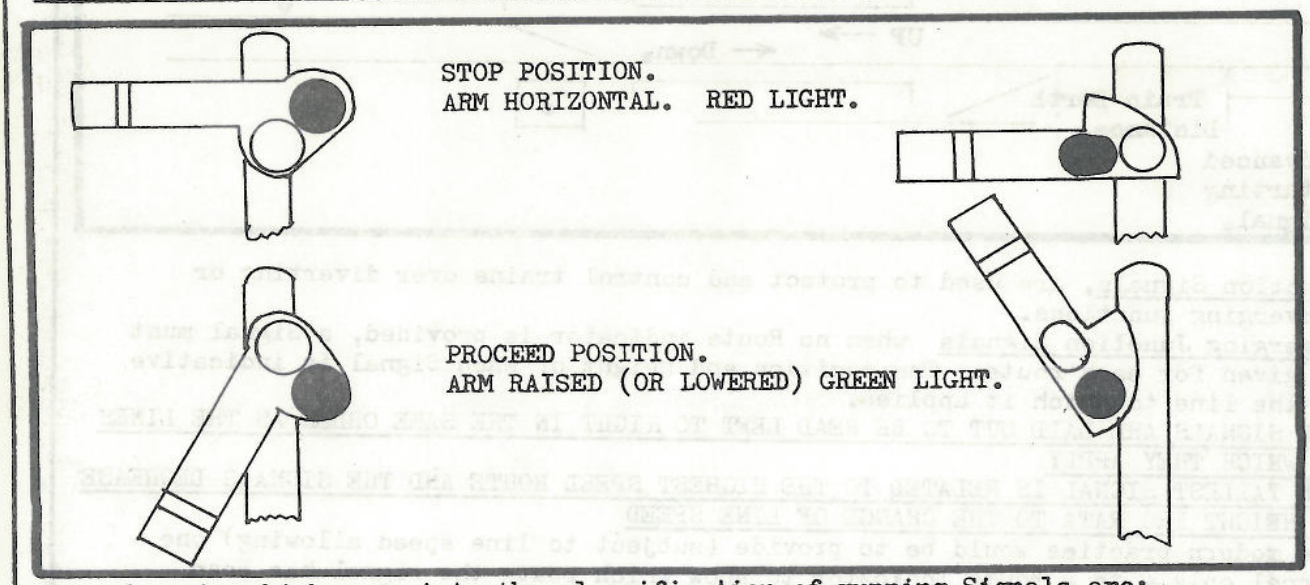
Course. BASIC ELECTRICAL SIGNALLING

Subject. Principles of Signalling and Signalling Layout.

As explained in Lecture 1. Any concentrated railway system requires a Signalling system to control the movement of the Trains.

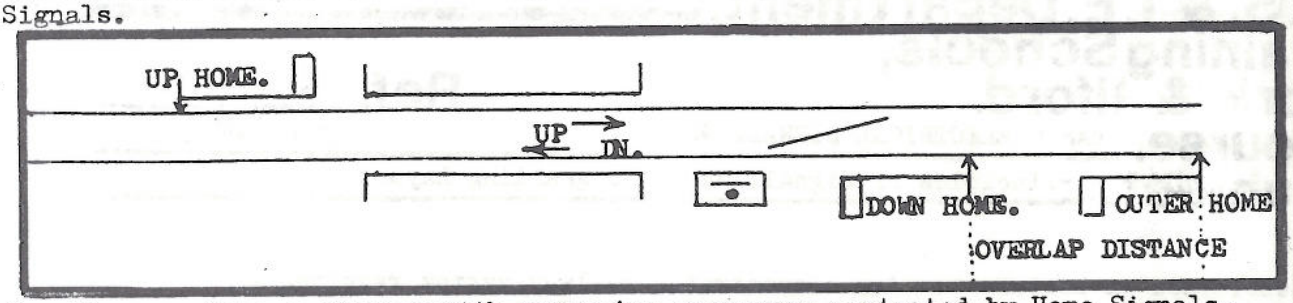
'RUNNING SIGNALS'.
RUNNING SIGNALS ARE SIGNALS WHICH CONTROL THE MOVEMENT OF TRAINS ALONG THROUGH LINES OR ROUTES. The term is used to differentiate between Signals read by through trains and those used for shunting movements.
Running Signals are divided into two main types STOP SIGNALS, DISTANT SIGNALS

'STOP SIGNALS'
Stop Signals are used to bring a train to a halt. They can be of two main types.
SEMAPHORE SIGNALS COLOUR LIGHT SIGNALS
SEMAPHORE SIGNALS ARE DIVIDED INTO TWO TYPES. UPPER QUADRANT AND LOWER QUADRANT. The standard is upper quadrant type.
WHEN THE ARM IS HORIZONTAL IT IS IN THE ON OR STOP POSITION
WHEN THE ARM IS RAISED (OR LOWERED) THE SIGNAL IS IN THE PROCEED POSITION.
BY NIGHT THE STOP ASPECT OF THE SIGNAL IS A RED LIGHT AND THE PROCEED ASPECT OF THE SIGNAL IS A GREEN LIGHT.
WHEN THE SIGNAL IS IN THE ON OR STOP POSITION ITS MEANING TO THE DRIVER IS:- STOP AT THE SIGNAL.
WHEN THE SIGNAL IS LOWERED OR IN THE OFF OR PROCEED POSITION ITS MEANING TO THE DRIVER IS:- PROCEED TO THE NEXT STOP SIGNAL
THE FACE OF ALL STOP SIGNALS ARMS ARE RED WITH A WHITE VERTICAL STRIPE

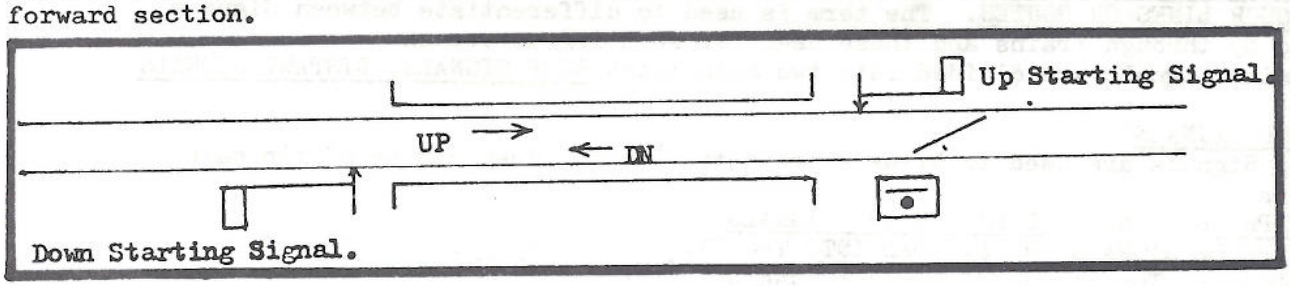


Stop Signals which come into the classification of running Signals are:-
HOME, STARTING, AND ADVANCED STARTING SIGNALS.
'HOME SIGNALS' are provided to protect a Station or Junction and where no Starting Signal is provided, control the entrance to the next Block Section. The position of a Home Signal will be determined in relation to such factors as, Sighting Gradient, Fouling point.
When a Home Signal is positioned an Overlap Distance in the rear of a second Home Signal or from a Fouling Point, it may be classed as an Outer Home Signal. In such cases special Block regulations apply.

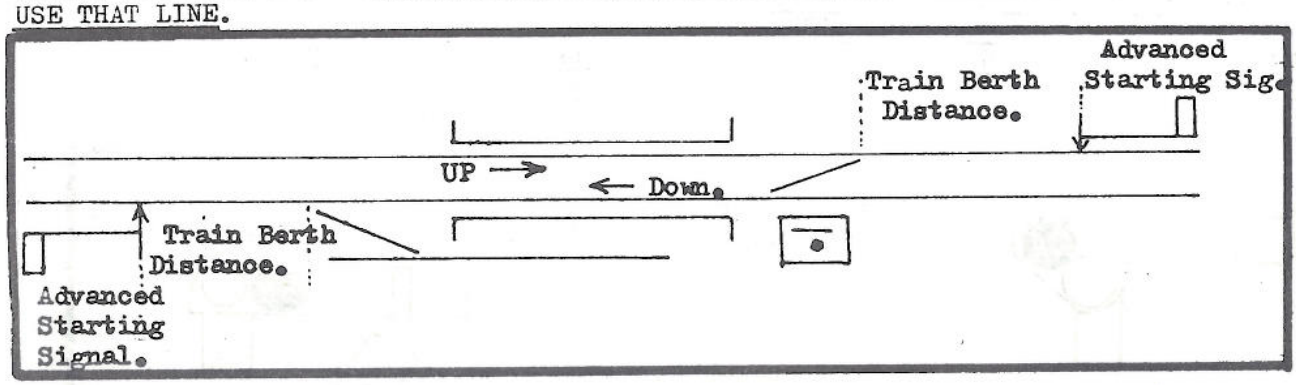
The following Diagram shows the application of Home Signals and Outer Home Signals.



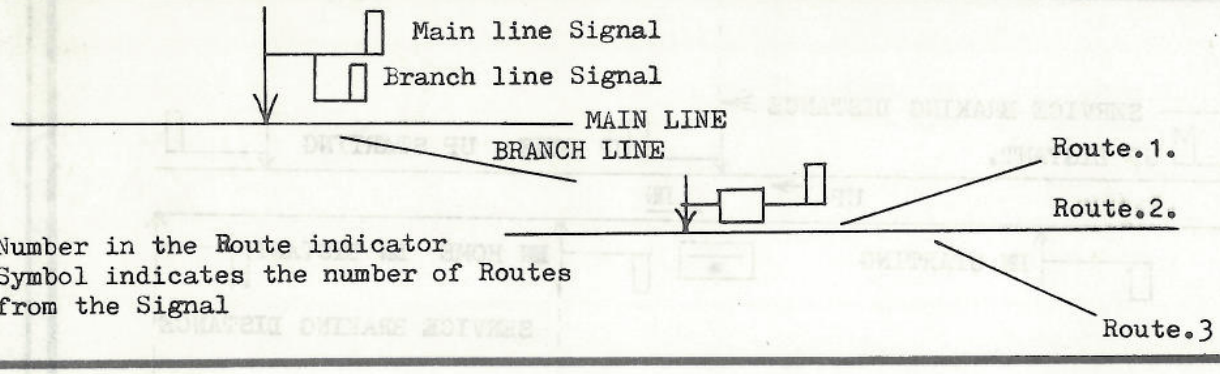
The Diagram shows a Station with reversing crossover protected by Home Signals. An example is also shown of the provision of an Outer Home on the down line. 'STARTING SIGNALS', are provided to authorise movement from a Station. When no Advanced Starting Signal is provided they will also control entrance into the forward section.



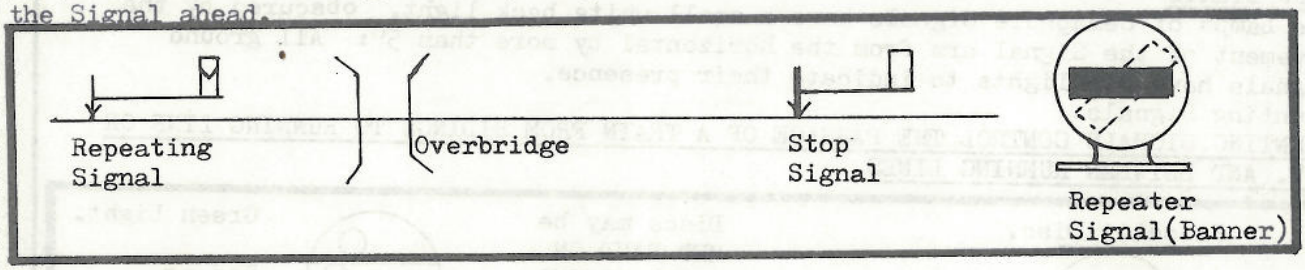
'ADVANCED STARTING SIGNALS', enable shunting movements to be made within their protection, they also allow trains to be held pending their acceptance by the forward Signal box. The Diagram shows Advanced Starting Signals in use, it should be noted that a TRAIN BERTH IS THE LENGTH OF THE LONGEST TRAIN LIKELY TO USE THAT LINE.



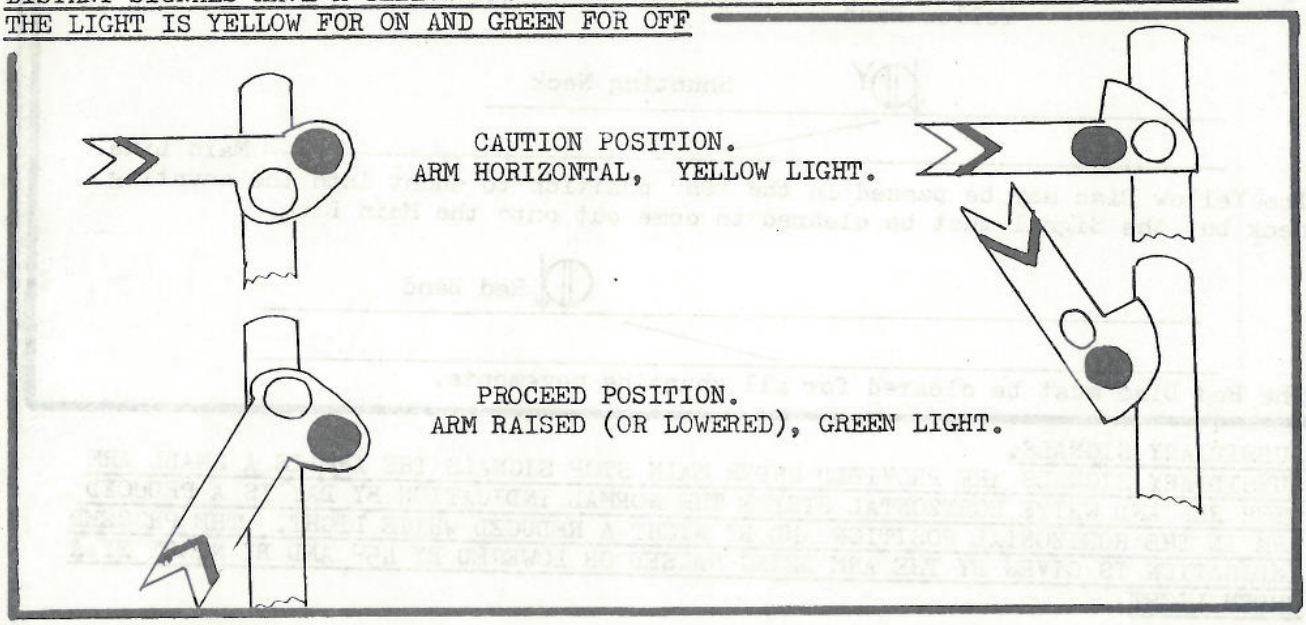
Junction Signals, are used to protect and control trains over diverting or converging junctions.
Diverging Junction Signals when no Route indicator is provided, a Signal must be given for each route. The position and height of each Signal is indicative of the line to which it applies.
THE SIGNALS ARE LAID OUT TO BE READ LEFT TO RIGHT IN THE SAME ORDER AS THE LINES TO WHICH THEY APPLY
THE TALLEST SIGNAL IS RELATED TO THE HIGHEST SPEED ROUTE AND THE SIGNALS DECREASE IN HEIGHT PRO RATA TO THE CHANGE OF LINE SPEED
The modern practice would be to provide (subject to line speed allowing) one Signal only with a route indicator to show which route the signal has been cleared for.

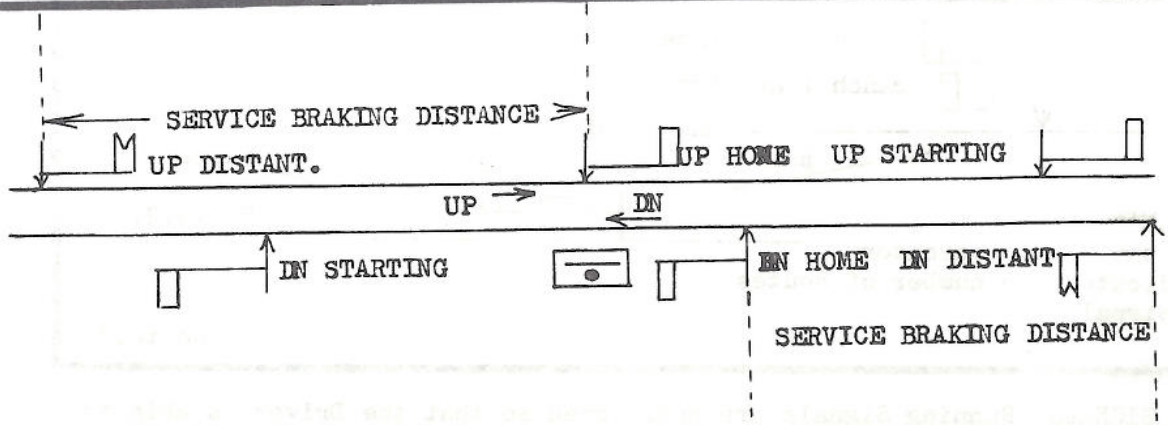


REPEATING SIGNALS Running Signals are positioned so that the Driver is able to "sight" them in sufficient time when approaching them. WHEN THE MAIN SIGNAL IS OBSCURED BY A BRIDGE OR STRUCTURE REPEATING SIGNALS ARE USED. They are not in themselves active Signals they only inform the Driver of the condition of the Signal ahead.



DISTANT SIGNALS
DISTANT SIGNALS ARE PROVIDED IN THE REAR OF STOP SIGNALS TO WHICH THEY APPLY.
DISTANT SIGNALS WARN THE DRIVER OF THE CONDITION OF THE STOP SIGNALS AHEAD.
WHEN THE ARM OF A DISTANT SIGNAL IS IN THE HORIZONTAL POSITION OR A YELLOW LIGHT IS SHOWING IT MEANS CAUTION, BE PREPARED TO STOP AT THE NEXT STOP SIGNAL
WHEN THE ARM IS LOWERED (OR RAISED) OR A GREEN LIGHT IS SHOWING IT MEANS, PROCEED EXPECTING TO FIND ALL SUCCESSIVE STOP SIGNALS CONTROLLED BY THE SAME BOX CLEAR
Distant Signals are provided in the rear of the Stop Signals to which they apply, THEY ARE POSITIONED AT THE SERVICE BRAKING DISTANCE IN THE REAR OF THE FIRST STOP SIGNAL TO WHICH THEY APPLY
Interlocking is provided to ensure that the Distant Signal cannot be cleared unless all the Stop Signals have been cleared.
DISTANT SIGNALS HAVE A YELLOW FISHTAILED END ARM WITH A BLACK CHEVRON, AT NIGHT THE LIGHT IS YELLOW FOR ON AND GREEN FOR OFF



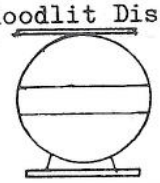


BACK LIGHTS

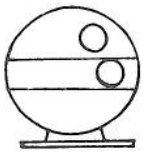
The Lamps of Semaphore Signals have a small white back light, obscured by the movement of the Signal arm from the horizontal by more than 5°: All ground Signals have Backlights to indicate their presence.

Shunting Signals.

SHUNTING SIGNALS CONTROL THE PASSAGE OF A TRAIN FROM SIDINGS TO RUNNING LINE OR V.V. AND BETWEEN RUNNING LINES



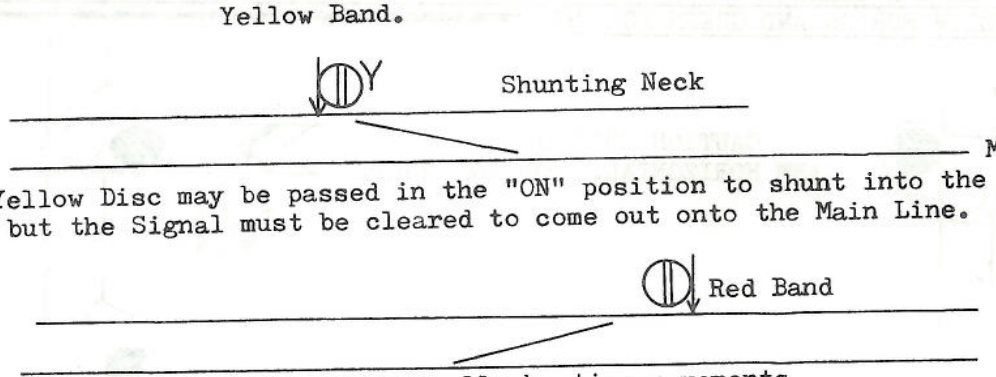
Discs may be
RED BAND ON
WHITE GROUND.
OR.
YELLOW BAND ON
BLACK GROUND



Green Light.

Red or
Yellow Light

SHUNTING SIGNALS MAY BE OF THE DISC OR FLOODLIT TYPE.
The Disc type has a RED BAND ON A WHITE GROUND WITH RED OR GREEN LIGHTS BY NIGHT or YELLOW BAND ON BLACK GROUND WITH YELLOW AND GREEN LIGHTS BY NIGHT
The band is in the Horizontal position for ON and is rotated through 45° for an OFF indication. WHEN CLEARED SHUNTING SIGNALS AUTHORISE THE DRIVER TO PROCEED AS FAR AS THE LINE IS CLEAR, BUT NOT TO PASS ANY SIGNAL AT DANGER
SHUNTING SIGNALS WITH A YELLOW BAND MAY BE PASSED WITHOUT BEING CLEARED FOR THE MOVEMENTS FOR WHICH THE SIGNAL WHEN CLEARED DOES NOT APPLY



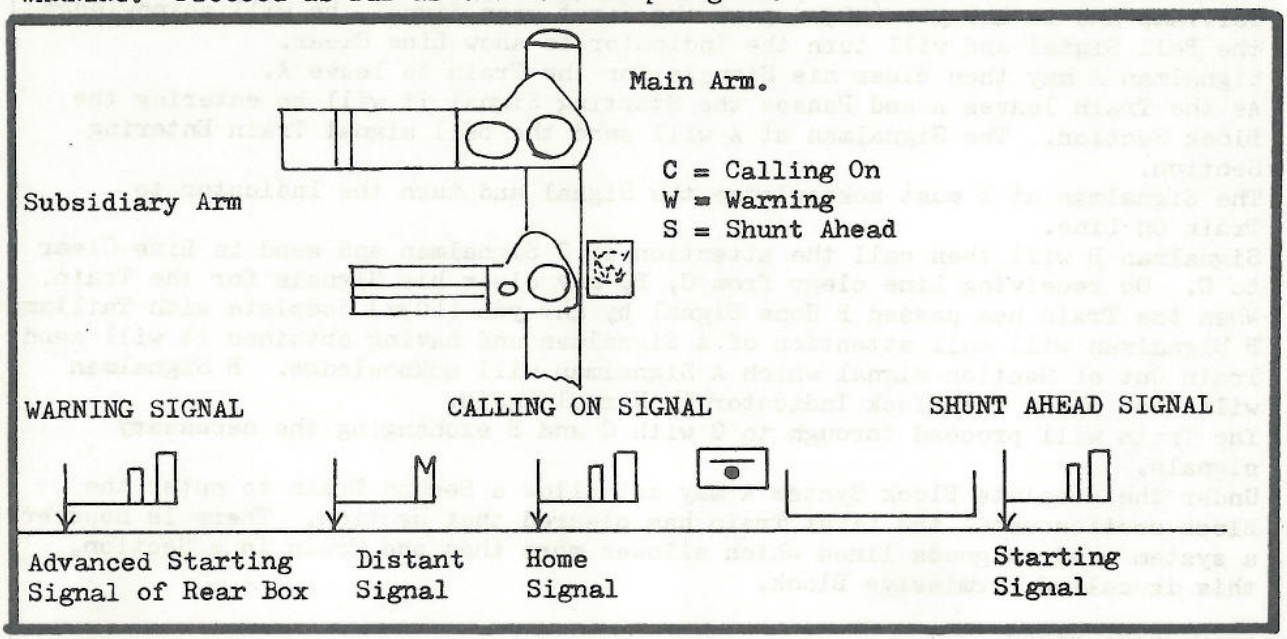
The Yellow Disc may be passed in the "ON" position to shunt into the shunting neck but the Signal must be cleared to come out onto the Main Line.

The Red Disc must be cleared for all shunting movements.

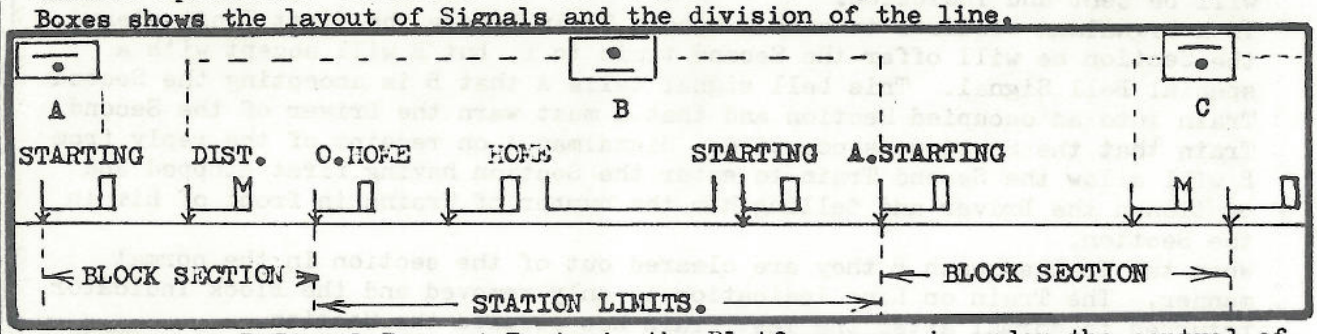
SUBSIDIARY SIGNALS.
SUBSIDIARY SIGNALS ARE PROVIDED UNDER MAIN STOP SIGNALS THE ARM IS A SMALL ARM WITH RED AND WHITE HORIZONTAL STRIPE THE NORMAL INDICATION BY DAY IS A REDUCED ARM IN THE HORIZONTAL POSITION AND BY NIGHT A REDUCED WHITE LIGHT. THE PROCEED INDICATION IS GIVEN BY THE ARM BEING RAISED OR LOWERED BY 45° AND BY NIGHT BY A GREEN LIGHT

Subsidiary Signals come under three main types.
CALLING ON. WARNING. SHUNT AHEAD

CALLING ON. The line towards the next Stop Signal is occupied, proceed cautiously prepared to stop short of any obstruction but do not pass any other signal at Danger.
SHUNT AHEAD. Proceed for shunting purposes only but do not pass any other danger Signal. Return behind the Signal before proceeding.
WARNING. Proceed as far as the next Stop Signal.



BLOCK WORKING
One of the main functions of a Signalling System is to ensure an adequate space interval between Trains on any one Line. The Block Signalling System is designed to work in conjunction with the Fixed Signals required for the purpose of Traffic Operation. Reference to the Diagram of a simple layout of three Signal Boxes shows the layout of Signals and the division of the line.



Referring to B Signal Box. A Train in the Platform area is under the control of B Signalman. It is protected in the rear by the Home and Outer Home Signals and can be held by the Starting or Advanced Starting Signals.
THIS SECTION OF LINE FROM THE FIRST STOP SIGNAL OF A SIGNALBOX TO THE LAST STOP SIGNAL OF THE SAME SIGNALBOX IS CALLED THE STATION LIMITS
If consideration is given to the section of line from A Starting Signal to B Outer Home Signal, it will be seen that:- A controls the entrance to the section but B controls the exit from the section. If accidents are to be avoided there must be communication between the two Signalmen over the operation of Trains in this Section. The communication system is called the Block Signalling System and the section of line is called the Block Section.
THE BLOCK SECTION IS THE SECTION OF LINE FROM THE LAST STOP SIGNAL OF THE BOX IN THE REAR TO THE FIRST STOP SIGNAL OF THE BOX IN ADVANCE

THE BLOCK SIGNALLING SYSTEM ENSURES AN ADEQUATE SPACE INTERVAL BETWEEN TRAINS

THE ABSOLUTE BLOCK SYSTEM IS TO PREVENT MORE THAN ONE TRAIN BEING IN ANY ONE BLOCK SECTION ON THE SAME LINE AT THE SAME TIME

MODE OF SIGNALLING BY ABSOLUTE BLOCK

The large diagram shows the layout of Signals and the Block instruments. With no Train in the section the Indicators will be showing Normal.
Prior to the dispatch of a Train from A the Signalman there must call attention of B and having obtained it send Is line clear signal. If B is sure that the line is clear i.e. the last train has come through the section complete with Taillamp and is 440 yds (403m) past the First stop Signal, he will acknowledge the Bell Signal and will turn the Indicator to show Line Clear.
Signalman A may then clear his Signals for the Train to leave A.
As the Train leaves A and Passes the Starting Signal it will be entering the Block Section. The Signalman at A will send the bell signal Train Entering Section.
The Signalman at B must acknowledge the Signal and turn the Indicator to Train On Line.
Signalman B will then call the attention of C Signalman and send is Line Clear to C. On receiving Line clear from C, B, may clear his Signals for the Train.
When the Train has passed B Home Signal by 440 yds (403m) complete with Taillamp B Signalman will call attention of A Signalman and having obtained it will send Train Out of Section signal which A Signalman will acknowledge. B Signalman will then place the Block Indicator to Normal again.
The Train will proceed through to C with C and B exchanging the necessary signals.
Under the Absolute Block System A may not allow a Second Train to enter the Block section until the first Train has cleared that section. There is however a system used on goods lines which allowes more than one Train in a Section, this is called Permissive Block.

PERMISSIVE BLOCK

UNDER PERMISSIVE BLOCK WORKING THE SIGNALMAN MAY ALLOW MORE THAN ONE TRAIN TO BE IN A BLOCK SECTION AT THE SAME TIME

With permissive working the Signalman at A offers the Train in the normal way for the First Train and that Train will enter the section and Train on Line will be sent and indicated.
If A Signalman requires to send a Second Train before the first Train clears the Section he will offer the Second train to B, but B will accept with a special Bell Signal. This bell signal tells A that B is accepting the Second Train into an occupied Section and that A must warn the Driver of the Second Train that the Section is occupied. Signalman A on receipt of the reply from B will allow the Second Train to enter the Section having first stopped and cautioned the Driver and telling him the number of Trains in front of him in the Section.
When the Trains reach B they are cleared out of the section in the normal manner. The Train on Line Indication is only removed and the Block Indicator returned to Normal after the last Train has cleared the Section.

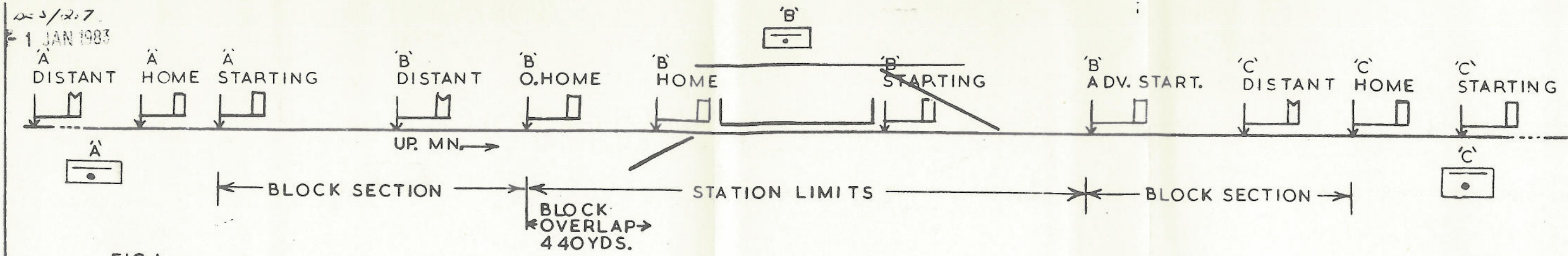
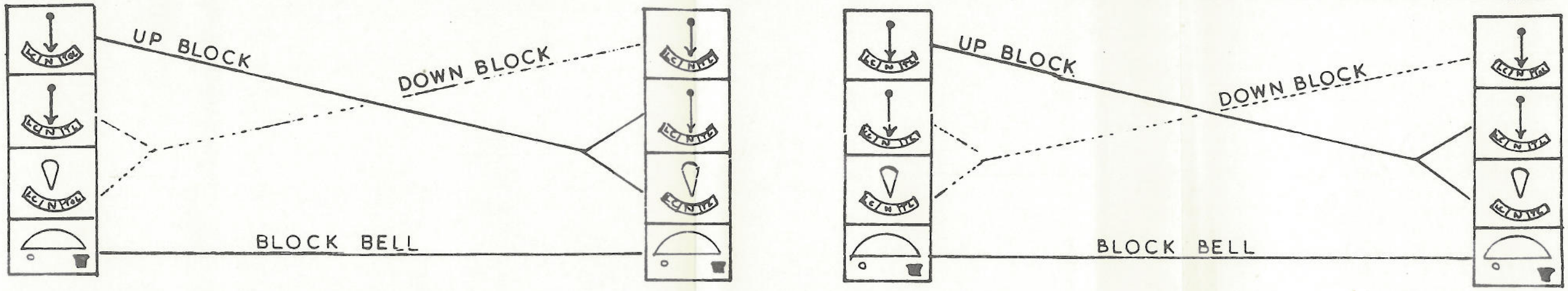


FIG.1.



CALL ATTENTION →
← ACKNOWLEDGE
SEND IS LINE CLEAR →
← ACCEPT & PEG L.C.
SEND TRAIN ENTERING SECTION →
(WHEN TRAIN LEAVES)
ACKNOWLEDGE &
← PEG T.O.L.

CALL ATTENTION →
← ACKNOWLEDGE
SEND IS LINE CLEAR →
← ACCEPT & PEG L.C.
CLEAR SIGNALS
← CALL ATTENTION
ACKNOWLEDGE →
SEND TRAIN OUT OF SECTION
← & PEG. N. (WHEN TRAIN PASSES CLEARANCE POINT)
ACKNOWLEDGE →
SEND TRAIN ENTERING SECTION →

FIG.2

P14A

C S & T E DEPT.
TRAINING SCHOOL.
YORK.

REF. B.M.S.3/1
- 1 JAN 1983

COURSE. Basic Electrical Signalling.

SUBJECT. Mechanical Interlocking

Interlocking - often referred to simply as locking - may be defined as a means of ensuring that certain levers shall not be able to be moved when other levers are in certain given positions depending on circumstances. This may be accomplished by mechanical or electrical means. The object of interlocking may be defined as follows:-

1. To ensure that the Signalman shall be unable to clear a fixed signal until all points are correctly set.

2. To prevent two conflicting Signals being cleared at one time.

3. To prevent the moving of any points until the protecting Signal is at Danger.

LEVER FRAMES

When the signalling of a layout has been agreed upon by all departments concerned, the next step is to determine the best method of numbering the layout and it is important that the numbering should be so arranged that:-

1. The Signalman does not have to pull or put back a lever between two adjacent levers which are in the reverse position (the reason being to give the Signalman a free and uninterrupted pull on the lever concerned).

2. Shunting signals are numbered so as to be positioned in close proximity to their relative point levers. This not only enables the Signalman to control shunting movements with a minimum of walking but also reduces complications of the locking mechanism.

3. Depending on the arrangement of the layout, it is desirable for various reasons, to consider the merits of placing the shunting signals at either end of the frame with main running signals in the centre or to number the levers so that running signals are at either end and shunting signals in the centre.

PREPARATION OF TABLES

To enable the Locking mechanism to be designed it is first necessary to compile a Locking Table. The Locking Table will give details of the locking required for each lever in respect of any other levers which may affect it, i.e.

a. What levers are required to be Pulled prior to pulling the lever concerned.

b. Having pulled the lever, which other levers will be locked by the pulling of that lever.

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PREPARATION OF TABLES Cont'd.

There are several styles of locking table in use on this Region but in future all tables will conform to the following standard:-

No.	Released by	Locks

In preparing a locking table it is necessary to bear the following points in mind.

1. Assume all levers are normal in the frame, and that the lever performs its locking when it is pulled, except where F.P. Locks stand "in" normal.

2. To lock the frame so as to obtain the maximum security in working.

3. To enable the signalman to obtain the maximum freedom of movement consistent with safety (e.g.) Shunting signals to read over all possible routes.

4. Having dealt with every lever in the frame it is advisable to go through the table and check the converse of all normal locks and cross out any overlocks.

5. For ease of reference the numbers on each line in each column should be placed in numerical order before the locking mechanism is prepared.

The following Simple rules can be used to determine the interlocking requirements:-

1. DISTANT Signal Lever is Released by all relevant STOP Signal Levers.

2. SIGNAL LEVERS require all POINT levers in the correct position for which they read, and lock them when pulled.

3. SIGNAL LEVERS must lock all other SIGNAL levers which if pulled would give a conflicting Signal.

4. It must not be possible to move any points connected with, or leading on to the route for which a Signal has been cleared until the Signal is replaced to Danger.

5. TRAILING POINTS in the rear of STOP SIGNALS must be locked either NORMAL OR REVERSE when the Signal is cleared.

6. STARTING SIGNALS are released by Line Clear (Electrically).

/Continued.....

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PREPARTION OF TABLES Cont'd.

7. HOME SIGNALS cannot be cleared unless the STARTING SIGNAL is at danger.

8. POINT LEVERS must be interlocked so as to prevent any accident.

CONSTRUCTION DETAILS

When the table of Locking has been prepared a diagram of the locking mechanism is produced, from which the Locking Fitter will assemble the mechanism.

A locking Frame is composed of Levers, Floor plates (Quadrants), Standards, Lever Shafts, Locking Box Brackets, Locking boxes, Toppets, Bridle irons (Connecting locks together) and Locks (See Fig. 1.).

LOCKING MECHANISM DESIGN

There are only two shapes of locks used on the E.R. Standard pattern frame (i.e.) broad nose and narrow nose as shown in Fig. 2A. In order to avoid conflicting notches the locks are positioned in the locking boxes as follows:-

a. Broad Nose Locks.

1. Release lock in the inside channel.

2. Lock in the outside channel.

b. Narrow Nose Locks

1. Lock in the inside channel
2. Both way lock in the inside channel
3. Both way lock in the outside channel
4. Release lock in the outside channel

c. Shows a number of examples of conflicting notches and also the correct method of avoiding conflicting notches in each case. Thus it is important that before carrying out any alteration to locking a check should be made in order to make sure that there are no existing notches in the tappets which would conflict with a proposed alteration.

LOCKING MECHANISMS

Figs. 2B. 3.4.5.6 and 7 are examples of interlocking between levers. It should be remembered that the levers are shown in the Normal Position at the start of each sequence.

Fig. 8. Shows a complete signalling layout, locking table and locking mechanism.

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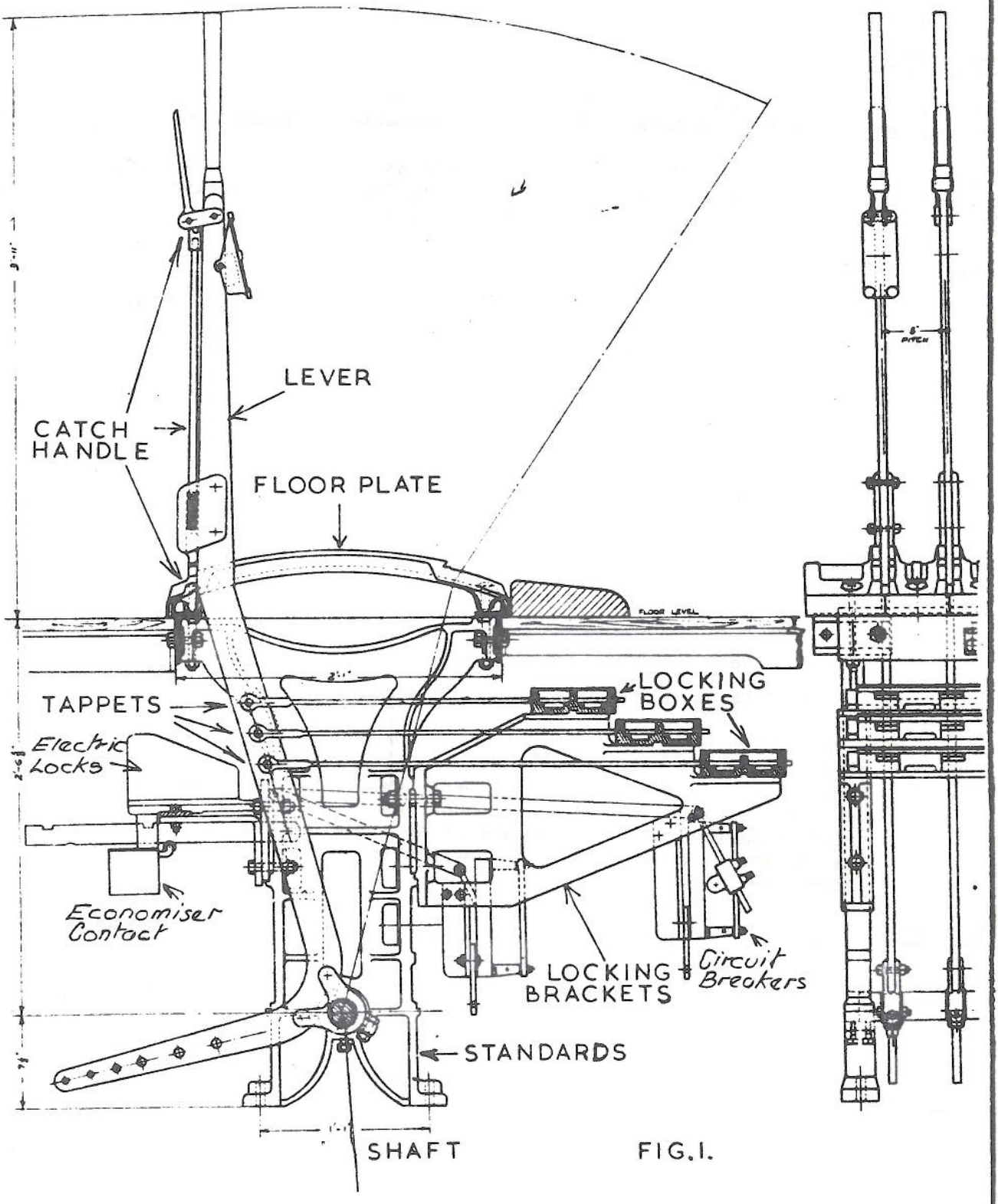

FIG.I.

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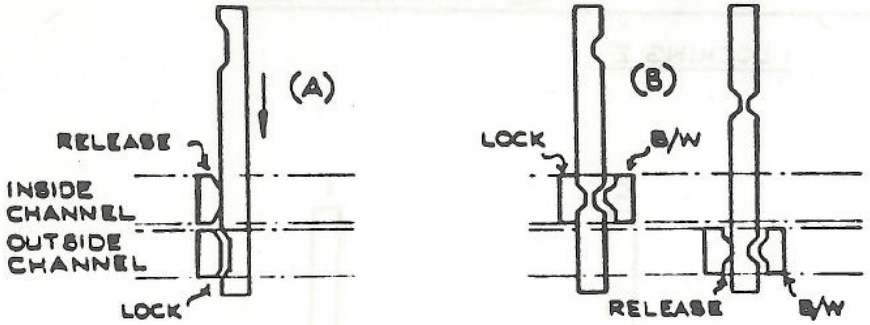
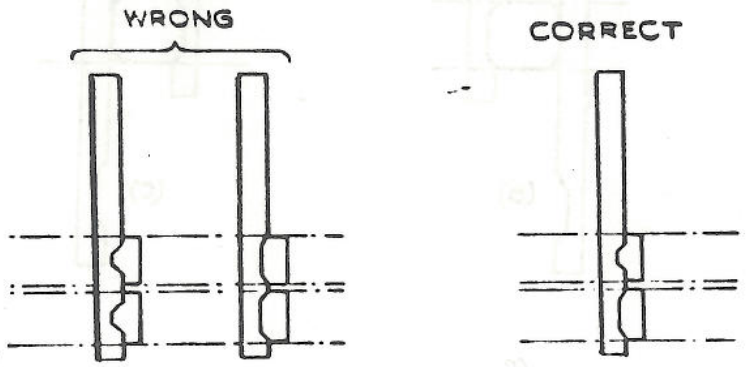
DIRECT LEVER LOCKING





C.

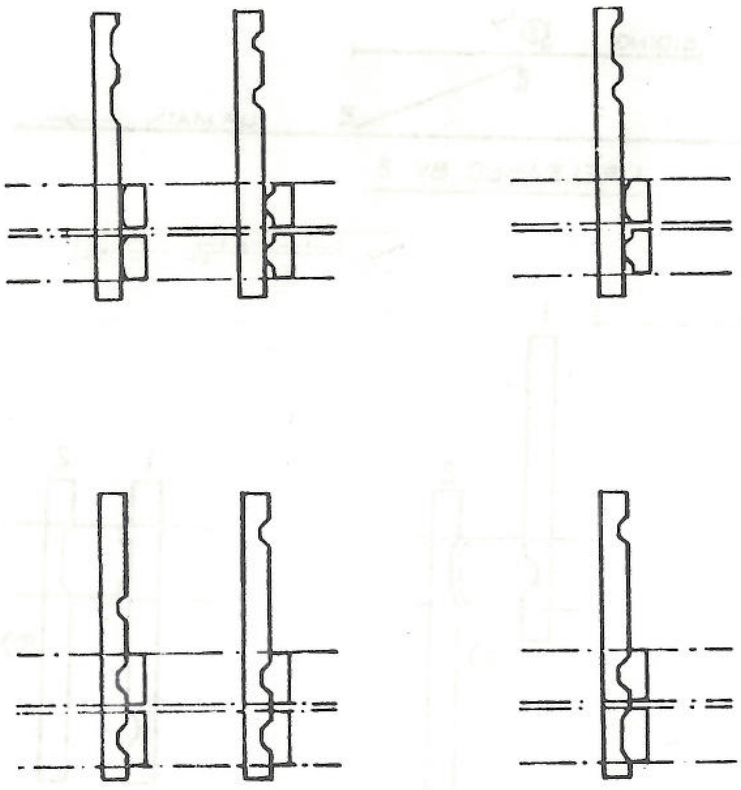


FIG.2.A.

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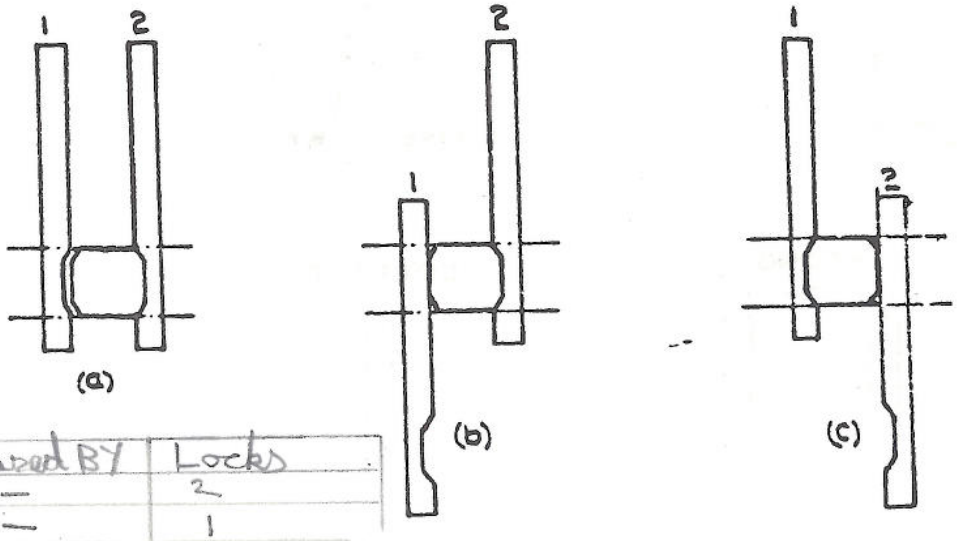
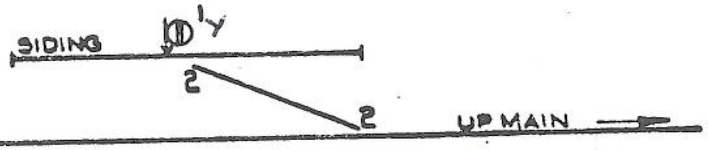
1 LOCKING 2



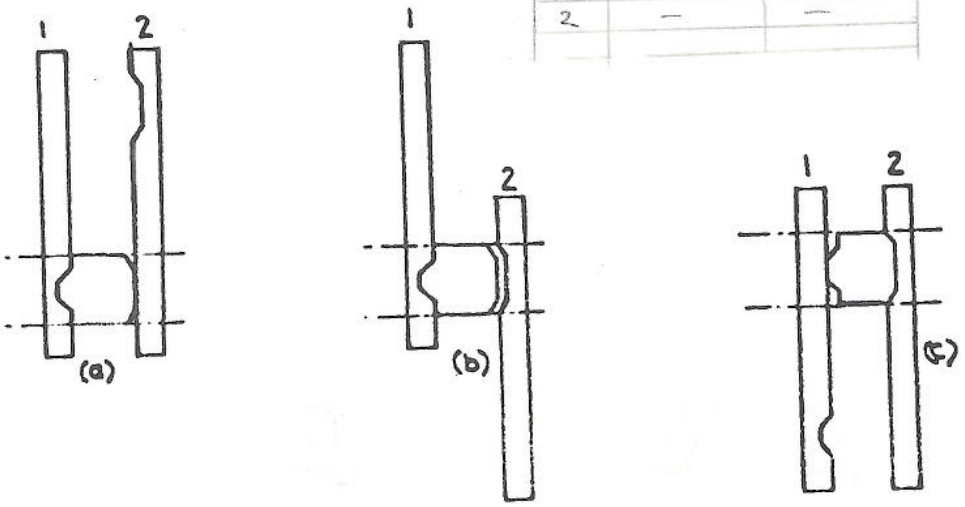
NO	Released BY	Locks
1	—	2
2	—	1

FIG.2.B.



1 RELEASED BY 2

No	Released by	Locks
1	2	—
2	—	—



1 released by 2, automatically locks 2 when pulled

FIG 3

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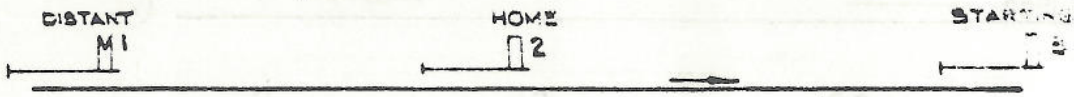
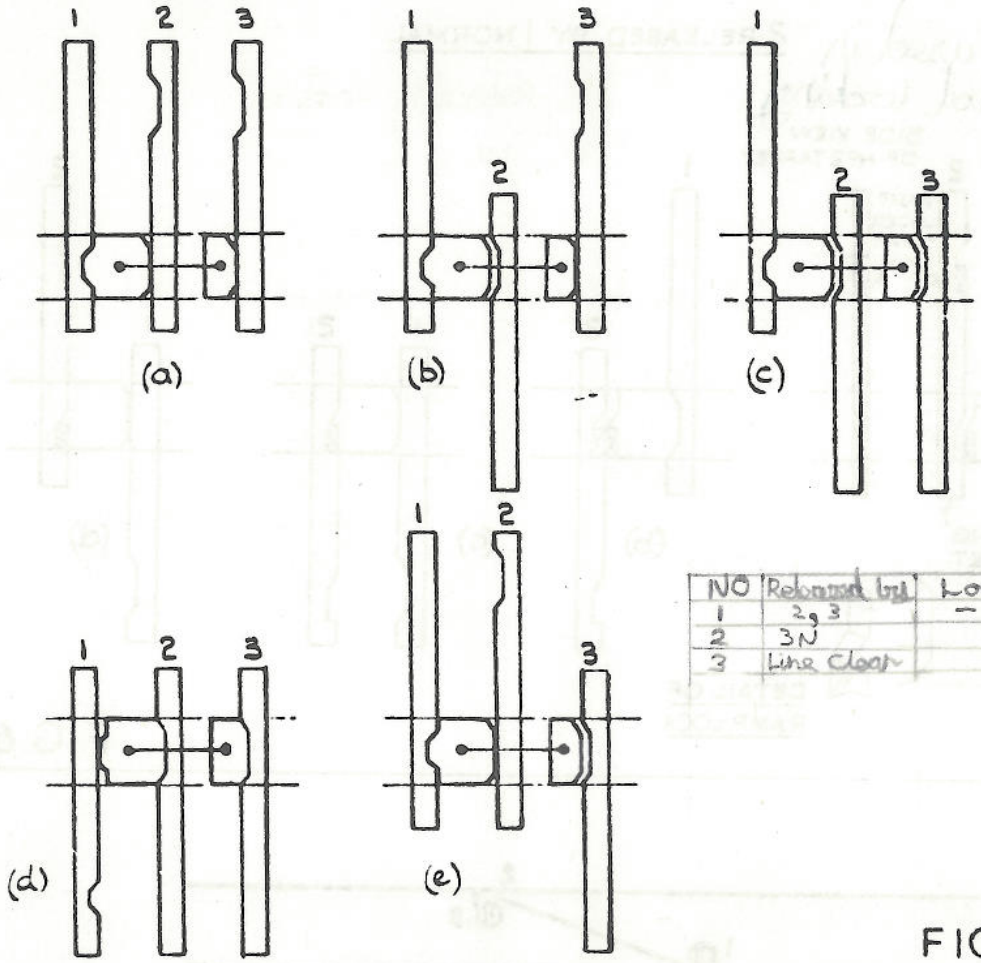
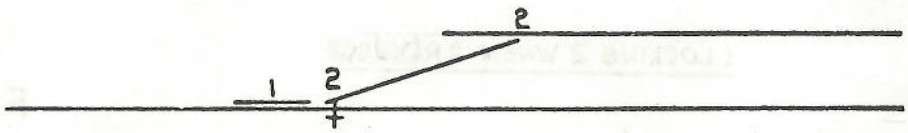


1 RELEASED BY 2 & 3



NO	Released by	Locks
1	2 & 3	—
2	3N	
3	Line Clear	

FIG.4.

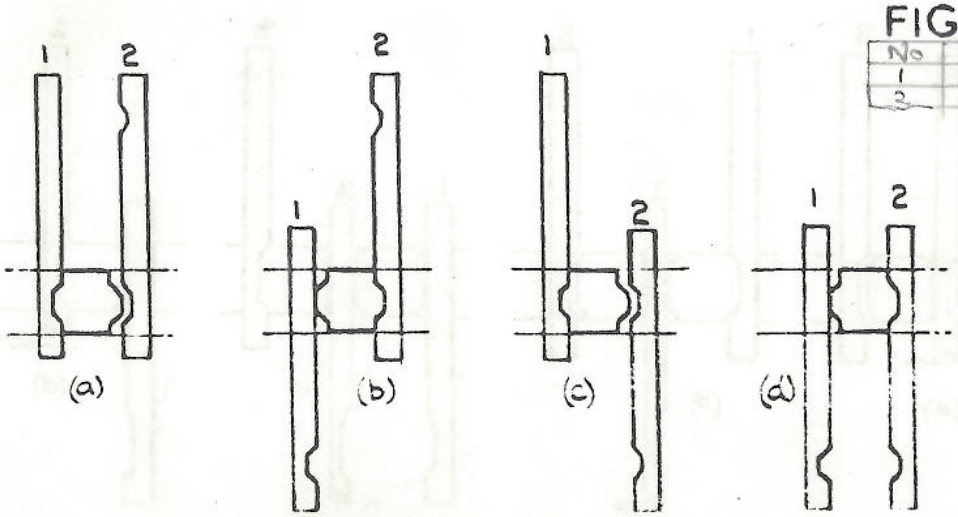


1 LOCKING 2 B/W

B/W = both ways

FIG.5.

No	Released by	Locks
1	—	2 B/W
2	1	—



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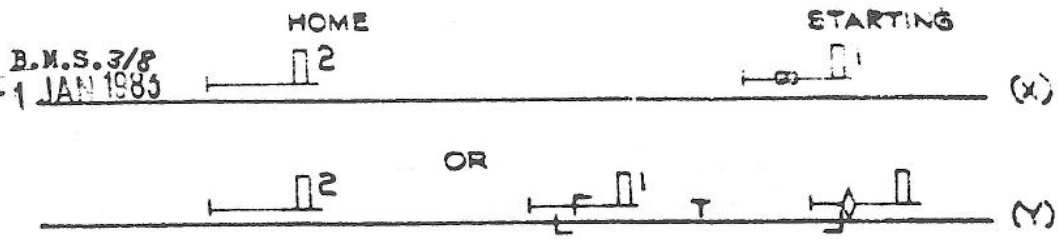


Ramp locking used in full sequencial locking

2 RELEASED BY 1 NORMAL

No	Released By	Locks
1		
2	1 N	

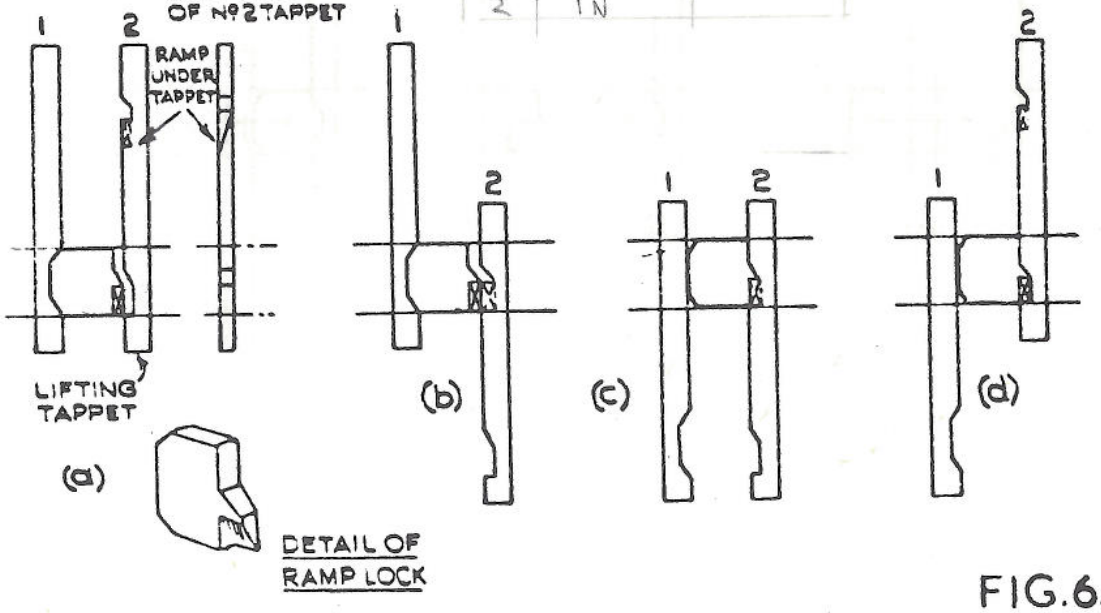
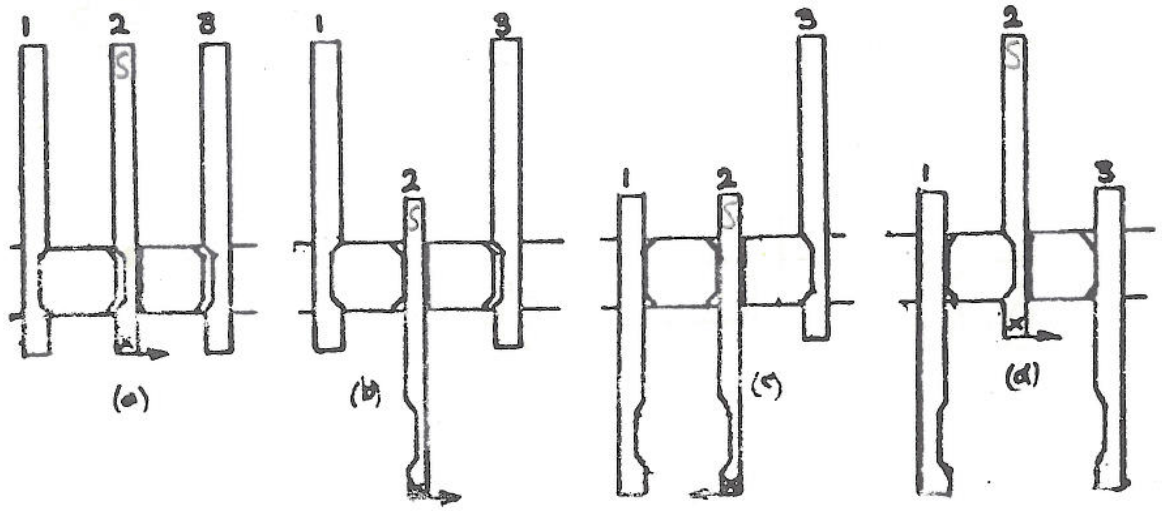


FIG.6.

No	Released by	Locks
1	2	(3W2R)
2		
3	2	(1W2R)

1 LOCKING 3 WHEN 2 REVERSE

FIG.7.



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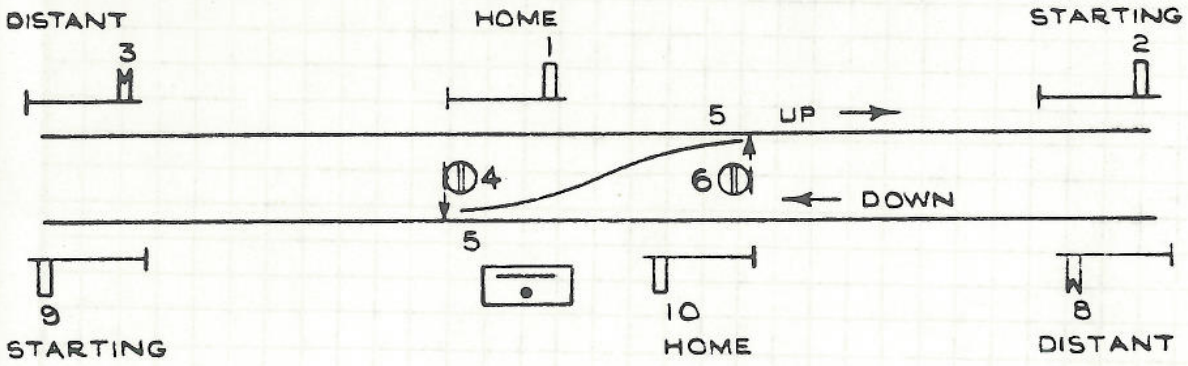

SPARE 7

NOS.	RELEASED BY	LOCKS
1	2N	5
2		5 B/W 6
3	1.2.	
4	5	6.9.
5		1.10
6	5	2.4.
7	SPARE	
8	9.10.	
9		4.5 B/W
10	9N	5

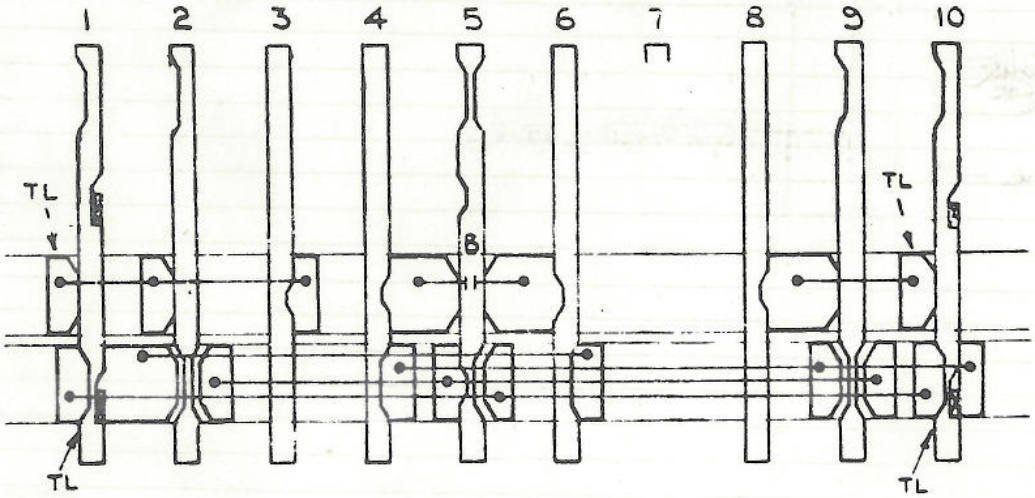

FIG.8.

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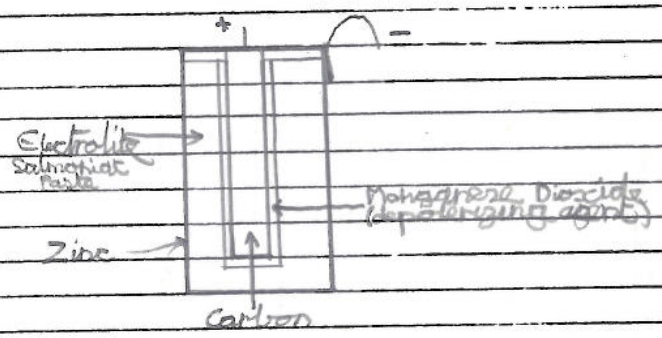

Generally speaking, power supplies for signalling purposes can be grouped under three headings:

1) PRIMARY CELLS
2) SECONDARY CELLS
3) ALTERNATING CURRENT APPARATUS

The types of electrical supply that we have previously discussed on the E.P.1. Course were:

a) Direct Current - D.C.
b) Alternating Current - A.C. - As supplied by the Central Electricity Generating Board (C.E.G.B.)

It was stated that with a D.C. supply, the current always flows in one direction but in an A.C. circuit it constantly changes direction. This change of direction in the mains supply is at a rate of 50 times per second. The A.C. supply is thus called 50 Cycle Supply or 50 Hertz (Hz).
For signalling relays a direct current supply is required. When possible it will be obtained from the C.E.G.B. and then changed to D.C. at the correst voltage. There are, however, many areas where Primary Cells are used as the only source of D.C. power supply.

PRIMARY CELLS

Primary cells are generally constructed as follows:

1) Container or outer case.
2) Positive element.
3) Negative element.
4) Electrolyte.
5) Depolariser.

Requirements for primary cells:

1) The E.M.F. should be large and remain constant.
2) The internal resistance should be small and remain constant.
3) The condition of the cell should be capable of being easily inspected and/or tested.
4) It should be easy to renew.
5) It should give off no offensive fumes.
6) It's initial cost should be relatively small.

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The two main types of primary cell in use on this region are as follows:

"LECHLANCHE" TYPE DRY CELL

Zinc container covered with cardboard.

Carbon for Positive Element.

Zinc Container acts as Negative Element.

Salamoniac Paste for Electrolyte.

Manganese Dioxide as Depolarising Agent.

"On Load" voltage approx. 1.3 volts (when new)

INERT "AIR DEPOLARISED" CAUSTIC SODA CELLS

Fibre or Plastic Container.

Carbon for Positive Element.

Zinc for Negative Element.

Booster Zinc fitted for extra life.

Porous Carbon as Depolarising Agent.

"On Load" voltage 1.2 volts (when new)

Caustic Potash Solution as Electrolyte.

Instructions for servicing on container side.

There are two inert caustic cells in use. The 618A and the 608A. The former should be removed from service and replaced when the "on load" voltage reaches 1.1 volts. The 608A cell should be changed when the "on load" voltage drops to 1.0 volt. Dry cells do not have this sharp fall off characteristic and should be replaced when the overall battery voltage falls below the required value or when individual cell "on load" voltages drop to 0.8 volts, whichever occurs first.

Ventilation is important for all primary cells and a continuous supply of fresh air is essential across the top of each cell. Inert Caustic Cells will not operate satisfactorily if ventilation is not provided.

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RECOMMENDED DISCHARGE RATES

Type of Cell	"Rated" Capacity Continuous	Weight lbs	Maximum Recommended Discharge Rates		
			Continuous	Intermittent	
				60x5 secs Daily	2x2 hrs Daily
D.S.3	2,000 hours	2	50 mA	375 mA	100 mA
D.S.1	2,600 hours	6	100 mA	500 mA	200 mA
A.D.513	850 Watt hrs	16	200 mA	5 Amps	600 mA
A.D.618A	1,000 " "	10*	400 mA	800 mA	800 mA
A.D.608A	2,000 " "	22*	1 Amp	2.5 Amps	1.5 Amp

* Weight before filling with water.

PRIMARY CELLS : TYPES AND APPLICATIONS

Type of cell	Description	Applications
D.S.1	1.4V dry cell	Electric detection Track circuit repeating
D.S.3	1.4V dry cell	Telephones (Ringing & microphone) Signal repeating, Light repeating
D.S.7	1.4V dry cell	Portable Field Type Telephones
A.D.513	1.4V Air Depolarised Cell	Circuits requiring intermittent currents:- Lever Locks, Signal motors, AWS Inductors.
A.D.608A	1.4V Air Depolarised Cell Inert Type.	Continuous loads:- Track circuits and Semaphore signal lights requiring over 400mA.
A.D.618A	1.4V Air Depolarised Cell Inert type.	Continuous loads under 400mA.

NOTE

1) As far as possible the type of cell chosen must be such that the continuous load is within the discharge rates shown in the table.
2) A single cell or bank of cells of the appropriate size should be used in preference to parallel banks of smaller cells.

The use of primary cells does, however, place many constraints on the Signal Engineer in terms of equipment and circuitry limitations, and, of course, the relatively high labour cost of replacing the cells. It is B.R. policy therefore, to eliminate the use of primary cells wherever possible, e.g.; where mains power is available.

It can also be appreciated that primary cells are completely unsuitable for providing the wide range of voltage and load requirements demanded by modern signalling installations, neither would they meet the important criteria of:-

Maximum Reliability of Supply.

SECONDARY CELLS

Secondary Cells used for railway signalling purposes are generally of two types; Lead Acid and Alkaline.

LEAD ACID CELLS

The composition of lead acid cells was discussed during the E.P.1 course. We will now consider their application and maintenance so far as railway signalling is concerned.

The barrery location should be clear, dry and have reasonable ventilation. Cells are usually connected in series, with the positive of each cell connected to the negative of the adjacent cell. The positive terminal of the battery as a whole should be connected to the positive of the charging source and the negative terminal of the battery connected to the negative of the charging source. All points of contact should be thoroughly clean and coated with petroleum jelly. Bolted connections should be firmly tight. Each cell should be checked with a voltmeter to ensure that polarity is correct.

THE STRENGTH OF THE ELECTROLYTE IS MEASURED IN TERMS OF "SPECIFIC GRAVITY", WHICH IS THE RATIO OF THE WEIGHT OF A GIVEN VOLUME OF ELECTROLYTE TO AN EQUAL VOLUME OF WATER.

Concentrated sulphuric acid has a specific gravity of about 1.835 and that of water (pure) is 1.000. The acid and water are mixed in proportion to give the specific gravity required. For example, electrolyte of 1.210 gravity is about 20% concentrated acid and 80% water by volume.

Specific gravity readings are given by an Hydrometer. THE SPECIFIC GRAVITY OF A LEAD ACID CELL IS NORMALLY 1.220. (or as recommended by the makers), whilst the 'on load' voltage of a fully charged cell is slightly in excess of two volts.

When it is necessary to mix sulphuric acid with water to the specific gravity desired for an electrolyte, "THE ACID MUST ALWAYS BE ADDED TO THE WATER."

If water is poured into a container of cencentrated acid, the heat so generated will cause spurts of acid solution to fly off in all directions, perhaps causing danger to persons and damage to equipment.

USE OF THE HYDROMETER AND SYRINGE

PROTECTIVE GOGGLES MUST BE WORN

Remove the cap from a battery cell, squeeze the suction bulb and insert the flexible tube into the cell. Slowly release all pressure in the suction bulb which will allow the maximum volume of electrolyte into the syphon jacket thus ensuring the hydrometer floats freely at any of the markings between 1.100 - 1.300 Specific Gravity.

Lift the instrument clear of the cell and make certain that the electrolyte in the syphon jacket is free from air bubbles as these can cause inaccurate readings.

Take Readings at Eye Level. If sighted below eye level an ellipse is observed around the stem of the hydrometer, lift the eyes until this ellipse disappears and then take the reading. Repeat for each cell.

Never Mix Acid & Alkaline - Always Use Clean Utensils

Syringes, hydrometers, filling bottles and other containers which have been used on one type of cell should be thoroughly rinsed in clean water before using on the other type.

INITIAL CHARGE

All types of batteries lose some of their charge during shipment, and while standing idle, therefore, upon installation it should be made certain that the battery is fully charged by giving it a freshening or booster charge. This initial charge should be given before the battery is connected to its ultimate load and should be given for as long as the specific gravity and voltage of any cell show any increase and then for some three hours after the last increase is observed. This charge should be carried out at the normal rate given by the manufacturer. If the charge rate is lower than that laid down then the three hour period should be lengthened proportionately. Any cell failing to achieve maximum specific gravity or charge voltage should not be placed into service.

The specific gravity of lead acid cells is normally 1.220.

The 'on load' voltage of a fully charged cell is approx. 2 volts.

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MAINTENANCE

Retular voltage and hydrometer readings must be taken. THE SPECIFIC GRAVITY OF THE ELECTROLYTE IS THE INDICATION OF THE CELLS CONDITION TO WHETHER OR NOT IT IS RECEIVING A SATISFACTORY CHARGE. FULL CHARGE = HIGH S.G. LOW CHARGE = LOW S.G.

Voltage tests are indicative of the condition of the cell plates, establishing that a satisfactory electrical potential is existing between the positive and negative electrodes. This test should be carried out with the cell discharging into a load, therefore the charging current must be switched off previously and the cells should have ceased gassing.

If it is impracticable to take voltage tests while 'on load' conditions exist then a 1 ohm shunt resistance connected across the cell will allow a voltage test to be made with the cell discharging quite heavily. The voltage should be steady for a 10 second period, at approx. 2 volts.

It is essential to keep the level of the electrolyte above the plates and topping up should be done with distilled water. To prevent leakage to earth, batteries should be stood on insulating material and location cupboard shelves kept dry and clearn. Adequate ventilation is important as secondary cells of all types give off considerable amount of explosive gases. Naked lights and smoking is prohibited in battery rooms and cells should not be disconnected while charging or discharging or while the cells are gassing as a spark may cause an explosion.

If cells, either when new or later, are to be put into storage for several months or longer, they should first be given a charge until all cells are gassing and the specific gravity has reached its normal full charge value. Cells should then be stored in a cool, dry place and must not be placed near a radiator or other source of heat. A thorough recharge is necessary before returning cells into service.

A lead acid cell should never be allowed to remain in a discharged condition for any appreciable time. If allowed to do so, the lead sulphate in the solution will grow on the plates in the form of hard white crystals. This is known as SULPHATION.

Abnormal sulphation closed the pores of the active material in the plates and in time will destroy them. When the battery is again placed on charge, after a periof of standing in a discharged condition, some of the lead sulphate, instead of changing back into spongy lead or lead peroxide, is dislodged from the plates in small particles and drops to the container bottom as sediment. This active material is lost forever. In normal operation all lead acid cells shed a small amount of active material from the positive plates.

To properly maintain lead acid cells they should be periodically discharged and charged.

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ALKALINE CELLS

Alkaline batteries are used for a large variety of purposes. They have almost every advantage over the lead acid type cell, except that of first cost which is higher, however, as an alkaline cell will outlast a lead acid cell, it is actually cheaper in the long run.

AN ALKALINE CELL HAS A SPECIFIC GRAVITY OF 1.190. THE SPECIFIC GRAVITY DOES NOT VARY DURING DISCHARGE. The cell case is usually steel, on which the electrolyte has no action, but the outer surface of the cell is sometimes plated to prevent atmospheric corrosion.

PREPARATION OF NICKEL CADMIUM CELLS FOR SERVICE

The cells are delivered with electrolyte but in a discharged condition. WEARING GOGGLES remove the transit plugs from the top of the vent and discard. Check the electrolyte level in all cells and correct where necessary by adding distilled water only, using the plastic filler bottle type PB4.
The cells should now be given a 'First Charge'. Details of charging Secondary cells are given later in this lecture.

MAINTENANCE PROCEDURE

1) PUT ON GOGGLES (this is for your own protection.)
2) Switch off battery charger and allow air to circulate so that any accomulation of gas can disperse. (Enforce air circulation by wafting or fanning where no motion of air is apparent).
3) Check the electrolyte level and top up with distilled water where necessary using Filler Bottle Type PB4 with Filler Tube and Probe. (For PA and PV cells with modified vent plugs, the insulated Probe No. 3 ($2\frac{1}{4}$" long) must be used).

   METHOD OF USING THE FILLER BOTTLE

   The bottle should be kept clean and contain pure distilled water. With the probe inserted through the filler vent the bottle should be raised in an inverted position above the cell. Gently squeezing the bottle will then force a little water into the cell. The bottle should then be held upright at a 'lower than cell' level and the finger pressure on the bottle relaxed. This will cause the probe to suck and extract electrolyte until the correct level is achieved. Care must be taken to ensure that whilst the sucking is taking place that some electrolyte is extracted initially, followed by the sucking of air. This indicates that the correct level is achieved even without a visible view of the cell interior.
4) At not less then yearly intervals test and record the specific gravity of cells. This should be between 1.160 and 1.200. This test should not be carried out on a cell which has been topped-up on the same day.

5) Ensure the exterior of the cells are clean and dry.

6) Ensure that all cell inter-connectors are secure, using an insulated box box spanner to eliminate spart risk. Do not turn the bottom gland retaining nuts which lie beneath the connectors.

7) Terminals must be kept lightly greased with petroleum jelly.

8) Measure and record the total battery voltage. Measure and record individual cell voltage on a progressive basis as frequently as directed.

If a cell is found to be faulty, it must be replaced. The new cell must have its transit stopper removed and electrolyte level checked. Before installation at site, the cell must be given an initial bench charge in accordance with installation instructions for first charge rates.

9) Cases containing cells must always be well ventilated by top and bottom louvres. Check that ventilation louvres are not obstructed.

10) CHARGING RATES

a) EXCESSIVE CHARGING RATE results in heavy water consumption, i.e. the electrolyte level drops more than $\frac{1}{2}$" per month and excessive gassing is evident.

b) INSUFFICIENT CHARGING RATE results in little or no water consumption.

c) The desirable charging rate is indicated by a consumption rate which gives a fall in water level of between $\frac{1}{8}$" and $\frac{1}{4}$" per month.

d) If the charger is a Constant Voltage type, it is normally set to give the correct voltage per cell connected, provided that the correct number of cells are installed for the size of charger. The voltage and charging current rating is pre-determined to suit the battery operating conditions and no adjustments are necessary once in service.

e) Where a charger is not a constant voltage type, the charging rate must be set to give the minimum charge necessary to keep the battery in a fully-charged state under normal operating conditions, bearing in mind there may be intermittent peak loads.

f) It is essential that the battery is not continually over-charged which produces excessive quantities of explosive gas.

DESIGN CONSIDERATIONS IN THE USE OF NICKEL CADMIUM CELLS

Alkaline secondary cells are used in two ways, for which there are different design requirements as follows:-

a) BUFFER BATTERIES

Where there is a guaranteed power supply and batteries are only installed to supply peak current requirements, e.g.; point machines. The battery will normally remain fully charged and provide about 1.45V per cell.

b) STANDBY BATTERIES

Where the batteries act as a 10 hour standby power supply, (12 hours in barrier applications), their capacity will be as shown in the following table.

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TABLE OF APPLICATIONS AND CAPACITIES OF NICKEL CADMIUM CELLS

TYPE	DESCRIPTION	CAPACITY	APPLICATIONS
RE 16	Single crated Cell	16 amp hrs. discharged at 1.6 amps over 10 hrs.	Track circuits, Line Circuits, AWS, Electrically lit semaphore signals, Motor operated and Colour light signals, Internal S. Box circuits.
RE 16	Five crated Cells	"	"
RE 44	Five crated Cells	44 amp hrs. discharged at 4.4 amps over 10 hrs.	"
DLS 4	Five crated Cells	40 amp. hrs. discharged at 8 amps over 5 hrs.	Point Machines
RV 8	Five crated Cells	80 amp hrs. discharged at 6.7 amps over 12 hrs.	Barriers and other forms of crossings.

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CHARGING OF SECONDARY CELLS

Storage batteries can be recharged after being partially or fully discharged by passing a direct current through them at the appropriate voltage. The usual source of direct current employed in railway signalling is via a rectifier which receives its power from an A.C. supply and delivers D.C. for use in the charging circuit.

There are several methods of charging batteries.

FIRST CHARGE RATES FOR NICKEL CADMIUM CELLS

Charge for 10 hours at the appropriate rate for the type of cell required. If lower charging currents are used the charging time should be increased proportionately.

RE 16	RE 44	DLS 4	RV8
4 amps average	11 amps average	10 amps average	20 amps

1) FRESHENING OR INSTALLATION CHARGE

All types of batteries lose some of their charge during shipment and while standing idle. Before installation of a battery can be considered complete, the battery should receive a freshening charge.

The charge for lead acid cells, if the normal charge rate is used, should be continued until all cells show no further increase in specific gravity and then for three hours more. If the charge rate is lower than the manufacturers recommended figure then the three hour period should be lengthened in proportion.

The charge for nickel cadmium (NIFE) alkaline cells requires to be continuous until the voltage on all cells in the battery is constant on discharge through a one ohm shunt resistor for ten seconds.

At the end of this pre-installation charge, a record should be taken of specific gravity, voltage, temperature readings and electrolyte level for future comparison with later readings.

2) FLOATING CHARGE

The term 'floating' can be applied to three general methods of charging, namely, 'Full Float', 'Modified Float' and 'Average Current Float'.

a) FULL FLOAT means maintaining a constant voltage at the battery terminals which allows enough current to flow through the battery to offset local action losses in each cell and also carry the entire load. The current value will vary with the needs of the battery and the load requirements. The voltage, however, will remain constant at the present value, preferably that recommended by the cell manufacturer. With a full float system, the rect fier must be of a size to handle the maximum loads. The battery will never discharge except when a power failure occurs, then the battery will carry the entire load until the power is restored.

"DEFINITION OF A FLOATING BATTERY"

A battery which is constantly connected, on the one hand to a discharge circuit which it supplies, and on the other hand to a charging circuit, set so that the mean charging current compensates for both discharge quantities.

b) MODIFIED FLOAT system is similar to the Full Float system except that the rectifier unit is not capable of dealing with the maximum load condition. The battery carries any load in excess of the rectifier capacity. The rectifier will not be damaged as it will protect itself by lowering its voltage output. When the load is reduced or terminated, the rectifier will supply charging current to the battery in proportion to the state of discharge, starting at a high rate and tapering off as the charge progresses until the battery is fully charged. At this point the current to the battery is just sufficient to maintain the recommended float voltage per cell. The amount of current necessary to produce this voltage per cell will vary with temperature, age and general cell condition.

"DEFINITION OF A BUFFER BATTERY"

A battery of secondary cells connected across a D.C. supply in order to diminish variations of the voltage and current supplied by the main supply.

c) AVERAGE CURRENT FLOAT with this method of charging, a Constant Current Rectifier is normally used. The battery discharges during the load periods and the rectifier unit charges the battery during the idle period. The rectifier output is set to equal the 24 hour discharge in amperehours plus the local action loss of the battery. This method works well when the rectifier output is adjusted properly and the load averages the same from day to day. If the load changes, the battery will either be overcharged or undercharged, depending on whether the load decreases or increases, unless the rectifier output is also changed by manual adjustment.

3) TRICKLE CHARGE

Trickle charge in signalling applications refers to the current requirements to compensate for the cells internal losses only. For example, suppose it is desired to hold in reserve a battery which must be ready for immediate use. In order to maintain the battery in a fully charged condition at all times, it is necessary to continually charge it at a rate that will just make up for the internal losses only. This rate is called the "Trickle Rate". In trickle charging, the battery is usually connected only to the charging circuit, and is only connected to the load circuits through a power-off relay when the regular source of power fails or becomes overloaded.

"DEFINITION OF TRICKLE CHARGE"

A steady charge with a very small current so as to compensate for losses due to local action, thus allowing the battery to always be in a fully charged state.

4) TWO-RATE CHARGE

In certain signalling installations the load is irregular and varies over wide limits. For example, at auto half barrier and full barrier installations. Since such a variable load makes it difficult to maintain the battery in a fully charged condition and not over-charge it excessively, a method of charging, called "Two Rate Charging" is employed. It involves the use of a relay to control the output of a rectifier in such a way that the relay is normally energised and a low rate of charge is delivered, this being sufficient to supply the internal losses of the battery and any steady connected load.

When the relay is de-energised due to the battery being called upon to deliver additional current, a high charge rate is automatically applied and this rate continues until the battery voltage reaches its fully charged value when the relay will again be energised and restore the low charge rate.

NOTE 1) All these charging methods aim at maintaining an average voltage under steady conditions. Normally the individual cell voltages should be:-

a) Lead Acid - 2.0 to 2.2 volts maximum.

b) Nickel cadmium - 1.4 to 1.45 volts maximum.

NOTE 2) The charging current required to compensate for the internal or local action losses of a secondary cell should be calculated at a minimum of 1 milliampere per ampere-hour of the cells rated capacity, i.e.; a cell rated at 50 A.H. would require a charging current of at least 50 milliamps to compensate for local action losses. As the cells deteriorate over the years then it may be necessary to increase this figure.

Fig. 1 shows a typical battery charger and illustrates the input and output waveforms.

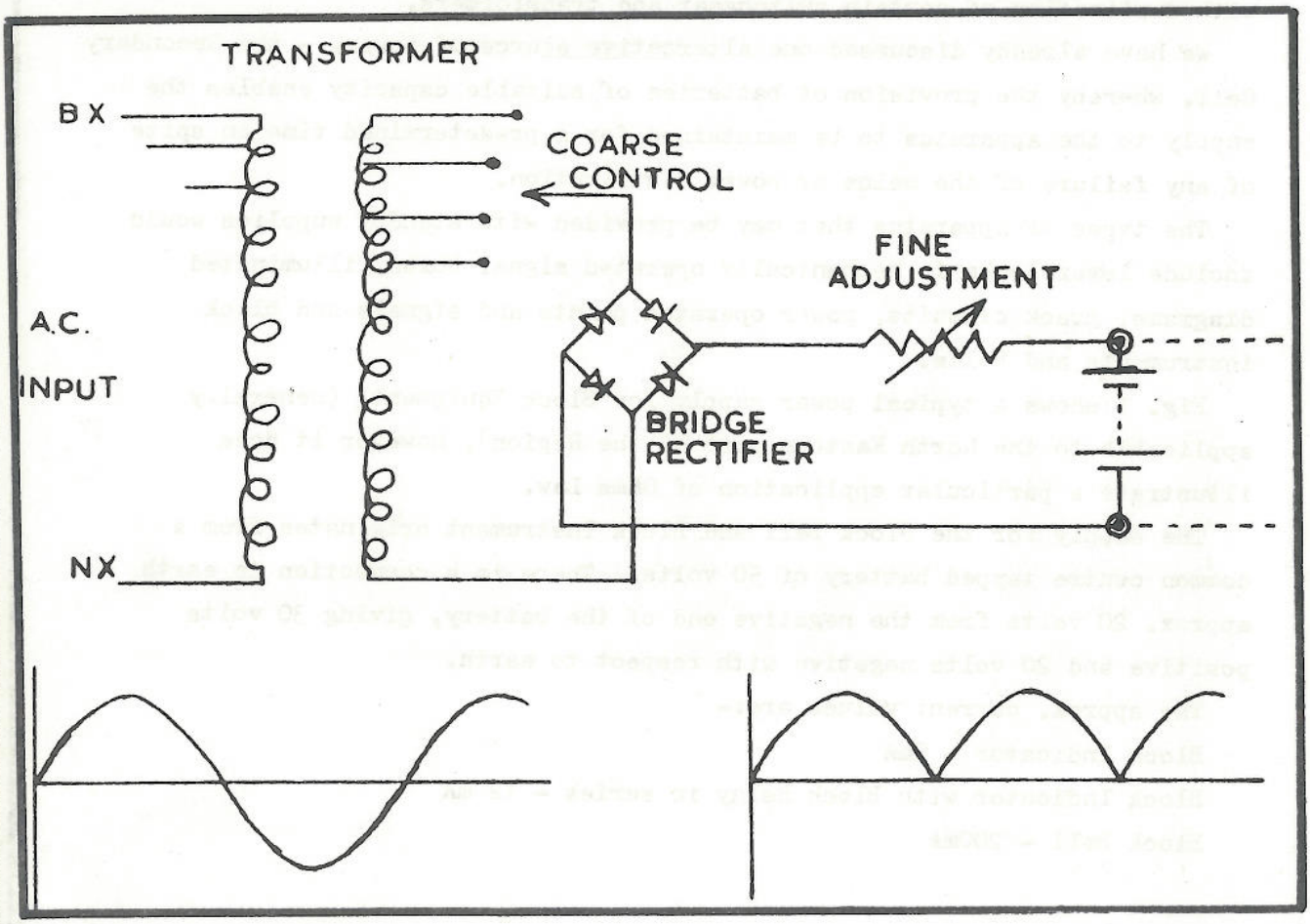

FIG. 1 TYPICAL BATTERY CHARGER.

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ALTERNATIVE SOURCES OF POWER SUPPLY FOR RAILWAY SIGNALLING

Where electrical power is used for railway signalling purposes, whether it is to supply major signalling installations, apparatus at a small wayside signal box or an isolated colour light signal, it is essential that everything possible should be done to maintain a continuous power supply, and to reduce delay to traffic to a minimum in the event of failure of the main source of supply, or of the distribution or any associated apparatus.

In order to achieve these objects it is necessary to have at least one alternative source of supply. In some cases an alternative path for the distribution in the form of a ring or duplicate main may be provided together with duplication of certain switchgear and transformers.

We have already discussed one alternative source of power, - the Secondary Cell, whereby the provision of batteries of suitable capacity enables the supply to the apparatus to be maintained for a predetermined time in spite of any failure of the mains or power distribution.

The types of apparatus that may be provided with standby supplies would include lever locks in mechanically operated signal boxes, illuminated diagrams, track circuits, power operated points and signals and block instruments and bells.

Fig. 1 shows a typical power supply for Block Equipment, (generally applicable to the North Eastern part of the Region), however it does illustrate a particular application of Ohms Law.

The supply for the Block Bell and Block Instrument originates from a common centre tapped battery of 50 volts. There is a connection to earth approx. 20 volts from the negative end of the battery, giving 30 volts positive and 20 volts negative with respect to earth.

The approx. current values are:-

Block Indicator - 5mA

Block Indicator with Block Relay in series - 12 mA

Block Bell - 200mA

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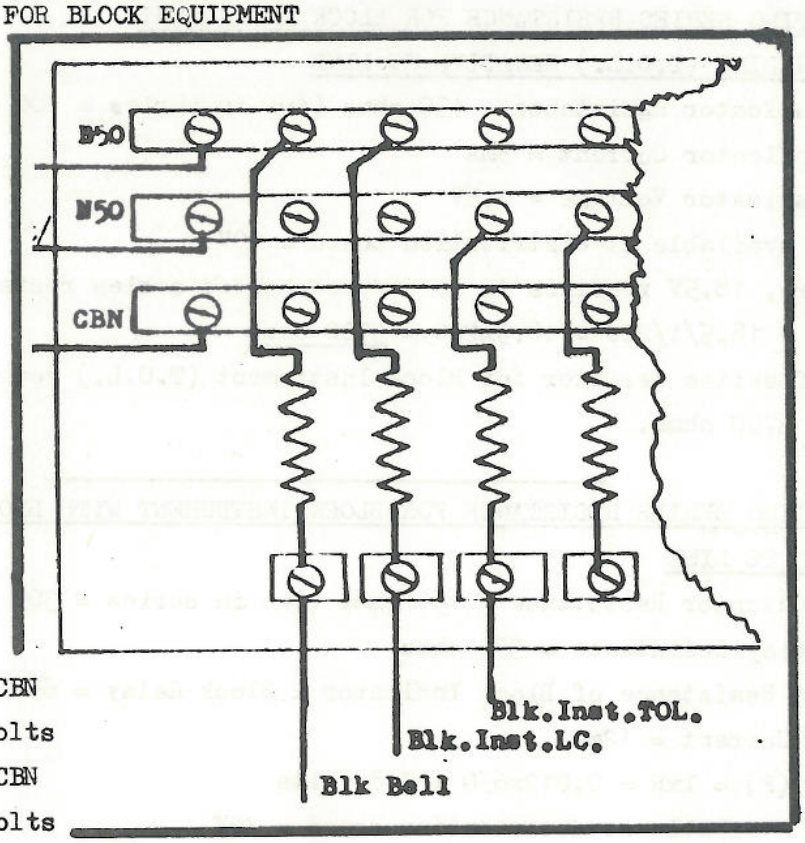
FIG. 1 POWER SUPPLIES FOR BLOCK EQUIPMENT



The supplies are taken from a distribution board, the required current/ voltage being obtained by the use of series resistors. These must be calculated in relation to the supply voltage used.

Voltage between B50 & CBN =30 volts

Voltage between N50 & CBN =20 volts

All calculations ignore Line Resistance.

CALCULATING SERIES RESISTANCE FOR BLOCK BELL

Block Bell Coil Resistance = 50 ohms

Block Bell Current = 200mA (1/5 of an amp)

Block Bell Voltage (E) = IxR = 1/5 x 50 = 10 volts

Voltage available at distribution board = 30V

Therefore, 20V requires to be dropped across the series resistance

R = E/I = 20/1/5 = 20x5 = 100 ohms

CALCULATING SERIES RESISTANCE FOR BLOCK INSTRUMENT (LINE CLEAR)

Block Indicator Resistance = 150 ohms (two in series = 300 ohms)

Block Indicator Current = 5mA (1/200th of an amp)

Block Indicator Voltage (E) = IxR = 1/200x300 = 1.5 volts

Voltage available at distribution board = 30V

Therefore, 28.5V requires to be dropped across series resistance

R = E/I = 28.5/1/200 = 28.5x200 = 5700 ohms

Value of series resistor for Block Instrument (L.C.) requires to be approx. 5700 ohms

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CALCULATING SERIES RESISTANCE FOR BLOCK INSTRUMENT
TRAIN ON LINE (T.O.L.) NEGATIVE TO LINE

Block Indicator Resistance = 150 ohms (two in series = 300 ohms)
Block Indicator Current = 5mA
Block Indicator Voltage = 1.5V
Voltage available at distribution board = 20V
Therefore, 18.5V requires to be dropped across series resistance
R = E/I = 18.5/1/200 = 18.5x200 = 3700 ohms
Value of series resistor for Block Instrument (T.O.L.) requires to be approx. 3700 ohms.

CALCULATING SERIES RESISTANCE FOR BLOCK INSTRUMENT WITH BLOCK RELAY (LINE CLEAR)
POSITIVE TO LINE

Block Indicator Resistance = 150 ohms (two in series = 300 ohms)
Block Relay Resistance = 350 ohms
Combined Resistance of Block Indicator & Block Relay = 650 ohms
Circuit Current = 12mA
Voltage (E) = IxR = 0.012x650 = 7.8 volts
Voltage available at distribution board = 30V
Therefore, 22.2V requires to be dropped across series resistance
R = E/I = 22.2/0.012 = 1850 ohms
Value of series resistor for Block Instrument with Block Relay requires to be approx. 1850 ohms.

Figs. 2 and 3 illustrate typical examples of wayside signal box power supplies. It can be seen that the incoming 240 volts A.C. is initially transformed down to 110 volts A.C.
The Lock Battery (12V.D.C.), Indicator Transformer (12V.A.C.), Common Battery (50V.D.C.), Power on Indicator (110V.A.C.) and Outside Battery (12V.D.C.) are all derived from the 110 volts A.C. The diagrams illustrate the importance that secondary (NIFE) cells play in providing standby power supplies.
Fig. 4 shows a point power supply with 'Floating' battery where the point operating voltage is 110 volts D.C. (as at Kings Cross Power Signal Box). Note also the duplication of switch gear and battery charges.

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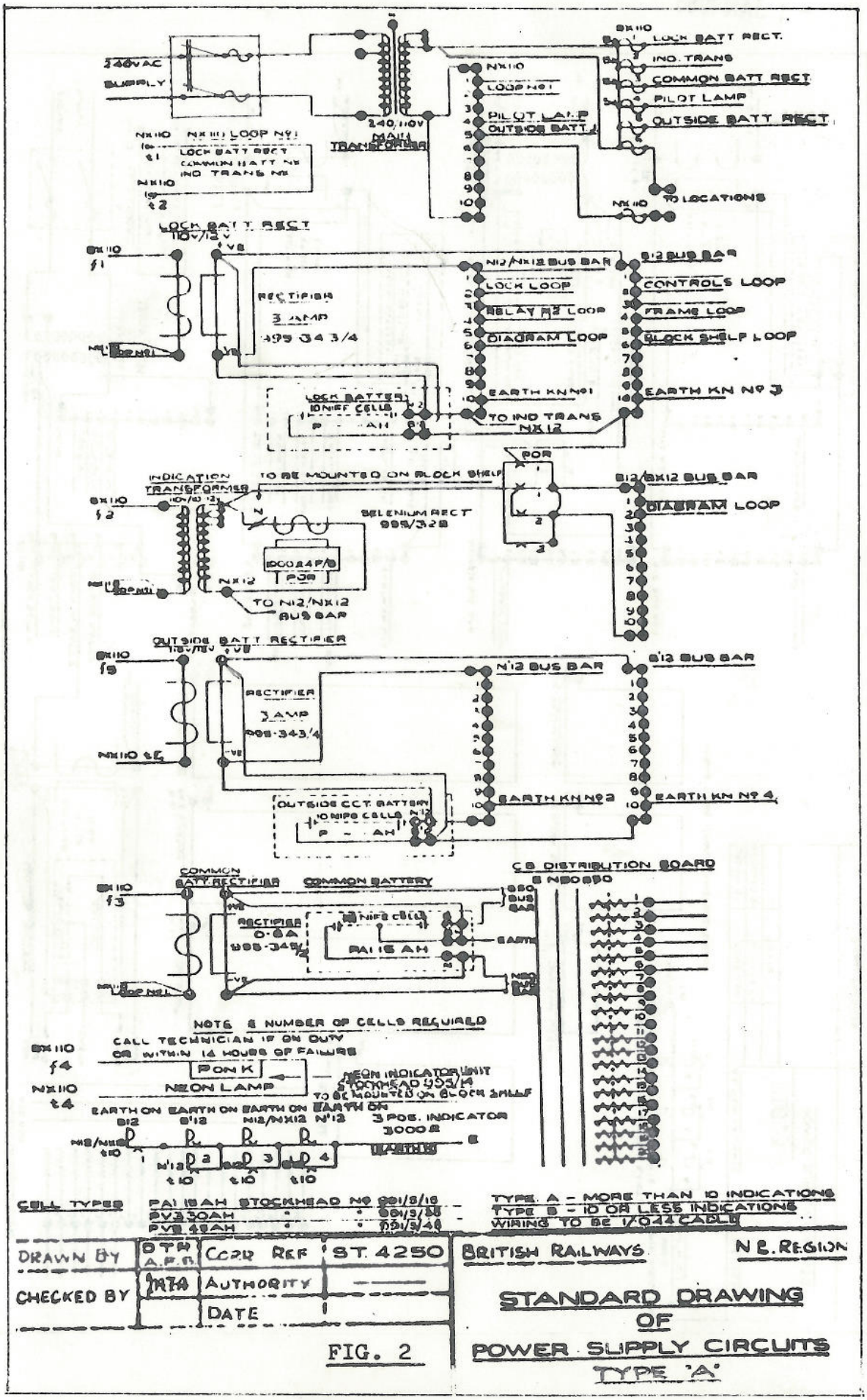

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BRITISH RAILWAYS — N.E. REGION

STANDARD DRAWING OF POWER SUPPLY CIRCUITS TYPE 'A'

FIG. 2

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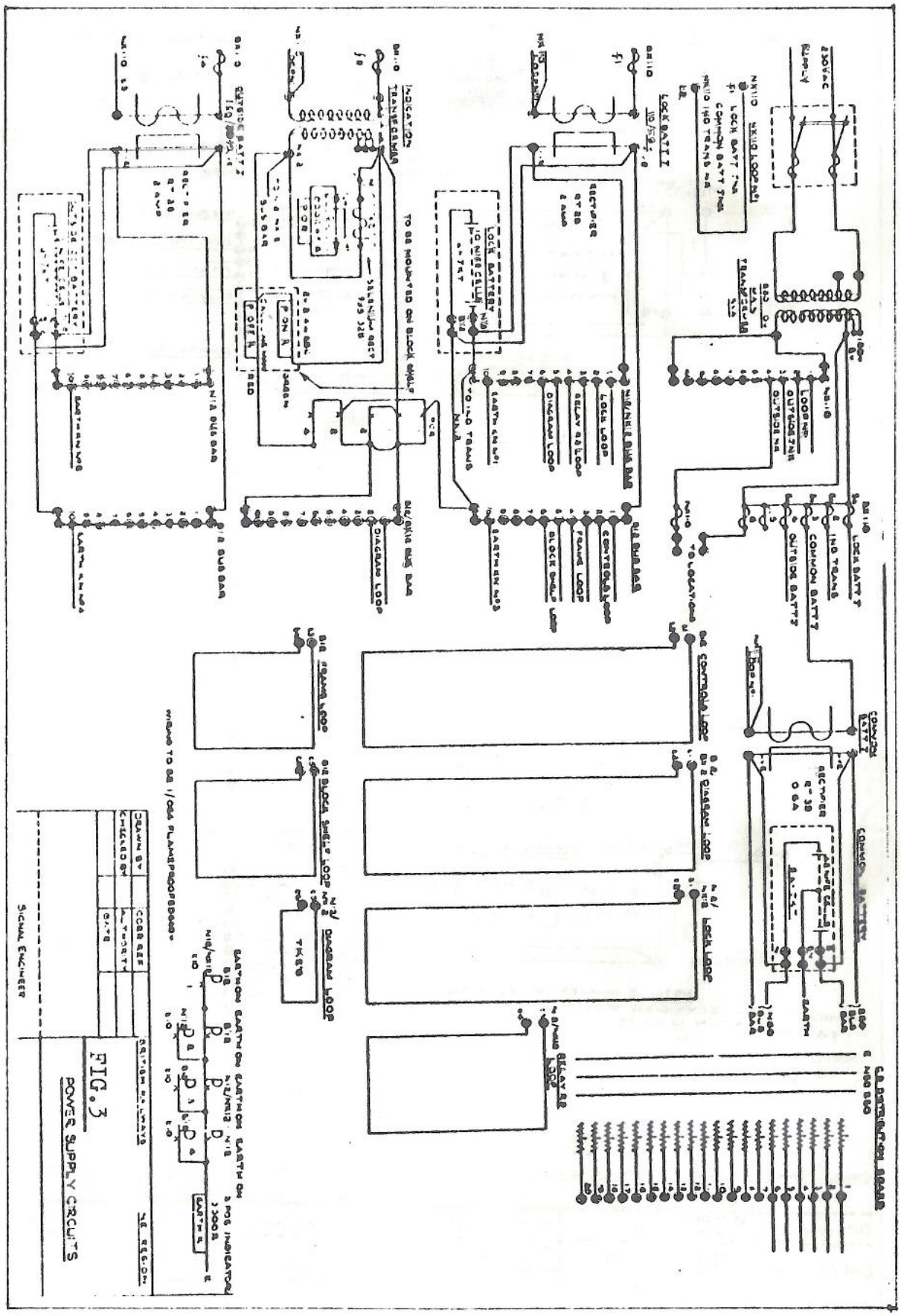

FIG. 3

POWER SUPPLY CIRCUITS

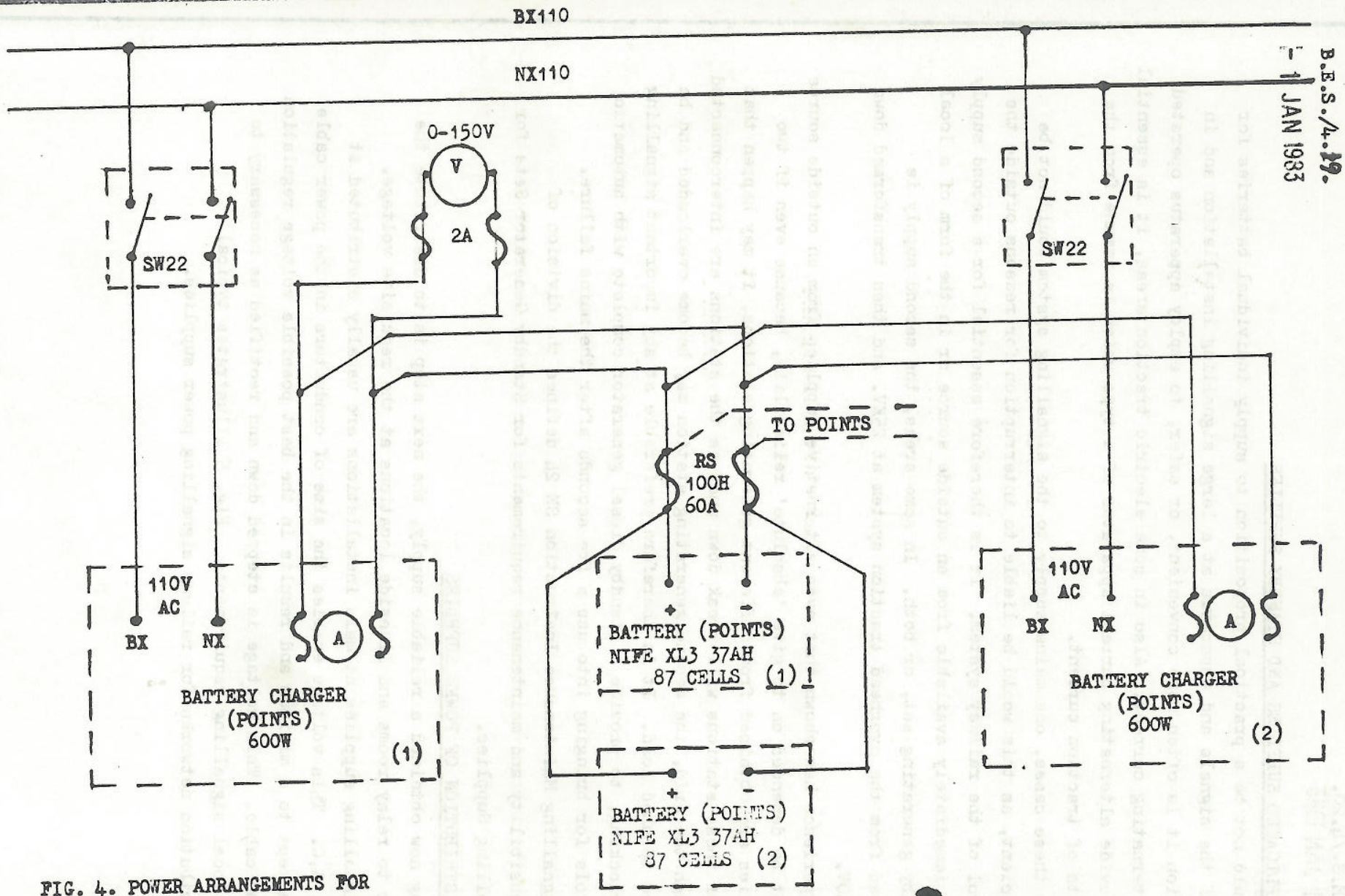

FIG. 4. POWER ARRANGEMENTS FOR MOTOR POINTS

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DUPLICATED SUPPLIES AND STANDBY SUPPLIES

It would not be a practical proposition to supply individual batteries for all of the signals and apparatus at a large signalling installation and in addition it is often more convenient, or safer, to employ apparatus operated by alternating current. Also in some electric traction areas, it is essential to provide alternating current apparatus of a type which is immune from the effects of traction current.

In these cases, one mains supply to the signalling system would not be sufficient, as this would be liable to interruption for reasons outside the control of the railway system. It is therefore essential for a second supply to be immediately available from an outside source or in the form of a local standby generating set, or both. In some areas, the second supply is derived from the overhead traction system at 25KV. and then transformed down to 650V.

Experience has shown that even alternative supplies from an outside source cannot be depended on to give 'absolute' reliability, because even if two supplies are obtained from different generating stations, it may happen that one of these stations will break down and, as the stations are interconnected through the grid, the second generating station may become overloaded and be forced to shed load. It is therefore preferable at any important signalling interlocking, to provide a standby diesel generator complete with automatic controls for bringing into use a fre seconds after the mains failure.

Signalling Maintenance Instruction SM 24 defines the division of responsibility and maintenance requirements for Standby Generator Sets for Signalling Supplies.

DISTRIBUTION OF POWER SUPPLIES

Having now obtained a reliable supply, the next step is to distribute the power to relay rooms and lineside locations at the requisite voltage.

Signalling supplies at main installations are usually distributed at 650V. A.C. This voltage enables the size of conductors in the power cable to be kept to a minimum and results in the best possible voltage regulation in the cable. This voltage is stepped down and rectified as necessary to suit local signalling requirements. Fig. 5 illustrates typical distribution networks for railway signalling power supplies.

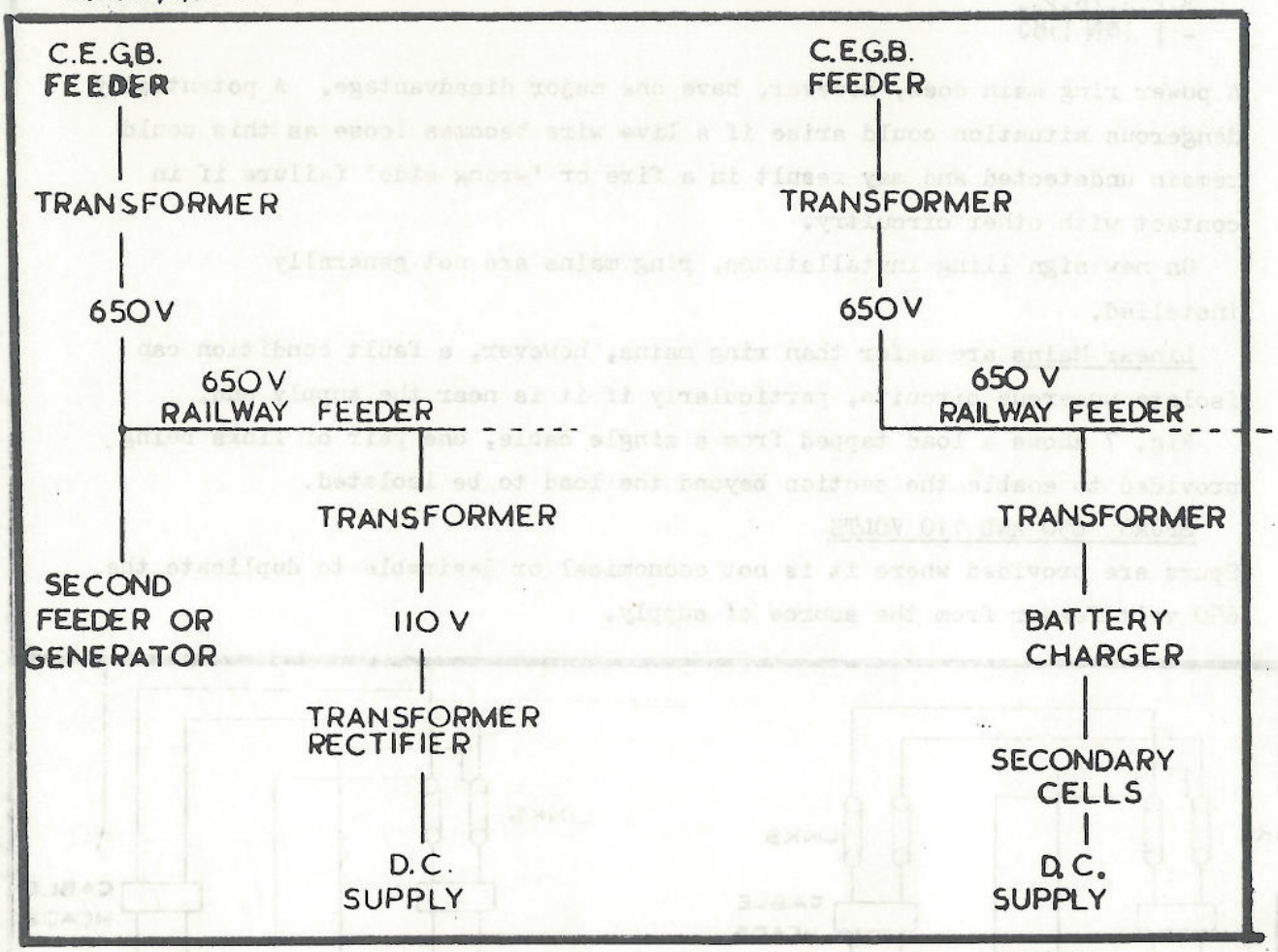

FIG. 5 TYPICAL DISTRIBUTION NETWORKS FOR SIGNALLING POWER SUPPLIES

At many important installations such as Power Signal Boxes and Remote Relay Rooms, it is usual to provide duplicate transformers. This avoids a complete shut down if a transformer should fail. The transformers are controlled through manually operated primary and secondary fuse switches so as to enable either transformer to be 'on load', leaving the other isolated or to enable both transformers to be connected in parallel.

TYPES OF DISTRIBUTION - RING AND LINEAR MAINS

Ring Mains have the advantage of maintaining supplies if a disconnection occurs in the circuit. Links are provided at every location so that any section of cable can be readily isolated if a fault arises, whilst any single disconnection in the cable will not cause a failure as the load is fed from either direction.

Fig. 6 shows a signalling load taken from a ring main. In this example, links are provided on either side of the load, thus enabling either section of cable to be disconnected, but a corresponding disconnection must be made at the next location before the section of cable is completely isolated.

A power ring main does, however, have one major disadvantage. A potentially dangerous situation could arise if a live wire becomes loose as this could remain undetected and may result in a fire or 'wrong side' failure if in contact with other circuitry.

On new sign lling installations, ring mains are not generally installed.

Linear Mains are safer than ring mains, however, a fault condition can isolate numerous circuits, particularly if it is near the supply end.

Fig. 7 shows a load tapped from a single cable, one pair of links being provided to enable the section beyond the load to be isolated.

SPURS 650 AND 110 VOLTS

Spurs are provided where it is not economical or desirable to duplicate the 650 volt feeder from the source of supply.

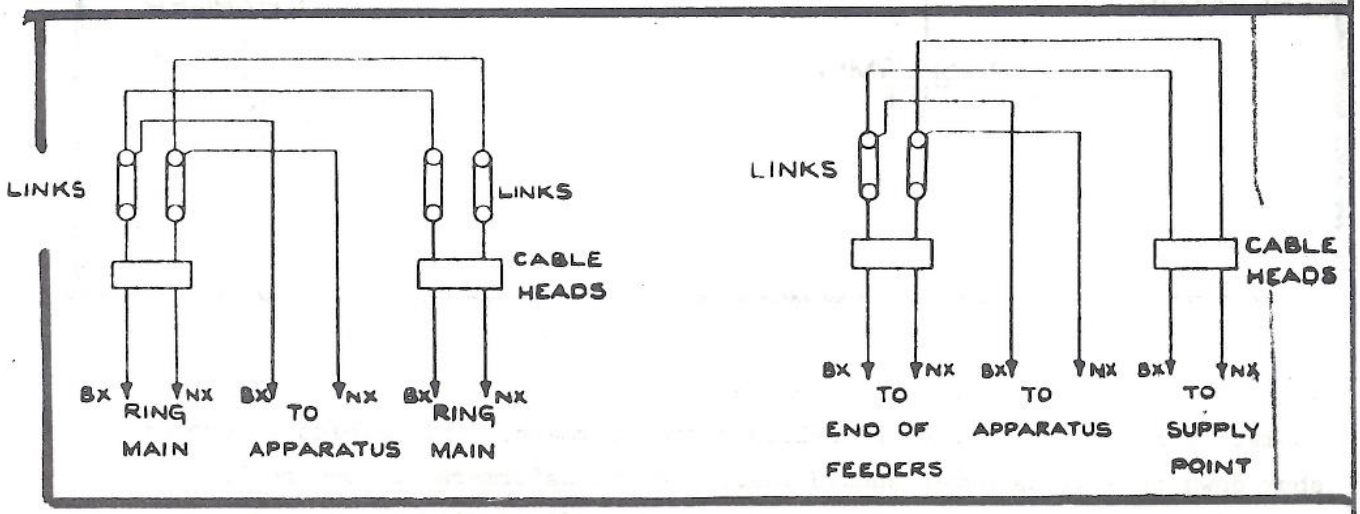

FIG. 6 LOAD TAPPED FROM RING MAIN.

FIG. 7 LOAD TAPPED FROM SINGLE CABLE

CABLE

Power cable is generally to BR Spec. 872 Type MD2 PCP 600/1000V. Every cable has a definite current rating and the size of the conductor used should be such that it will carry the necessary current without any undue temperature rise or voltage drop, allowance always being made for any future possible loads.

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FUSES

Throughout the distribution, from the point of supply, down to the signalling circuits fed from the signalbox or location bus-bars, particular attention must be paid to fuse discrimination. By this is meant that the fuse ratings must be such that a short circuit, wherever it occurs, will take the nearest fuse in the circuit and thus result in the isolation of that portion of the circuit only, leaving the remaining circuits functioning normally.

Fuse ratings are calculated when the installation is planned and replacement fuses must be of the same value - Never of a Higher Rating.

Overload circuit - breakers are in common use, and are designed to break the circuit at a suitable pre-determined overload.

Spare fuses of the correct size and type should be kept adjacent to the equipment ready for use in event of a fuse 'blowing'.

ROUTINE TESTS

1) Standby generator and changeover apparatus must be operated and tested at laid down frequencies.
2) Voltage and load readings to be checked and recorded.
3) Earth Leakage Indicators must be checked for correct operation.

POWER SUPPLY DIAGRAMS

Power supply diagrams should be kept up to date, with any amendments that may have been carried out.

Remember - Power equipment failure can cause serious disruption to traffic operation.

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POWER SUPPLIES - SAFETY PRECAUTIONS

Safety Precautions to be observed at all times when working with Secondary Cells

1) Goggles Must Be Worn when dealing with cells.
2) Keep batteries upright
3) Ensure there is good air circulation to disperse any accumulation of gas before starting work.
4) Do not smoke or permit naked lights near batteries or do anything likely to cause sparks near a battery.
5) Do not allow metal objects to rest on the battery or fall across the terminals.
6) When mixing or handling electrolyte, goggles and rubber gloves must be worn. Do not spill electrolyte on the skin or clothing.

ACCIDENTAL SKIN BURN OR ELECTROLYTE IN THE EYES

SKIN BURNS - Wash liberally with clean water.

ELECTROLYTE IN THE EYES - Immediately use the eye wash bottle or wash out thoroughly with clean water. The filler bottle should not be used for this purpose.

ELECTROLYTE ON CLOTHING - Immediately remove the contaminated clothing.

All the above instructions are contained in a safety notice, as shown below and a copy of the notice must be prominently displayed in battery rooms.

BATTERY CHARGING PRECAUTIONS

Prevent Explosions

Ensure that there is a good circulation of air to disperse any accumulation of gas before starting work.
Never smoke or use naked flames in the battery charging area.
Do nothing that may cause a spark:
never tighten or loosen connections while cells are on charge or discharge or gassing.
keep all connections tight using an insulated spanner.
keep other metal objects away from the tops of batteries.

Avoid Injury from Electrolyte

Wear protective clothing and eye protection. If electrolyte splashes —
in EYES: Immediately use eye-wash bottle or wash out thoroughly with water.
on SKIN: Rinse liberally with water.
on CLOTHING: Immediately remove contaminated clothing.

Don't Spill Electrolyte

but if you do so accidentally, swill down the spillage immediately with plenty of water — BUT NEVER DO THIS IN SUB STATIONS WHERE THERE IS HIGH TENSION ELECTRICAL EQUIPMENT. — Report [illegible] and obtain advice.

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Instruction SM 12 states:-

Switch off the battery charger and allow air to circulate so that any accumulation of gas can disperse. (Ensure air circulation by wafting or fanning where no motion of air is apparent). The instruction requires the battery charger switched off for two reasons:-

1) From a safety angle, gassing will be reduced whilst maintenance work is carried out.
2) The bank of cells will supply the load current and any faulty cell will be detected when the cells are tested.

It must be realised of course that the battery charger must be switched on again to check the charging current and before leaving the Location/Battery Room.

SAFETY PRECAUTIONS TO BE OBSERVED WHEN WORKING WITH PRIMARY CELLS

Both the 618 and 608 type Inert cells use Caustic Soda as the electrolyte so the following precautions need to be taken:-

1) Always ensure the cell is kept upright when being transported, stored or is in service. Cells in service must be well ventilated.
2) Caustic Soda and its solutions coming in contact with the skin or eyes can cause serious burns. Goggles Must Be Worn.
3) If caustic soda comes into contact with skin or eyes wash thoroughly with clean water.

Remember Batteries are no more dangerous than many other types of equipment as long as they are handled correctly.

SAFETY PRECAUTIONS TO BE OBSERVED WHEN WORKING ON POWER SUPPLIES

Railway signalling uses power supplies at various voltages, a typical voltage being 650V which is used extensively for power distribution to power cubicles and apparatus cases located alongside the track.

Power supply cubicles, disconnection links etc. connected to a 650V supply should have preminent labels displayed stating or indicating that the equipment is connected to a High Voltage Source. Transformers and other equipment having exposed terminals should be fitted with insulated protective covers. Individual terminals can be fitted with insulated sleeves and insulated nuts to give the required protection.

WORKING ON LIVE EQUIPMENT

If it becomes necessary to work on live equipment it is essential that Rubber Gloves suitable for High Voltages are used in conjunction with a Rubber Mat and that any tools used are Insulated.

Rubber Gloves and Mats can be found in Relay Rooms etc. where power supply cubicles are installed. The rubber gloves are marked on the cuff with the year of manufacture, month and size and that they are to be tested in accordance with BS697.

Replacement tested gloves are provided on a regular basis.

British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools, York & Ilford.

Ref. B.E.S./ 6/1 - 1 JAN 1983

Course. Basic Electrical Signalling

Subject. D.C. Track Circuits. Operation and Definition of Terms

DEFINITION

The track circuit is the basis of modern signalling. ITS FIRST PURPOSE IS TO PROVE THAT A SECTION OF TRACK IS CLEAR OF ALL VEHICLES. That being done points may be operated and signals then cleared for trains tommove with the assurance that it is safe for the movement to take place.

The second purpose of a track circuit is to detect the presence of a train and to lock the route ahead of it and so ensure its safe transit.

The track circuit also provides the indications on the signalling control panel which advises the operator of the whereabouts of all vehicles on his section of the line and enables the train describer to keep in step with train movements.

PRINCIPLE OF OPERATION

The running rails are used as conductors connecting a source of electrical energy at one end of the track circuit to a relay at the other.

Fig. 1 illustrates the principle of operation of a simple battery fed track circuit of the type which may be found on non-electrified lines where no power supply is available. The track is shown in the clear condition.

The running rails of a section of line are electrically isolated by the provision of four insulated rail joints. One end of the section is connected through a variable resistance to a primary battery, and the other end to a track relay. Current flows from the battery through the VARIABLE FEED RESISTANCE WHICH REGULATES THE FLOW OF CURRENT via the positive track rail to the track relay. The current flows through the relay winding whence it returns through the negative track rail to the negative of the battery. THIS CURRENT FLOW ENERGISES THE RELAY WHICH CLOSES ITS FRONT CONTACTS.

It should be noted that with this simple type of track circuit, it was usual for the relay to be located at the end of the track circuit at which the train enters it, and of course, the battery is at the leaving end.

Fig. 2 shows the same track circuit occupied by a train. Current flows from the battery through the variable resistance to the positive track rail. The two rails are now bridged by the whells and axles of the train whose electrical resistance is negligable compared with that of the winding of the track relay. The current chooses the line of least resistance and returns through the wheels and axles to the negative rail and the battery. The relay is thus by-passed, "shunted" is the proper term, and practically no current passes through the winding. THUS WITH THE TRACK OCCUPIED THE RELAY BECOMES ELECTRICALLY DE-ENERGISED AND ITS FRONT CONTACTS ARE OPENED, thus interrupting indication and signalling circuits which may be controlled through them. Back or bottom contacts of the track relay are closed when the relay is de-energised.

The track circuit is limited in its workable length by two factors. The first is the leakage of current from one rail to the other through the rail fixings, the sleepers and ballast-(in parallel). The second is the resistance of the rails themselves and the rail bonds. The latter are not required for welded track and the resistance is then that of the rails alone.

A SHORT CIRCUIT OR A DISCONNECTION OF ANY KIND IN THE BATTERY, REGULATING RESISTANCE OR RELAY COIL, OR A DISCONTINUITY IN THE PATH THROUGH THE RAILS FOR ANY REASON (for example a broken rail), WILL CAUSE THE RELAY TO BECOME DE-ENERGISED, thus simulating the presence of a train. THIS IS THE MORE RESTRICTIVE CONDITION AND THE TRACK CIRCUIT CAN THEREFORE BE SAID TO BE "FAIL SAFE".

DEFINITION OF TERMS AND COMPONENT VALUES

The essential parts of a direct current track circuit are :

1) Rails and bonding.
2) Insulated joints
3) Battery
4) Feed (or regulating) resistance.
5) Relay.

RAILS AND BONDING

The rails provide a low resistance path for the current. BOND WIRES ARE PROVIDED TO ENSURE THAT THERE IS A LOW RESISTANCE PATH FROM ONE RAIL TO THE NEXT, as the fish-plated joint cannot be relied upon for this purpose. The most common bond is a No 8 S.W.G. galvanised iron wire 5' 6" long, duplicated to meet the contingency of broken bonds. The bond wires are inserted into a 9/32" hole on the 4ft. side of the rail (or by the current prescribed method) and securely fixed by a tapered channel pin.

INSULATED JOINTS

These are fitted at the ends of a track circuit in each rail - and in turnouts to CONFINE THE CIRCUIT TO THE REQUIRED AREA. A common form of insulated joint consists of a fibre end post to separate the rail ends, four fibre plates to insulate the fishplates from the rails, four fibre ferrules for the fishplate bolts and two special steel fishplates which are narrower than standard to allow for the thickness of the fibre plates. Standard fishplate bolts are used, with the rail holes reamered out to take the $1\frac{1}{4}$" dia. fibre ferrules.

Another type of insulated joint employs a fishplate made of laminated insulating material. An end post is still required, but the use of side fibres, ferrules, reamering, etc; is obviated. INSULATED RAIL JOINTS ARE OF SEVERAL DIFFERENT TYPES BUT ALL ARE DESIGNED TO ELECTRICALLY ISOLATE ONE RAIL FROM THE NEXT ADJACENT RAIL.

BATTERY

Where primary cells are used for D.C. track circuits, regional practices should be observed, the correct cells being given in the current instruction on "Types and Applications of Primary Cells". The voltage required for the track circuit can be realised by any primary cell now in use, but its length of service is dependant on its capacity (which is generally related to physical size). The practice at present is to employ one inert caustic cell type AD 618A or EMU 1 where current requirements are below 400 milliamps. For track circuits requiring current in excess of this, the correct battery is one cell type AD 608A.

FEED RESISTANCE

The feed resistance regulates the flow of current to the track circuit, and prevents a short circuit on the battery when the track is occupied. At present it is an adjustable resistance giving a maximum of 13.2 ohms in steps of 0.1 ohms and requires to be adjusted to obtain correct Track Circuit operation.

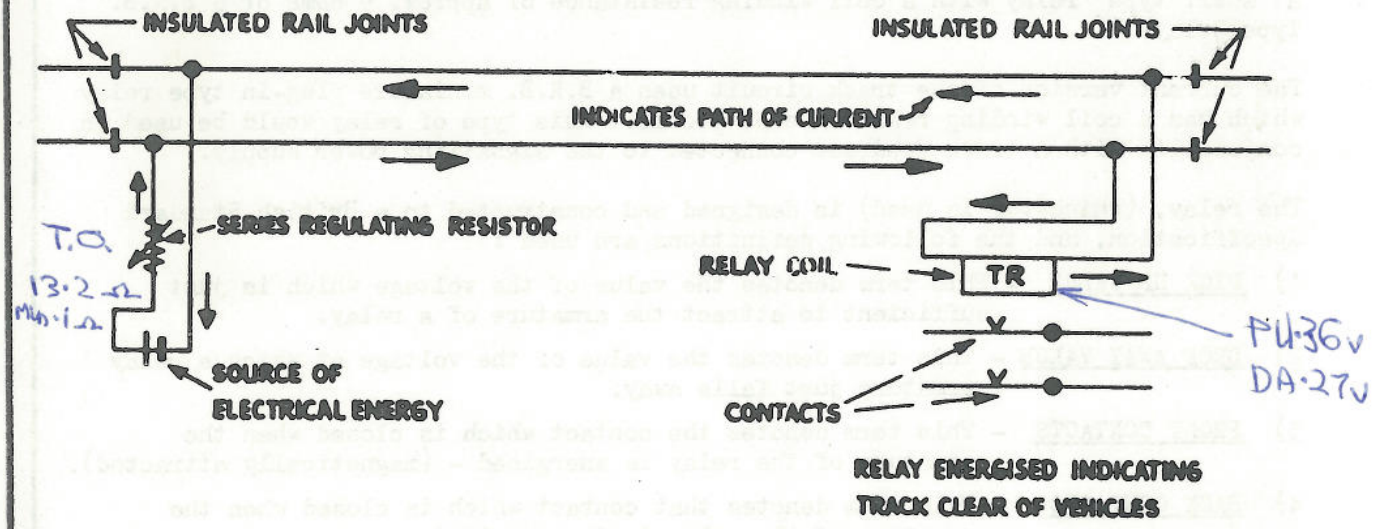

Fig 1 Basic Track Circuit
Clear

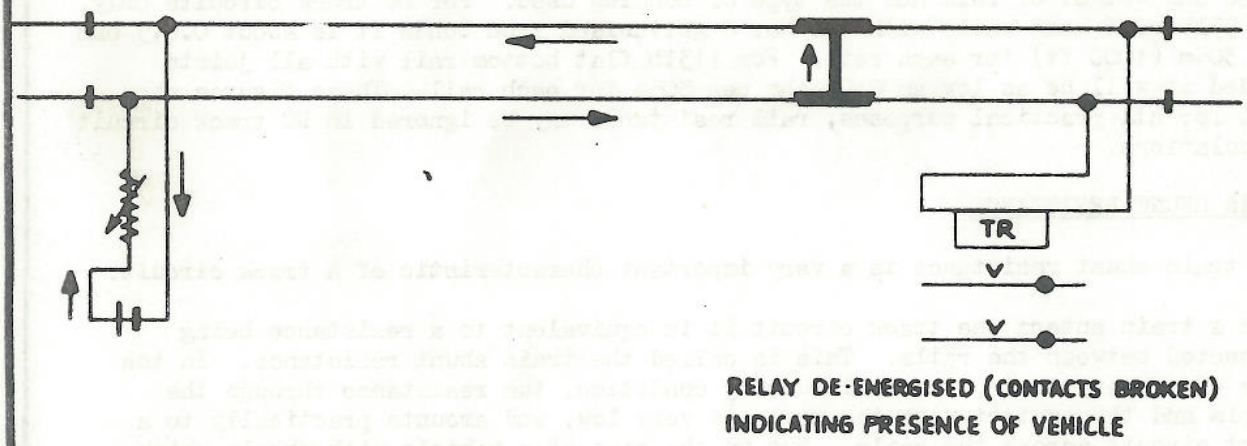

Fig 2 Basic Track Circuit
Occupied

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RELAY

The relay used is essentially an electro-magnet of the neutral type. It can be a "shelf type" relay with a coil winding resistance of approx. 9 ohms or a B.R.B. Type Relay.

The current version of the track circuit uses a B.R.B. miniature plug-in type relay which has a coil winding resistance of 4 ohms. This type of relay would be used in conjunction with a track feed set connected to the signalling power supply.

The relay, (whichever is used) is designed and constructed to a British Standard Specification, and the following definitions are used :

1) PICK UP VALUE - This term denotes the value of the voltage which is just sufficient to attract the armature of a relay.

2) DROP AWAY VALUE - This term denotes the value of the voltage at which a relay armature just falls away.

3) FRONT CONTACTS - This term denotes the contact which is closed when the armature of the relay is energised - (magnetically attracted).

4) BACK CONTACTS - This term denotes that contact which is closed when the armature of the relay is de-energised.

BALLAST RESISTANCE

THE RAIL TO RAIL RESISTANCE IS THE RESISTANCE MEASURED BETWEEN THE TWO RAILS WITH THE SUPPLY AND RELAY DISCONNECTED AND IS CALLED THE 'BALLAST RESISTANCE'. It may vary from 50 ohms per 305m (1000ft) for well ballasted dry track with insulated rail fixings (as for flat bottom track) to as low as 0.5 ohm per 305m in wet conditions, or when the ballast is dirty. It will be appreciated that THE BALLAST RESISTANCE IS CONSTANTLY VARYING WITH THE WEATHER CONDITIONS, and therefore the adjustment of the regulating resistance must take into account the highest and lowest values of the ballast resistance for the track circuit.

RAIL RESISTANCE

The rail resistance is constant for a given track circuit but varies for different types and weight of rail and the type of bonding used. For DC track circuits only, for 95lb bull head rails with two No. 8 galvanised iron bonds it is about 0.075 ohm per 305m (1000 ft) for each rail. For 113lb flat bottom rail with all joints welded it will be as low as 0.01 ohm per 305m for each rail. These figures show that for all practical purposes, rail resistance may be ignored in DC track circuit calculations.

TRAIN SHUNT RESISTANCE

The train shunt resistance is a very important characteristic of a track circuit.

When a train enters the track circuit it is equivalent to a resistance being connected between the rails. This is called the train shunt resistance. In the case of a heavy train in normal running condition, the resistance through the wheels and the contact with the rails is very low, and amounts practically to a short circuit across the rails. But in the case of a vehicle with wheels which may be rusty through standing idle the resistance may be much higher. It is of vital importance that such a vehicle shall operate the track circuit as surely as one in good condition.

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TRAIN SHUNT RESISTANCE (Cont'd)

Contamination of the rail head increases the contact resistance, and to cover both the effects of rusty wheels and contaminated rails it is usual to specify a minimum train shunt resistance at which the track circuit will operate reliably. It must not be throught advisable to obtain as higher train shunt resistance as possible, because this would make the track circuits undesirably susceptible to the effects of rain storms. It is usual to specify a minimum train shunt of 0.5ohm.

As an indication of the performance under actual working conditions of track circuits, it is considered necessary to take measurements which will answer the following questions :

1) WHAT IS THE MAXIMUM TRAIN SHUNT WHICH MAY BE APPLIED TO THE TRACK CIRCUIT AND JUST CAUSE THE RELAY TO DROP ?

The resistance answering to No 1 above is called the - DROP SHUNT

2) WHAT IS THE MAXIMUM TRAIN SHUNT WHICH MAY BE APPLIED TO THE TRACK CIRCUIT SO THAT THE RELAY WILL JUST FAIL TO PICK UP ?

The resistance answering to No 2 above is called the - PREVENT SHUNT

THE DROP SHUNT RESISTANCE IS THE MAXIMUM RESISTANCE WHICH, WHEN PLACED ACROSS THE RAILS, WILL CAUSE THE RELAY TO BE ON THE POINT OF DROPPING AWAY. THE LOWEST ALLOWABLE DROP SHUNT FOR A DC TRACK IS 0.5 ohm.

THE PREVENT SHUNT RESISTANCE IS THAT RESISTANCE WHICH, WHEN PLACED ACROSS THE RAILS, WILL CAUSE THE RELAY TO BE ON THE POINT OF PICKING UP.

The drop and prevent shunt resistances are measured by aid of an instrument called a 'Train Shunt', which is merely a variable resistance with one dial marked off in ohms and another dial marked off in tenths of an ohm.

TRAIN SHUNT INSTRUMENT

WHEN TAKING THE DROP SHUNT, THE INSTRUMENT IS SET TO ITS HIGHEST VALUE AND CONNECTED ACROSS THE RAILS AT THE RELAY END OF THE TRACK CIRCUIT, THE RESISTANCE IS THEN DECREASED UNTIL THE RELAY JUST DROPS. The reading on the train shunt instrument is then the drop shunt resistance for that track circuit under the conditions prevailing at the time of the test.

WHEN TAKING THE PREVENT SHUNT, THE INSTRUMENT IS SET TO ITS LOWEST VALUE AND CONNECTED ACROSS THE RAILS AT THE RELAY END OF THE TRACK CIRCUIT, THE RESISTANCE IS THEN INCREASED UNTIL THE RELAY JUST PICKS. The reading on the train shunt instrument is then the prevent shunt resistance for that track circuit under the conditions prevailing at the time of the test.

The method and frequency of testing track circuits (Including the tests above), should be carried out as per current Signalling Installation and Maintenance Instructions.

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TRACK CIRCUIT INDICATION CIRCUIT

Fig. 3 shows a typical arrangements for indicating on a signalbox or illuminated diagram, the condition of a track circuit. The panel indication lamp is illuminated to indicate the presence of a train on the track circuit.

A feed is taken over the front contacts of the T.R. to energise the coil of the Track Repeating Relay (T.P.R.). The T.P.R. thus acts as a 'slave' of the T.R.

When the track is 'occupied' by a train, the T.R. is de-energised and this in turn disconnects the circuit to the T.P.R. coil. The T.P.R. is now de-energised and its 'back' contacts 'make!

A feed is now taken over the T.P.R. back contacts and illuminates a lamp (or lamps) on the signalmans panel, thus, EVERY TIME THE TRACK CIRCUIT IS 'OCCUPIED', THE TRACK INDICATION LAMP IS ILLUMINATED.

It can be seen that numerous track circuit indication lamps can be illuminated via the back contacts of their respective T.P.R.s, thus enabling the signalman to monitor all the trains in his particular area.

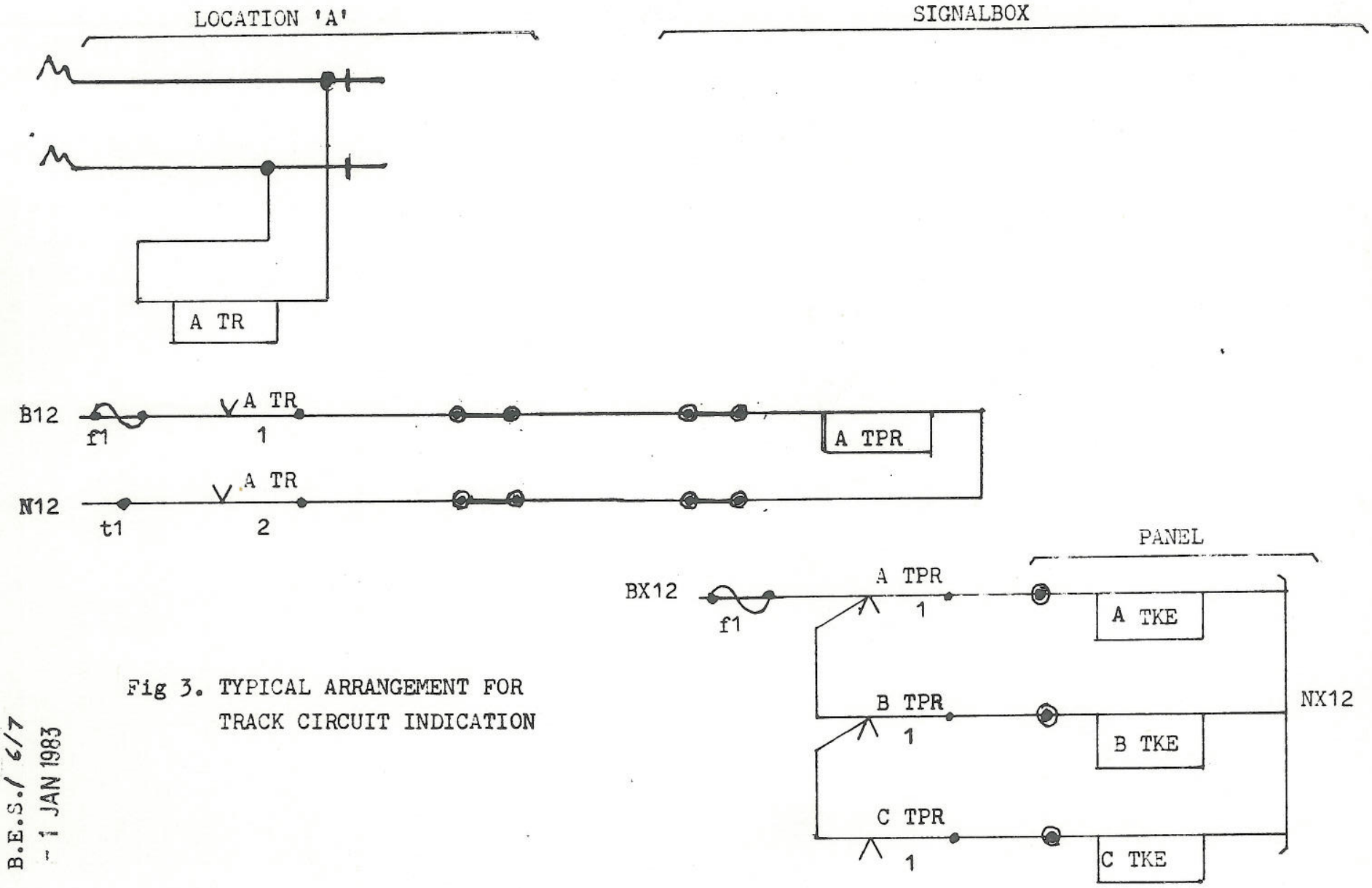

Fig 3. TYPICAL ARRANGEMENT FOR TRACK CIRCUIT INDICATION

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TRACK CIRCUIT ADJUSTMENT

When setting up a track circuit, it is desirable that the lower voltage limit on the relay is not less than 50% above the relay pick up value under average conditions. This ensures that the drop shunt is not too high and so avoids failure of the track circuit under wet weather conditions. The upper voltage limit on the relay should be such that THE DROP SHUNT ACROSS THE RAILS AT THE RELAY END OF THE TRACK IS NOT LESS THAN 0.5 ohm AT ANY TIME. The object is to ensure that the track circuit will operate satisfactorily when occupied or fail safe.

Ballast conditions play an important part in the operation of track circuits and the following principles should be remembered:

WET BALLAST - LOW BALLAST RESISTANCE.
LOW RELAY VOLTAGE
HIGH DROP AWAY SHUNT.

DRY BALLAST - HIGH BALLAST RESISTANCE
HIGH RELAY VOLTAGE
LOW DROP AWAY SHUNT.

SETTING UP (Assuming average conditions)

When the installation of the track circuit is complete, the track feed links should be slipped to disconnect the track feed, and a voltmeter connected across the two rails. A zero reading should be obtained indicating no extraneous feed to the track circuit. Re-connect the links.

Set the feed resistance to give a voltage across the rails at the feed end that is the Relay Pick Up Voltage + 50.

Walk down the track making occasional voltage checks across the two rails. There should be no sudden drop in voltage, but you may find a slight drop in voltage between the feed end volts and relay end volts, dependent on the length of track circuit and the physical characteristics of the track, i.e., whether it is C.W.R. or bonded track.

At the track relay location, check that the track relay is energised and measure the relay voltage on the R1 and R2 terminals. A Drop Shunt Test must now be made.

ON SETTING UP, OR FOLLOWING ALTERATIONS, THE TEST MUST FIRST BE MADE ACROSS THE RAILS AT THE RELAY END.

The train shunt is set to a high value and connected across the rails. The resistance of the train shunt is then decreased until the track relay just drops away. - Read the resistance value. - Repeat the test three times, disconnecting the shunt from the rails between tests. The average of the three readings is the Drop Shunt Value.

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THE MINIMUM PERMISSABLE DROP SHUNT ON A D.C. TRACK CIRCUIT IS 0.5 OHM.

The adjustment of the track circuit voltage is assessed from the train shunt result.

A typical value for a track circuit under average conditions would be a drop shunt in the order of 0.8 to 0.9 ohm.

If on test the DROP SHUNT IS HIGH - DECREASE THE FEED RESISTANCE TO INCREASE THE TRACK VOLTAGE.

If on test the DROP SHUNT IS LOW - INCREASE THE FEED RESISTANCE TO DECREASE THE TRACK VOLTAGE.

DROP SHUNT TOO LOW INDICATES A POSSIBILITY OF FALSE CLEARANCE.
(Wrong side Failure)

DROP SHUNT TOO HIGH INDICATES A POSSIBILITY OF FALSE OCCUPIED
Condition (Right Side Failure).

When the voltage and shunt are correct, enter on the Track Record Card :-

Volts Across Rails
Volts Across Relay
Drop Shunt Across Rails
Value of Track Feed Resistance.

A further test is now made in the track relay location. The voltmetere is connected across the relay terminals or links and also the train shunt instrument. The shunt, (set at a high value), is reduced until the relay just drops away. The shunt value and the voltage reading at 'drop away', should be noted and recorded.

There should be no difference between the drop away voltage shown by the meter and that stated on the relay label.

Typical entries on Track Circuit Maintenance Record Cards are shown overleaf.

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TRACK CIRCUIT MAINTENANCE RECORD CARD A.C. OR D.C.

BR.12206

SIGNAL BOX OR LOCALITY:- ILFORD S.B.

TRACK CIRCUIT NUMBER:- 10

THIS RECORD MUST BE KEPT IN THE TRACK RELAY LOCATION

CARDS WHEN FILLED MUST BE SENT TO INSPECTOR.

Feed Resistance/ Reactance/ Capacitance	Volts Across Rails at Feed End	RELAY END		Technicians Signature	Date	Ballast Condition 1. Wet 2. Damp 3. Dry 4. Frozen 5. Flooded
		Volts Across Relay Tmls.	Shunt at Rails to Drop Relay			
2.3	0.6v	0.56v	o.9	A.N.Other	22.2.82	3
Readings taken across relay coils. D.A.Volts						
		0.27v	o.8			

MAINTENANCE VISITS

On maintenance visits (12/13 weekly), only the test across the relay coil is made, the drop shunt and drop away voltage being observed. Allowing for changes in weather conditions, any change in these values must be recorded and if they give cause for concern, investigated.

The track circuit should be examined in accordance to the following extract from the Signalling Maintenance Instruction.

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EXTRACT FROM SIGNALLING MAINTENANCE INSTRUCTION SM9

TRACK CIRCUITS, MAINTENANCE TESTING AND EXAMINATION

1.0 GENERAL

1.1. A check of Track Circuits must be carried out by the Technicians as part of their normal duties when visiting sites or walking through a Section.

1.2. Two specific tasks must be carried out at 12/13 weekly intervals to ensure reliability and satisfactory operation. There are :-

1.2.1. Drop-away shunt test.

1.2.2. Track circuit examination.

1.3. Each Track Circuit test and examination must be scheduled and the Supervisor must ensure that these are satisfactorily carried out.

2.0. TRACK CIRCUIT TESTS

2.1. TESTS ACROSS THE RAILS

On installation full tests must be carried out, the shunt must be taken across the rails, and details recorded on B.R.13396. This must be repeated every time there is an alteration to the Track Circuit; e.g. alteration to the adjustment in the feed setting is made, relaying has taken place, the track relay is changed, leads or jumpers have been renewed. When satisfactory settings have been obtained a further test as in 2.2 should be carried out and these values also recorded. The record card to be kept at the site of the relay.

2.2. TESTS ACROSS THE RELAY

Where the Track Circuit is of a linear type, either D.C. or A.C. (see the Appendix 'A' to this instruction for details) the scheduled 12/13 weekly drop-away shunt test must be carried out with the shunt and voltmeter across the track relay coils or track relay leads in the location case or Relay Room where the relay is housed.

In electrified areas the shunt must be placed on the incoming links and not on the relay terminals so that the filters/chokes, etc. at the relay end are still in circuit.

Where the Track Circuit is of the non-linear, i.e. pulse type or high frequency above 83½Hz (see Appendix 'A' to this instruction for details) the shunt must still be taken across the rails.

2.3. OBJECTIVE OF TESTS ON TRACK RELAYS

The objective of the tests is to ensure that the relay action is sharp and positive when the drop-shunt value is applied. The Technician must ensure by visual observation that the relay is clean and dry and that the relay operation is satisfactory with no significant change in the drop-away voltage. The voltage and drop-away shunt values as in 2.2, must be recorded and if any change gives cause for concern, a shunt test across the rails is 0.50 ohm, except on some impedence bond Track Circuits.

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3.0 TRACK CIRCUIT EXAMINATION

3.1. OBJECTIVE

The objective of the scheduled 12/13 weekly examination is to find and remove potential failures and ensure that as far as possible the Track Circuit will function satisfactorily until the next examination. Any obstructions or conditions likely to prove detrimental to the reliability of the Track Circuit must be dealt with immediately if practicable or brought to the notice of the Supervisor or man in charge and dealt with as soon as possible.

3.2. ACTION

It is essential that action is taken to deal with any condition likely to cause a failure. Where other Departments are involved it is not sufficient just to advise a member of that Department, action must result if a failure is to be avoided and trains are not to be delayed.

3.3. DETAILS

Specific attention must be given to the Examination of the following items :-

3.3.1. Track circuit rail connections

3.3.2 Leads, cables and jumpers

3.3.3. Insulation deterioration, and rail burring over insulation.

4.0 TRACK CIRCUIT CHECKING

The following items must be checked :-

4.1. Metallic debris around insulations and points and crossings.

4.2. Bonds, loose bolts, fixings and clips associated with points and crossings.

4.3. Points rodding and signal wires etc., touching or liable to touch either rail (in electrical areas, traction jumpers and bonds must be clear of all rails to which they are not bonded).

4.4. Rail and Clip insulation on Continuous Welded Rail.

4.5. Bonds on Plain Line.

4.6. Condition of Ballast.

FAULT LOCATION

The aim of maintenance work is to reduce to a minimum the number of failures. By an analysis of failures that have occurred, we can be made aware of the items that should be given close attention on maintenance work.

The following are extracts from failure reports and show the percentage rate for track circuit components.

Feed Resistance	0.09 per cent
Track Circuit Insulation	9.02 "
Track Circuit Bonding	3.83 "
Track Circuit Rail Connectors	4.19 "
Track Circuit Rail Leads	30.25 "
Track Circuit Interupter	2.34 "
Relay D.C. (other than B.R.B.)	1.17 "
Terminal Links	0.90 "
Cable Multicore	4.77 "
Internal Wiring	1.66 "
Fuses	3.18 "
Relays (Miniature)	1.17 "

FAULT LOCATION (Cont'd.)

The above are just extracts from a long list. The total failures in one year can be in the order of 2000, pointing to the need for good installation and maintenance and efficient fault finding.

The 'Flow Chart' illustrates the 'Methodical Approach' to fault finding. Experience has shown that, in any type of failure situation, the methodical approach is a much more effective method than the haphazard approach. The chart may look complex, but examination will show that it is just 'Common Sense'.

The chart reveals that there are several inherent hazards to effective track circuit operation, and we will now look at some of these in more detail.

BROKEN TRACK TAIL CABLE

The standard type of track cable now in use is 50/0.25mm, and is connected to the rail by means of a 'Ross Courtney Connector'. (Method of termination illustrated in Fig. 1).

The track cable normally lies on top of the ballast where it should be visible to all maintenance staff (S. & T. and D.C.E.). As you have already noted, 30.25% of all track circuit failures are caused through faulty track tail cables. These can be attributed to two main areas of potential failure. - The first is Track Termination Corrosion. This of course, is due to poor maintenance, as the rail connection should have been inspected by the technician and re-terminated.

The second area of potential failure is damage caused by the D.C.E's Mechanised Maintenance Machines and by Plant used during Relaying Operations. Before work of this nature takes place, the technician should familiarise all concerned as the location of all cross track cables, thus avoiding later damage. (And unnecessary extra repair work on the part of the technician).

INSULATED RAIL JOINTS

Track circuit fault conditions may occur if two adjoining rails are allowed to burr over the 'T' section of an insulated rail joint.

Another potential hazard to correct track circuit operation is metal swarf and/or brake dust bridging across an insulated joint. Brake dust contamination is particularly prevalent in terminal station areas where brake application is necessary for all approaching trains.

If you suspect an insulated block joint is faulty, you must call on the services of the D.C.E.'s department, who, if necessary will replace the defective joint.

CONCRETE SLEEPERS

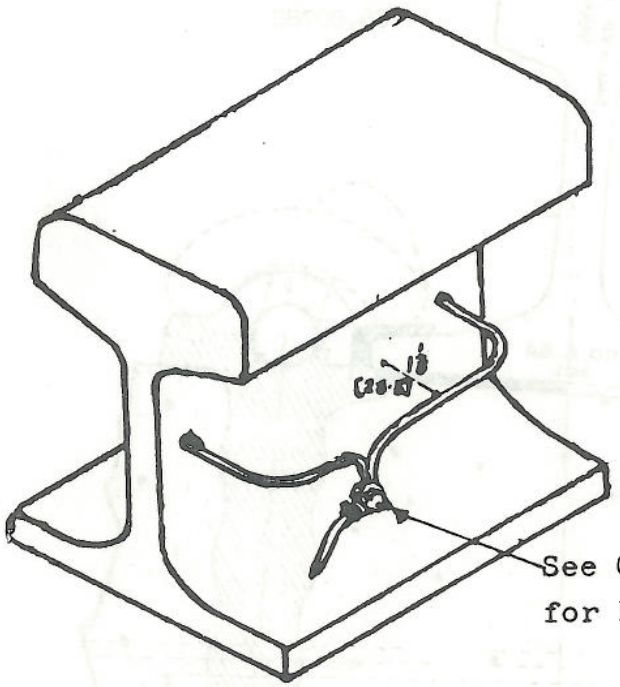
Concrete sleepers are a further inherent hazard to the correct operation of a track circuit. The concrete is re-inforced with metal rods which form a 'potential' short circuit path for current flow.

The rails are fastened to the sleepers by means of a metal housing and clip. A type of clip which is rapidly becoming standard is the 'Pandrol Clip'.

CONCRETE SLEEPERS (Cont'd.)

Fig. 2 illustrates a concrete sleeper and fittings. There are four Pandrol Clips per sleeper (two per rail).

You will note that a 'Thermo Plastic Insulator' is inserted between the clip and the rail. The Insulator prevents a short circuit via the rail, clip, concrete sleeper re-inforcings, (numerous metal rods which run the length of each sleeper) and through to the other rail.



Detail of Cable Attachment

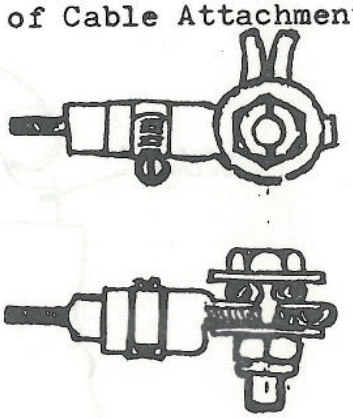


Fig. 1 Track Circuit Connectors.

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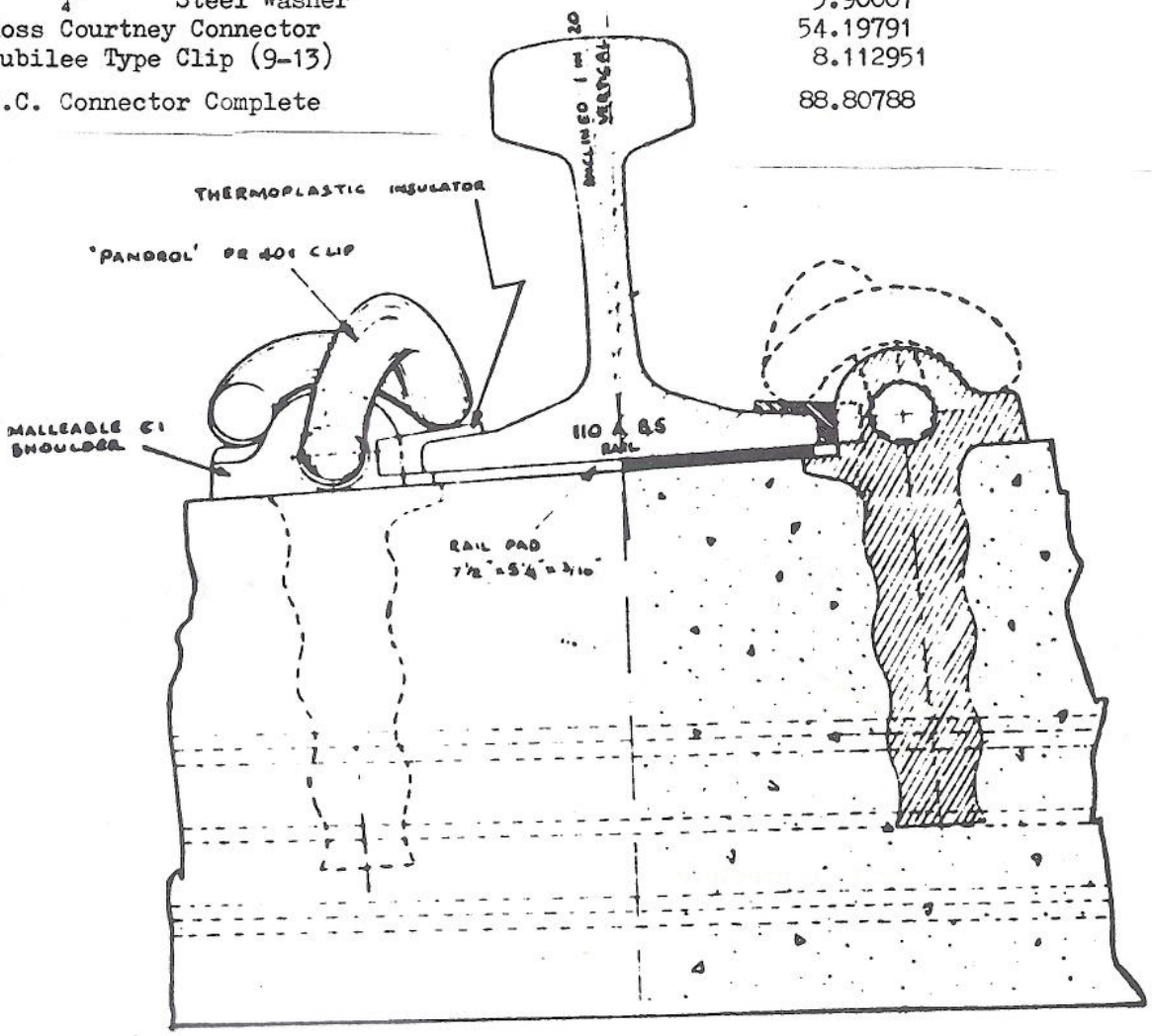
50.025mm cable to be attached to bond wire by a Ross Courtney No. 6 Facile Terminal and Jubilee Clip, fastened with a $\frac{1}{4}$" BSW x 1" (M6 x 25) C.P. Steel Hex. Setscrew 2-$\frac{3}{4}$" (19) o.d. cp Steel Washers and a self-lock nut. (Dimensions in brackets are in millimetres).

Components List

1" x $\frac{1}{4}$" Whit Steel Set Screw	35.32380
$\frac{1}{4}$" Whit Aerotight Nut	3.79929
$\frac{1}{4}$" Steel Washer	3.90007
Ross Courtney Connector	54.19791
Jubilee Type Clip (9-13)	8.112951
T.C. Connector Complete	88.80788



ELEVATION / SECTION ON 'SS'

(SCALE 3/8" = 1")

Fig 2 Rail fastenings on concrete sleeper by 'Pandrol Clip'

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The 'Thermo Plastic Insulators' however, are subject to wear, and occasionally a situation arises where two of these insulators, (one on each side of the same sleeper), have worn through, thus creating a short circuit.

You will appreciate that this type of failure may be difficult to locate as there may be several hundred insulators to examine. A device which considerably assists in the location of this type of fault is the ' Pandrol to Rail Insulation Detector', (P.R.I.D.). This machine, which resembles a wheel barrow, is pushed along the line, sweeping the pandrol clips with metal brushes. If a continuity exists between the rail and Pandrol Clip, an audible alarm is given.

BONDING

The correct installation and maintenance of bonds is an essential requirements for the correct operation of a track circuit.

A broken bond may give rise to a 'High Resistance' joint, and a bond that has been incorrectly installed, i.e. - the bond pin not being 'driven home' sufficiently, will also result in a high resistance.

The above conditions are 'obvious' types of potential failure, however, what is not always quite so obvious, is the overall bonding requirements, particularly where points and crossings (P and C) are concerned.

Where points and crossings occur, intermediate insulated rail joints are provided to maintain effective continuity of polarity of each rail. These intermediate joints are usually located in the turnout rather than in the main running line in order to limit the rate of wear.

Figs. 3 and 4 show typical bonding plans for two common layouts. The insulated joints are located in positions which enable point locking to be released at the earliest opportunity.

SERIES AND PARALLEL BONDING

Inadvertent disconnection of any bond between adjacent components of a track circuit must result in the latter 'failing safe', that is, showing 'track occupied'. This is achieved by bonding all parts of the track circuit in series wherever possible. Fig. 5 shows a typical case of series bonding, whilst Fig. 6 illustrates the danger of 'over bonding'.

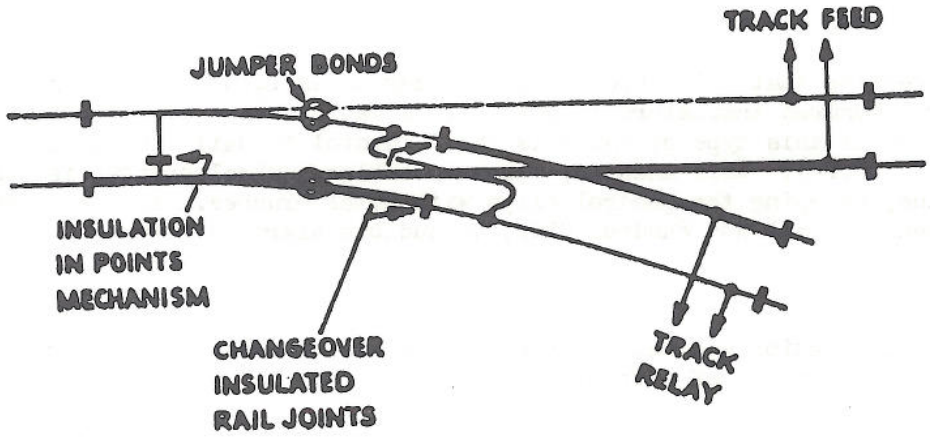

Fig 3 Typical Bonding of Track Circuit
Through Single Ended Set of Points.

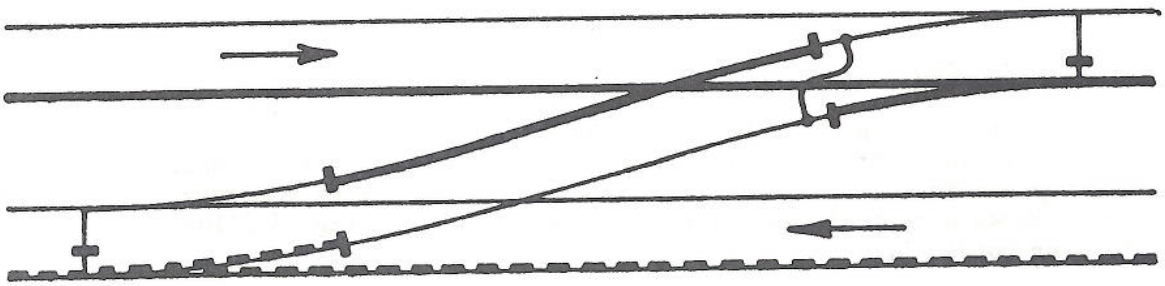

Fig 4 Typical Bonding Through Double Ended Points

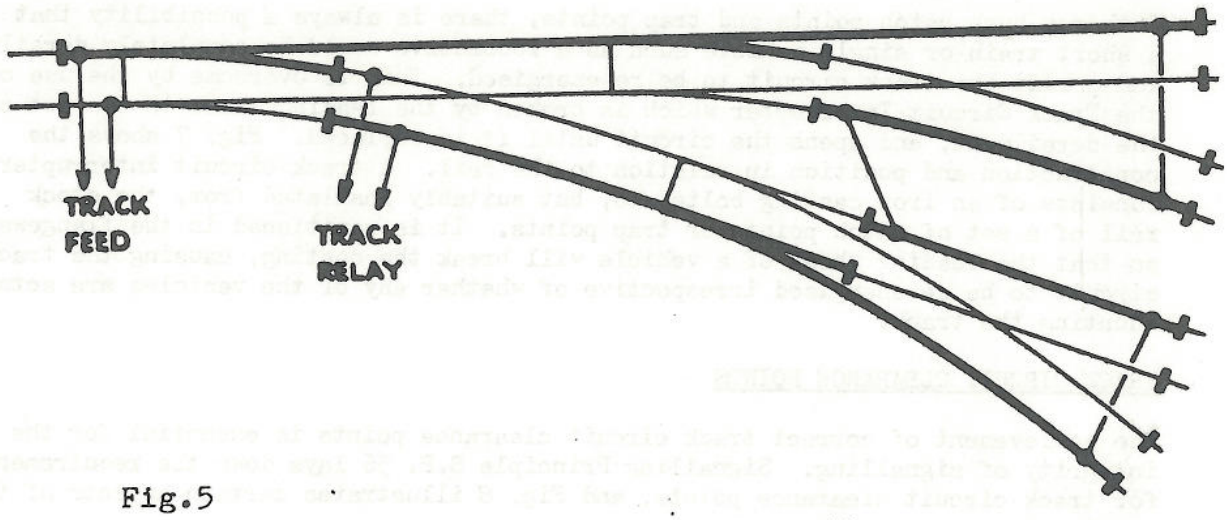

Fig.5
Typical Series Bonding of Track Circuits

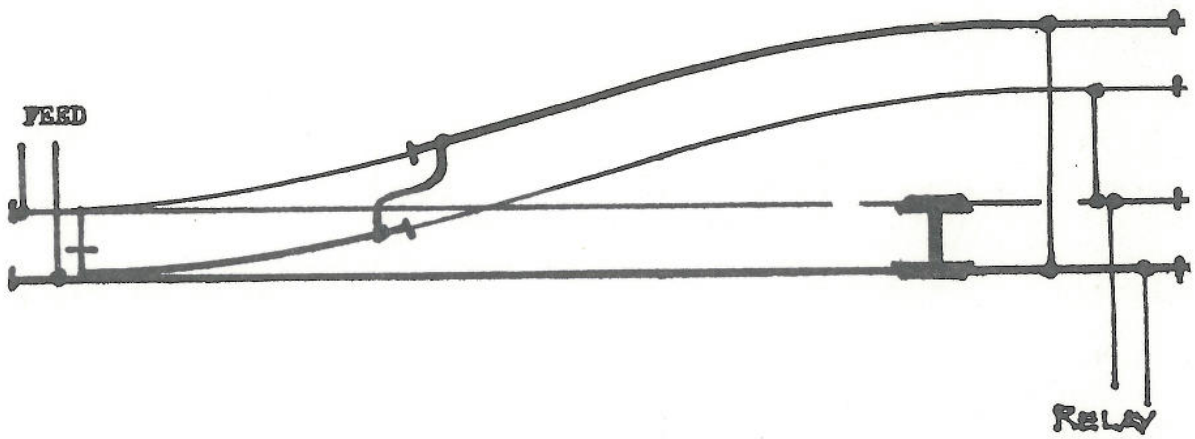

Fig 6
Danger of 'Over Bonding'

The bonding illustrated in Fig. 6 would enable the track relay to remain energised despite a disconnection in the circuit, and with two disconnections in one leg, a train could remain undetected, thus a 'wrong side' failure would exist.

TRACK CIRCUIT INTERRUPTER

With run back catch points and trap points, there is always a possibility that a short train or single vehicle such as a locomotive could be completely derailed and permit the track circuit to be re-energised. This is overcome by the use of the Track Circuit Interrupter which is broken by the leading wheel in the act of the derailment, and opens the circuit until it is replaced. Fig. 7 shows the construction and position in relation to the rail. A track circuit interrupter consists of an iron casting bolted to, but suitably insulated from, the stock rail of a set of catch points or trap points. It is positioned in the flangeway so that the leading wheel of a vehicle will break the casting, causing the track circuit to be de-energised irrespective of whether any of the vehicles are actually shunting the track.

TRACK CIRCUIT CLEARANCE POINTS

The achievement of correct track circuit clearance points is essential for the integrity of signalling. Signalling Principle S.P. 36 lays down the requirements for track circuit clearance points, and Fig. 8 illustrates certain aspects of these requirements.

We have now discussed some of the inherent hazards to effective track circuit operation. The technician must be aware of these hazards in order that he may effectively overcome them by correct installation and maintenance and by the methodical approach to fault finding.

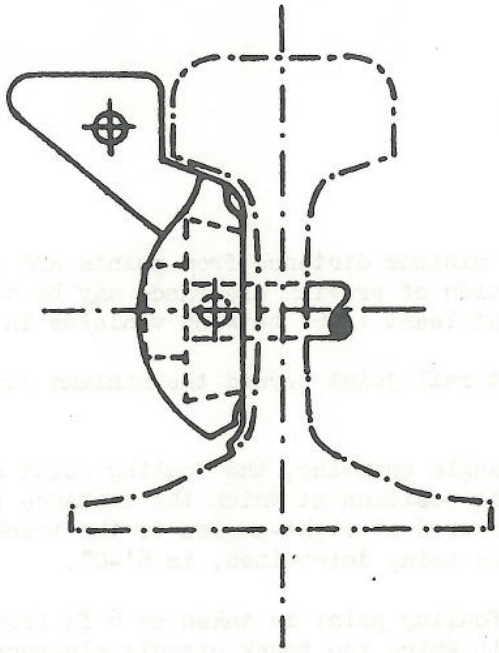

Fig. 7 Track Circuit Interrupter Assembly

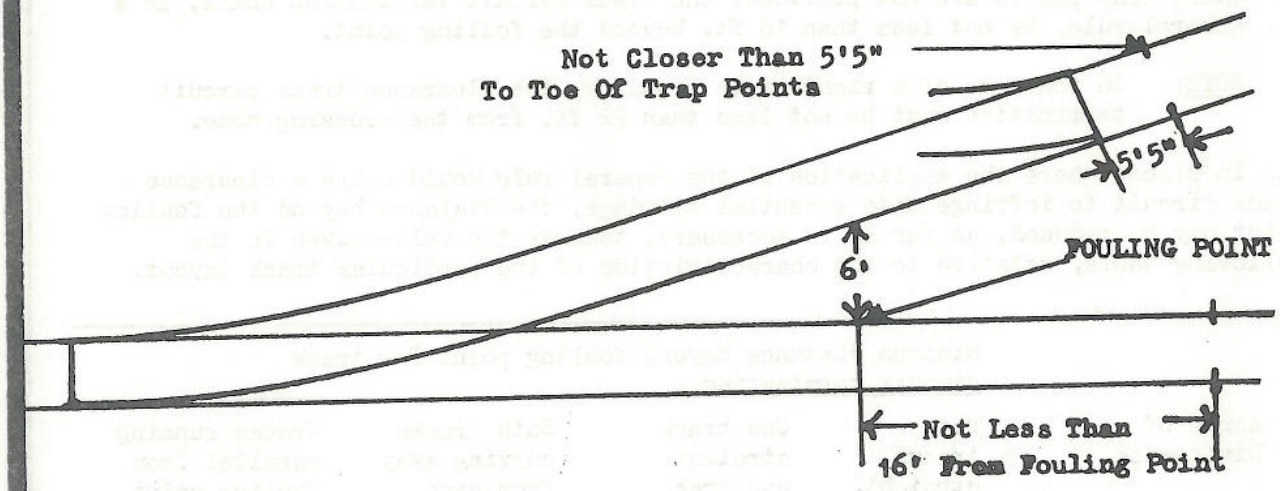

Fig. 8 Typical Example of Track Circuit Clearance Points

B.E.S./ 6.21
- 1 JAN 1983

TRACK CIRCUIT CLEARANCE POINTS

FOREWORD

This principle establishes the minimum distance from points and crossings at which track circuits having the function of proving clearance may be terminated to ensure a passing clearance of at least 1'-6" between vehicles in all circumstances.

Generally, the first convenient rail joint beyond the minimum distance should be used.

Except in the case of a right-angle crossing, the fouling point as referred to in this Principle is defined as the position at which the distance between the outside edges of the rails, measured at right-angles to the track in which the track circuit clearance point is being determined, is 6'-0".

At a right-angle crossing the fouling point is taken as 6 ft from the crossing nose measured along the track in which the track circuit clearance point is being determined.

PROVISIONS

1. Where trap points are provided, the track circuit termination shall be not closer than the first rail joint beyond the toe of such trap points (usually the 5'-5" joint).

2. Where trap points are not provided, the track circuit termination shall, as a general rule, be not less than 16 ft. beyond the fouling point.

   NOTE: In the case of a right-angle crossing, the clearance track circuit termination must be not less than 22 ft. from the crossing nose.

3. In places where the application of the general rule would cause a clearance track circuit to infringe upon essential standage, the distance beyond the fouling point may be reduced, as far as is necessary, towards the value given in the following table, relative to the characteristics of the particular track layout.

Angle of Divergence.	Minimum distance beyond fouling point for track circuit termination			
	Both tracks straight.	One track straight one track curving away.	Both tracks curving away from each other.	Tracks running parallel from fouling point.
	Ft.	Ft.	Ft.	Ft.
1 in 0 (90°)	*	*	*	-
1 in 1 (45°)	14	*	*	-
1 in 6	8	11	*	6
1 in 8	7	10	*	3
1 in 10	6	9	13	0
1 in 12	5	8	13	0
1 in 16	3	7	9	0
1 in 20	2	5	9	0
1 in 24	1	3	7	0

* = No reduction

PROVISIONS (Continued)

4. When the application of the values in the foregoing table still does not satisfy standage requirements, detailed calculations must be made.

5. The distances quoted in provisions 2 and 3 do not include any tolerance for easing back of vehicles after they have passed clear and, where necessary, an allowance must be added to cover this possibility. The importance of the allowance for easing back increases as the crossing angle approaches a right-angle.

NOTES

(i) In this Signalling Principle, account has been taken of the clearance requirements of all types of rolling stock at present in being or under consideration, including Mark III passenger coaches, High Speed Diesel and Advanced Passenger Train, and two axle freight wagons having an overhang of just over 10 ft., which is the maximum anticipated in this country.

(ii) Where the rail surface is particularly liable to become coated as to create a risk of a 'false clear' condition of a track circuit, special precautions such as the provision of welded stainless steel strip may have to be taken.

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YOU ARE INFORMED THAT A TRACK CIRCUIT WHICH IS CLEAR IS SHOWING OCCUPIED.

CAN THE SIGNALMAN CLEAR THE PRECEDING SIGNAL. YES. DE THE TPR. DE - ENERGISED. NO. YES. LOCATE FAULT IN TRK. CIRCUIT. IS FEED INTO RELAY ROOM PRESENT. YES. CHECK TPR CIRCUIT IN RELAY ROOM. INCLUDING RELAY. NO.

NO.

AT WHICH POINT CAN YOU ARRIVE MOST QUICKLY (FEED END IS BEST.)

GO TO TRACK CIRCUIT.

FEED END.

*2-IS RAIL VOLTAGE LOW. YES. IS FEED SET OR BATTERY VOLTAGE NORMAL. NO. CHECK REASON RENEW IF REQUIRED.

NO. *4.

YES.

TEST VOLTAGE ACROSS FEED RESISTANCE.

IF VERY HIGH (NEARLY BATTERY VOLTS.) IF ZERO. LOOK FOR DISCONNECTION IN FEED CIRCUIT TO RAILS.

REMOVE ONE TRACK FEED LINK.

HAS READING DROPPED. YES REPLACE LINK REMOVE ONE FEED FROM RAIL.

NO.

LOOK FOR SHORT IN LOCATION WIRING.

HAS THE READING DROPPED.

NO. YES.

REPLACE FEED AND TEST INSULATED JOINTS.

IS FAULT FOUND. NO

LOOK FOR SHORT IN TAIL CABLES.

POSSIBLE NEED FOR C.C.E.

MEASURE FEED VOLTS AND CURRENT.

WALK THROUGH TO RELAY END LOOKING FOR SHORT ESPECIALLY AT P.& C.

EX YES IS FAULT FOUND.

NO.

MEASURE RELAY VOLTS AND CURRENT. DETERMINE BALLAST RESISTANCE.

IS BALLAST RESISTANCE LESS THAN 2.OHMS.

YES. NO.

DOES THE BALLAST RESISTANCE INDICATE A DEAD SHORT. YES. HAVE YOU BEEN TO RELAY END ALREADY. YES.

NO.

CONTACT SUPERVISOR TO LIASE WITH THE C.C.E.

NO.

INSPECT INSULATED JOINTS. IS FAULT FOUND. NO.

YES.

EXAMINE TRACK CIRCUIT AND TAIL CABLES FOR SHORT.

MID POINT OF TRACK.

IS RAIL VOLTAGE GREATER THAN PICK VOLTS OF RELAY.

YES YES NO.

WALK TOWARDS RELAY END. WALK TOWARDS FEED END.

*4

AS YOU WALK ALONG TRACK.

CHECK RAIL VOLTAGE BEYOND EACH JOINT.

ARE YOU GOING TOWARDS FEED END. NO.

YES.

HAS RAIL VOLTS SUDDENLY RISEN. YES. HAS RAIL VOLTS SUDDENLY DROPPED.

NO. CLOSELY INSPECT JOINT FOR CONTINUITY. NO.

WALK TO NEXT JOINT.

WHICH END ARE YOU AT.

*2 FEED. NEITHER.

RELAY. *3.

IS FAULT FOUND. YES.

NO.

*1.

ADJUST FEED RESISTANCE.

NO.

IS FAULT CLEARED. YES.

IS FAULT FOUND. NO. IF ANY P.&.C. ARE PRESENT, ISOLATE SECTIONS OF TRACK TO NARROW DOWN LOCATION OF SHORT. AWAIT C.C.E. TO ISOLATE RAILS TO LOCATE SHORT.

YES.

RELAY END.

*3 IS RAIL VOLTAGE GREATER THAN PICK UP VOLTAGE OF RELAY.

NO. TEST INSULATED JOINT.

IS FAULT FOUND. YES.

NO.

*4

LOCATE FAULT IN TPR. CIRCUIT IN LOCATION. NO. IS TPR. FEED GOING OUT FROM LOCATION.

YES.

CHECK TPR FEED BACK TO RELAY ROOM VIA INTERMEDIATE LOCATIONS.

IS FAULT FOUND.

NO. YES.

*1.

YES. IS TPR. ENERGISED. NO.

YES.

IS FEED PRESENT ON LOCATION TERMINALS.

NO. YES.

LOCATE FAULT IN TAIL CABLES TO TRACK.

LOCATE FAULT IN TR. CIRCUIT.

British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools,
York & Ilford.

Ref. B.E.S./ 7.1
- 1 JAN 1965

Course. Basic Electrical Signalling

Subject. Signal Arm and Light Repeating Circuits.

WHEN A SIGNAL IS OUT OF THE VISIBLE RANGE OF THE SIGNALMAN, OR WHEN INTERLOCKING CIRCUITS ARE REQUIRED TO PROVE THE CONDITION OF THE SIGNAL ARM OR LIGHT, REPEATING CIRCUITS ARE INSTALLED.

A Circuit breaker is fitted to the Signal Arm as shown below. The contacts of the circuit breaker are adjusted to provide ON and OFF contacts.
The contacts must be operated between close limits so that indication is given as follows :

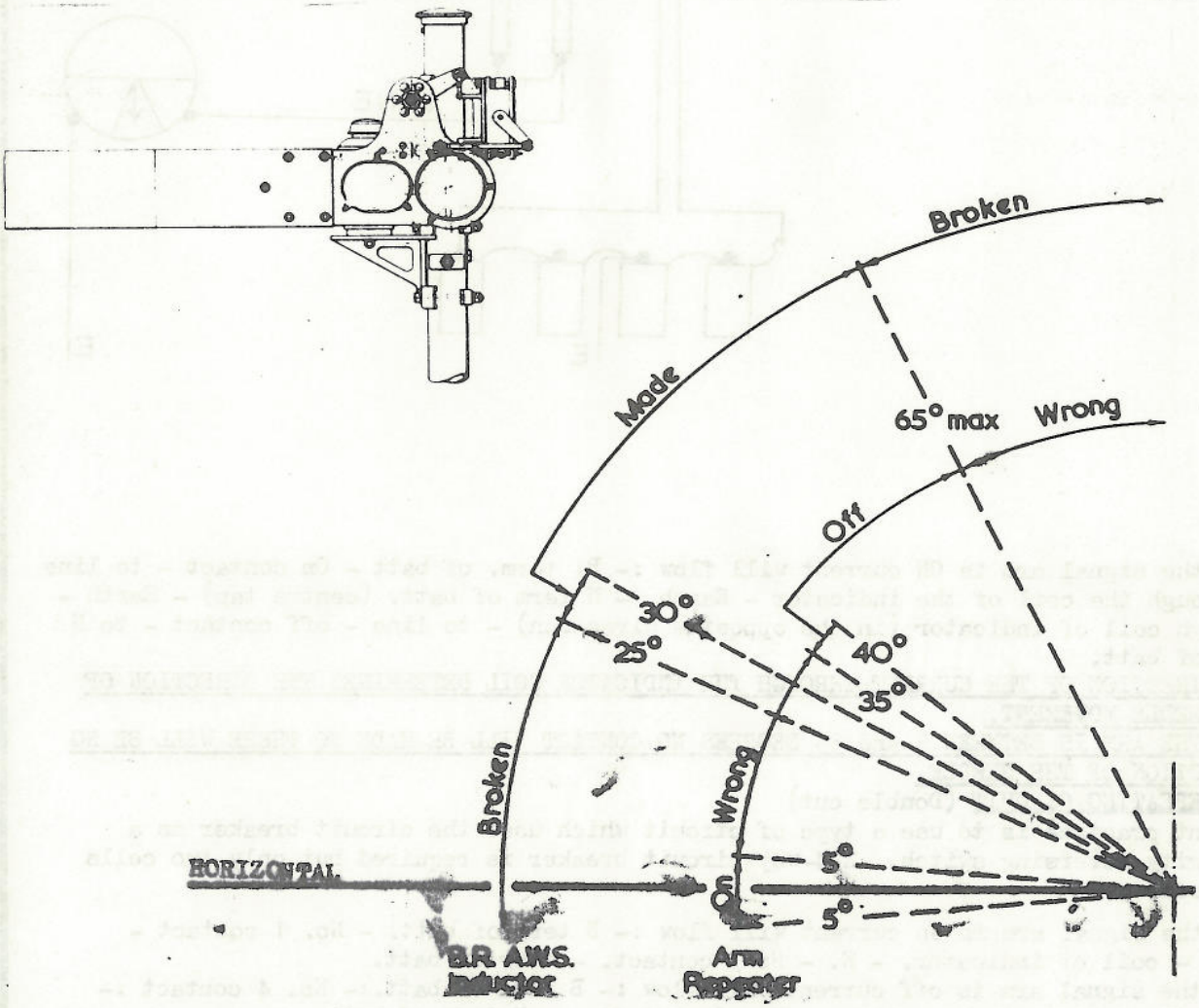
ON CONTACT IS MADE WITH THE ARM BETWEEN 0 and 5 DEGREES OF HORIZONTAL.

OFF CONTACT IS MADE WITH THE ARM BETWEEN 35 and 65 DEGREES OF HORIZONTAL.

NO CONTACT IS MADE WITH THE ARM BETWEEN 5 and 35 DEGREES OR WITH THE ARM OVER 65 DEGREES OF THE HORIZONTAL.

THE ABOVE APPLY FOR SIGNAL REPEATING. THE SETTINGS FOR A.W.S. CONTROL DIFFER

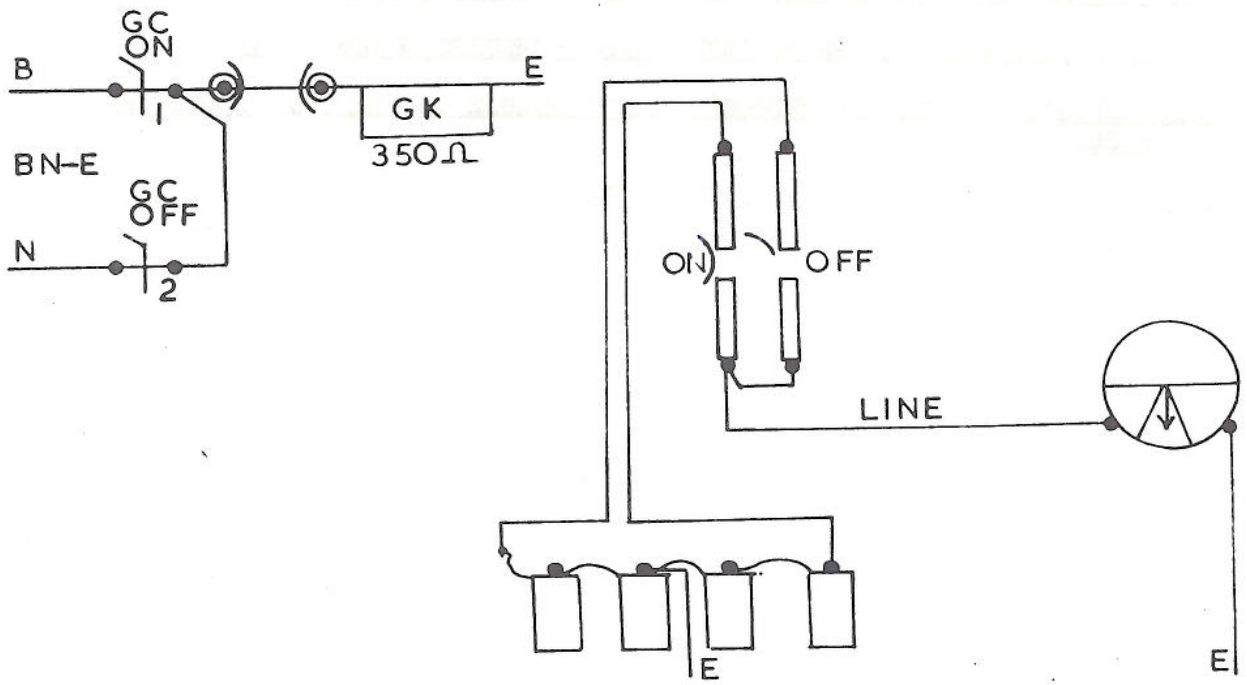
THE INDICATIONS GIVEN TO THE SIGNALMAN ARE ON, OFF, AND WRONG, RESPECTIVELY.



THE INDICATOR USED FOR ARM REPEATING CIRCUITS IS A THREE POSITION INDICATOR.
FOR DISTANT SIGNALS A YELLOW GROUND IS USED.
FOR STOP SIGNALS A RED GROUND IS USED.
WHEN USED FOR INDICATION ONLY A 350 OHM RESISTANCE INDICATOR IS USED.
WHEN USED WITH A SERIES RELAY (GPR) A 50 OHM RESISTANCE INDICATOR IS USED.

The indicator circuit requires a D.C. supply often obtained from Primary Cells using DS.3 or AR 40. type cells.
Two cells are required giving a nominal 3 volt supply. (i.e. Connected in Series).
Power may be used from a Transformer/Rectifier with standby Secondary Cells as required.

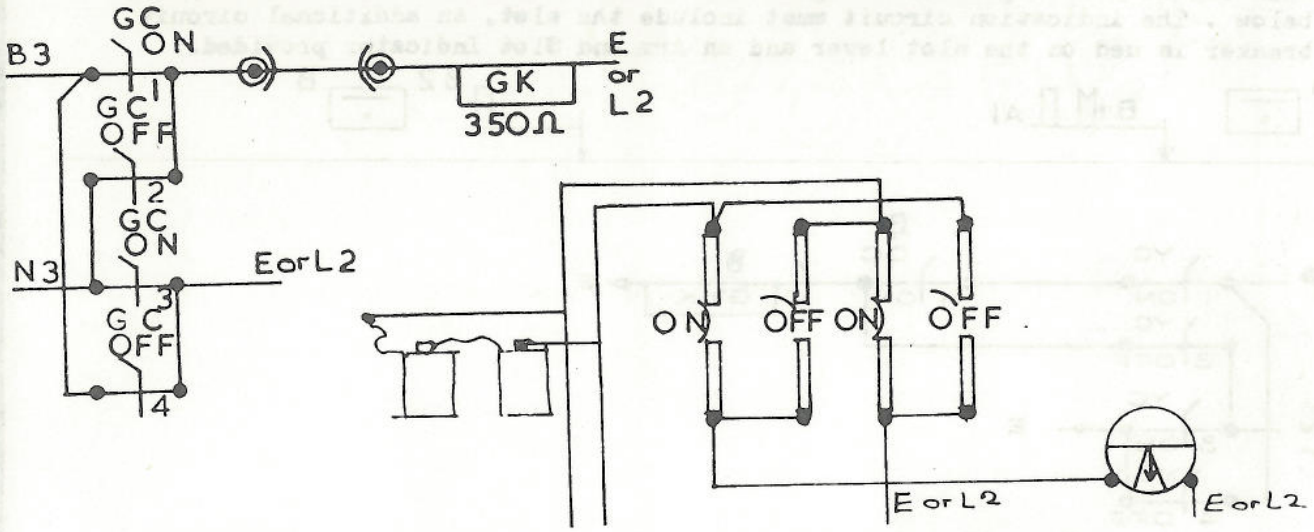
ARM REPEATER CIRCUIT (Centre Tap Battery)
Early type of arm repeating circuits used a centre tapped battery and a Two band circuit breaker.
WRITTEN CIRCUIT. ACTUAL WIRING DIAGRAM.



When the signal arm is ON current will flow :- B. term. of batt - On contact - to line - through the coil of the indicator - Earth. - N term of batt. (centre tap) - Earth - through coil of indicator (in the opposite direction) - to line - off contact - to N term of batt.
THE DIRECTION OF THE CURRENT THROUGH THE INDICATOR COIL DETERMINES THE DIRECTION OF THE NEEDLE MOVEMENT.
WHEN THE ARM IS BETWEEN 5 and 35 DEGREES NO CONTACT WILL BE MADE SO THERE WILL BE NO DEFLECTION OF THE NEEDLE.
ARM REPEATING CIRCUIT (Double cut)
Current practice is to use a type of circuit which uses the circuit breaker as a 'polarity reversing switch. A 4-way circuit breaker is required but only two cells are used.

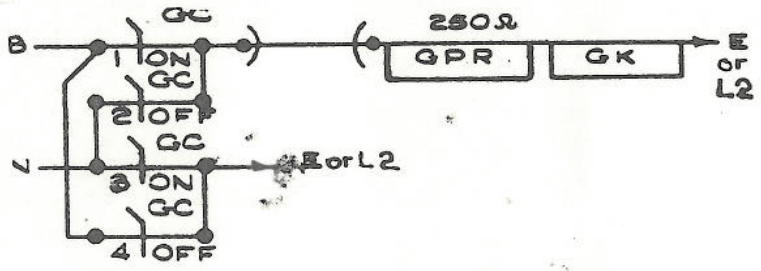
When the signal arm is on current will flow :- B term of batt. - No. 1 contact - Line. - coil of indicator. - E. - No 3 contact. - Nter of batt.
When the signal arm is off current will flow :- B term of batt.:- No. 4 contact :- E.: coil of indicator.; - Line;.- No. 2 contact.; - N term of batt.
The direction of the current through the coil is thus again reversed with the movements of the signal arm.

WRITTEN CIRCUIT. ACTUAL WIRING



WHEN INTERLOCKING REQUIRES THE PROVING OF THE SIGNAL ARM A SIGNAL REPEATING RELAY MUST BE INCLUDED IN THE CIRCUIT. THIS RELAY IS WIRED IN SERIES WITH THE INDICATOR. so the battery must be increased to 6 volts. In addition the indicator must be changed to one of 50 ohms resistance.

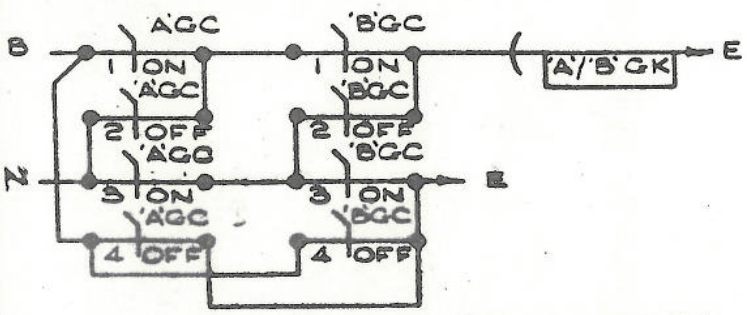
ARM REPEATING CIRCUIT WITH SIGNAL REPEATING RELAY



THE G.P.R. IS A THREE POSITION POLAR RELAY.
250 OHMS RESISTANCE.
OPERATING CURRENT.
6 to 12 mA.

At junctions where two or more signals read from or to the same lines it is not possible to clear more than one signal at once, under these conditions one indicator may be used for two or more signals. A typical layout and circuit is shown.

TWO ARMS ON ONE INDICATOR



TWO ARMS ON ONE INDICATOR.

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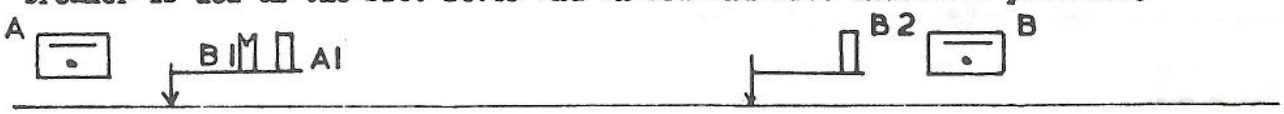
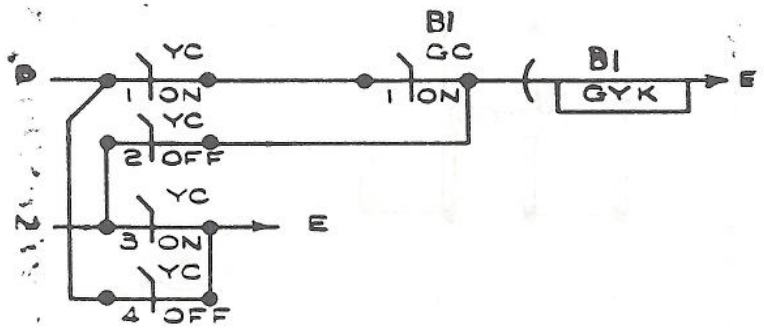
When the distant signal of a signal box is SLOT CONTROLLED as in the layout below . The indication circuit must include the slot. An additional circuit breaker is ued on the slot lever and an Arm and Slot Indicator provided.

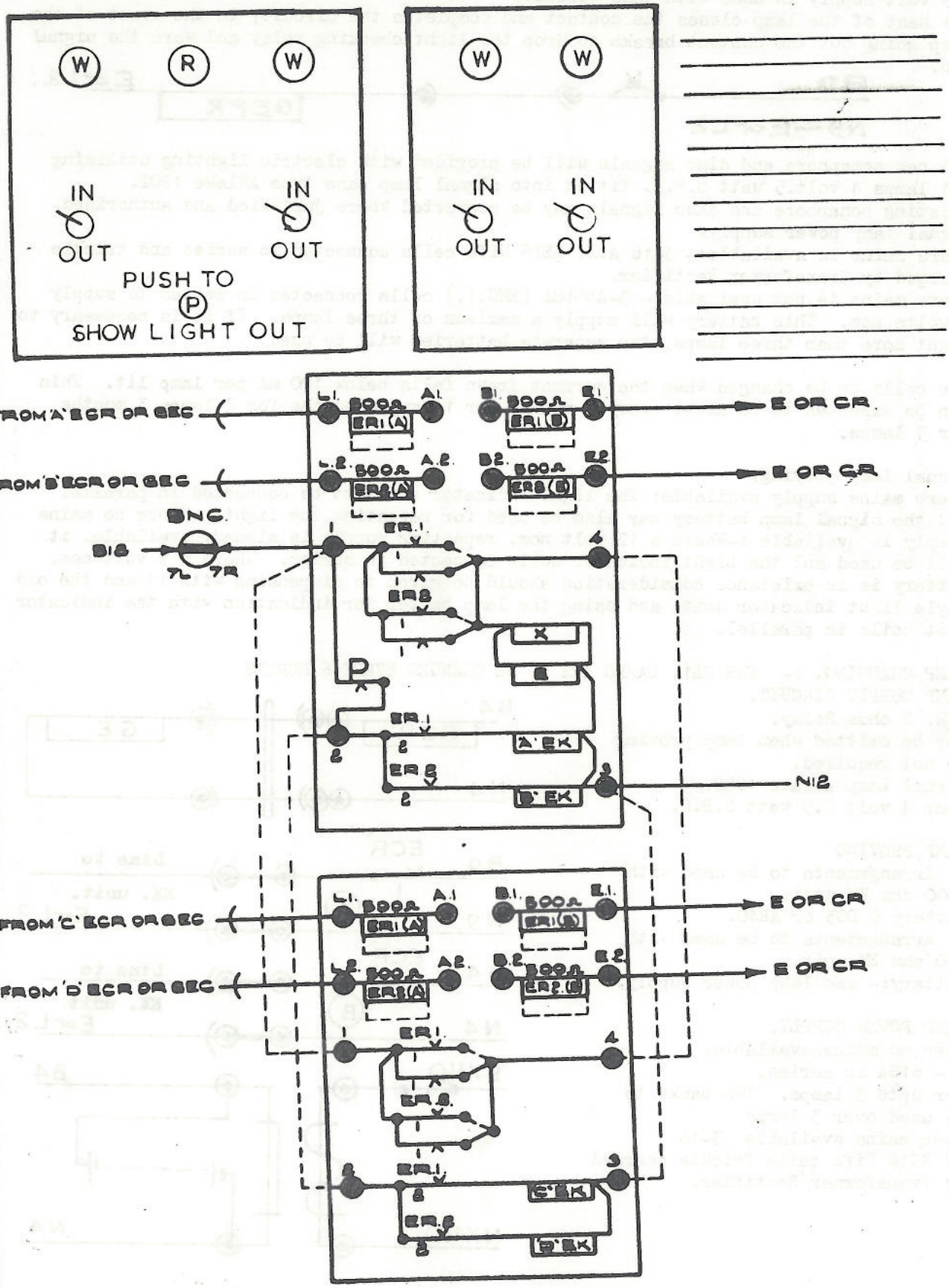




ARM & SLOT.

BES 7.5 1 JAN 1983

When required the Signal light is repeated into the signal box and the indication given to the signal man on a Light indicator unit.
Two sections are available :- Master Unit and Auxiliary Unit.



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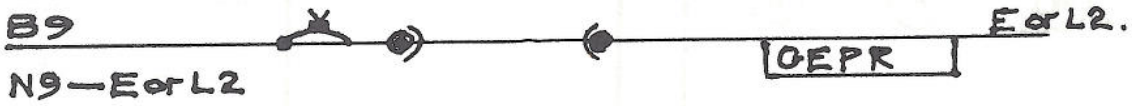
On sections where the signals are lit by oil lamp, a Pyrometer is fitted into the signal lamp case. The pyrometer is a Bimetal strip contact (:- Two different metals which expand at different rates).
A 9 volt supply is used with this circuit.
The heat of the lamp closes the contact and completes the circuit, in the event of the lamp going out the contact breaks to drop the light checking relay and warn the signal man.

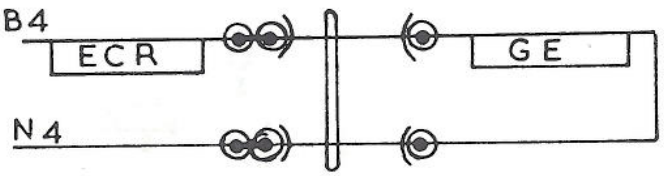


All new semaphore and disc signals will be provided with electric lighting utilising SL1 lamps 4 volt.5 watt S.B.C. fitted into signal lamp case type Adlake 1202.
Existing semaphore and disc signals may be converted where justified and authorised.
Signal lamp power supply.
Where mains is available:- 3-16 A.H. RE16 Nife cells connected in series and trickle charged by Transformer Rectifier.
Where mains is not available:- 3-AD618A (EMU.1.) cells connected in series to supply 4 volts nom. This battery will supply a maximum of three lamps. If it is necessary to light more than three lamps, two separate batteries will be used.

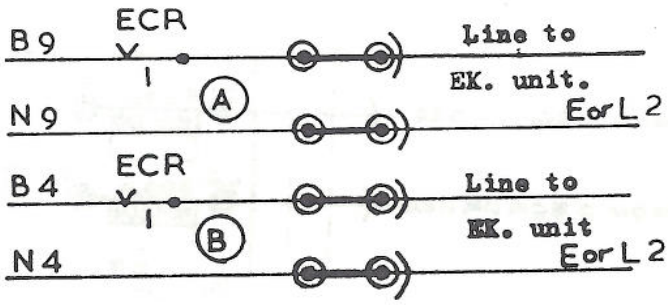
The cells to be changed when the current drawn falls below 100 mA per lamp lit. This can be expected to be about every 9 months for 1 lamp 6 months for 2 lamps 3 months for 3 lamps.

Signal lamp proving.
Where mains supply available: The light indicator coils to be connected in parallel and the signal lamp battery may also be used for repeating the light. Where no mains supply is available :-Where a 12 volt nom. repeating supply is already available, it will be used and the Light indicator coils connected in series. Where a 9 volt nom. battery is in existance consideration should be given to dispensing with it and the old style light indicator unit, and using the lamp batter for indication with the indicator unit coils in parallel.

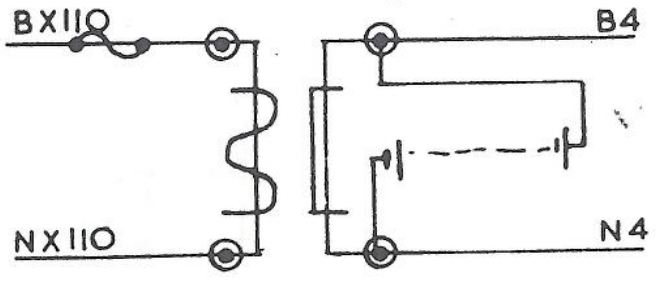
LAMP CHANGING. :- THE SL1. LAMPS ARE TO BE CHANGED EVERY 6 MONTHS
LAMP SUPPLY CIRCUIT.
ECR. 2 ohms Relay.
May be omitted when lamp proving is not required.
Signal Lamp Adlake 1202.
Lamp 4 volt 0.5 watt S.B.C.



LAMP PROVING
A. Arrangements to be used with 1000 ohm EK unit.
Battery 6 DS3 or AR40.
B. Arrangements to be used with 250 ohm EK unit.
Battery:- see lamp power supply.



LAMP POWER SUPPLY.
When no mains available.
3 - 618A in series.
for upto 3 lamps. Two banks to be used over 3 lamps.
When mains available 3-16 AH RE16 Nife cells Trickle charged by Transformer/Rectifier.



C S & T E DEPT.
TRAINING SCHOOL.
YORK.

REF. B.E.S./8.1

1 JAN 19[illegible]

COURSE. Basic Electrical Signalling

SUBJECT. Electrical Detection.

Detection of point switches and facing point lock positions can be done either mechanically or electrically.
It is necessary to prove that points lay in their correct position,(and are locked if they are facing points),before a signal can be cleared for a movement over them.
Where semaphore signalling exists signal wires can be routed through mechanical detectors as required,before operating the signal arm,thus proving points in the route are fitting correctly to the stock rail and they are set for the particular route.
Colour light signals,before being allowed to clear,also require the points to be proved in the correct position and fitting to the stock rail,(and are locked if they are facing points),by electrical detection. Electrical detection is more versatile than mechanical detection,it allows for points to be detected at greater distances from the signal box.
Various makes and styles are to be found in use,but for new work the B.R.B standard point detector will be used.
On very long switches (FV and longer),a supplementary detector box has to be fitted at the middle drive position.

Point Detectors Electrical

Electrical point detector boxes must be kept clean and in proper adjustment.

To avoid intermittent breaking of the detection circuit when switches are run over, all points must be adjusted and maintained so that they fit well up to the stock rails without excessive force. Driving of the switch rails may cause the lock stretcher bar or blade to bear on the body of the detector and prevent contacts from closing. Both these features if requiring attention should be brought to the attention of the Chief Civil Engineer's representative.

In detectors having a contact for each position of the switch rails, the contact for the open position should be set coarser than that for the closed position for each side of the points. In detectors having rollers riding on cam faces of detector slides this feature is inherent in the design.

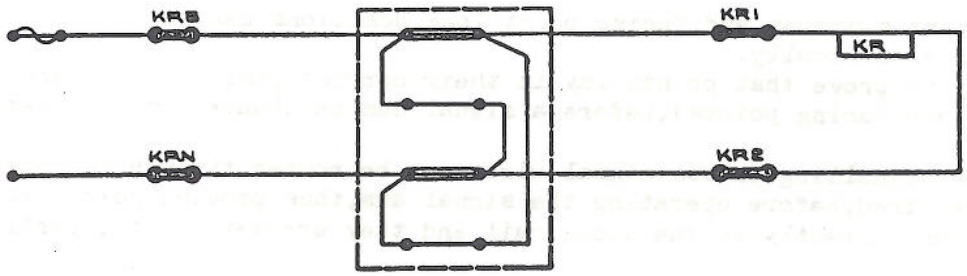
In detectors in which the lock detection and point detection slides actuate the same contact carrier, care must be taken to adjust the point detection slides so that the contacts would 'make' or 'break' (according to the conditions of the test) regardless of the position of the lock slide.

Electric point detectors should be adjusted and maintained so that under the condition of test where the thick (5mm) end of the point checking gauge is placed between the switch and stock rails opposite the first slide chair bolt the detection circuit would just break down.

With a view to ensuring good detection the relevant items in Sections 32 and 33 of BR 13445 (Instructions to staff engaged on maintenance of signalling apparatus) should be noted.

DETECTION

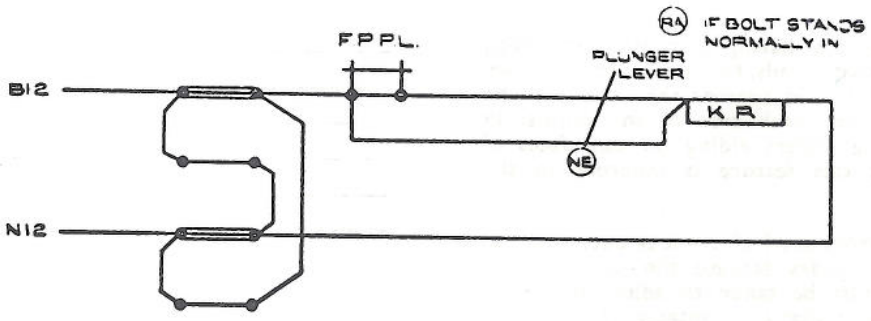
SINGLE TRAILING



FEED FROM LOCATION NEAR POINTS

K.R. LINES TO SIGNAL BOX VIA MAIN CABLES

D.C. 12 VOLT DETECTION



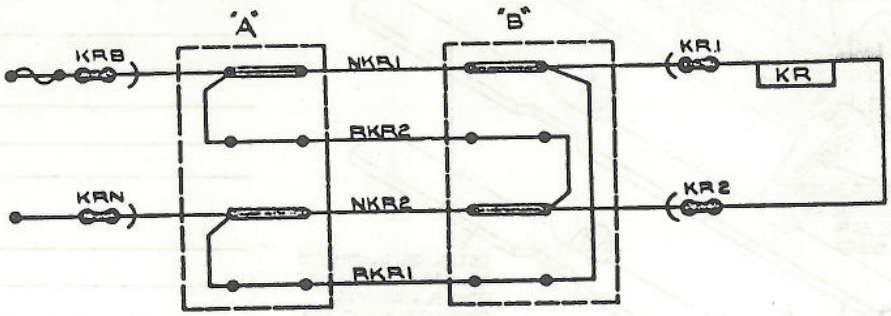
FACING SINGLE ENDED POINTS

(MECHANICALLY OPERATED)

B.E.S. /8.3 1 JAN 1983

DETECTION DOUBLE-ENDED TRAILING MECHANICALLY OPERATED

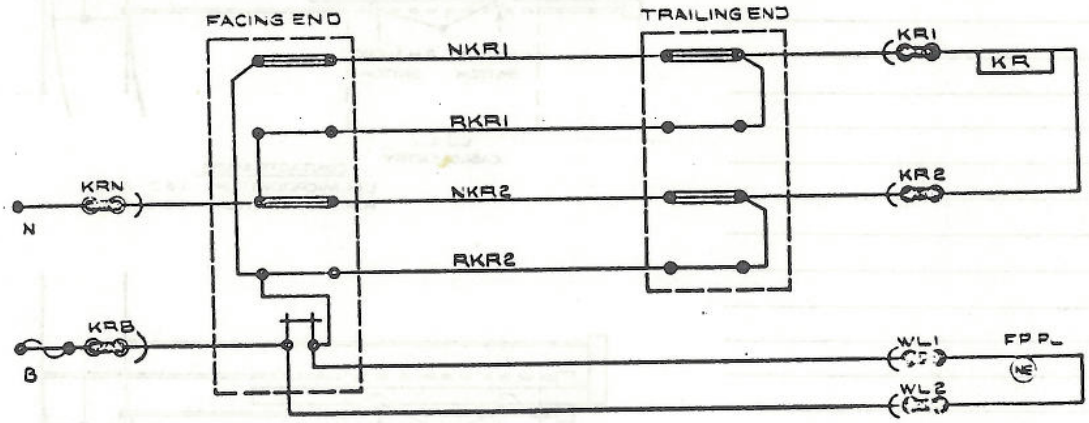
FEED AT "A" — KR. AT "B"



DETECTION

DOUBLE-ENDED, ONE FACING - ONE TRAILING MECHANICALLY OPERATED.

FEED AT FACING END. KR AT TRAILING END.



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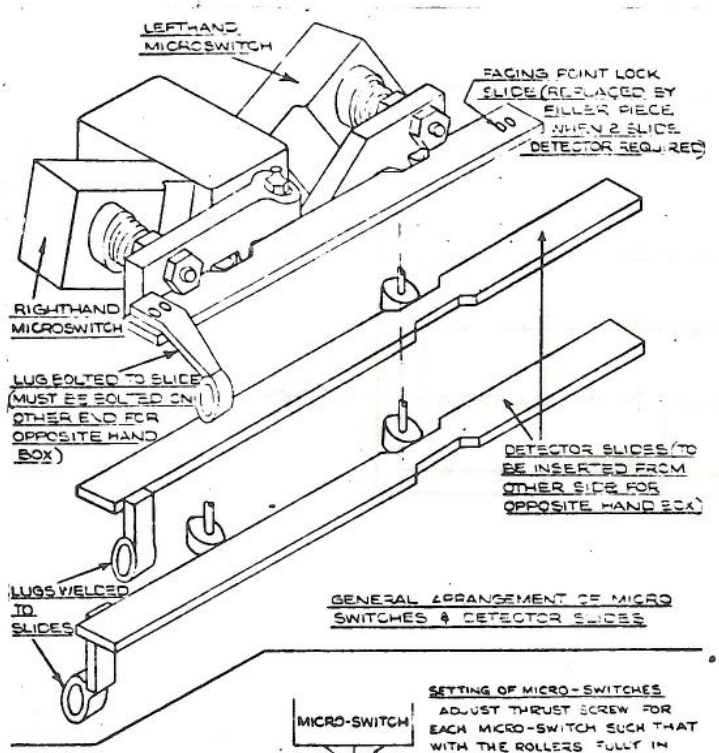
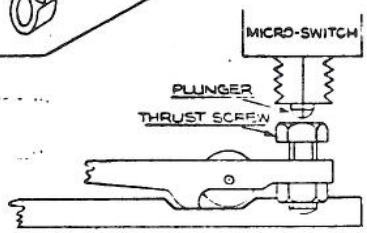
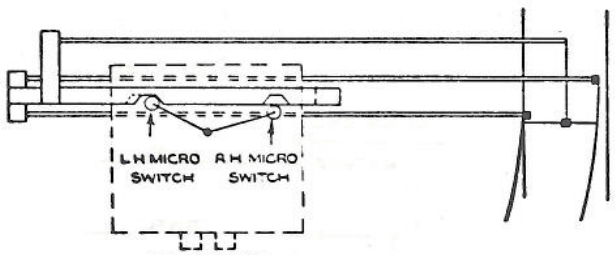


GENERAL ARRANGEMENT OF MICRO SWITCHES & DETECTOR SLIDES



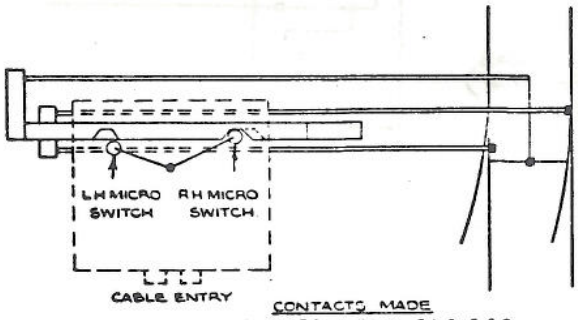
SETTING OF MICRO-SWITCHES

ADJUST THRUST SCREW FOR EACH MICRO-SWITCH SUCH THAT WITH THE ROLLERS FULLY IN THE NOTCHES IN THE SLIDES, CONTACTS 1-2 & 4-5 ARE BROKEN WHEN A 2mm GAUGE IS INSERTED BETWEEN THRUST SCREW & MICRO-SWITCH PLUNGER BUT ARE STILL MADE WHEN THE 2mm GAUGE IS WITHDRAWN & A 1·5mm INSERTED.



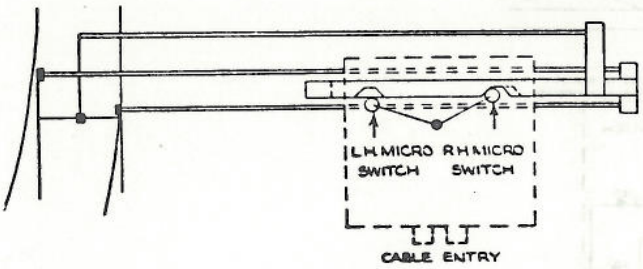
CONTACTS MADE

L.H. MICROSWITCH 1 & 2 4 & 5
R.H. MICROSWITCH 2 & 3 5 & 6

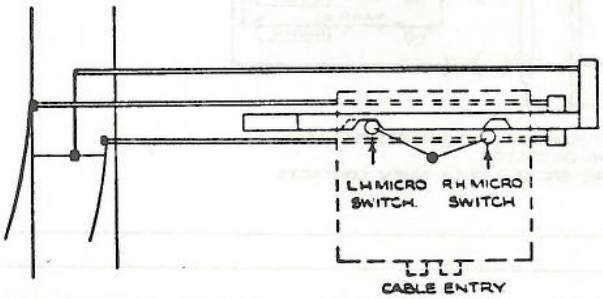


CONTACTS MADE

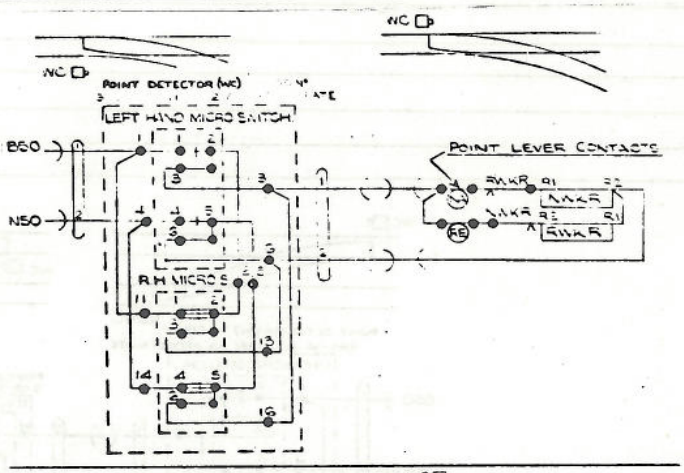
L.H. MICROSWITCH 2 & 3 5 & 6
R.H. MICROSWITCH 1 & 2 4 & 5

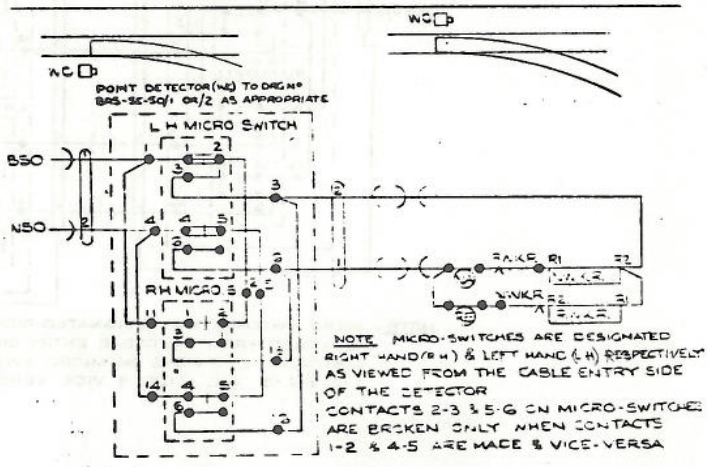


CONTACTS MADE
L.H. MICROSWITCH 2 & 3 5 & 6
R.H. MICROSWITCH 1 & 2 4 & 5

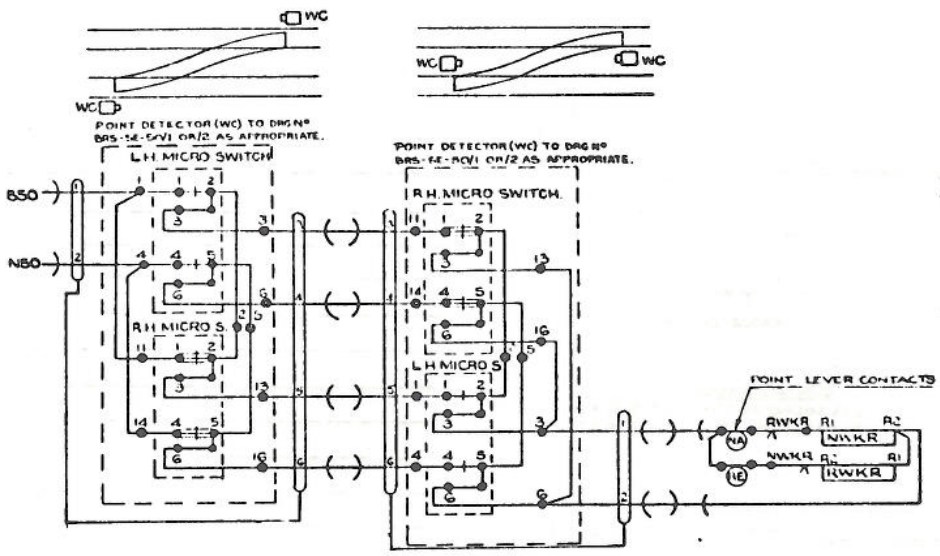


CONTACTS MADE
L.H. MICROSWITCH 1 & 2 4 & 5
R.H. MICROSWITCH 2 & 3 5 & 6

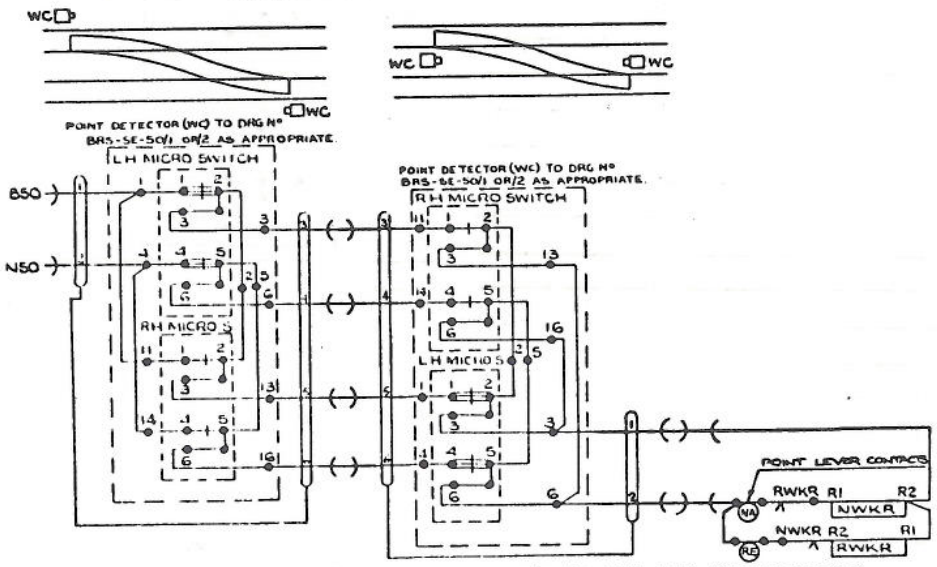




NOTE MICRO-SWITCHES ARE DESIGNATED RIGHT HAND (R.H.) & LEFT HAND (L.H.) RESPECTIVELY AS VIEWED FROM THE CABLE ENTRY SIDE OF THE DETECTOR
CONTACTS 2-3 & 5-6 ON MICRO-SWITCHES ARE BROKEN ONLY WHEN CONTACTS 1-2 & 4-5 ARE MADE & VICE-VERSA

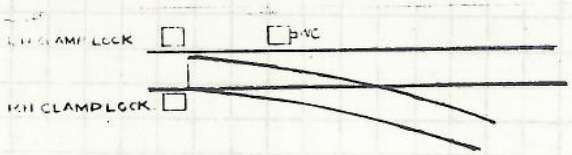


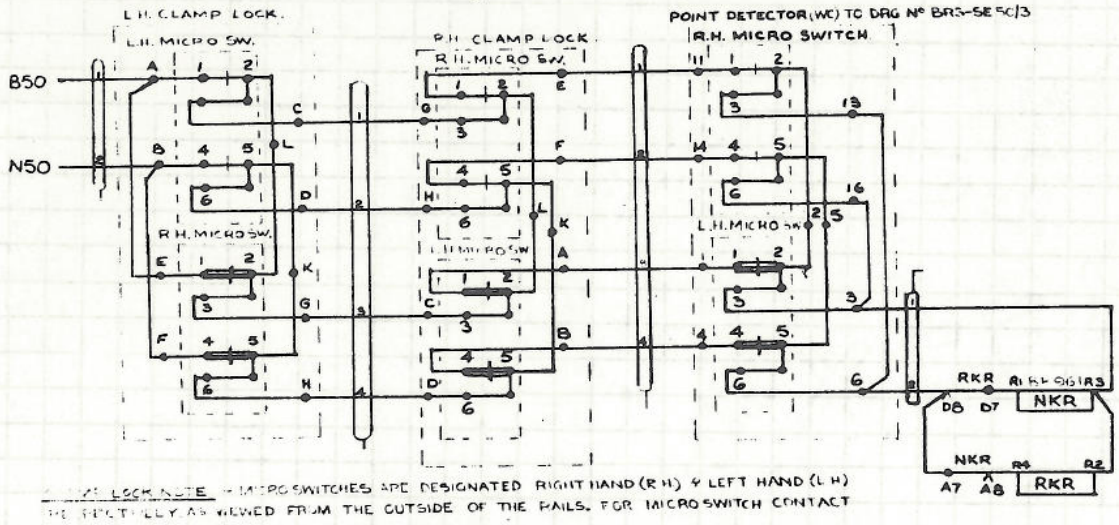
NOTE: MICRO SWITCHES ARE DESIGNATED RIGHT HAND(RH) & LEFTHAND(LH) RESPECTIVELY AS VIEWED FROM THE CABLE ENTRY SIDE OF THE DETECTOR. CONTACTS 2.-3 & 5.-6 ON MICRO SWITCHES ARE BROKEN ONLY WHEN CONTACTS 1-2. & 4.-5 ARE MADE & VICE VERSA.



NOTE: MICRO SWITCHES ARE DESIGNATED RIGHT HAND (R H) & LEFTHAND(L H) RESPECTIVELY AS VIEWED FROM THE CABLE ENTRY SIDE OF THE DETECTOR. CONTACTS 2-3 & 5-6 ON MICRO SWITCHES ARE BROKEN ONLY WHEN CONTACTS 1-2 & 4-5 ARE MADE & VICE VERSA

B.E.S. / 8·7 F 1 JAN 1983

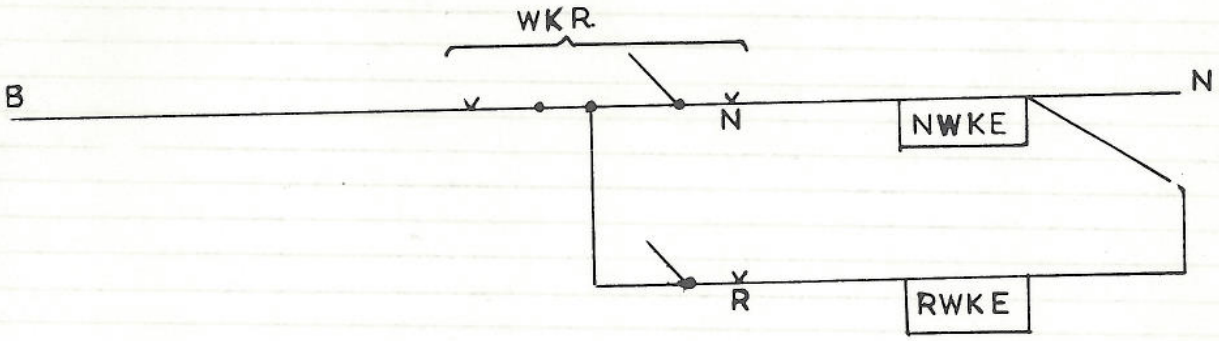




CLAMP LOCK NOTE - MICROSWITCHES ARE DESIGNATED RIGHT HAND (R.H.) & LEFT HAND (L.H.) RESPECTIVELY AS VIEWED FROM THE OUTSIDE OF THE RAILS. FOR MICROSWITCH CONTACT DETAILS SEE SHEET

POINT DETECTOR NOTE - MICROSWITCHES ARE DESIGNATED RIGHT HAND (R.H.) & LEFT HAND (L.H.) RESPECTIVELY AS VIEWED FROM THE CABLE ENTRY SIDE OF THE DETECTOR
WITH POINTS AS SHOWN ABOVE R.H. MICROSWITCH 2&3, 5&6 CONTACTS MADE. L.H. MICROSWITCH 1&2, 4&5 CONTACTS MADE
WITH POINTS REVERSED R.H. MICROSWITCH 1&2, 4&5 CONTACTS MADE. L.H. MICROSWITCH 2&3, 5&6 CONTACTS MADE
CONTACTS 2-3 & 5-6 ON MICROSWITCHES ARE BROKEN ONLY WHEN CONTACTS 1-2 & 4-5 ARE MADE & VICE VERSA

Typical Point Indication Circuit.



BES/ 8.8

- 1 JAN 1983

C S & T E DEPT.
TRAINING SCHOOL.
YORK.

REF. BES./9.1

- 1 JAN 1983

COURSE. Basic Electrical Signalling.

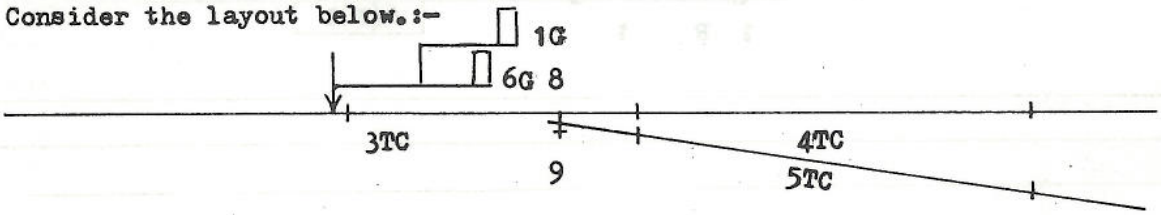
SUBJECT. Simple Electric Lock Circuits

When designing Interlocking for a lever frame two methods of lever locking may be considered.:-

Mechanical interlocking, between levers.
Electrical looking of any lever.

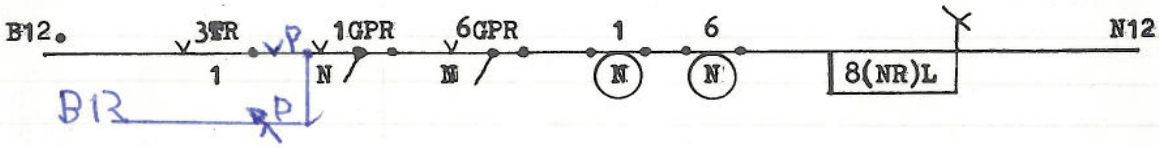
Mechanical interlocking is efficient and requires little maintainance, but it is limited to use between levers in the same frame, When external features , such as Track circuits, Signal arm repeaters, point detectors, etc. need inclusion in the interlocking, Electric locks must be used.

Consider the layout below.:-

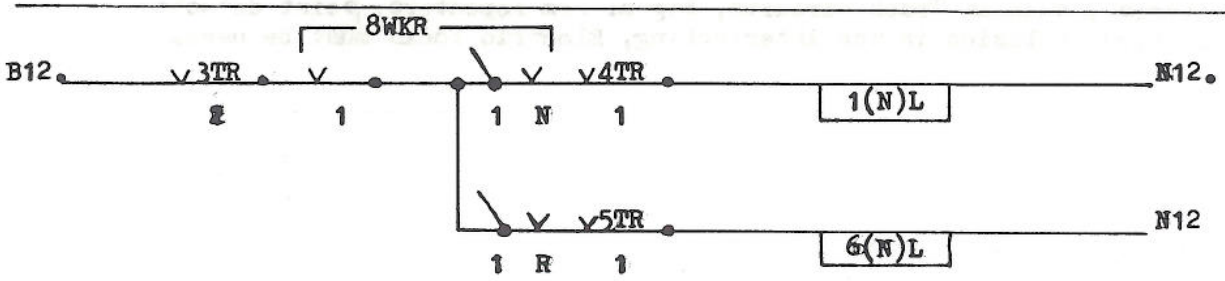


It should not be possible to move No. 8 points if a train is standing on the points , or between the signal and the points. No.1 and 6 Signals should also be at danger if the points are free to move or moving.A circuit can be designed that will meet this requirement and used to control an electric lock on No. 8 lever that will lock No.8 lever in the Normal and Reverse positions. A track circuit can be installed over No 8. points that will operate No. 3. Track relay, de-energising it when the track is occupied.
No. 1 and 6 Signals can be fitted with a repeating circuit proving the Arms normal. These repeating circuits can be combined or independent circuits. Circuit breakers fitted to the signal levers can be used to ensure that they are in the correct position ie. Normal.

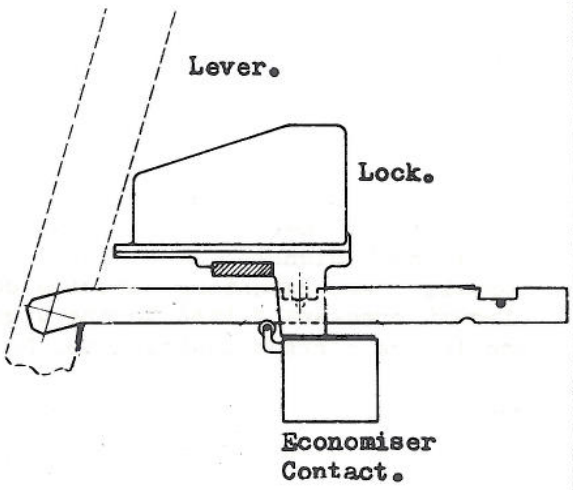
All or some of these features can be used in a Circuit for No.8.Lever lock.



The interlocking can be extended over the signal levers.
No. 1 lever should only be able to be pulled to clear the signal when No. 3 and 4 tracks are clear and the points normal.
No. 6 lever would require No. 3 and 5 tracks clear and the points reverse. A point detection circuit would be required on No. 8 points to control a point detection relay.
Electric locks fitted on No. 1 and 6 signals would lock the lever in the normal position only. (This applies to this example only, in practice other locking would be added.)



The electric lock is generally fitted at the rear of the frame.
The lock operates from 12 volt Dc. but some 24 volt locks are in use.
The cutting of the notches in the plunger and the setting of the lock positions is discussed in section. 5/1.



British Railways, Eastern Region.
C.S. & T.E. Department.
Training Schools,
York & Ilford.

Ref. B.E.S./10.1
1 JAN 1983

Course. Basic Electrical Signalling

Subject. British Standard Symbols Part. 1. Definitions and Terms

In any large organisation there will be a need to exchange information. There will be a need for one section to produce a Plan or Diagram that may require to be read by many other sections. If misunderstanding is to be avoided it is important that when Plans are produced that all persons in the Industry use the same Symbols to represent items of equipment. To this end the British Standards Institute has produced a standard for Railway Signalling Symbols.

Part. 1. of this standard was produced in 1930 and covers Schematic Symbols for use on Plans and Diagrams. They are intended for use on plans and diagrams showing the layout of Signalling Installations and Equipment they do not show the component parts of the apparatus used.
The symbols are laid out in the following order.

SIGNALS
POINTS
TRACK DETAILS
APPARATUS
LEVEL CROSSINGS
TRACK DIRECTION
SIGNAL BOXES.

Although some of the symbols may resemble the apparatus, it should be remembered that they are "Symbols" and not "Mimic" Diagrams of the equipment.

BES/10.2

– 1 JAN 1963

SIGNAL MECHANICAL STOP

DISTANT

MECHANICAL WITH ELECTRIC REPLACER STOP

DISTANT

POWER ALL TYPES STOP

DISTANT

PERMISSIVE

FIXED ARM STOP

DISTANT

SLOT OPERATED FROM ANOTHER BOX STOP

DISTANT

SLOT OPERATED BY STOP SIGNAL AHEAD

MULTIPLE SLOTTING

BANNER SIGNAL

REPEATING SIGNAL STOP

DISTANT

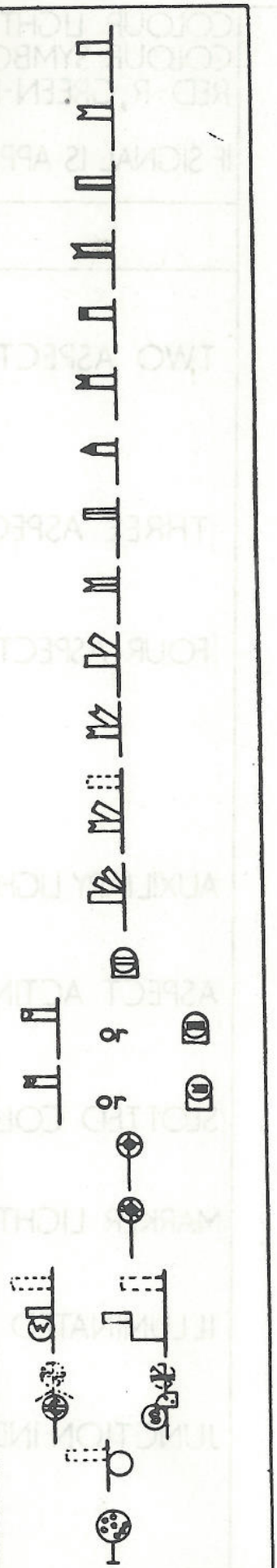
FOG .2. ASPECT

FOG .3. ASPECT

SUBSIDIARY SIGNALS
C - CALL ON
S - SHUNT AHEAD
W - WARNING

SIGNAL LAMP INTENSIFIED

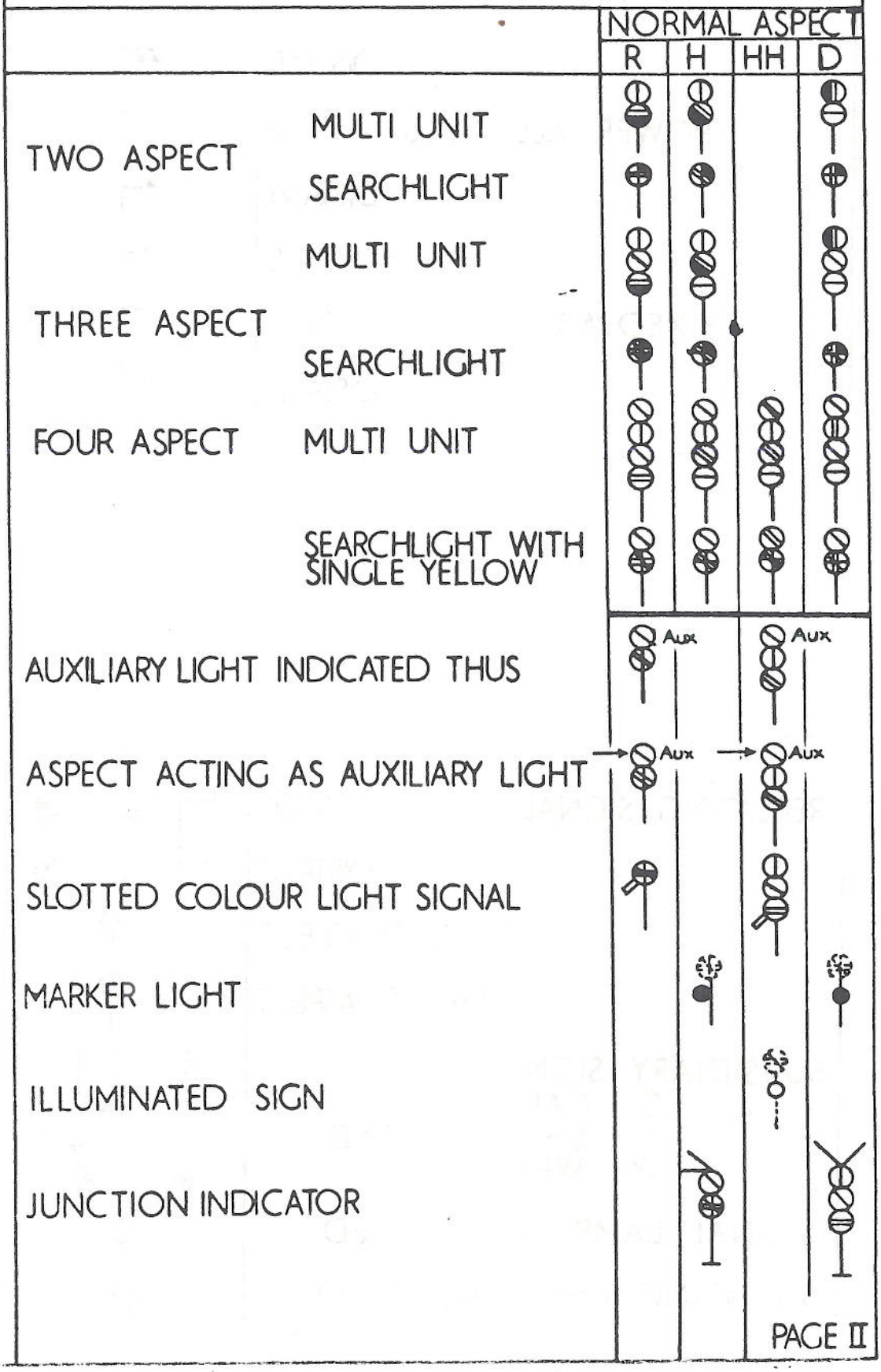
SHUNTING SPEED INDICATOR



PAGE 1.

COLOUR LIGHT SIGNALS.
COLOUR SYMBOL, RED ⊖, YELLOW ⊘, GREEN ⊕.
RED - R, GREEN - D, YELLOW - H, DOUBLE YELLOW - HH.

IF SIGNAL IS APPROACH LIGHTED SHADE AS SHOWN



SHUNTING SIGNAL MECHANICAL

SINGLE NORMAL RED

NORMAL YELLOW

DOUBLE

POWER OPERATED

FLOODLIGHTING

SHUNTING SIGNAL POSITION LIGHT

DOUBLE

THREE ASPECT

SLOTTED SIGNALS

POINT INDICATOR

ROUTE INDICATOR SIGNAL

DOUBLE SIDED

JUNCTION INDICATOR REPEATER

SIGNAL NOT IN USE

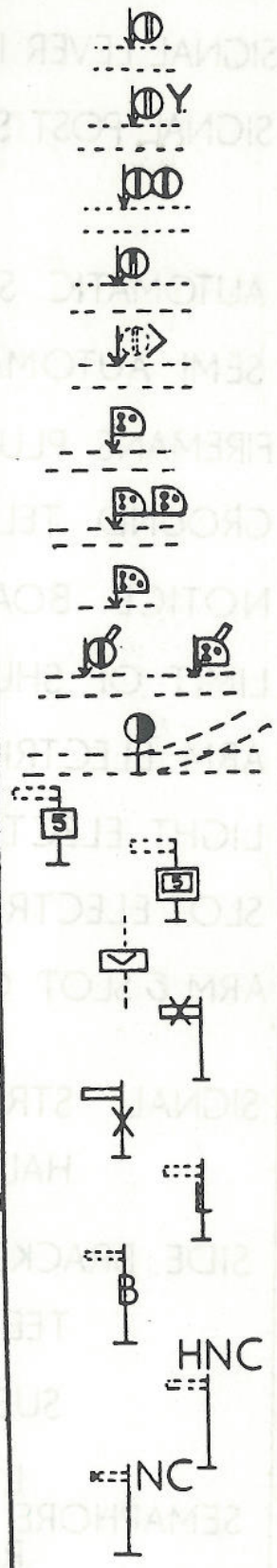
SIGNAL TO BE REMOVED

SIGNAL LEVER ELECTRICALLY LOCKED

SIGNAL LEVER RELEASED BY THE BLOCK AT LINE CLEAR

SIGNAL PROVED NORMAL IN THE BLOCK CIRCUIT HOME

DISTANT



SIGNAL LEVER RELEASED BY TOKEN

SIGNAL LEVER INTERLOCKED BY KEY

SIGNAL POST SIGN - 'D' SIGN

DIAMOND SIGN

AUTOMATIC SIGNAL SIGN

SEMI AUTOMATIC SIGNAL SIGN

FIREMANS PLUNGER

GROUND TELEPHONE

NOTICE BOARD

LIMIT OF SHUNT SIGNAL

ARM ELECTRICALLY INDICATED

LIGHT ELECTRICALLY INDICATED

SLOT ELECTRICALLY INDICATED

ARM & SLOT ON SLOT OFF INDICATED

SIGNAL STRAIGHT POST

HALF BRACKET

SIDE BRACKET ON STRAIGHT POST

TEE BRACKET

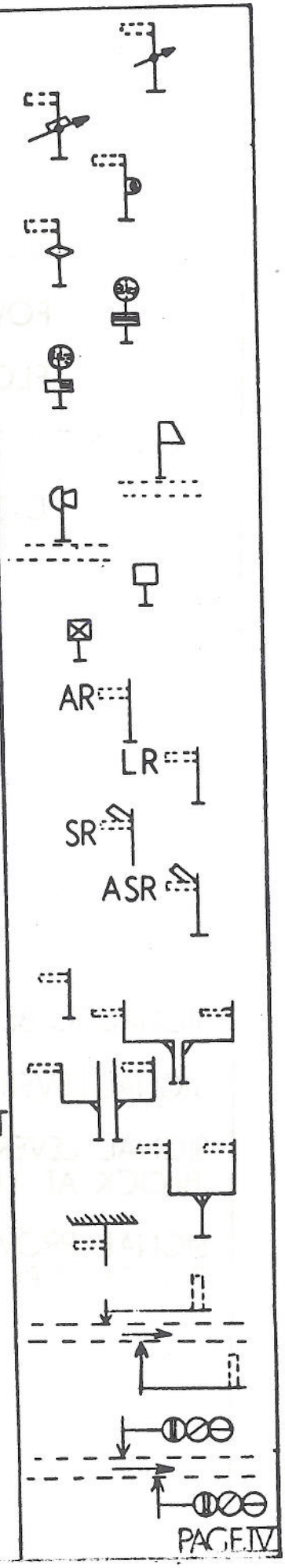
SUSPENDED DOLL

SEMAPHORE LEFT HAND LOCATION

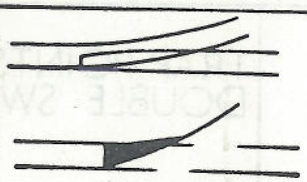
RIGHT HAND LOCATION

COLOUR LIGHT LEFT HAND LOCATION

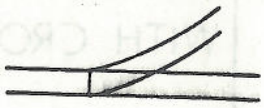
RIGHT HAND LOCATION



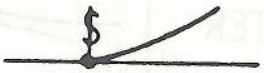
THE LIE OF POINTS CAN BE SHOWN :-



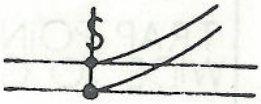
POINTS HAND WORKED



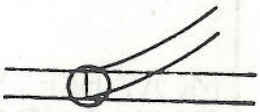
SPRING 1 WAY



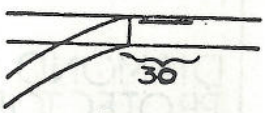
SPRING BOTH WAY



POINTS WORKED FROM SIGNAL BOX

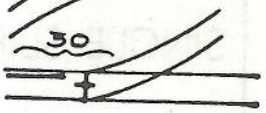


POINTS WITHOUT LOCK WITH BAR SINGLE LEVER

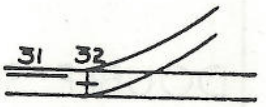


AS ABOVE WITH TWO LEVERS

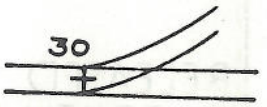
POINTS WITH LOCK AND BAR SINGLE LEVER



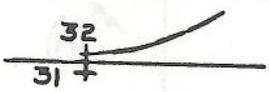
AS ABOVE WITH TWO LEVERS

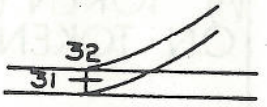


POINTS WITH LOCK WITHOUT BAR SINGLE LEVER

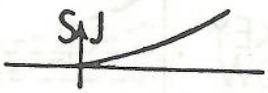


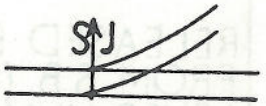
AS ABOVE WITH TWO LEVERS





SLOTTED JOINT CONTROL

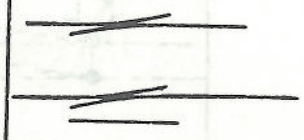


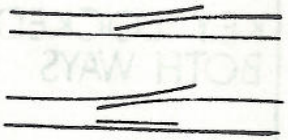


SCOTCH BLOCK

DERAILER

TRAP POINTS SINGLE SWITCH. WITH GUARD RAIL





TRAP POINTS DOUBLE SWITCH

WITH CROSSING

T.C. INTERRUPTER

TRAP POINTS WIDE TO GAUGE

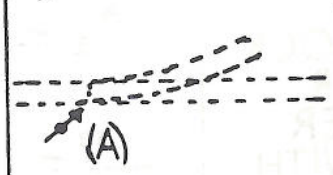
MOVABLE SWITCH DIAMONDS

DIAMOND CROSSING PROTECTORS

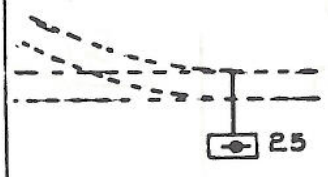
SINGLE SLIP

DOUBLE SLIP

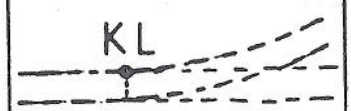
RELEASED BY (A) TOKEN (B) KEY ON TOKEN



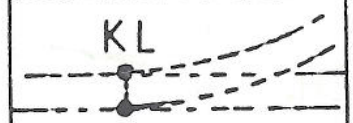
RELEASED BY KEY FROM S.B. (SHOW LEVER NUMBER)



POINTS KEY LOCKED ONE WAY



KEY LOCKED BOTH WAYS



INSULATING RAIL JOINTS
TRACK CIRCUIT IN BOTH DIRECTIONS

TRACK CIRCUIT ON LEFT

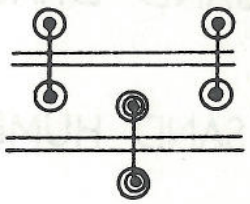
TRACK CIRCUIT ON RIGHT

TRACK CIRCUIT
SINGLE LINE PLANS

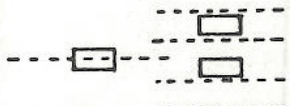
DOUBLE LINE PLANS

SINGLE RAIL TRACK CIRCUIT

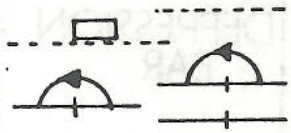
AXLE COUNTERS { IN OR OUT TREADLES { IN & OUT



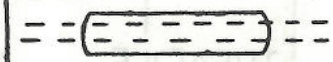
IMPEDANCE BOND



RELAYING OR CUT SECTION IN TRACK CIRCUIT. (ARROW DENOTES RIGHT CONTROLS LEFT).

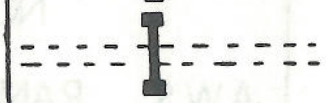


BRIDGE MOVABLE SPAN



SIGNAL BRIDGE

AS ABOVE & TRACTION STRUCTURE



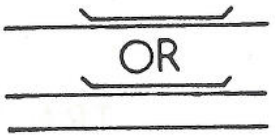
TOKEN { RECEIVER

DELIVERER

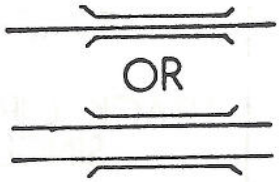
EXCHANGER

CAR RETARDERS

SINGLE RAIL

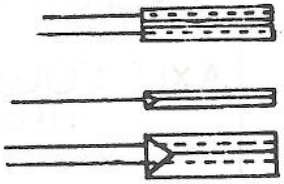


DOUBLE RAIL

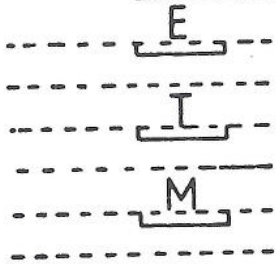


SAND DRAG

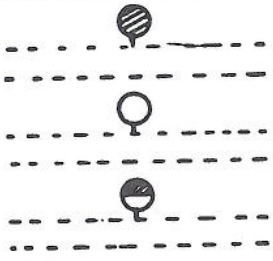
SAND HUMP



DEPRESSION BAR
- ELECTRICAL
- ELEC WITH TRACK
- MECHANICAL



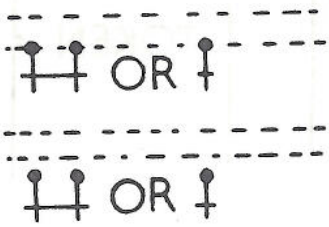
TREADLE
- MECHANICAL
- ELECTRICAL
  - NORMAL OPEN CONTACTS
  - NORMAL CLOSED CONTACTS



A.W.S. RAMP

A.W.S. INDUCTOR

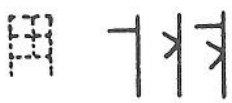
DETONATOR PLACER EMERGENCY
- ON
- OFF



DETONATOR PLACER MAGAZINE TYPE

FOGMAN'S POST

FOGMAN'S REPEATERS



GONG OR SIREN

BELL SINGLE STROKE

BELL TREMBLER

POINT MACHINE POWER

POINT MACHINE DUAL CONTROL

CLEARANCE BAR OPERATED FROM .SB

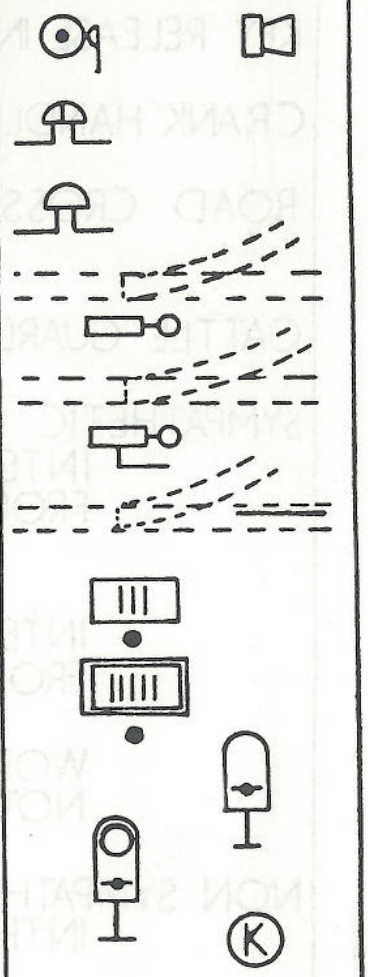
GROUND FRAME UNCOVERED

GROUND FRAME COVERED

SWITCH LOCK

SWITCH LOCK & INDICATOR TRACK

OCCUPATION KEY INSTRUMENT



	PEG	NON PEG
BLOCK INSTRUMENT PERMISSIVE		
BLOCK INSTRUMENT ABSOLUTE NON-CONTROLLED		
BLOCK INSTRUMENT ABSOLUTE CONTROLLED		

COMBINED BLOCK INSTRUMENT

BLOCK SWITCH — PLAIN

BLOCK SWITCH — WITH CONTROL

PAGE IX

KEY RELEASE INSTRUMENT

CRANK HANDLE INSTRUMENT

ROAD CROSSING

CATTLE GUARD CROSSING

SYMPATHETIC GATES
INTERLOCKED & WORKED FROM S.B.

INTERLOCKED & WORKED FROM GROUND

WORKED BY GATEMAN & NOT INTERLOCKED

NON SYMPATHETIC GATES
INTERLOCKED

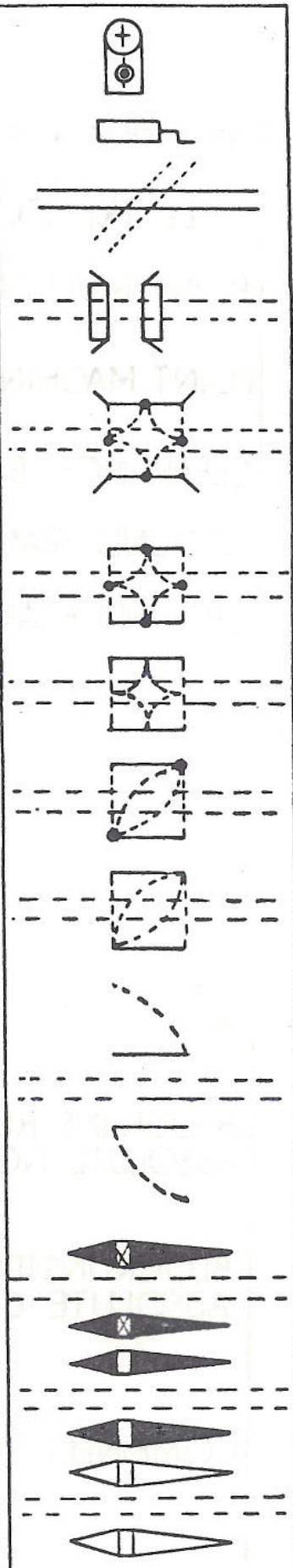
NOT INTERLOCKED

OCCUPATION CROSSING

LIFTING BARRIERS
INTERLOCKED & WORKED FROM S.B.

INTERLOCKED & WORKED FROM GROUND

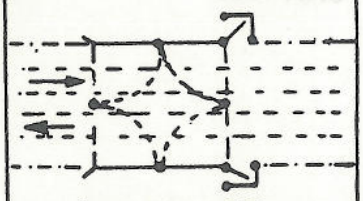
NON INTERLOCKED & WORKED FROM GROUND



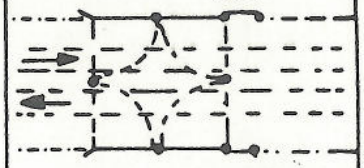
PAGE X

WICKETS

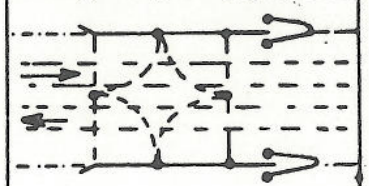
ANGLE PEN



SPRING



CAGE



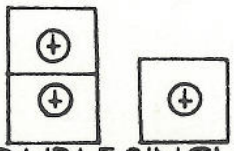
LOCKS WHERE PROVIDED

ROAD CROSSING SIGNAL

AUDIBLE

VISUAL

LEVEL CROSSING BLOCK INDICATOR

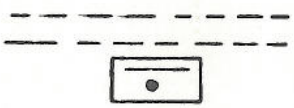


WARNING BOARD

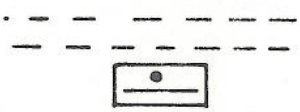
TRAFFIC DIRECTION

OPERATOR FACING TRACK

SIGNAL BOX



OPERATOR WITH BACK TO TRACK



BES/10·14

- 1 JAN 1983

British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools,
York & Ilford.

Ref. B.E.S./10.15

1 JAN 1983

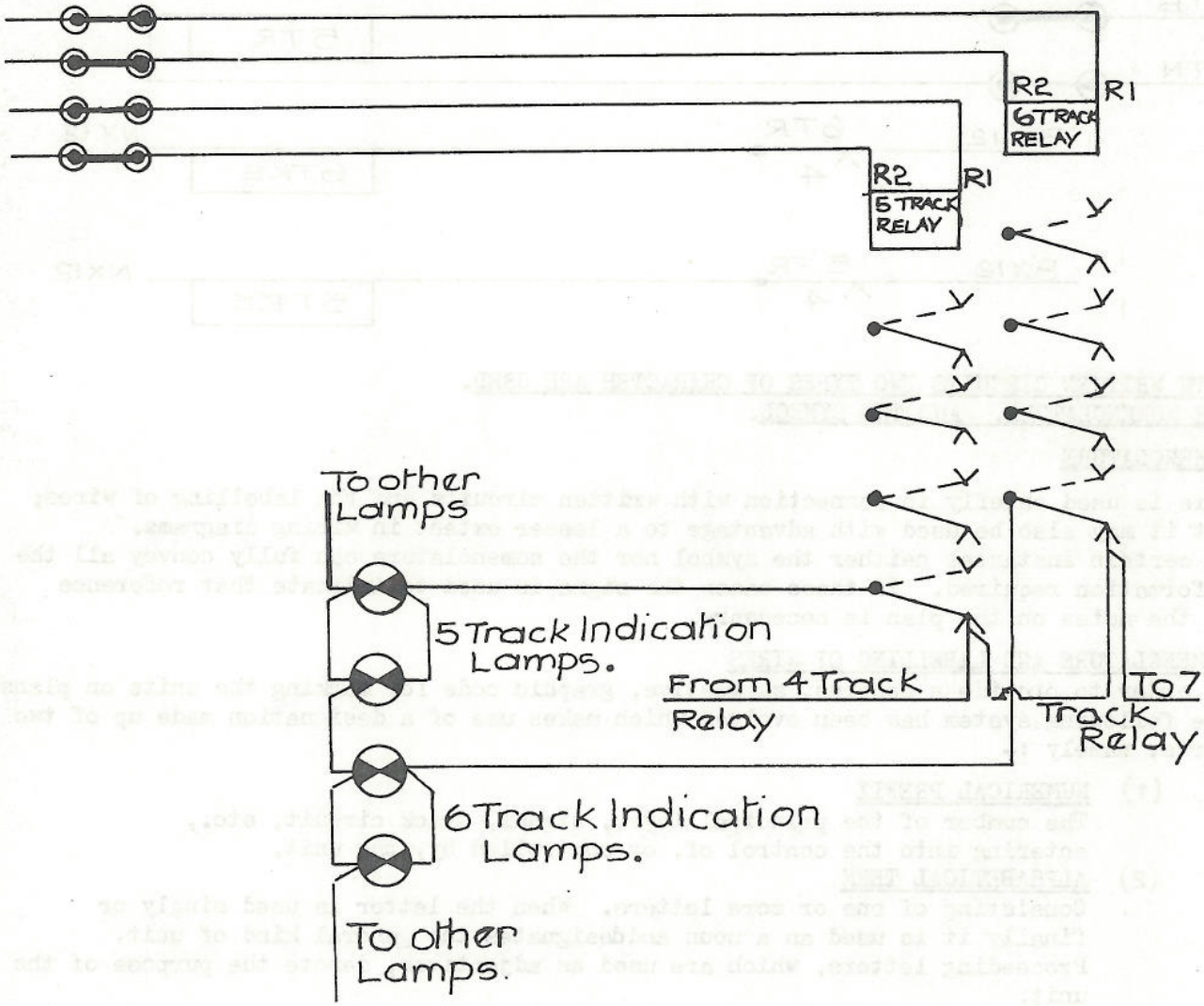
Course. Basic Electrical Signalling

Subject. British Standard Railway Signalling Symbols. (Introduction.)

CIRCUIT DIAGRAMS CAN BE DIVIDED INTO TWO MAIN TYPES, THE WIRING DIAGRAM AND THE WRITTEN DIAGRAM

THE WIRING DIAGRAM

A wiring diagram is, generally, one in which each complete piece of apparatus is represented, e.g. a relay would be shown with its coil and contacts. The wiring diagram would show the connections to the coils and contacts in one position on the diagram. An example is given below of a Track circuit with Track indication lamp.

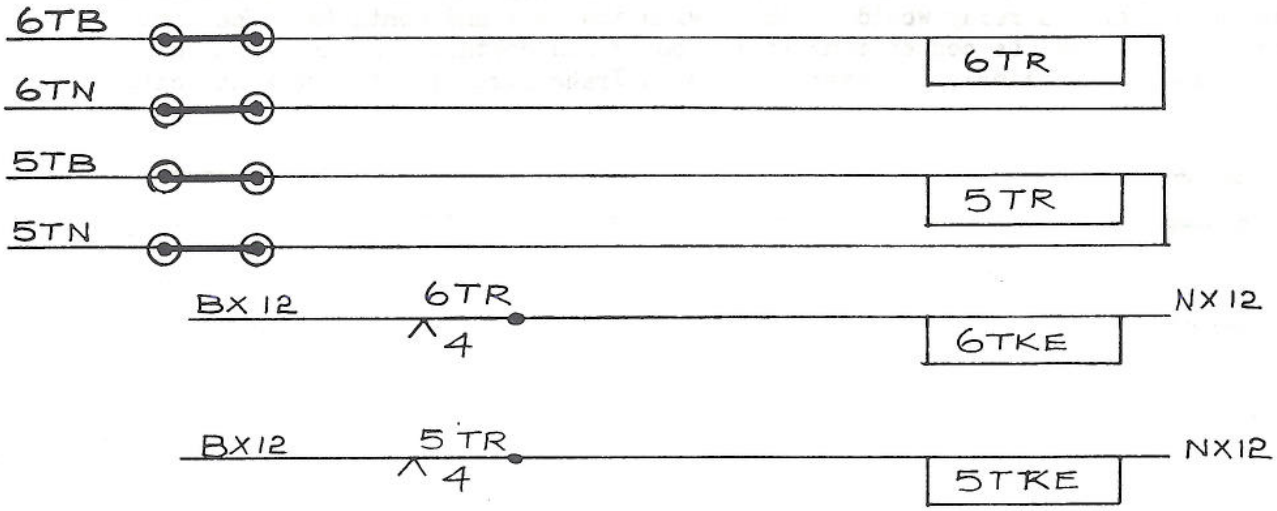


B.E.S./ 10.16 1 JAN 1983

When wiring diagrams are used confusion can arise due to the many wires crossing and the difficulty in obtaining good diagram layout.

THE WRITTEN CIRCUIT

A written circuit is an abridged and simplified circuit diagram in which symbols with abbreviated designations are drawn in a straight line the two ends of which represent the source of supply. The symbols can be compared to shorthand and a line in a written circuit diagram is read left to right in a similar manner to reading a line of writing. A written circuit is shown below for the same circuits as the former wiring diagram.



WITH WRITTEN CIRCUITS TWO TYPES OF CHARACTER ARE USED.
THE NOMENCLATURE. AND THE SYMBOL.

NOMENCLATURE

This is used chiefly in connection with written circuits and the labelling of wires; but it may also be used with advantage to a lesser extent in wiring diagrams.
In certain instances neither the symbol nor the nomenclature can fully convey all the information required. In these cases the signa is used to indicate that reference to the notes on the plan is necessary.

NOMENCLATURE AND LABELLING OF WIRES

In order to provide a concise, suggestive, graphic code for marking the units on plans, the following system has been evolved which makes use of a designation made up of two parts, namely :-

(1) NUMERICAL PREFIX
The number of the principal lever, signal, track circuit, etc., entering into the control of, or controlled by, the unit.

(2) ALPHABETICAL TERM
Consisting of one or more letters. When the letter is used singly or finally it is used as a noun anddesignates the general kind of unit. Proceeding letters, which are used as adjectives, denote the purpose of the unit.

Where reference is to be made to the position of levers, switches, push buttons or any other device operated by the Signalman, as in the case of a lever lock or a relay representing a lever position, the letters shall be in brackets immediately before the final letter, as shown below :-

LEVER LOCK	LOCK RELAY	LOCK RELAY
(NB) L	(N) LR	(R) LR

or with the numerical prefix added :-

10(NB)L	10(N)LR	10(R)LR

The complete designation of a unit is written as follows :-

10 HR (Without dots or dashes)

(Numerical Prefix)	(Prefix Letter)	(Final Letter)
10	H	R

In this example, 10 is the number of the signal, but when used to refer to the signal will be :- 10G. When the figure is used alone, it will be understood to the lever, thumb switch, push button or other equipment actuated by the Signalman for the control of the signal.

The letter R means relay in general, and the letter H meaning yellow, indicates that the function of this relay is to control the yellow aspect of 10 signal therefore :-

10 refers to lever, H. means yellow (adjective) and R means relay (noun).

As far as practicable assigned letters are suggested, either because they are the first letter in the words they represent, for example: B. Block: or because of usage : D. Clear: H. Caution. But many letters stand for names which cannot be associated, and are arbitrary symbols only, as J. Rectifier: U. train description apparatus. Some of the letters represent several different meanings or words, depending on their position with respect to numerals and other letters; if the scheme is used consistently there should be no mistake in meaning.

INDICES are used to denote :-

(1) A SPECIFIC TERMINAL as in the following example :-

10HR 3F means terminal of NO: 3 FRONT CONTACT ON 10 HR

(2) A SPECIFIC SIGNAL where more than one is operated by one lever, as in the following example:-

10 (6) UG means a ROUTE SIGNAL apparatus working in conjunction with SIGNAL NO: 1- displaying the indication for NO: 6 ROUTE

(3) A SPECIFIC RELAY where more than one is connected in parallel on account of insufficiency of contacts on one relay (E.G.) -

10 TPR means relay repeating the relay of track circuit NO: 10

NOTE Where more than one track repeating relay is used, controlled direct from the track relay, these may be indicated by adding a numerical index to the letter P such as :-

10 TP^1R 10TP^2R, etc.

where relays are connected in cascade, the second or subsequent relays may be indicated by using additional P's. such as :-

10 TPR, 10TPPR, etc.

Other examples of common combinations are given below :-

10 RGE = Electric lamp illuminating danger aspect of 10 signal.

10 HGE = Electric lamp illuminating caution aspect of 10 signal.

Cont'd ...

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10 DGE = Electric lamp illuminating clear aspect of 10 signal.
10 RK = Indicator (visual) for light on 10 signal.
10 RGK = Indicator (visual) showing danger aspect of 10 signal.
10 HGK = Indicator (visual) showing caution aspect of 10 signal.
10 DGK = Indicator (visual) showing clear aspect of 10 signal.

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1 JAN 1983

MEANING OF LETTERS

Description term (Prefix letter)		Apparatus (Last Letter)	
A.	Approach ; Automatic	A.	
B.	Block ; Bolt	B.	Block instrument
C.	Checking or proving ; Coding.	C.	Contact
D.	Clear (green) : Decoding	D.	
E.	Light ; Heat (externally applied) Emergency ; Earth.	E.	Electric lamp (illuminating) ; Earth
F.	Fog	F.	Fogging apparatus (e.g. detonator placer)
		f.	Fuse
G.	Signal	G.	Signal apparatus, including Light Signals
		g.	Lightning arrester.
H.	Caution (Yellow)	H.	Capacitor.
HH.	Preliminary caution (double yellow)		
I.		I.	Inductor.
J.	Time (delayed action)	J.	Rectifier
K.	Indicating or detecting.	K.	Indicator (visual)
L.	Locking; Left	L.	Lock
M.	Marker ; Magnetic	M.	Motor
N.	Normal	N.	Release ; Hand-operated switch; Push button or key.
O.	Retarder	O.	Resistor
P.	Repeating	P.	Lever Latch or trigger contact
Q.	Treadle or bar	Q.	Local coil of double-element relay
R.	Reverse ; Right; Danger (red)	R.	Relay or contactor (line or track element of double - element relay).
S.	Stick	S.	
		t.	terminal
T.	Track circuit	T.	Transformer ; Transmitter.
U.	Route (aspect displayed to be shown in brackets).	U.	Train description apparatus (for route indicating).
V.	Trainstop	V.	Trainstop apparatus
W.	Points	W.	Points operating apparatus
X.	Audible indicator (such as bell, buzzer, horn) Level or Highway crossing.	X.	Audible indicator (such as bell, buzzer, horn.)
Y.	Slotting or disengaging	Y.	Disengaging apparatus
Z.	Special (to be explained on plan).	Z.	Special unit (to be explained on plan).
Up.	Up (direction of traffic)		
Dn.	Down (direction of traffic).		

C S & T E DEPT.
TRAINING SCHOOL.
YORK.

REF. B.E.S/10.21

E 1 JAN 1983

COURSE. Basic Electrical Signalling.

SUBJECT. Commonly Used Symbols. (For written circuit diagrams.)

CONTACT ON NON-POLARISED TWO POSITION ARMATURE

CONTACT ON POLARISED TWO POSITION ARMATURE

CONTACT ON THREE POSITION POLARISED ARMATURE

TWO POSITION RELAY
BATTERY FLOW ARM TO CONTACT

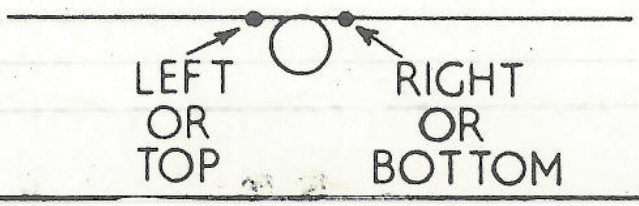
THREE POSITION RELAY

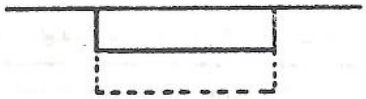
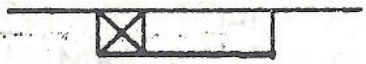
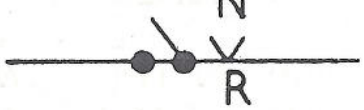
TWO POSITION RELAY
BATTERY FLOW CONTACT TO ARM

THREE POSITION RELAY

IN A WRITTEN CIRCUIT, WHERE THE POLARITY IS NOT INDICATED, THE LEFT, OR UPPER, TERMINATION OF THE LINE IS CONSIDERED TO BE POSITIVE, OR FEED OF SUPPLY

LEVER CONTACTS SHOULD BE NUMBERED, THE ONE ON THE LEFT, TOP, OR REMOTE POSITION, BEING GIVEN THE LOWEST NUMBER
THE NOMENCLATURE WOULD BE :-
L LEFT OR TOP
R RIGHT OR BOTTOM



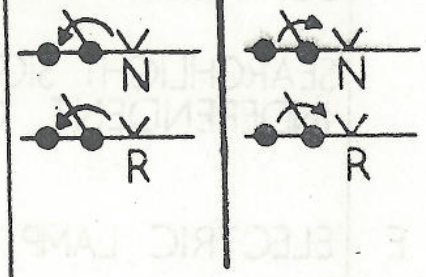
	ELECTRO MAGNET GENERAL SYMBOL	
	WITH DOUBLE WINDING OR SYSTEM REQUIRING TWO ENERGISED WINDINGS	
	SLOW TO RELEASE	
	SLOW TO PICK UP	
	CONTACTS ON NON-POLARISED ARMATURE	
F	CLOSED WHEN ENERGISED	
B	CLOSED WHEN DE-ENERGISED	
A	ARM	
	CONTACTS ON THREE POSITION POLARISED ARMATURE	
N	MADE WHEN RELAY ENERGISED .N.	
D	MADE WHEN RELAY DE-ENERGISED	
R	MADE WHEN RELAY ENERGISED .R.	
A	ARM	
	CONTACTS ON TWO POSITION POLARISED ARMATURE EITHER CONTACT REMAINING CLOSED UNTIL RELAY IS OPERATED TO THE OPPOSITE POSITION	
N	N. CONTACT	
R	R. CONTACT	
A	A. ARM	

1 JAN 1983

CONTACTS ON TWO POSITION POLARISED ARMATURE. BIASED TO ONE POSITION BY MAGNETISM GRAVITY OR SPRING. ARROW SHOWS DIRECTION OF BIAS

BIASED TO

NORMAL | REVERSE



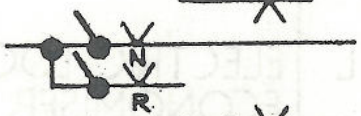
N. N. CONTACT

R. R. CONTACT

A. ARM

EXAMPLES OF DEPENDENT CONTACTS:- NON-POLARISED

TWO POSITION POLARISED

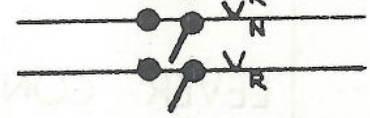


THREE POSITION POLARISED

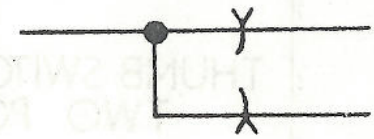
EXAMPLES OF INDEPENDENT CONTACTS:- NON-POLARISED

TWO POSITION POLARISED

THREE POSITION POLARISED



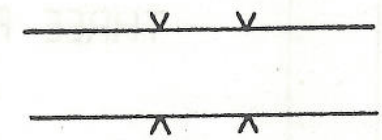
BRIDGING CONTACTS ON NON-POLARISED ARMATURE BOTH CONTACTS CLOSED DURING MOVEMENT OF ARMATURE.



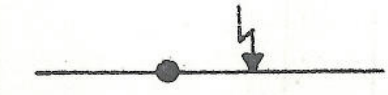
DOUBLE BREAK CONTACTS ON NON-POLARISED ARMATURE

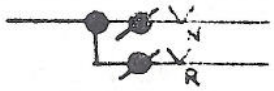
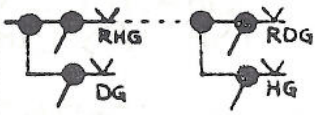
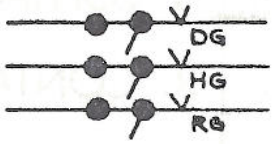
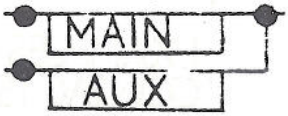
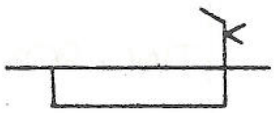
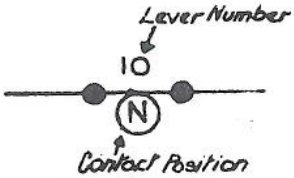
F. FRONT OR TOP

B. BACK OR BOTTOM

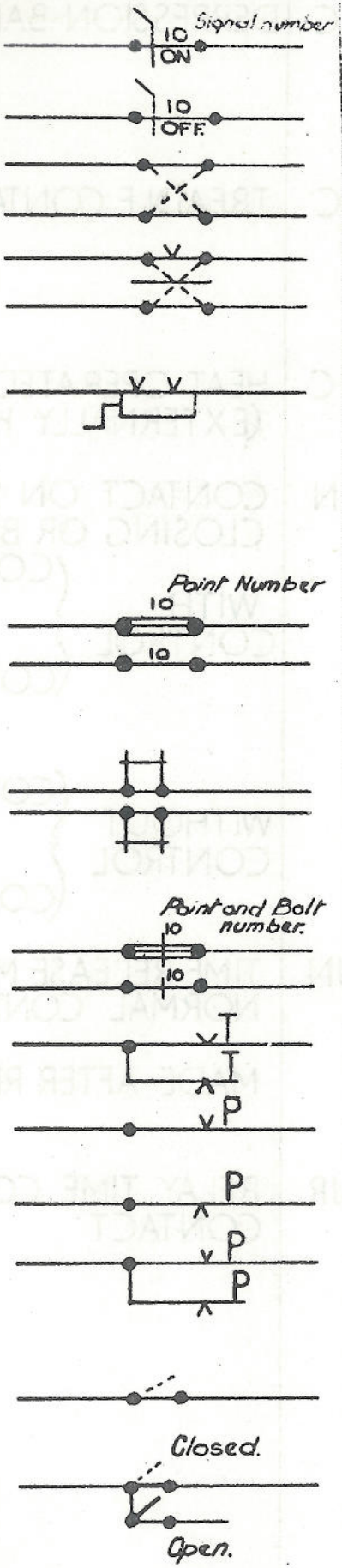


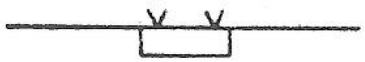
CONTACT FITTED WITH MAGNETIC BLOW-OUT



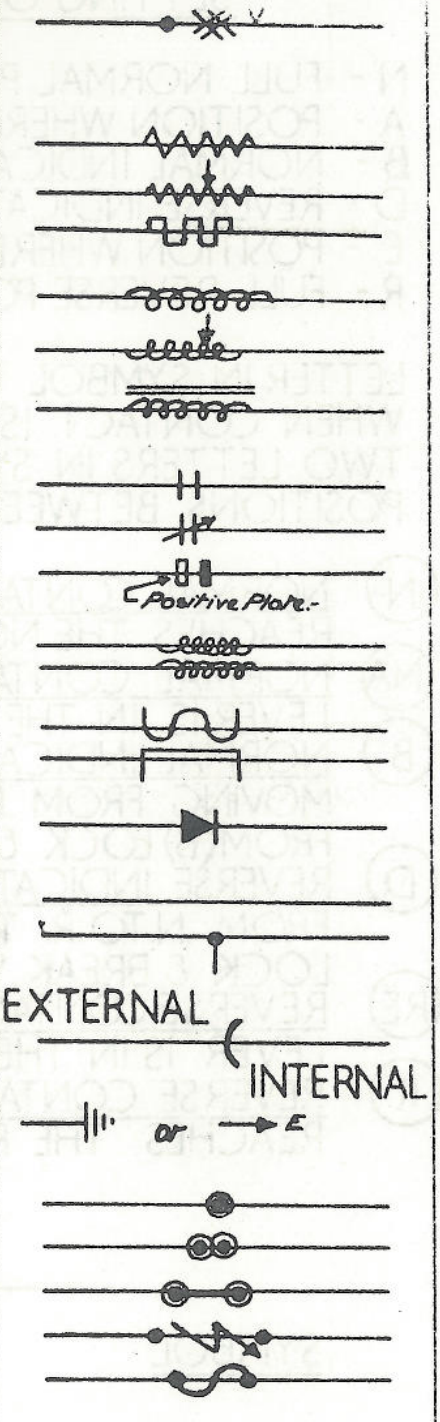
	CONTACT ON FLASHER RELAY	
	SEARCHLIGHT SIGNAL SINGLE DEPENDENT CONTACTS	
	SEARCHLIGHT SIGNAL INDEPENDENT CONTACTS	
E	ELECTRIC LAMP DOUBLE POLE	
E	ELECTRIC LAMP TRIPLE POLE	
L	ELECTRIC LOCK WITH BUILT IN ECONOMISER CONTACTS	
	LOCK PROVING CONTACT	
LCC	LOCK OUT CONTACT LOCK IN CONTACT	
	LEVER CONTACT	
	THUMB SWITCH TWO POSITION NORMAL	
	REVERSE	
	THREE POSITION LEFT	
	CENTRE	
	RIGHT	

		ARM OR SLOT CONTACTS FOR TWO POSITION SIGNALS.
	C	CLOSED IN ON POSITION.
	C	CLOSED IN OFF POSITION.
	C	POLE CHANGING CONTACTS.
	C	POLE CHANGING CONTACTS WITH OPEN POSITION.
	C	PROVING CIRCUIT CONTROLLER CONTACTS CLOSED BY INSERTION OF HAND CRANK OR LEVER.
	WC	DETECTOR CONTACTS FOR POINTS ONLY. CONTACT CLOSED WITH POINTS NORMAL. REVERSE.
	WC	DETECTOR CONTACTS FOR BOLT ONLY BOLT IN BOLT OUT
	WC	DETECTOR CONTACTS FOR BOTH POINTS & BOLTS. POINTS NORMAL BOLT IN POINTS REVERSE BOLT IN
	N	KEY BREAK AND MAKE
	N	PUSH OR PLUNGER BREAK
		MAKE
		BREAK & MAKE
	N	SWITCH HAND OPERATED ONE WAY
		TWO WAY



C	DEPRESSION BAR CONTACT CLOSED	
	OPEN	
C	TREADLE CONTACT OPEN	
	CLOSED	
C	HEAT OPERATED CONTACT (EXTERNALLY HEATED)	
N	CONTACT ON SIGNAL BOX CLOSING OR BLOCK SWITCH WITH CONTROL (CONTACT OPEN	
	WITH CONTROL (CONTACT CLOSED	
	WITHOUT CONTROL (CONTACT OPEN	
	WITHOUT CONTROL (CONTACT CLOSED	
JN	TIME RELEASE MANUAL NORMAL CONTACT	
	MADE AFTER RELEASE TIME	
JR	RELAY TIME CONTROLLED CONTACT	
	FRONT	
	BACK	

	C	SPECIAL CONTACT. REQUIRES REFERENCE TO NOTES. ADD NUMERALS AS REQUIRED.
	O	RESISTOR GENERAL SYMBOL VARIABLE NON INDUCTIVE
	I	INDUCTOR GENERAL SYMBOL VARIABLE WITH IRON CORE
	H	CAPACITOR FIXED VARIABLE ELECTROLYTIC
	T	TRANSFORMER
	J	RECTIFIER SET
		RECTIFIER HALF WAVE
		CONDUCTOR TEE CONNECTION DEMARCATION
	E	CONNECTION TO EARTH
	t	TERMINAL BLOCK SINGLE DOUBLE WITH DISCONNECTION LINK
	g	LIGHTNING ARRESTER
	f	FUSE



BES/10.28 1 JAN 1963

SETTING OF LEVER CONTACT BANDS

N - FULL NORMAL POSITION OF LEVER
A - POSITION WHERE LEVER HAS JUST CLEARED(N)LOCK
B - NORMAL INDICATION POSITION
D - REVERSE INDICATION POSITION
E - POSITION WHERE LEVER HAS JUST CLEARED(R)LOCK
R - FULL REVERSE POSITION OF LEVER

LETTER IN SYMBOL INDICATES POSITION OF LEVER WHEN CONTACT IS MADE.
TWO LETTERS IN SYMBOL INDICATE THE LEVER POSITIONS BETWEEN WHICH THE CONTACT IS MADE.

(N) NORMAL CONTACT TO BREAK BEFORE THE LEVER REACHES THE NORMAL LOCK POSITION.

(NA) NORMAL CONTACT TO BREAK JUST AFTER THE LEVER IS IN THE NORMAL LOCK POSITION.

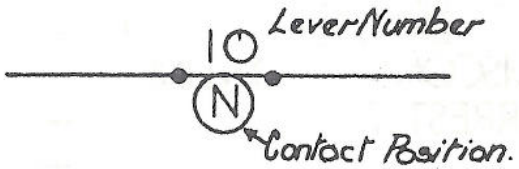
(B) NORMAL INDICATION CONTACT WITH LEVER MOVING FROM .R. TO .N. TO MAKE WHEN LEVER 1" FROM(B) LOCK & BREAK WHEN ½" PAST(B)LOCK.

(D) REVERSE INDICATION CONTACT WITH LEVER MOVING FROM .N.TO.R. TO MAKE WHEN LEVER 1" FROM(D) LOCK & BREAK WHEN ½" PAST (D)LOCK.

(RE) REVERSE CONTACT TO BREAK JUST AFTER THE LEVER IS IN THE REVERSE LOCK POSITION.

(R) REVERSE CONTACT TO BREAK BEFORE THE LEVER REACHES THE REVERSE LOCK POSITION.

SYMBOL



British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools, York & Ilford.

B.E.S./10.29
Symbol Prog. Stage 1.

Ref. 11 JAN 1983

Course. Teaching Programme

Subject. Symbols and Written circuit construction

To obtain the full benefit from using this teaching programme, YOU MUST READ EACH PARAGRAPH CAREFULLY. Do not read the full manual, read each paragraph and take any action as instructed.
Do not move from a paragraph until you have understood the meaning.

Railway signalling wiring diagrams use a type of diagram called a:-
WRITTEN CIRCUIT.

Written circuits use SYMBOLS to represent items of signalling equipment and instruments.
For example a Relay contact can be represented by a symbol :-
The dot being the arm terminal and the Arrow above the line representing a contact made when a relay is energised.
ARM TERMINAL CONTACT MADE WHEN RELAY IS ENERGISED.

Items of signalling equipment are also represented by Symbols and carry letters to describe their function. An example is a Signal lamp.
In the alphabetical code G. means signal. E. means lamp.
G.E. thus means signal lamp.
The general symbol for equipment is :-
The top left hand corner being one terminal the top right hand corner being the other terminal.

Terminal t1 Terminal t2.

A circuit may now be constructed so that the Lamp is lit over the relay contact.
REMEMBER THAT CONTACT SYMBOLS MAY BE SHOWN EITHER WAY i.e.
THIS: OR THIS.

THE GENERAL USE IS THUS :-

To light the lamp a POSITIVE and NEGATIVE supply will be required. And they are represented by the letters B. and N. respectively.
Circuits are always drawn to be read from left to right, just as you would read a book.
It follows therefore that, if current flows from POSITIVE to NEGATIVE the POSTIVE WILL BE AT THE LEFT OF THE DIAGRAM AND THE NEGATIVE AT THE RIGHT OF THE DIAGRAM.
The other parts of the circuit will fall between Pos. and Neg.
The symbols can now be set down in the order required.

B. GE N.

By drawing in the wires we can now show how the circuit is to be connected up.

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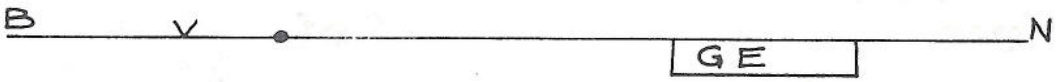
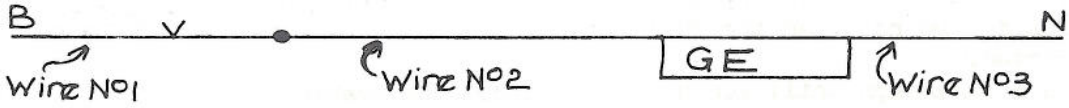
For neatness the connecting wires are drawn as straight lines between the terminals so that the complete circuit appears as below.



The connecting line between the component parts of a circuit indicate connecting wires, so the circuit can be read as an instruction.



*

From the positive supply connect a wire to the front contact of a relay (Wire No. 1).
From the arm terminal of the relay contact connect a wire to the Left hand terminal t1. of a Signal Lamp. (Wire No. 2).
From the Right hand terminal t2. of the Signal lamp connect a wire to the Negative supply.

**

You should now be able to connect this circuit on the Training panel. Insert Programme board No. 1. into the socket at the rear and place Symbol Sheet No. 1 on the face plate.

Being careful to select the correct Symbols follow the instructions from * to ** above.
If you have connected up the circuit correctly and used the correct symbols the lamp will light. If the lamp fails to light check your circuit and choice of symbols.

When the lamp lights telling you the circuit is correct copy the circuit by tracing the wiring and copying the symbols. The result should match the example at the top of the page :-

The above exercise services as an introduction to the construction of written circuits. Make sure you have understood before you move on to the next stage. The instructor will help you with any problems.

When you have completed this exercise, take your diagram to the Instructor for checking before you proceed.

British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools, York & Ilford.

Course. Teaching Programme

Subject. Symbols and written circuit construction.

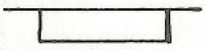
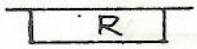
Ref. B.E.S./10.31 Symbol Prog. Stage 2.

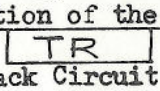
11 JAN 1983

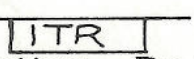
To obtain the full benefit from using this teaching programme, you must read each paragraph carefully. Do not read past a paragraph until you have understood the instruction and carried out any action required.

In Stage 1. you were introduced to the use of Symbols in written circuits. This Stage will deal with the Symbols used for Relays.

RELAYS ARE ELECTRO MAGNETIC DEVICES The contacts of the Relay are operated by linking them to the ARMATURE of the Relay. When current flows through the COIL of the Relay, it becomes an Electro Magnet and attracts the ARMATURE. The ARMATURE is linked to the contacts and so when the ARMATURE moves, the CONTACTS are operated.

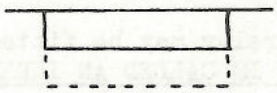
The most simple Relay to understand is the D.C. NEUTRAL RELAY.
THE COIL IS NON POLARISED, WHICH MEANS THAT CURRENT CAN FLOW EITHER WAY THROUGH THE COIL AND THE RELAY WILL STILL OPERATE.
The symbol for the Relay coil is the general symbol :- 
To identify it as a Relay the letter R is written in the symbol.:- 

To identify the function of the Relay a prefix letter is used
e.g. Track Relay. 

The number of the Track Circuit is also given.
So, No. 1 Track Circuit Relay would be :- 

Other letters can be used to describe other functions. The full alphabetical code is given in your Training Course handbook.

The terminals of the coil are the top left corner of the symbol and the top right corner of the symbol. They are called R1. and R2. respectively. THE USUAL METHOD OF CONNECTION IS THAT THE R.1. IS FED FROM THE POSITIVE SIDE OF THE CIRCUIT, WHILE THE R2 IS CONNECTED TO NEGATIVE.

Certain Relays are DOUBLE WOUND RELAYS and require two coils to be energised before the contacts will operate. The terminals of these relays are called R1 R2 R3 R4. The symbol for a Double wound relay is :- 
Details of the operation of this relay will be covered later.

DC NEUTRAL RELAYS ARE CALLED, TWO POSITION ARMATURE RELAYS
because the armature can be in one of two positions i.e. UP or DOWN.
The ARMATURE IS UP WHEN THE COIL IS ENERGISED (Current flowing through the coil).
The ARMATURE IS DOWN WHEN THE COIL IS DE-ENERGISED (No current flowing in coil.)

The type of DC Neutral Relay may Differ, but they all work on the same principle.
In use at the present time are.
Shelf type Relays. BRB. Type plug in Relays. Key switch Relays etc.
A relay is identified on a circuit diagram by the type of symbol used to represent its contacts. We shall now consider these contact symbols.

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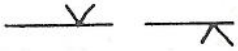
There are three parts used in the symbols.

THE ARM TERMINAL :- Indicates one side of the contact 

The CONTACT which may be front or back contact 

THE FRONT CONTACT IS MADE TO THE ARM WHEN THE RELAY IS UP (ENERGISED)

THE BACK CONTACT IS MADE TO THE ARM WHEN THE RELAY IS DOWN (DE-ENERGISED)

THE FRONT CONTACT SYMBOL IS :- 

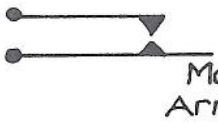
THE BACK CONTACT SYMBOL IS :- 

The complete symbols are :-

CONTACT MADE WHEN RELAY ENERGISED:- 

CONTACT MADE WHEN RELAY DE-ENERGISED 

The type of contact may differ but the symbol is the same.

SYMBOL	BRB.	Sketch of actual contact. SHELF TYPE.
		

Contacts require the relay to be energised to make the contact, and the contacts are broken when the relay is de-energised.

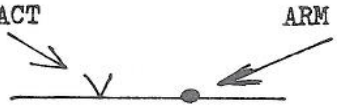
Contacts are made when the relay is de-energised and broken when the relay is energised.

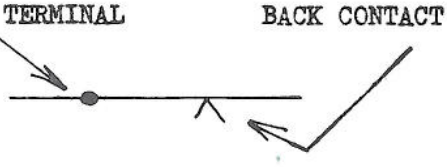
A relay may be fitted with many contacts, and WHEN EACH CONTACT HAS ITS OWN ARM IT IS CALLED AN INDEPENDANT CONTACT.

Thus this symbol means,
CONTACT OF A TWO POSITION ARMATURE RELAY
CLOSED WHEN THE RELAY IS ENERGISED
INDEPENDENT CONTACT. 

And this symbol means,
CONTACT OF A TWO POSITION ARMATURE RELAY
CLOSED WHEN THE RELAY IS DE-ENERGISED
INDEPENDENT CONTACT. 

THE PARTS ARE CALLED.

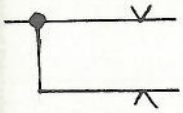
FRONT CONTACT ARM TERMINAL 

ARM TERMINAL BACK CONTACT 

The symbols may be drawn either way round.

Relays can be fitted with another type of contact called a DEPENDENT CONTACTS. With this type of contact the ARM terminal is made to one contact when the relay is de-energised and to another when the relay is energised. The two contacts are therefore DEPENDENT on one Armature.
Examples of Dependent contacts are.

SYMBOL



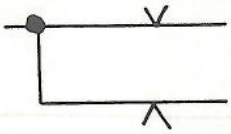
Sketch of actual contact.

BRB type

Not Used.

Shelf Type.

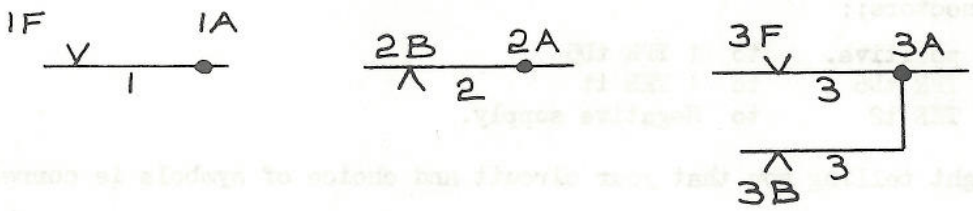
Thus this Symbol Means.
CONTACT OF A TWO POSITION ARMATURE RELAY
FRONT CONTACT MADE WHEN RELAY IS ENERGISED
BACK CONTACT MADE WHEN RELAY IS DE-ENERGISED.
DEPENDENT CONTACT.



CONTACT NUMBERING

A Relay may have more than one set of contacts. To identify a particular contact two systems are used one on BRB relays the other on Shelf type relays.
BRB. TYPE CONTACT MARKING.
On BRB type relays each contact is marked with a letter and a number. This identifies its position on the Relay plug board. (See Training Course Handbook).

SHELF TYPE RELAYS CONTACT MARKING
With this type of Relay each "FINGER" is identified with a number.



The relay contact is further identified by giving the name of the relay over the top of the contact :-

The above contact is thus :-
AN INDEPENDENT CONTACT OF NUMBER 1 TRACK RELAY
AN INDEPENDENT CONTACT OF NUMBER 1 TRACK RELAY. MADE WHEN THE RELAY IS ENERGISED
NUMBER 1 FINGER.

Make sure you understand the foregoing information before you continue, ask the Instructor if you are in doubt.

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Exercise.
Connect Programme Board No. 2 into the Training Panel and Fit Symbol Board No. 2 on the Faceplate.

Using the plug connectors :-

Connect the supply positive to : 1 TR 4F

Connect.; 1 TR 4A to 1 TPR R1

Connect.; 1 TPR R2 to Negative supply

If you have completed the circuit correctly the lamp will light. If the lamp fails to light, check your circuit and choice of symbols.

B12 N12

By following the wires from B of supply, draw the symbols in the sequence and manner shown on the faceplate, using the above line.

Study the diagram, It is a circuit used in signalling. It is an example of one relay controlling another and is called a TRACK REPEATING RELAY CIRCUIT.
Each time 1 Track relay is energised, its contacts close and current can flow through the coil of 1 Track repeating relay.
When 1 Track Relay is de-energised its contacts break, thus de-energising 1 Track repeating relay.
1 TPR thus REPEATS 1 TR.
Take your diagram to the Instructor for checking before proceeding.
Remove the connectors from the panel before continuing with the next exercise.

Using the plug connectors;;

Connect the supply positive. to 1 TPR tD5
Connect.; 1 TPR tD6 to 1 TKE t1
Connect.; 1 TKE t2 to Negative supply.

The lamp should light telling you that your circuit and choice of symbols is correct.

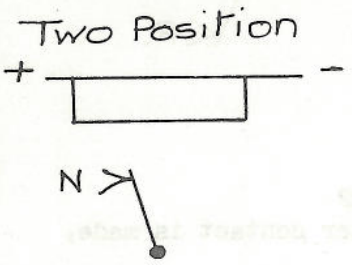
Bx12 NX12

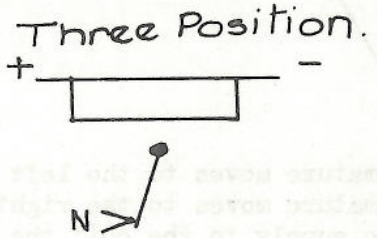
By following the wires from B of supply, draw the symbols in the sequence and manner shown on the faceplate.
Study the diagram, it is a circuit used in signalling. When you have reached a conclusion on its use, take it to the Instructor to discuss your results. If you cannot reach a conclusion the Instructor will help you.

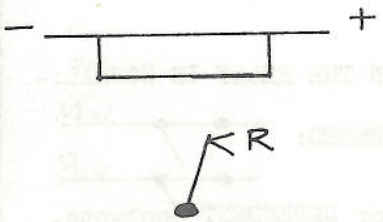
REFER TO YOUR TRAINING HANDBOOK IF YOU ARE NOT SURE OF THE MEANING OF ANY SYMBOL OR LETTERS.

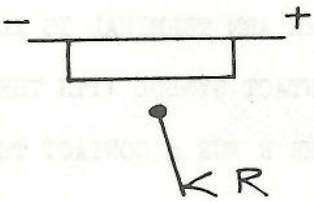
The relays discussed so far have been DC NEUTRAL TWO POSITION ARMATURE RELAYS.
Another style of relay in use is the POLAR RELAY.
IN SHELF TYPE RELAYS THERE ARE TWO STYLES OF POLAR RELAYS :-
TWO POSITION POLAR ARMATURE RELAYS & THREE POSITION POLAR ARMATURE RELAYS

WITH BOTH TYPES OF POLAR RELAYS. THE ARMATURE MOVES TO THE LEFT OR TO THE RIGHT DEPENDING ON THE DIRECTION OF CURRENT THROUGH THE COIL OF THE RELAY.





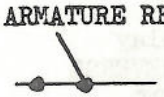




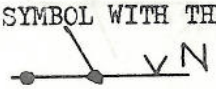
THE ARMATURE MOVES TO THE LEFT WITH A+ TO R1 & - TO R2.
THE ARMATURE MOVES TO THE RIGHT WITH A- TO R1 & - TO R2.
LEFT IS CALLED NORMAL RIGHT IS CALLED REVERSE
TWO POSITION ARMATURE RELAY
THE CONSTRUCTION OF THE TWO POSITION ARMATURE RELAY IS SUCH THAT IT STOPS IN THE LAST POSITION IT WAS ENERGISED TOO UNTIL IT IS ENERGISED IN THE OPPOSITE DIRECTION.

THE SYMBOL FOR A TWO POSITION POLAR ARMATURE RELAY IS :-

TO THIS THE ARM TERMINAL IS ADDED:



THEN A CONTACT SYMBOL WITH THE LETTER N FOR A CONTACT MADE WHEN THE IS NORMAL :-



OR THE LETTER R FOR A CONTACT MADE WHEN THE RELAY IS REVERSED:-

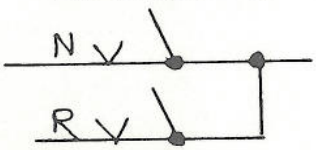
As with the DC Neutral relay the contacts may be INDEPENDENT. i.e. they each have their own Arm terminal. Or the contacts may be DEPENDENT I.E. An ARM terminal CAN make to either a Normal or Reverse contact.

The symbols for TWO POSITION ARMATURE RELAYS ARE :

Contact of a Two position armature relay MADE WHEN NORMAL INDEPENDENT CONTACT :-

Contact of a Two position armature relay MADE WHEN REVERSE INDEPENDENT CONTACT :-

Contact of a Two position armature relay
NORMAL CONTACT MADE WHEN RELAY NORMAL
REVERSE CONTACT MADE WHEN RELAY REVERSED.
DEPENDENT CONTACTS.



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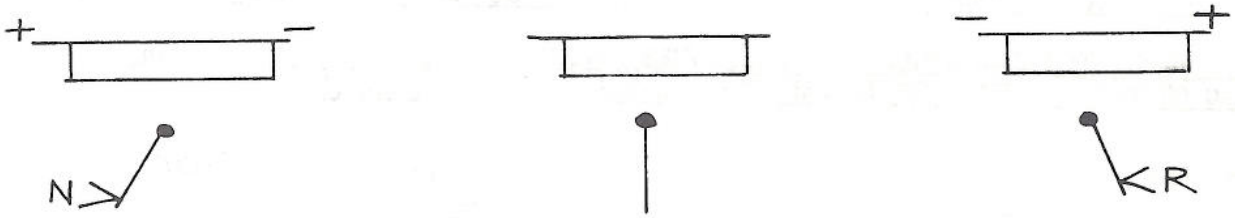
The second type of polar relay to be considered is the :-
THREE POSITION POLAR ARMATURE RELAY
WITH THE THREE POSITION POLAR RELAY THE CONTACTS CAN BE IN ONE OF THREE POSITIONS NORMAL REVERSE OR DE-ENERGISED.



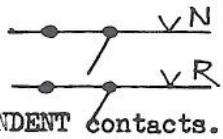
The armature moves to the left (NORMAL) with + to R1 & - to R2
The armature moves to the right (REVERSE) with - to R1 & + to R2
With no supply to the coil the Armature hangs central and neither contact is made.

THE SYMBOL FOR A THREE POSITION POLAR ARMATURE RELAY IS :-

TO THIS THE ARM TERMINAL IS ADDED :-

THEN A CONTACT SYMBOL WITH THE LETTER N FOR A CONTACT MADE WHEN THE RELAY IS NORMAL:-

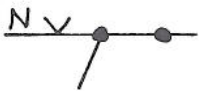
OR A LETTER R FOR A CONTACT THAT IS MADE WHEN THE RELAY IS REVERSED:



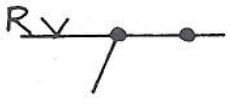
As with the preceeding relays the contacts may be INDEPENDENT or DEPENDENT contacts.

The symbols for THREE POSITION ARMATURE RELAYS ARE.

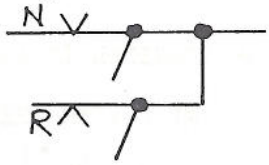
Contact of a Three position armature relay
MADE WHEN NORMAL INDEPENDENT CONTACT :-



Contact of a Three position armature relay
MADE WHEN REVERSE INDEPENDENT CONTACT :-



Contact of a Three position armature relay
NORMAL CONTACT MADE WHEN RELAY NORMAL REVERSE
CONTACT MADE WHEN RELAY REVERSE DEPENDENT
CONTACTS :-



Make sure you understand the foregoing information before you continue, ask the Instructor if you are in doubt.
Study your Training Course Manual, all of the symbols used are contained in it.

When you are sure you understand insert Programme board 3. into the Training panel and place Symbol Board 3 on the faceplate.

Using the plug connectors provided construct a circuit as follows ;-

Connect the supply Positive to :- The Back contact of a DC neutral relay (Independent contact).

Connect the arm of the same relay contact to: The Reverse contact of a Three Position Polar relay. (Independent contact).

Connect the arm of the same relay contact to :- the R1 terminal of a relay coil.

Connect the R2 terminal of the same relay :- The supply Negative.

If you have used the correct symbols and made the correct connections the lamp will light.

B12 N12

By following the wires from B of supply, draw the symbols in the sequence and manner shown on the faceplate.

Take your diagram to the Instructor for checking before you proceed.

Remove the plug connectors from the Training panel but leave the Programme Board and symbol board in place.

Connect the Positive of the supply to :- The Arm terminal of a Set of DEPENDENT contacts of a TWO position polar relay.

Connect the NORMAL contact of the above relay to :- The t1. of a Normal indication Lamp.

Connect the Reverse contact of the same relay to :- The t1. of a Reverse indication light.

Connect the t2 of the Normal indication light to:- The t2 of the Reverse indication light.

Connect the t2 of the Normal indication light (Second connection) to:- The supply Negative.

Again the lamp will light if your work is correct.

By tracing through your wiring and copying the symbols draw the circuit in the space below. You will find it differs slightly from the ones that you have done before in that more than one line is used.

Study the diagram and try to reach a conclusion on a use for this type of circuit in railway signalling.

When you have reached a conclusion take your diagram to your Instructor to discuss your results.

If you cannot reach a conclusion the Instructor will help you.

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British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools, York & Ilford.

Ref. B.E.S./10.39 Symbol Prog. Stage 3.

1 JAN 1983

Course. Teaching Programme

Subject. Symbols and written circuit construction

Stage 1. and 2. introduced you to the basic principles of circuit diagram construction and symbols. It is now intended to move on to a selection of Symbols in common use and to incorporate them into some simple circuits. All the symbols are included in your Training handbook and study of it will help you in these exercises.

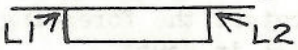
When electrical interlocking is required on a Lever frame, the lever needs to be fitted with two items of equipment i.e.
AN ELECTRIC LOCK and a CIRCUIT BREAKER.

The electric lock is an electro magnetic device. When current flows in the coil of the lock the lock 'dog' is lifted and the lever is free to move.
The lock may be made to lock the lever in any position.

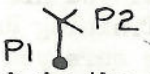
The symbol for the coil of an Electric lock is :-

To this an Economiser contact is fitted so that the Electric lock is only energised when required. The symbol for this contact is :-

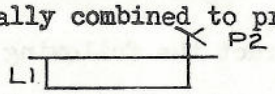
The terminals of the Electric lock coil are the top left and top right corners of the Symbol and are called L1 and L2 respectively.



The terminals of the Economising contact are called the P1.



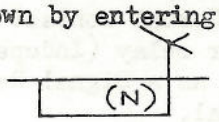
The two symbols are generally combined to produce a Symbol which is the combination of the two:-



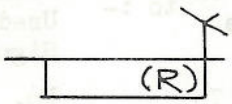
The connections to the lock are referred to by the above terms.

Lever locks can be made to lock the lever in any position and the position in which the lever is locked is shown by entering the appropriate letter in the symbol.

Lever locked normal.

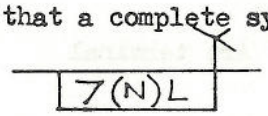


Lever locked reverse.

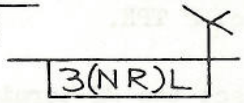


To this information the lever number is added so that a complete symbol would appear thus :-

No. 7 Lever lock locking the lever Normal :-



No. 3 Lever lock locking the lever Normal and Reverse.



To determine the position of the Lever a second device is fitted, the CIRCUIT BREAKER. The device is nothing more than a Rotary switch. It can be adjusted so that its contacts make, or break in any required lever position.

The standard Symbol for a circuit breaker of any type fitted to a lever is :-

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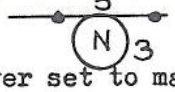
The number of the lever to which the circuit breaker is fitted is shown thus :-

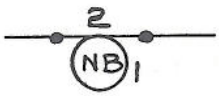
The circuit breaker may have more than one contact band so the number of the contact band is shown thus :-

The final piece of information is the lever position in which the Circuit breaker contact is made, this is shown thus :-

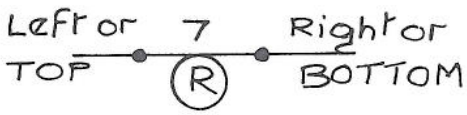
A complete symbol for a
CIRCUIT BREAKER FITTED TO NO 5 LEVER SET TO MAKE WHEN THE LEVER IS NORMAL No 3 Band.



A circuit breaker on No 2 lever set to make when the lever is anywhere between Normal and Normal Check No. 1 band.



The dots represent the terminals. Left and Right and Top and Bottom are synonymous.



Make sure you understand the foregoing information before you continue, ask the Instructor if you are in doubt.
Study your Training Handbook, all of the symbols used are shown in it.
When you are sure you understand, Insert Programme Board 4. into the Training Panel and place Symbol Board 4 on the faceplate.
Using the plug connectors provided construct the following circuit.

Connect the B12 volt supply to :-		The Top terminal of No 1 Band of a Circuit Breaker on No 7 lever set to make when the Lever is Normal.
Connect the Bottom terminal of No. 1 Band of a circuit breaker on No. 7 lever set to make when the lever is normal.	to :-	The Normal contact of a Three position Polar relay (Independent contact). Used as a Signal Repeating Relay on No. 7 Signal.
Connect the Arm terminal of No. 7 GPR	to :-	No. 1 Front contact of a Track repeating Relay for No. 2 Track Circuit.
Connect the No. 1 Arm terminal of No. 2 TPR.	to :-	The L1 terminal of an electric lock on No. 8 Lever effective in the Normal and Reverse lever positions.
Connect the P2 terminal of 8 (NR)L.	to :-	N12 volt supply.

If you have used the correct symbols and made the correct connections the lamp will light.

By following the wires from B12 to N12, draw the circuit by copying the symbols in the sequence and manner shown on the faceplate.

The diagram is for the Releasing of No. 8 point lever by No. 7 Signal at normal and No. 2 track circuit clear. It is a basic circuit for a common piece of electrical interlocking.
Take your diagram to the Instructor for checking before you proceed.

Remove the plug connectors, Symbol board and Programme board from the Training panel and Fit Programme board No. 5 and Symbol board No. 5.
The following circuit will combine many of the symbols already used. The circuit will be described using correct nomeclatures only. As you build the circuit make sure that you understand the terms used, checking in your Training handbook if you have any doubt.

Connect B12 f 1R	to:-	8TR 1F
Connect 8TR 1A	to:-	6WKR 1A (Dependent contact)
Connect 6WKR 1N	to:-	1GPR N (Independent contact)
Connect 1 GPR A	to:-	1 N 1 L
Connect 1 N 1R	to:-	3 TPR 1F
Connect 3 TPR1A	to:-	2 2(N)L L1
Connect 2 (N) L P2	to:-	N12 t1
Connect 6WKR 1R	to:-	5 GPR N (Independent contact).
Connect 5GPR A	to:-	5 N 1L
Connect 5 N 1R	to:-	6 TPR 1F
Connect 6 TPR 1A	to:-	4 (N)L L1
Connect 4(N)L P2	to:-	2(N) L P2

If you have selected the correct symbols and wired them correctly the lamp will light.

Copy the circuit by following through the wiring as you have done before.

The circuit is again a Basic signalling circuit.
No. 2 and No. 4 Signals are junction signals
No. 2 Signal reads over No. 6 points Normal and No. 4 Signal reads over No. 6 points Reverse.
No. 1 Signal is the Signal ahead of No. 2 signal.
No. 5 Signal is the Signal ahead of No. 4 Signal.
No. 8 Track runs from 2/4 signal to No. 6 Points.
No. 3 Track runs from 8 Track End to No. 1 signal.
No. 6 Track runs from 8 Track End to No. 5 Signal

The circuit is designed to prevent a signal clearing unless the 'Section of line to the next signal is clear, the points set, and the signal ahead, is at Danger.

Draw the layout of the track showing the points signals and track circuits USING THE CORRECT SYMBOLS.

When you have completed your drawings and feel that you understand them, take them to the Instructor for checking and discussion.

British Railways, Eastern Region.

C.S. & T.E. Department.

Training Schools, York & Ilford.

Ref. APPENDIX 1/1

1 JAN 1983

Course. Basic Electrical Signalling

Subject. Simple Electromagnetic devices.

TREMBLER BELLS (Diag. 1.)

One of the common uses of the Electromagnetic coil is in the Trembler Bell circuit. THIS TYPE OF BELL GIVES A CONTINUOUS RING and is often used as an alarm device. Two coils are wound and mounted on a soft iron bar to form a horse shoe magnet. Care must be taken that the magnetic fields of the two coils are the correct magnetic polarity with respect to each other of the fiels will cancel out. An armature (moving piece) of soft iron is mounted on a steel spring in such a manner that it just stands clear of the ends of the coil.

If current is caused to flow through the coil it will become a magnet and attract the soft iron.

To make the action repetitive the current to the coil is taken through a contact that is only made when the armature is in its normal position, thus the movement of the armature interupts the current and causes the armature to vibrate.

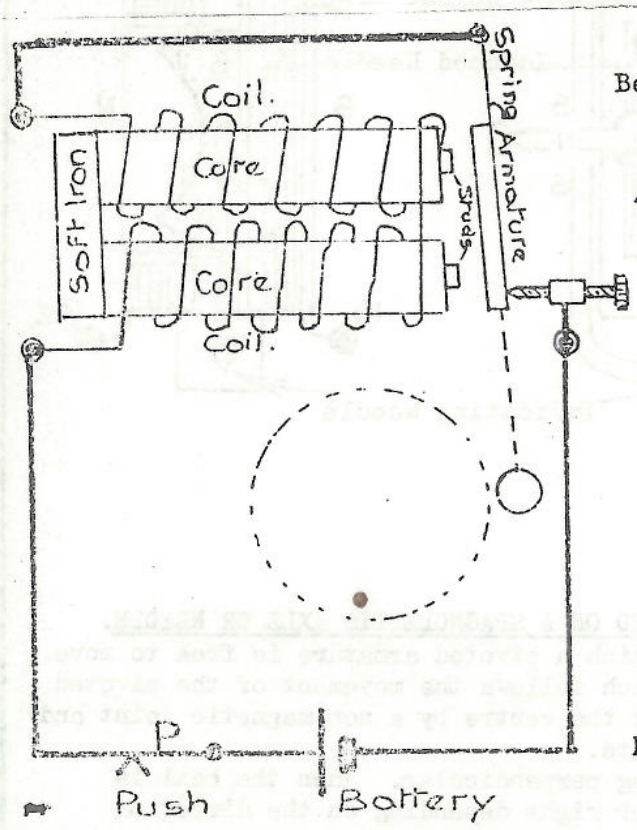
If a striking hammer is attached to the armature and a bell is fitted a continuous ring is produced.

BUZZERS

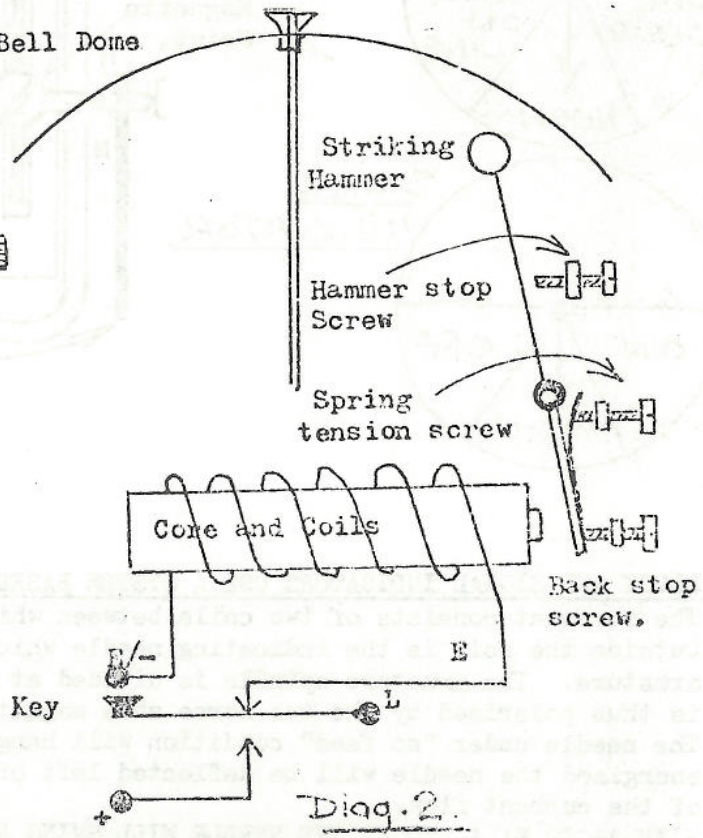
The buzzer works in the same manner as the trembler bell, but the striker and bell are not fitted. When the armature vibrates a buzzing is produced the tone of which can be altered by adjusting the air gap between the armature and the coils.

Residual stops.

If the armature of the bell was allowed to come into contact with the core of the coil, it would tend to hold there after the current was switched off. Small Brass or Copper studs called Residual studs are fitted to prevent this. (Residual Magnetisism and the use of residual studs is covered in more detail when Relays are taught).



Diag. 1.



Diag. 2.

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SINGLE STROKE BELLS. (Diag. 2.)

SINGLE STROKE BELLS ARE IN COMMON USE IN BLOCK BELLS, in the standard block they form part of the complete unit.

The bell is actuated by electromagnetism. It has two coils mounted on to a soft iron bar thus forming a horse shoe magnet. The armature is pivoted in front of the coil in such a manner that it forms a 'flap', the striking hammer is fixed to the armature so that when the armature is attracted by the coil the hammer strikes the dome of the bell.

The block bell is fitted with a key to operate the bell in the adjacent signal box. One common Block bell line is shared by the bells at each end of the section and to prevent a signalman ringing his own bell when ringing out the bell coil is fed through the normal contact of the ringing key.

EACH COIL OF THE BELL HAS A RESISTANCE OF 25 ohms. THUS WITH BOTH COILS CONNECTED IN SERIES THE TOTAL RESISTANCE OF THE BLOCK BELL IS 50 ohms

THE OPERATING CURRENT OF THE BLOCK BELL 200 mA

Three adjustment screws are provided; their respective functions are :-

Back Stop Screw: Adjusts the position of the armature in relation to the coil thus sets the air gap.

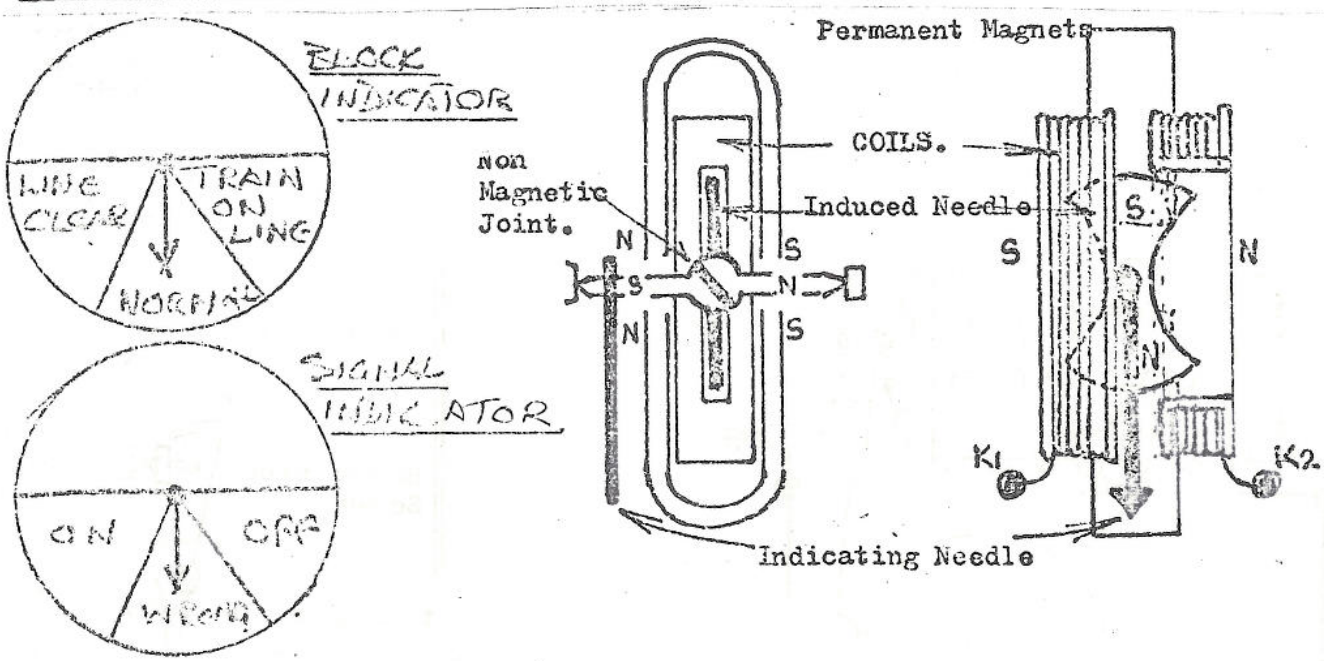
Hold off spring tension screw:- Adjusts the tension of the spring returning the armature to its normal position.

Hammer stop screw: Is adjusted so as to allow the hammer to just strike the bell dome.

IT IS IMPORTANT THAT THE BELL IS CORRECTLY ADJUSTED TO OBTAIN MOST EFFICIENT PERFORMANCE OF THE BELL.

SINGLE STROKE BELLS GIVE ONE BEAT ONLY EACH TIME THE KEY IS PRESSED

BLOCK AND SIGNAL INDICATORS



BLOCK AND SIGNAL INDICATORS USE A SYSTEM BASED ON A SPAGNOLETTIS AXLE OR NEEDLE.

The movement consists of two coils between which a pivoted armature is free to move. Outside the coil is the indicating needle which follows the movement of the pivoted armature. The armature spindle is divided at the centre by a non magnetic joint and is thus polarised by the two horse shoe magnets.

The needle under "no feed" condition will hang perpendicular. When the coil is energised the needle will be deflected left or right depending on the direction of the current flow.

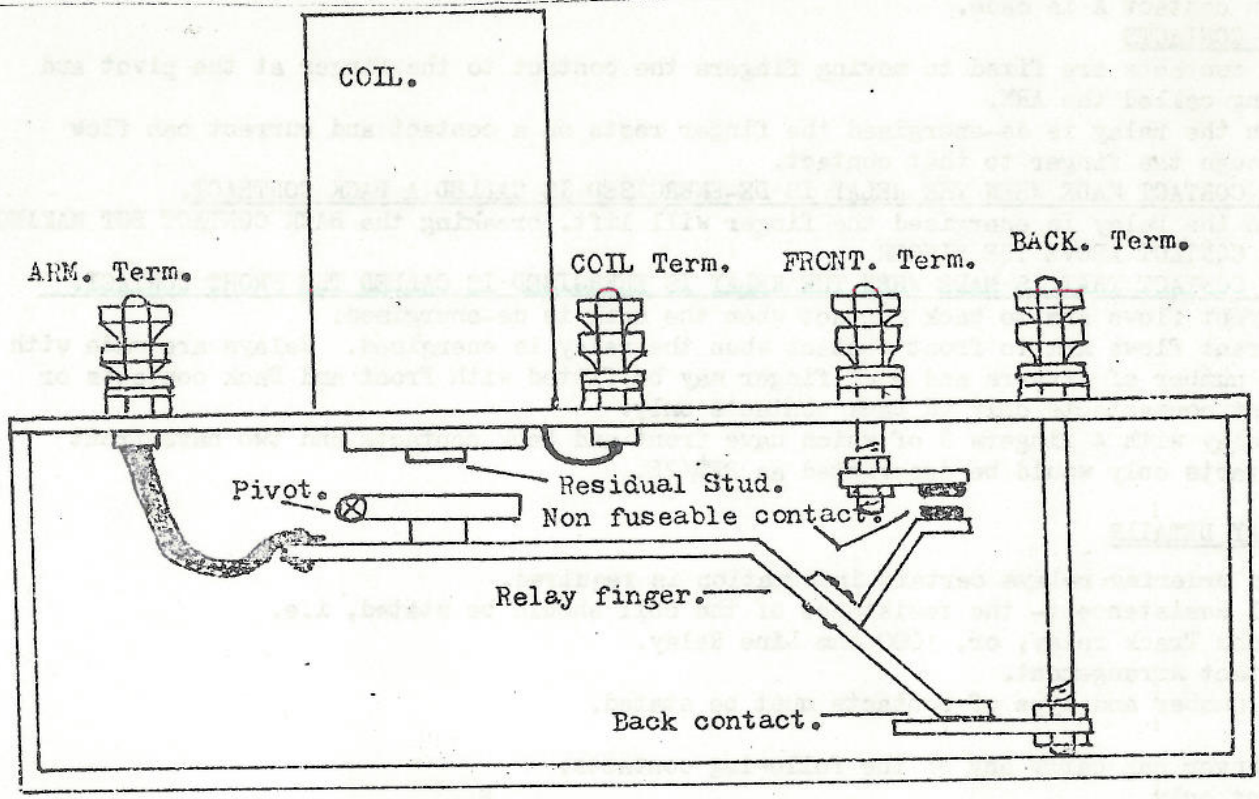
WITH A+ TO K1 A- TO K2 THE NEEDLE WILL SWING LEFT.

WITH A- TO K1 AND A+ TO K2 THE NEEDLE WILL SWING RIGHT.

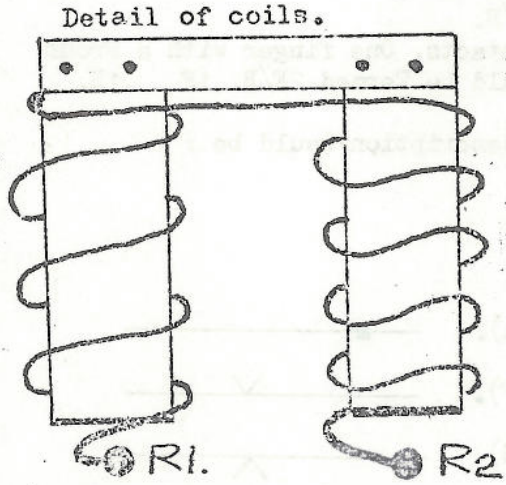
WITH NO FEED THE NEEDLE HANGS CENTRAL.

THE COILS OF A BLOCK INDICATOR ARE 75 OHMS RESISTANCE. THUS WITH TWO COILS IN SERIES THE TOTAL RESISTANCE IS 150 OHMS. THE MINIMUM OPERATING CURRENT IS IN THE ORDER OF 5 TO 6mA.
SIGNAL INDICATOR COILS ARE MADE IN TWO RESISTANCE VALUES 350 AND 50 OHMS WITH AN OPERATING CURRENT OF APPROX. 5mA.

The use of and circuits for this equipment will be covered later.



Detail of coils.



Any relay is a remote controlled switch. Operated by an electro magnetic coil.

There are two distinct and separate functions to the Relay.
THE OPERATING COIL. CAUSES THE FINGERS TO MOVE WHEN ENERGISED OR DE-ENERGISED.

THE CONTACTS, MADE OR BROKEN WHEN THE FINGERS MOVE.

THE OPERATING COIL
For the relay being described the coil is DESIGNED TO OPERATE WITH DIRECT CURRENT. THE POLARITY OF THE SUPPLY IS NOT CRITICAL IT IS THUS TERMED NEUTRAL however the usual polarity is POS. TO R1. NEG TO R2.
The energisation of the coil makes it into an Electro magnet which attracts the soft iron armature and fingers thus moving the contacts.
The relay can be in one of two states ENERGISED OR DE-ENERGISED. it thus can be termed a TWO POSITION ARMATURE RELAY.
The current can be controlled in the coil by any external circuit. This circuit would be termed the RELAY OPERATING CIRCUIT.

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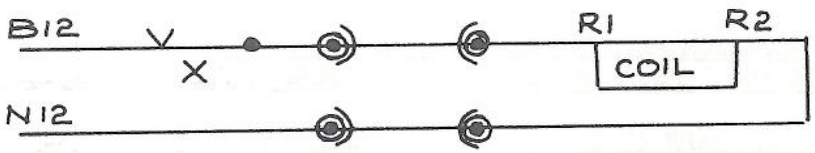


Above is a simple operating circuit:- the coil of the relay will only be energised when contact X is made.

THE CONTACTS

The contacts are fixed to moving fingers the contact to the finger at the pivot and being called the ARM.

When the relay is de-energised the finger rests on a contact and current can flow through the finger to that contact.

THE CONTACT MADE WHEN THE RELAY IS DE-ENERGISED IS CALLED A BACK CONTRACT.

When the relay is energised the finger will lift, breaking the BACK CONTACT BUT MAKING THE CONTACT ABOVE THE FINGER

THE CONTACT THAT IS MADE WHEN THE RELAY IS ENERGISED IS CALLED THE FRONT CONTACT.

Current flows Arm to back contact when the coil is de-energised.

Current flows Arm to front contact when the relay is energised. Relays are made with any number of fingers and each finger may be fitted with Front and Back contacts or front contactacts only CR back contacts only.

A relay with 4 fingers 2 of which have front and back contacts and two have front contacts only would be describted as 2FB/2F.

RELAY DETAILS

When ordering relays certain information is required.

Coil Resistance :- the resistance of the coil should be stated, i.e.

10 ohm Track relay, or, 1000 ohm Line Relay.

Contact Arrangement.

The number and type of contacts must be stated.

A finger can carry any of the following contacts.

Front only	F.
Back only	B.
Front and Back	F/B.

Thus a relay with:- Two fingers with front and back contacts, One finger with a Front contact only and a Finger with a Back contact only, would be Termed 2F/B. 1F 1B.

If this relay was for use on a Track circuit the full description would be :

RELAY. D.C. NEUTRAL 10ohm 2F/B 1F. 1B.

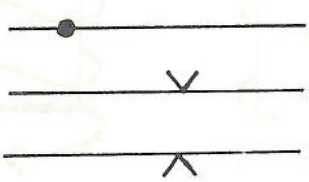
Contact terminology and Symbols.

The contact terms are :-

ARM. The connection to the relay finger. (A).

FRONT. The connection to the contact which is closed when the relay is energised. (F).

BACK. The connection to the contact which is closed when the relay is de-energised. (B).



British Railways Eastern Region

C S & T E DEPT.
TRAINING SCHOOL.
YORK.

REF. BES. APPENDIX. 2.

11 JAN 1983

COURSE. Basic Electrical Signalling.

SUBJECT. Instructions and Safety.

In addition to the technical knowledge covered in this book, a good understanding of rules and regulations and departmental instructions is required.
Personal safety on the line is covered in detail on the basic mechanical and induction training courses, reference should be made to these notebooks.
Safety on the electrified lines is covered in detail in the instruction book of the same name issued by your division.
Further information is given concerning departmental work in the instruction booklet. BR13445 which has been refered to throughout this course.
Appropriate rules and regulations have been covered with the subjects to which they refer throughout the course, these should be revised and section E. of the rule book studied in detail.
The instructor will explain any rule or regulation that you do not understand.