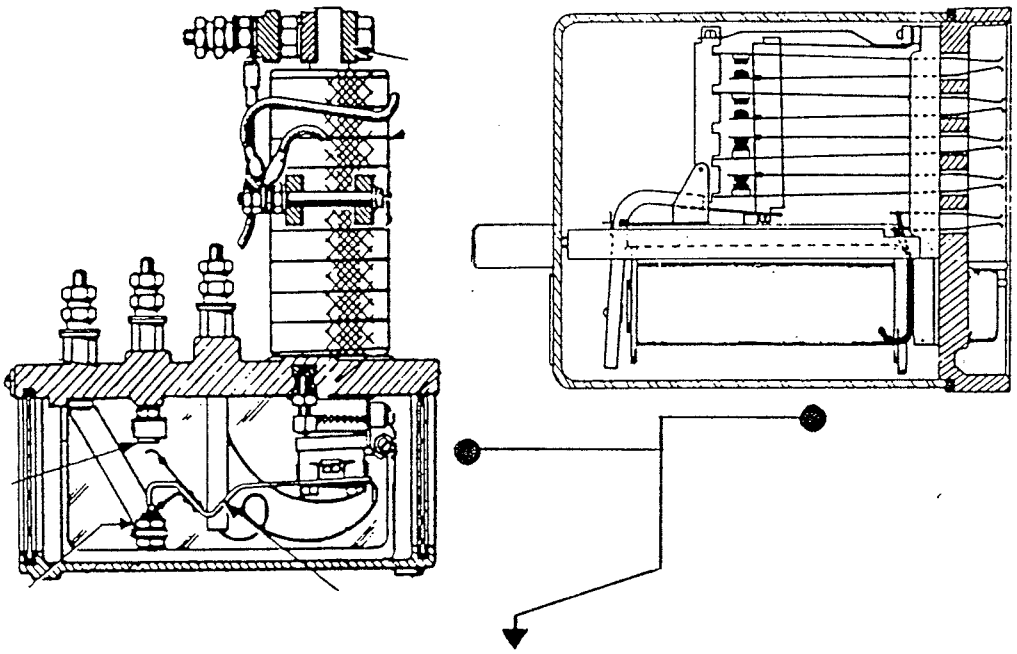
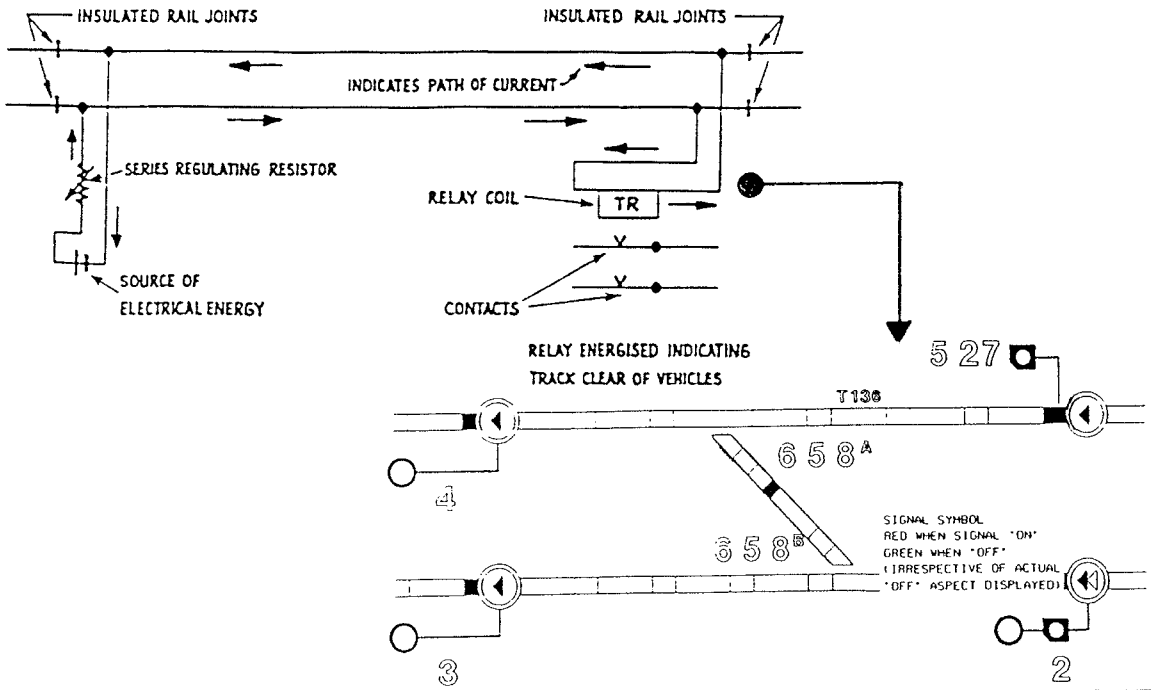
DIRECTOR OF S & T ENGINEERING.
WEST MIDLANDS PROJECTS GROUP.

# *RELAYS AND THEIR USES*





## INTRODUCTION

Relays are in common use in railway signalling and have been for many years. A relay can be described as an electrically operated remote switch, the operation of one relay controlling many different circuits via control contacts.

Relays used in signalling circuits are of the electro-magnetic type and consist essentially of an operating coil or coils which, when energised, set up a magnetic field which operates a contact mechanism.

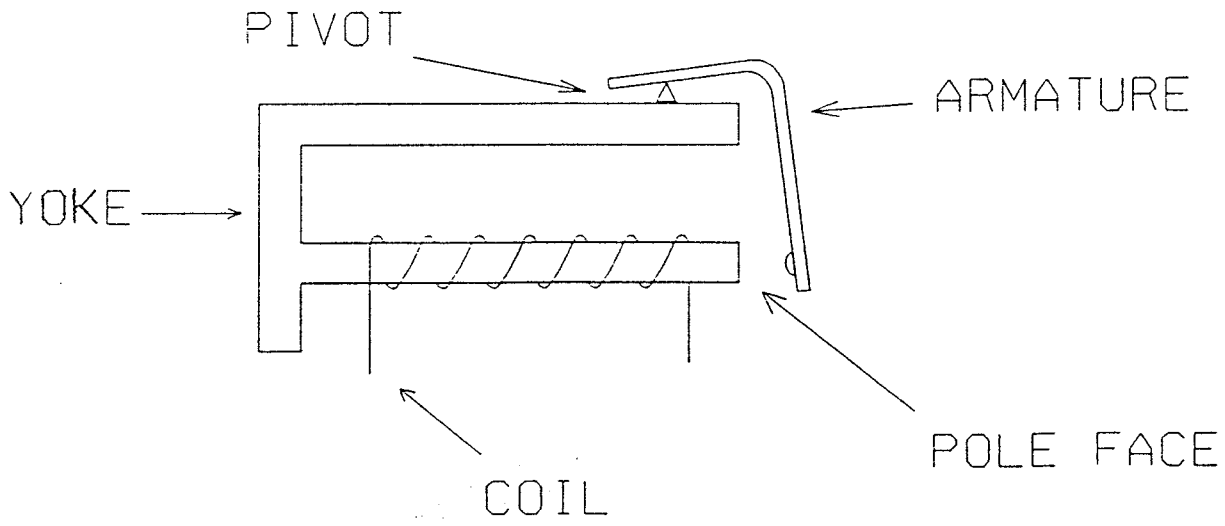
Electrically there are two types of relay A.C. and D.C. In electric traction areas, signalling has to be immune to interference from stray traction currents. A.C. relays are used in D.C. traction areas, D.C. relays being used with A.C. traction and in non-electrified areas.

## PRINCIPLES OF OPERATION

### 1. D.C. Relays

A D.C. Relay consists of a coil of insulated wire wound around an iron core. The iron core is fastened to a yoke and pivoted on the end of the yoke is the armature.

All diagrams relate to BR Spec 930 plug in D.C. relays.

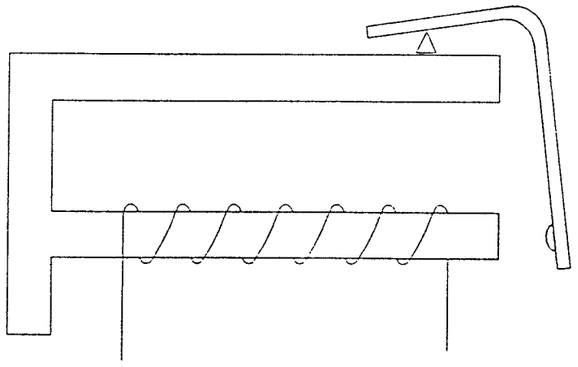



When voltage is applied to the coil, current flows and an electro magnetic field is produced, North pole at one end and South pole at the other. The South pole passes easily through yoke and armature and appears on the armature opposite the pole face.

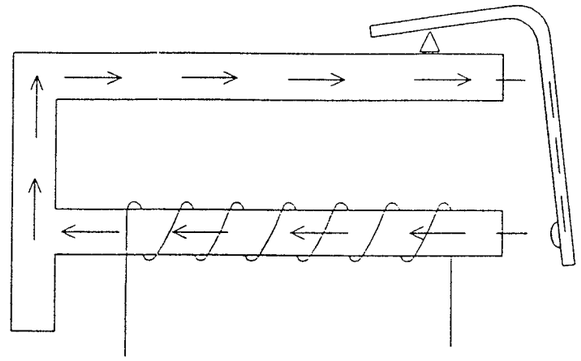
continued

As unlike poles attract, the armature, which has a South pole present is attracted to the pole face (North pole) and hence the armature swings on its pivot to the pole face. The relay is now said to be energised or picked.

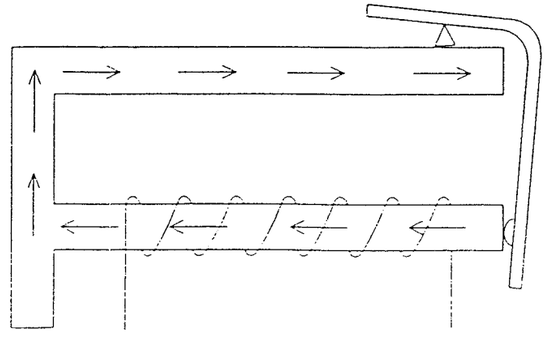
When the voltage is removed from the coil, the current stops flowing and the electro-magnetic field collapses. There is now no force to hold the armature against the pole face and it returns to its original position (sometimes aided by a return spring). The relay is now said to be de-energised or dropped.



NO VOLTAGE APPLIED, NO MAGNETIC FIELD, RELAY DE-ENERGISED



VOLTAGE APPLIED, MAGNETIC FIELD BUILDS UP, ARMATURE STARTS TO ATTRACT



MAGNETIC FIELD AT FULL STRENGTH, ARMATURE ATTRACTED RELAY ENERGISED

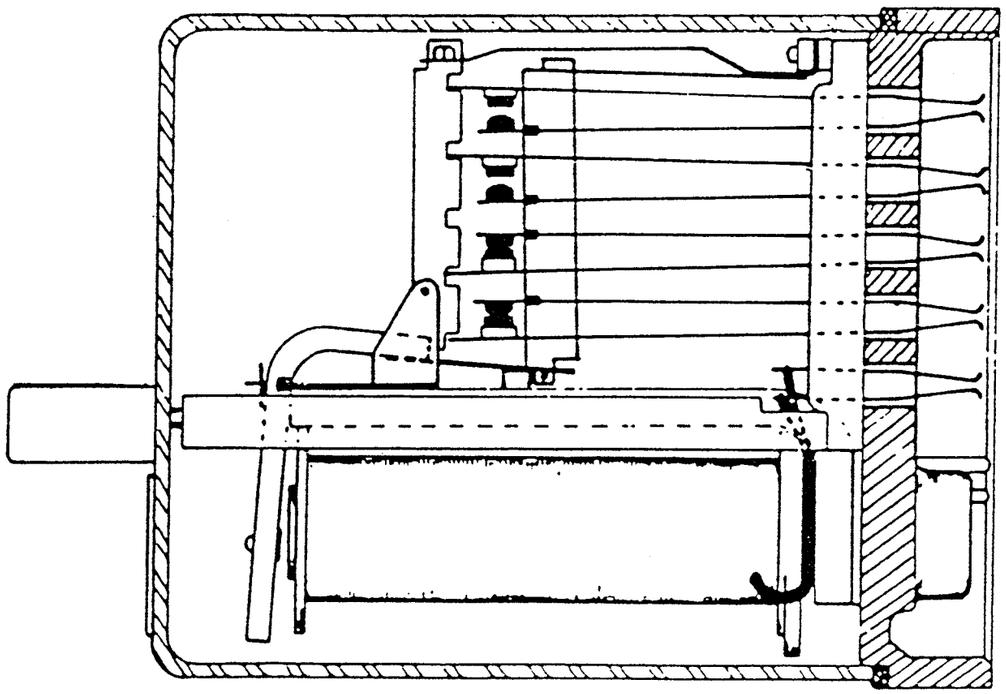
continued

## CONTACT OPERATION

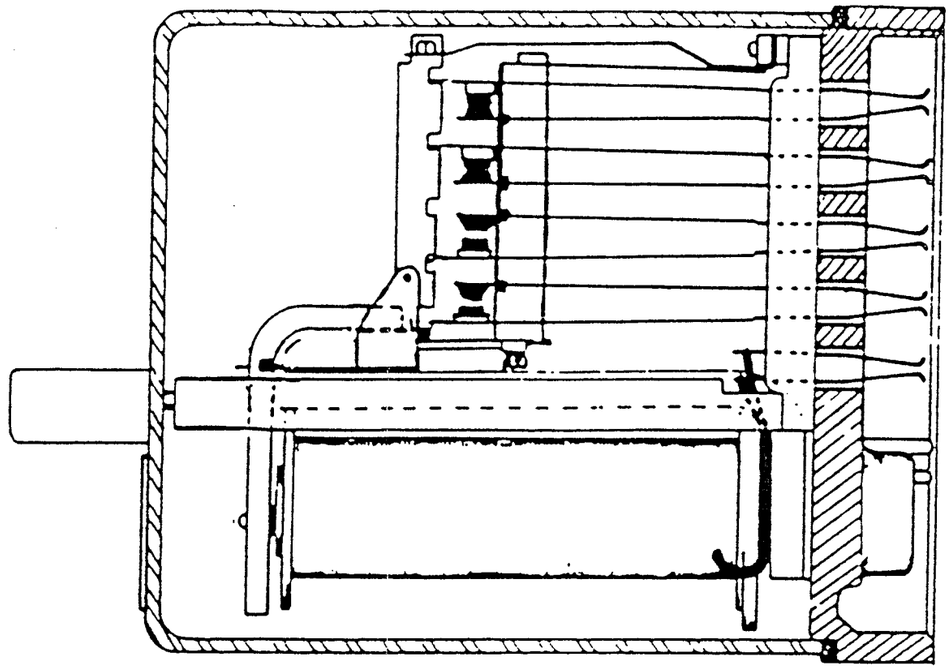
Fastened to the upper end of the armature is a drive bar which in turn is connected to up to Four contacts. When the armature is attracted to the pole this drive bar moves upwards and hence the contacts move. The other half of a contact pair is called the arm and this is held in one position by the buffer bar. When the contacts move upwards, then a front arm and contact make and the back arm and contact break.

Each contact pair can be considered to be an individual on/off switch.

In a BR 930 spec relay, for example, there is a facility for 16 contact pairs and hence energisation of the relay can control up to 16 different circuits.



RELAY DE-ENERGISED, FRONT CONTACTS BROKEN, BACK CONTACTS MADE



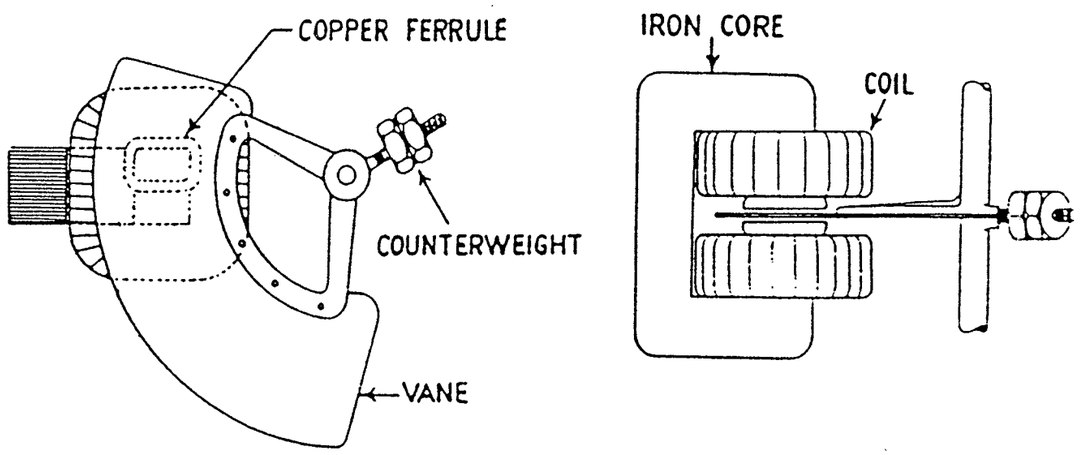
RELAY ENERGISED, FRONT CONTACTS MADE, BACK CONTACTS BROKEN

continued

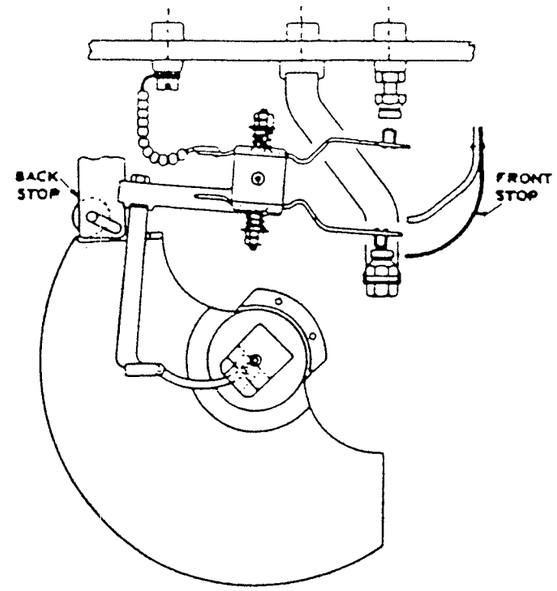
## 2. A.C. Relays

The A.C. relay consists of a pivoted vane linked up to a contact carrier. This vane is pivoted to move in the air gap between the coils of an electro-magnet.

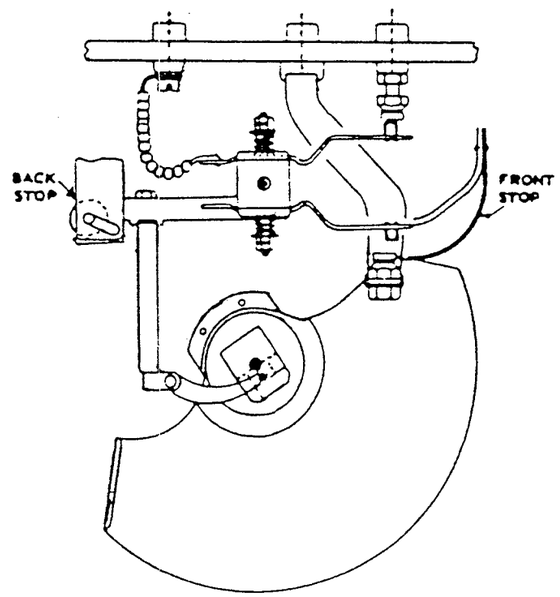
The coil is carried on a special shaped core made of laminated iron, the two pole faces of which form the gap in which the vane is suspended. The poles are fitted with a copper ferrule which covers half of each face.




When an A.C. voltage is applied to the coil, a magnetic flux is produced. This flux is the sum of the two different fluxes produced by the ferruled and unferruled sections of the pole face. As one flux lags the other, a phase displacement occurs, the result of this torque is exerted on the vane causing it to rotate. When the vane moves to its front stop the front contacts of the relay are made.




RELAY DE-ENERGISED, FRONT CONTACTS BROKEN, BACK CONTACTS MADE



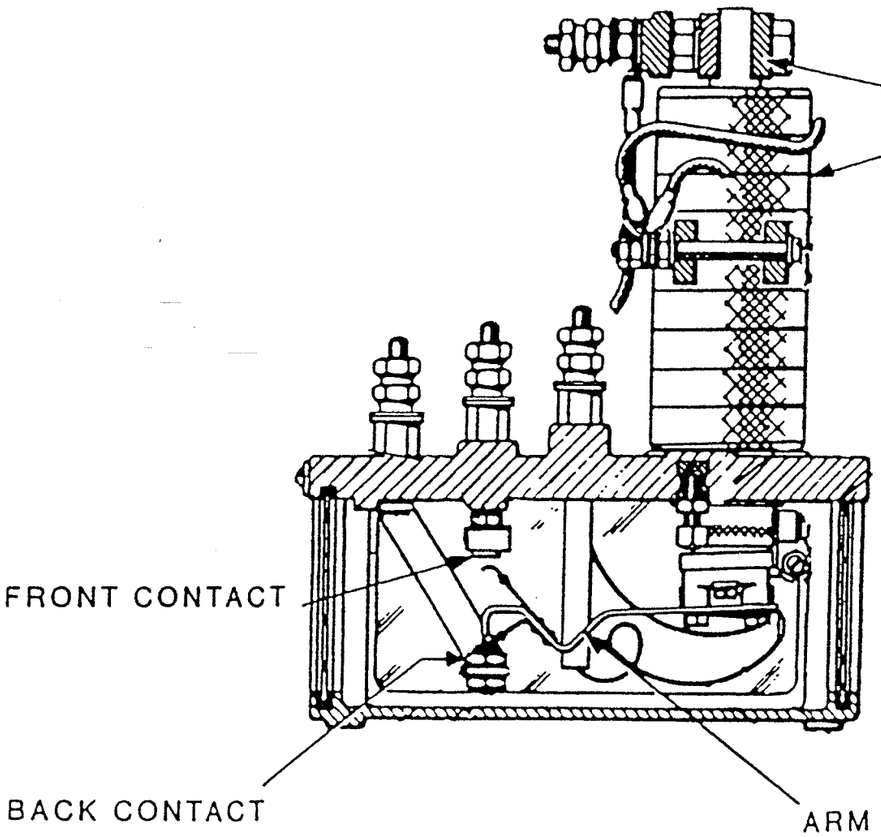

RELAY ENERGISED, FRONT CONTACTS MADE, BACK CONTACTS BROKEN

continued

## SHELF TYPE RELAYS

### Coils and Contacts

The diagram below shows the basic components of a Shelf Type D.C. Neutral relay.



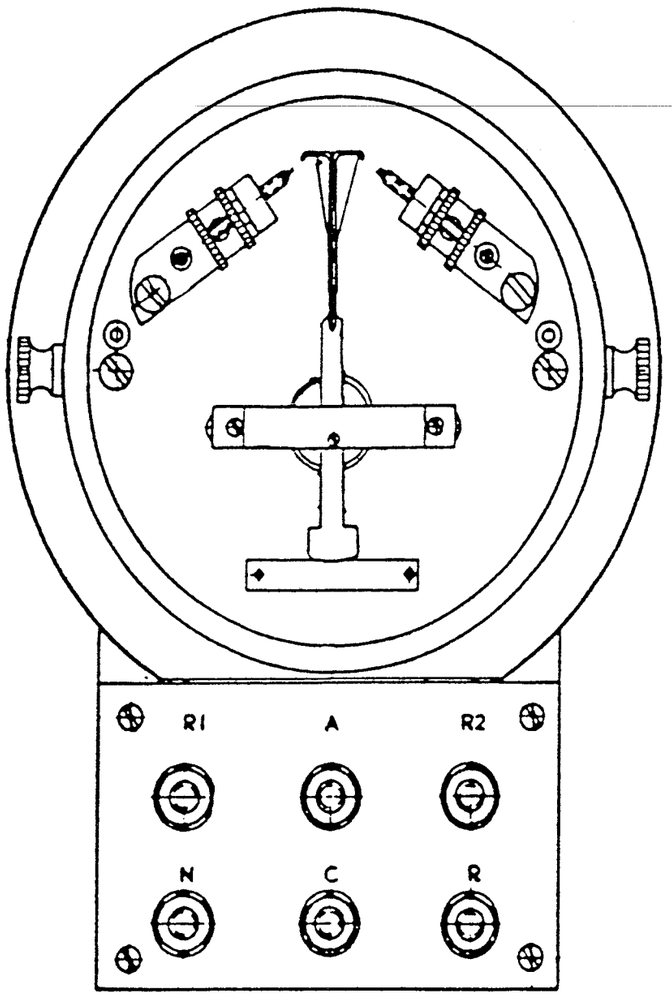

The contacts are sealed inside an enclosed glazed container, the coils being mounted on top. All external wiring connections are made onto OBA terminal studs.

As many relays control vital signalling safety functions, the choice of contact material is most important. The front contacts of safety relays are always made of silver impregnated carbon. This is used to prevent contacts becoming welded together in the event of an abnormal flow of current. The arm is usually made from phosphor bronze with a 99% silver contact tip. Back contacts are also made of silver.

See Example "A", Figure 1.

continued

## POLAR MOVING IRON (MI) RELAY




This type of Polar relay is known as the three position relay. A two position version is also available. This is fitted with a spring operated armature, which ensures it returns to a particular position (either Normal or Reverse) when no voltage is applied. The relay is said to be biased to either Normal or Reverse.

### Coils and Contacts

The standard coil fitted is the 250 ohm although 350 and 1000 ohm versions are available. Coil connections are marked R1 and R2.

Only one set of contacts is normally provided. These are an Arm, a Normal and a Reverse and are marked A, N and R.

Polar relays are usually fitted with round cases and are mounted on a vertical board.

See Example "B", Figure 2.

continued

## DIRECT CURRENT (DC) POLAR-NEUTRAL RELAY

The circuits may be arranged through the neutral contacts and the polar contacts in series, so that it may be said that the neutral contacts control the current while the polar contacts select the function to be operated.

Polar contacts are not biased so when no current flows the contacts will remain closed in the direction they were last deflected, the local current being cut off by series connected neutral contacts.

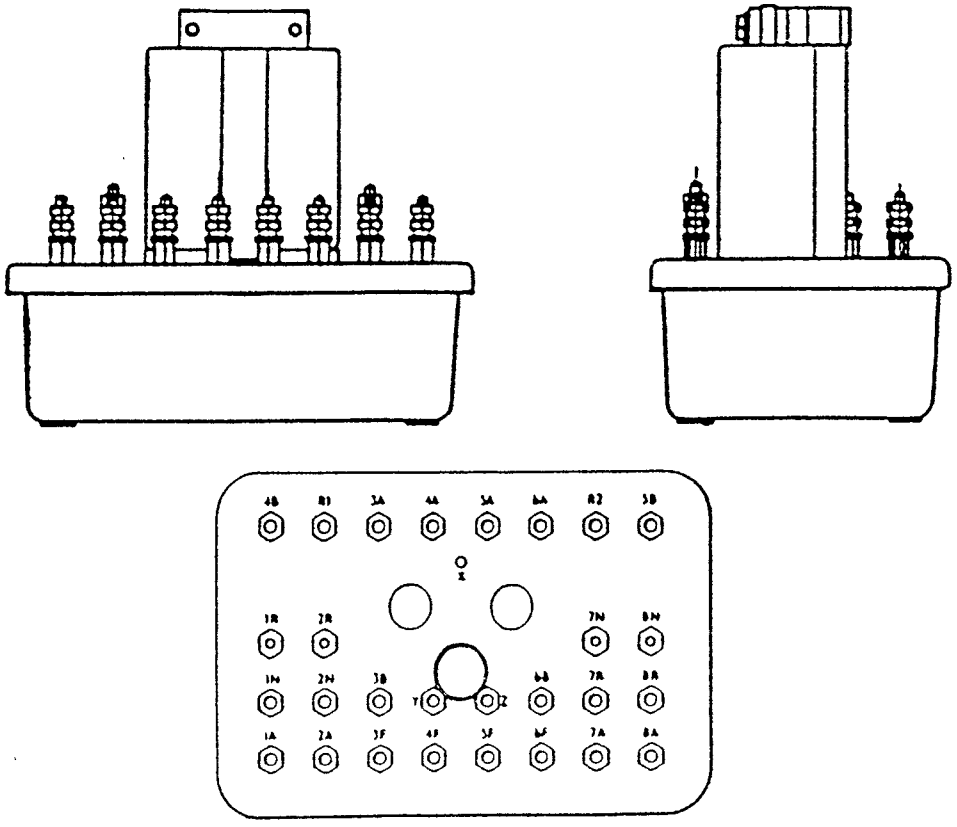
### Coils and Contacts

Standard coils of 250 and 1000 ohm and a 2000 ohm version are available. Connections are R1 and R2.

There are Four front/Back, Four Normal/Reverse and Two Front/Back, Two Normal/Reverse contact arrangements available. The neutral contacts are carbon/silver, the polar contacts are silver.

The relays are used in point machine control and detection circuits & signal repeating circuits.

See Example "C", Figure 2.

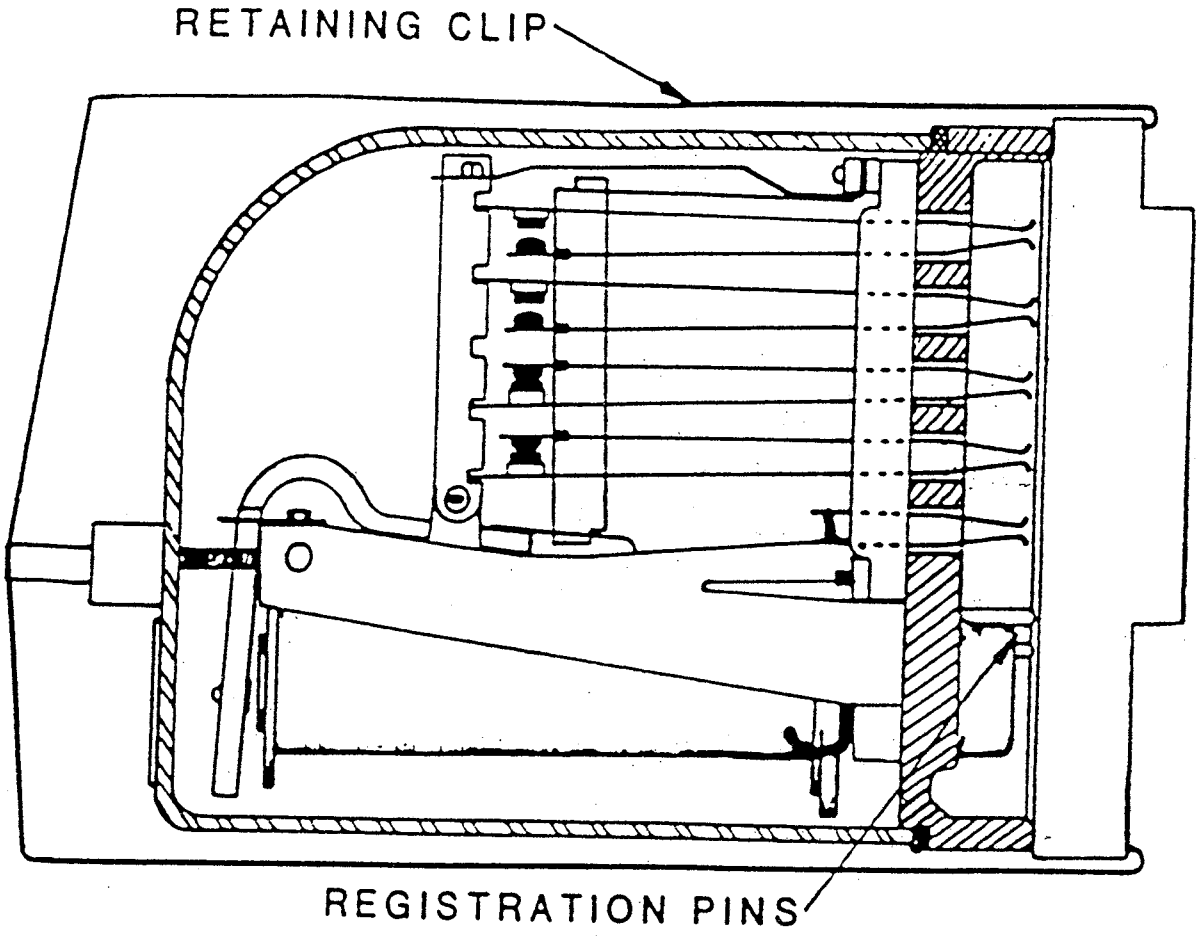


continued

## RELAY SPECIFICATION 930 PLUG IN RELAYS

One of the first relays produced to the I.R.S.E. Spec. was the S.G.E. Type Z miniature relay.

The diagram below shows the relay attached to a plugboard. Also visible is the retaining clip, the purpose of which is to hold the relay in position. To remove the relay the retaining clip is pushed to one side.



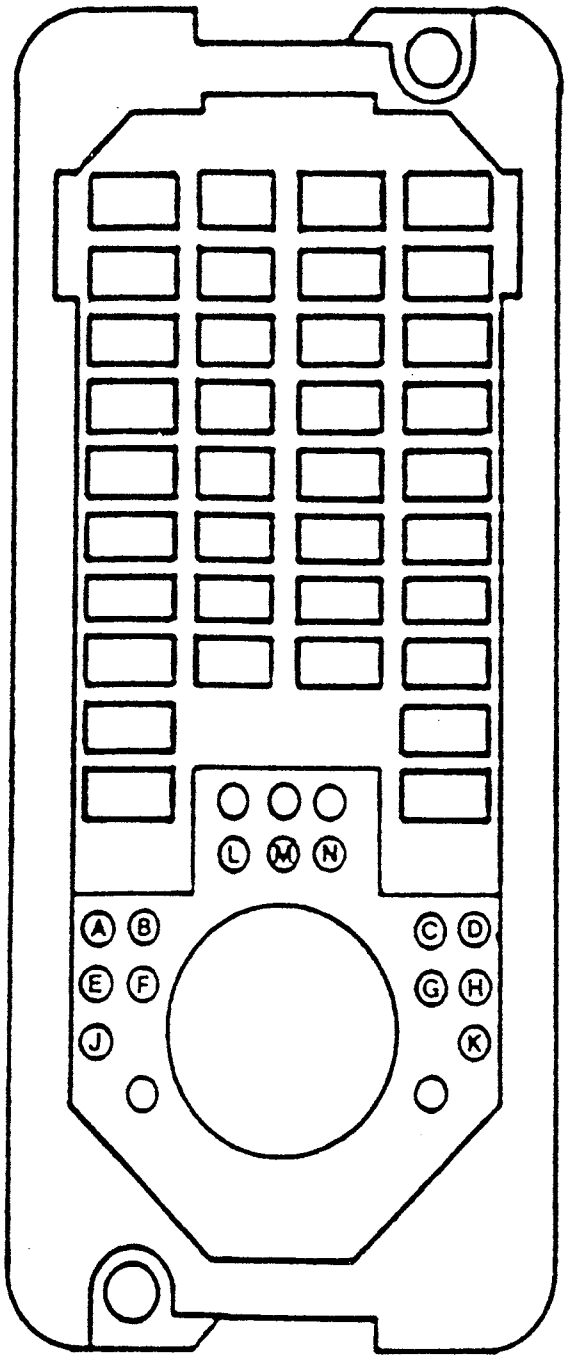

### Pin Codes

Also visible are the registration pins that 'code' the relay type. There are usually five registration pins in the back of a relay and when installed the base should be drilled with five holes to allow the correct relay to be fitted. If more than five holes are drilled by accident, the base is considered unsafe and must be destroyed.

The holes in the base are each allocated an identification letter.

continued

## PLUGBOARD




## PIN CODE CHART

| CODE | A | B | C | D | E | F | G | H | J | K |
|---|---|---|---|---|---|---|---|---|---|---|
| 001 | A | B | C | D | E | | | | | |
| 002 | A | B | C | D | | F | | | | |
| 003 | A | B | C | | E | F | | | | |
| 004 | A | B | | D | E | F | | | | |
| 011 | A | B | | | E | F | G | | | |
| 023 | A | B | | | E | F | | H | | |
| 024 | A | B | | | E | | G | H | | |
| 049 | A | B | | | | F | | H | J | |

The pin code shown is an extract of the chart to be found in the Relay Specification document itself.

It shows which holes are to be drilled in the "plugboard" for a particular code of relay.

continued

Although all relays of this type are termed 930 relays, it is only the D.C. neutral relay that conforms to spec. 930. The other variations all have a different spec. no. in the 930, 940 or 960 series. The list below shows relays in common use on BR today.

| BR SPEC. | FUNCTION | CONTACTS | PIN CODE |
|---|---|---|---|
| 930 (N) | Neutral | 8F 8B<br>12F 4B | 004<br>003 |
| 931 (NA) | A.C. Immune Neutral | 8F 8B<br>12F 4B | 024<br>023 |
| 932 (BA) | A.C. Immune Biased | 8F 8B<br>12F 4B | 028<br>027 |
| 933 (SPA) | A.C. Immune Slow Pick Up | 8F 4B | 043 |
| 934 (SRA) | A.C. Immune Slow Release (250 Ohms) | 8F 4B | 063 |
| 935 (L) | Magnetically Latched | 11F 4B | 011 |
| 936 (PS) | Polarised Magnetic Stick | 8N 8R | 016 |
| 937 (J) | Thermal Time Element (30 - 120 secs) | 2F 1B | 1059 |
| 938 (T) | 4 Ohm Track | 2F | 101 |
| 941 (ECX) | Lamp Proving for A.C. Signal Head | 4F | 071 |
| 942 (UCX) | Lamp Proving for Position light type Jcn. Indicator | 2F 2B | 070 |
| 943 (BCA) | Point Contactor | 2HDF 4B | 172 |
| 949 (CJ) | (7.5 secs) for Points (non-safety) | 1F 3B | 6047 |
| 960 (NN) | Twin Neutral | 6F 2B 6F 2B<br>4F 4B 4F 4B | 212<br>211 |

continued

**RELAYS & THEIR USES**

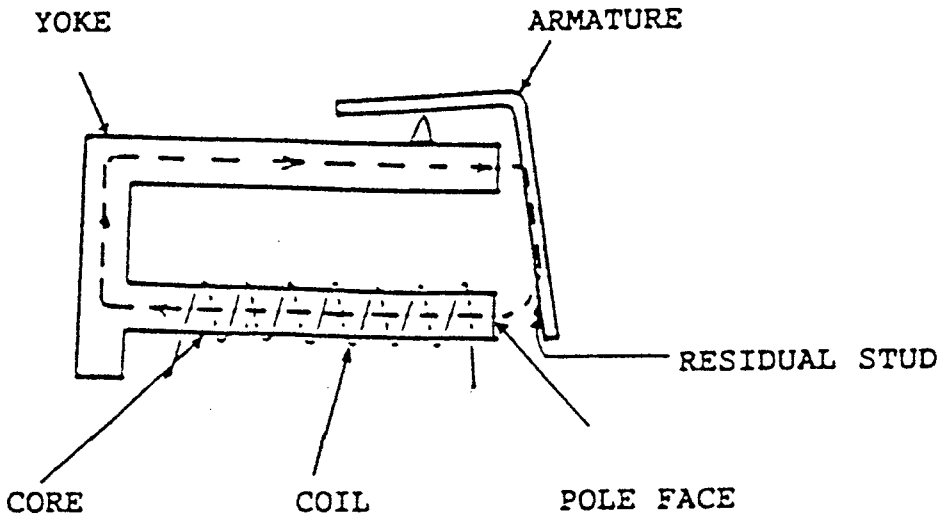
| BR SPEC. | FUNCTION | CONTACTS | PIN CODE |
|---|---|---|---|
| 961 (BBA) | Twin A.C. Immune Biased | 6F 2B 6F 2B<br>4F 4B 4F 4B | 049<br>017 |
| 962 (JN) | Twin Thermal<br>(30 - 120 secs)/Neutral | 2F 1B<br>6F 2B | 1059 |
| 963 (NNS) | Twin<br>Slow to Pick & Drop | 6F 2B 6F 2B<br>4F 4B 4F 4B | 216<br>215 |
| 966 (TA) | 9 Ohm Track | 2F | 110 |

continued

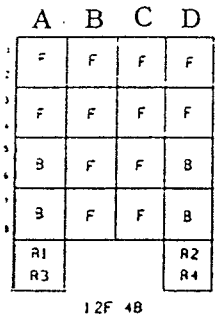
## Neutral Relay (Spec. 930)

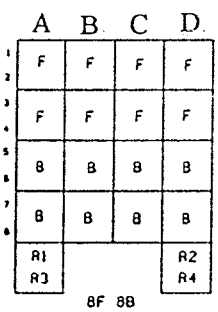
As the name suggests, the relay will operate with the current through its coil in either direction. The relay to the basic specification 930 is not A.C immune.

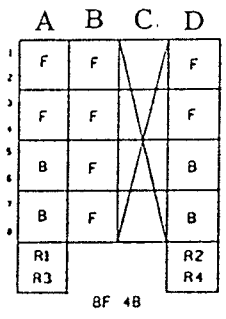
The contact arrangement can consist of up to 16 contacts in a 4 by 4 configuration, split into groups of front and back contacts ie. 12F 4B, 8F 8B.

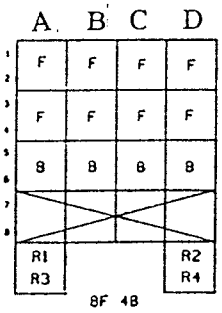


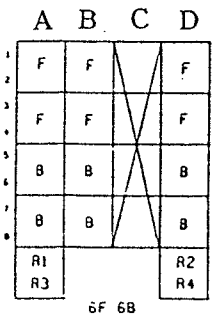

### Alternative Contact Arrangements

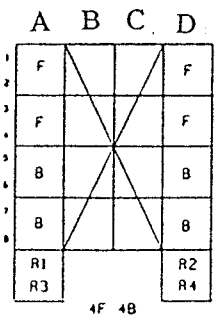


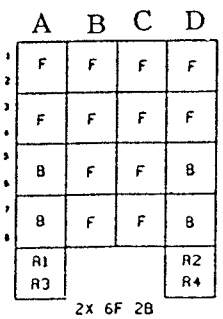




continued

## A.C. Immune D.C. Relay (931)

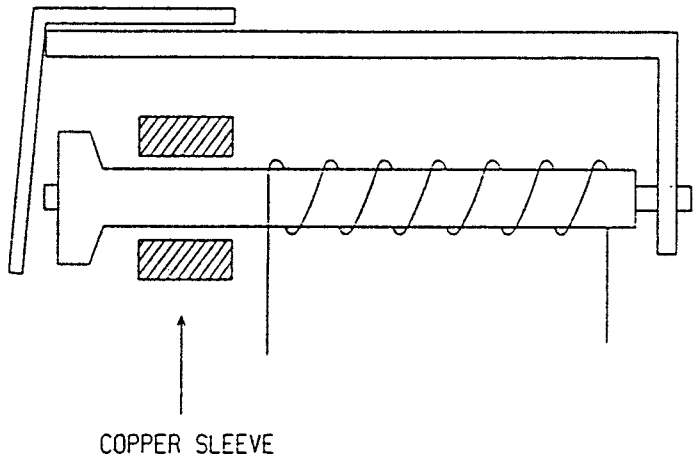
All D.C. relays are A.C. immune to a certain extent, however in A.C. traction areas it is important that any induced A.C. will not effect the operation of the relay, which could possibly cause a wrong side failure.

To achieve A.C. immunity a small copper sleeve is placed between the core and the armature and this delays the response of the relay.

## Slow Release Relay (934)

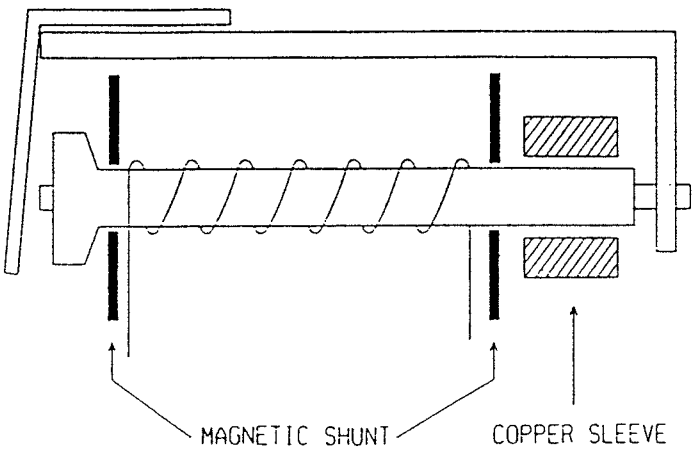
By increasing the size of the sleeve a slow release characteristic may be achieved.

The delay release is between 250 - 300 m secs. However, it must be remembered, the copper sleeve also makes the relay slow to operate.




## Slow Pick-Up Relay (933)

As with the slow release relay, a copper sleeve is used, but this time placed at the heel end of the core. However, if this alone was relied upon, the relay would also be slow to release, so in addition a magnetic shunt is introduced.




continued

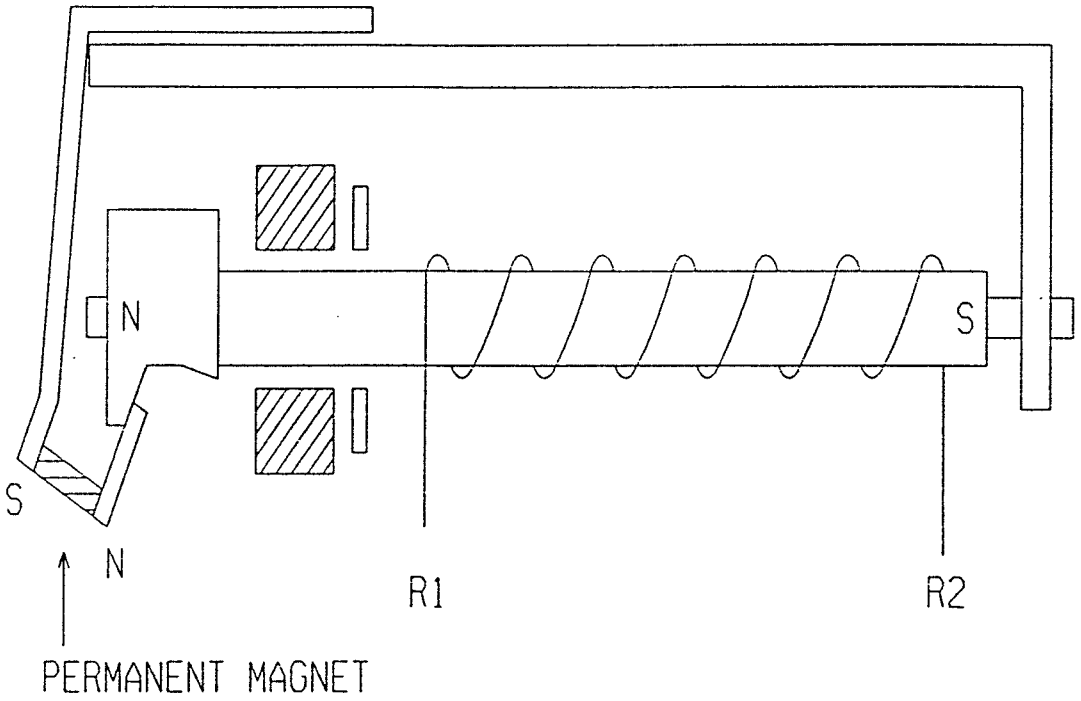
## Biased Relay (932)

This is a relay which will only pick with the current in the correct direction through its coil.

This is usually achieved by connecting a magnet to the end of its armature, such that with normal direction of current through the coil the magnet will be repelled and the armature picked.

If the current is reversed the coil flux is in the same direction as the magnet flux, thus increasing magnetic attraction, and so the armature would remain down.

The relay is also usually required to be A.C. immune.




+ ve R1 - ve R2 relay will energise

- ve R1 + ve R2 relay will **not** energise

## Twin Armature Relay (960, 961 etc.)

This is a single normal 930 spec relay base/case containing two entirely separate relay coils and contact stacks. Operating separate armatures.

Relay 1 R1/R3 (Contact Stack A/B)

Relay 2 R2/R4 (Contact Stack C/D)

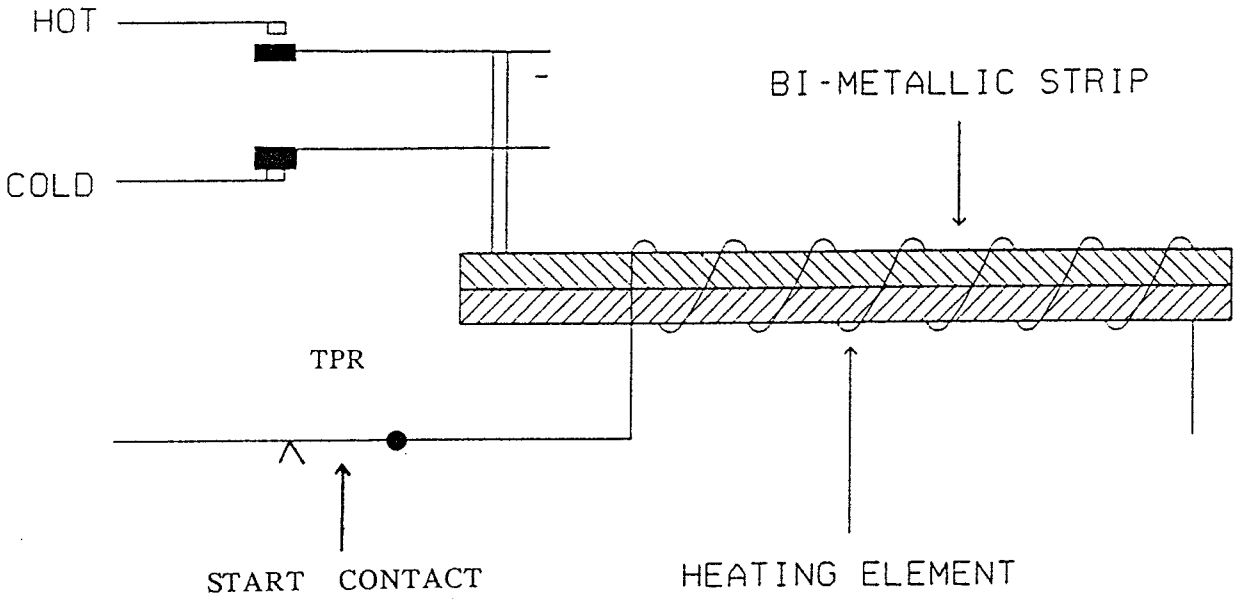
Used where few contacts are required for each relay ie. 2 x 6F 2B.

continued

## Timing Relays (937)

### Thermal Type

This uses a bi-metallic strip which bends with heat, and then cools down each time closing a contact, the timing is complete once the cold contacts have made.




### Synchronous Motor Type

This unit consists of a motor, which rotates a pair of contacts. The motor is normally 110v A.C. fed. The time may be altered by altering the distance the contacts have to move before they complete the circuit.

Use: Timing Circuits 30 - 240 secs. Code 189.
2 - 50 secs. Code 191.

## Time Delay Unit (949)

This is normally used as the points timer (WJR) in point control circuitry. It has a delayed pick-up of nominally 7.5 secs, achieved using a capacitor/resistor network delaying build-up of flux in a P.O. 3000 relay coil.

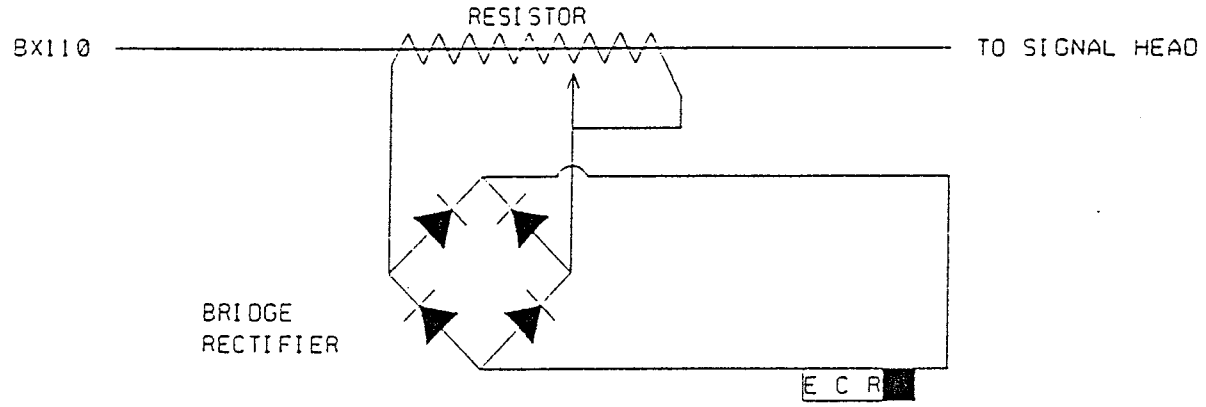
Use: Overload protection for point machine circuits.

continued

## A.C. Lamp Proving Relay (941)

This usually works along-side a resistor/rectifier unit (ECRO/J) from which it received a full-wave rectified current. It is essentially a D.C. neutral relay, fitted with a slug, to prevent contact chatter and the relay dropping away during filament or aspect changeover. It is a current sensitive relay, proving a filament intact in the lamp. As standard lamps are used, once the ECRO/J has been set, it should not need to be adjusted.

The new regional standard is to use a fixed ECRO/J unit, which is combined with the relay, thus only taking up one relay base.

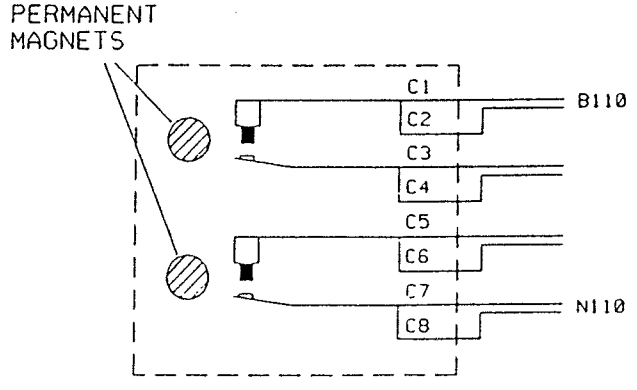


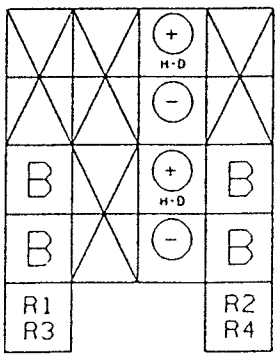

## Point Contactor (943)

Point machines and clamp locks draw heavy current (8 - 10 amps) to begin their movement, hence relay contacts that this current flows through must not be damaged by the current. If normal contacts were used, when the contacts start to open an arc would be formed that would burn the contact elements or weld them together.

To overcome this problem, magnets are place next to the contacts such, that when the arc tries to form, it is blown out by the magnets' field. (Magnetic Blow-out).

The relay is biased, so care must be taken to ensure the polarities to the coil are correct, also the current through the contacts must be in the correct direction for the magnetic blow-out to function.

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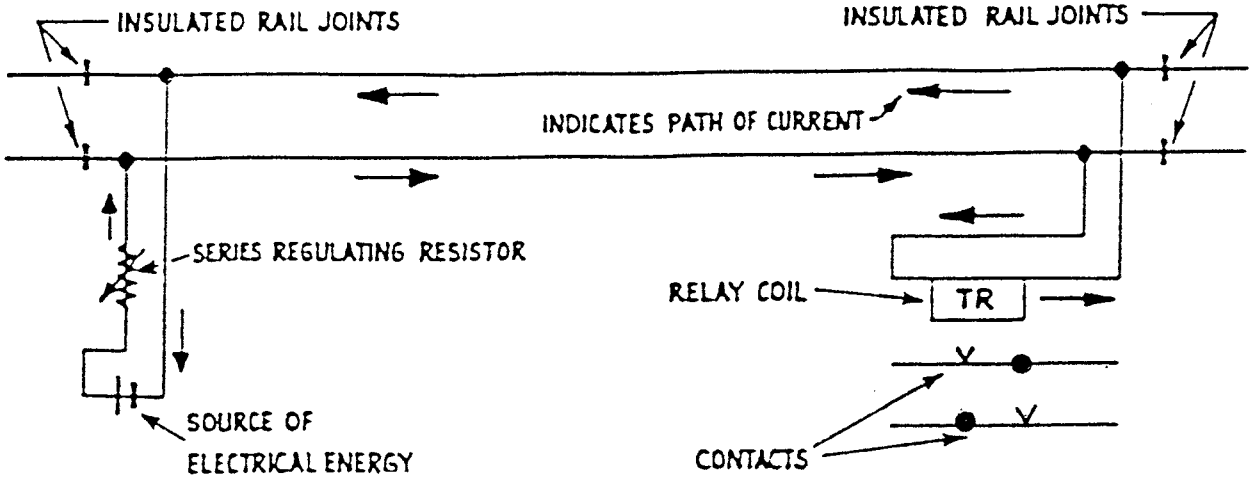
## RELAYS IN SIGNALLING APPLICATIONS

As mentioned in the introduction the relay is at the heart of all today's signalling. This section will briefly cover the application of relays in different functions.

### Track Circuit Relays

The track circuit forms the keystone of all modern signalling. In its basic form it consists of a power supply, a relay and rails with insulated joints. The insulated joints are provided to separate different track circuits.




RELAY ENERGISED INDICATING TRACK CLEAR OF VEHICLES

With the track circuit clear the flow of current is:-

(a) From (+ve) battery, through the feed resistor to the positive rail.

(b) From the positive rail, through the track relay coils, and back to the negative rail.

(c) From the negative rail to the battery negative terminal.

ie. The circuit is a "series" one and complete or "closed".

continued

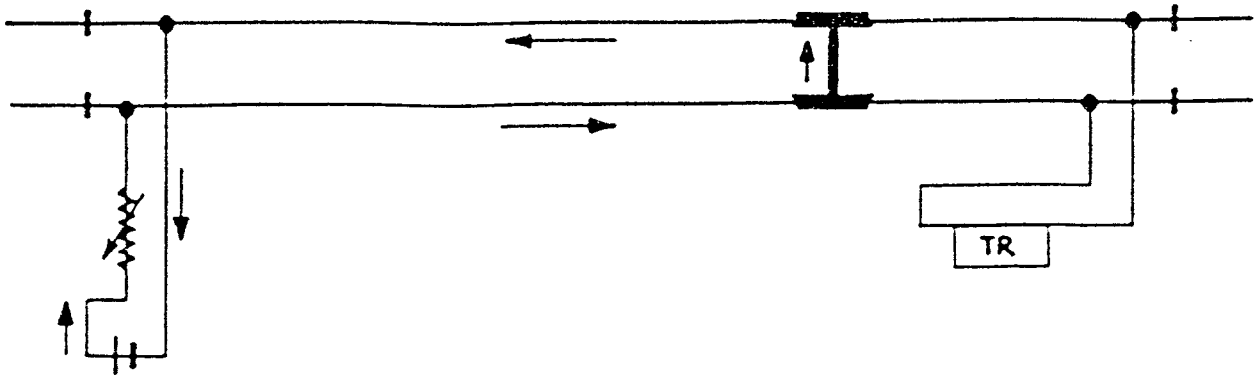
When the track circuit is occupied the current flow is altered as follows:-

(a) From the battery (+ ve), through the feed resistor to the positive rail.

(b) The Train Wheels & Axles make a short circuit between the positive and negative rails. As this offers the LEAST RESISTANCE PATH to the current, the majority of the current will flow through the wheels and axles to the negative rail and back to the battery.

(c) Some current will still flow through the rails to the track relay but it will be very small.

The relay is thus de-energised as the current has been shunted away.



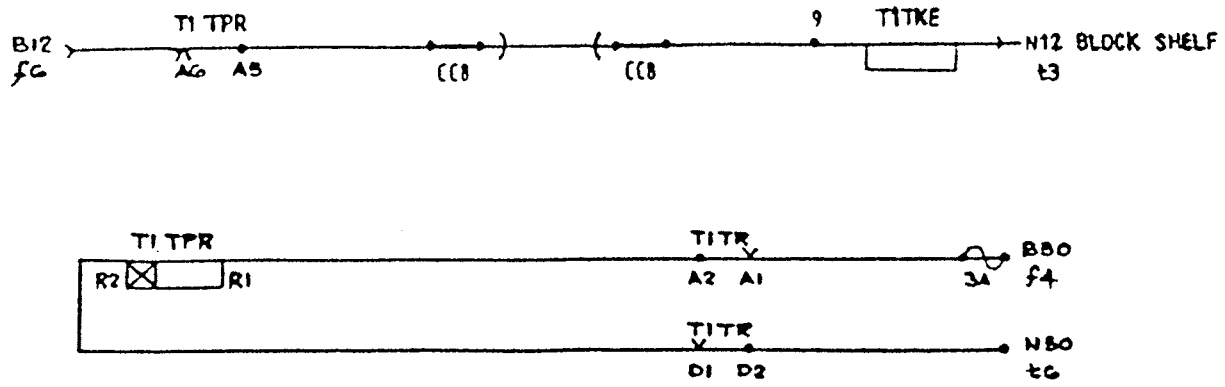

RELAY DE-ENERGISED (FRONT CONTACTS BROKEN) INDICATING PRESENCE OF VEHICLE.

When first introduced in 1872 the track circuit was used just to indicate to the signalman the whereabouts of a train. Now the track circuit is used to control signals, lock points and perform many varied control functions.

continued

## Track Circuit Indications

Small red lamps are used to indicate the state of the track circuit. The power to the lamp is fed over the back contact of the Track Repeating Relay (TPR) which in turn is operated by the Track Relay (TR).

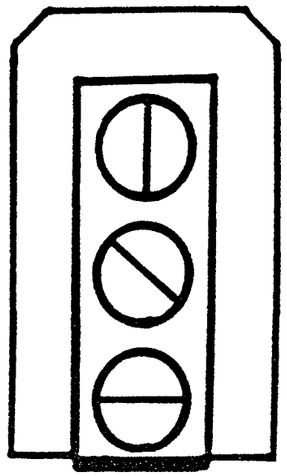



When a train runs onto the track circuit the TR de-energises opening its front contacts. This cuts the feed to the TPR, when the TPR is down its back contacts make and send a feed to the indicator lamps.

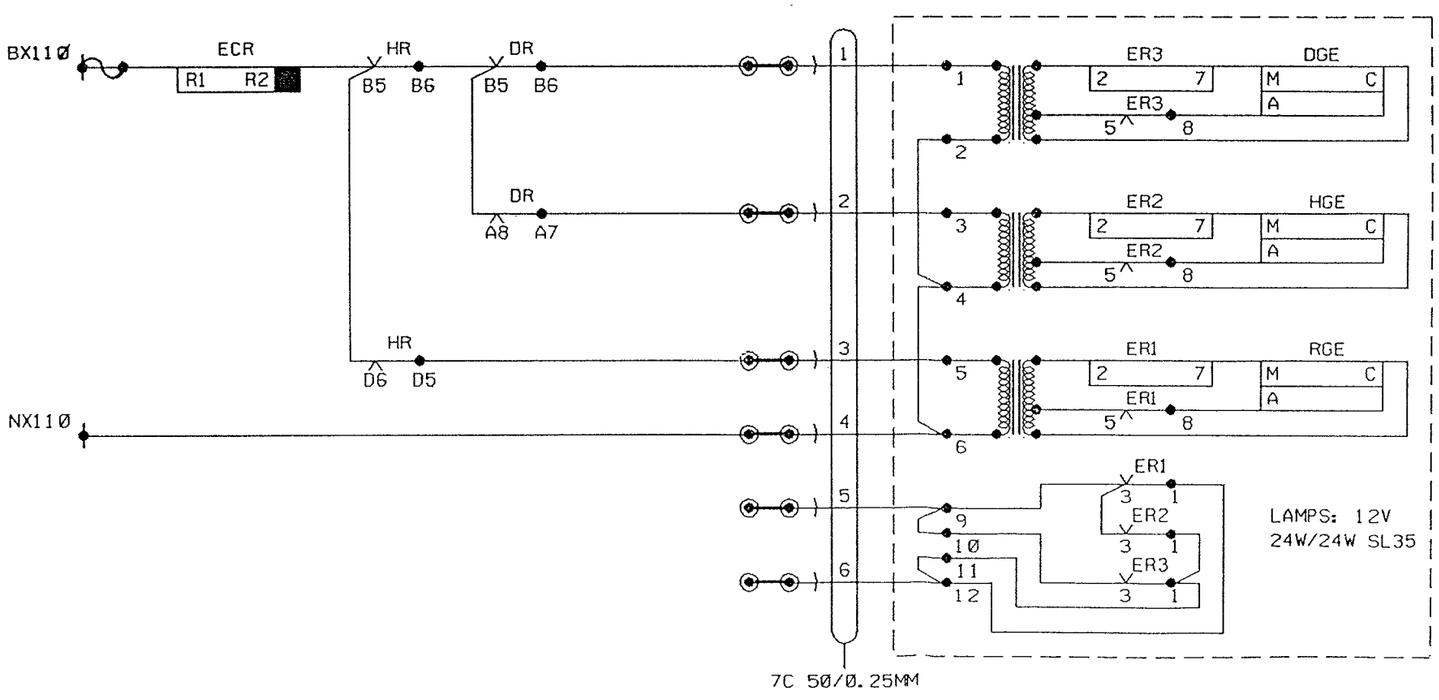
The track repeating relay has to be used with a track relay for two main reasons. Firstly the TR has only two front contacts, secondly the TPR has a delayed pick up time. This is provided to prevent the track indication from showing clear should the track relay momentarily pick, then drop again.

continued

## 3 Aspect Colour Light Signal



There are three relays involved with the operation of a 3 aspect colour light signal. These are the ECR (lamp checking relay) which proves there is a light in the signal. The HR (yellow relay), which when energised will cause the signal to display a yellow aspect and the DR (green relay), which illuminates the green lamp. The relays are connected as follows, also refer to Figure 3.




If the signal is showing red the relays will be in the following states:-

| | |
|---|---|
| ECR | ENERGISED. |
| HR | de-energised. |
| DR | de-energised. |

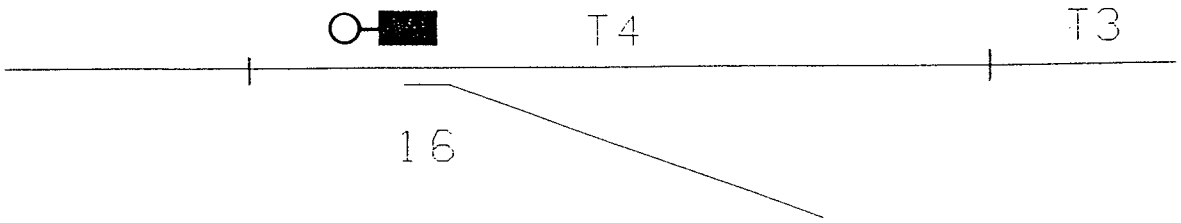
The BX 110 flows, via the ECR through the HR back contact and out to the signal-head transformer for the RED aspect. As all the transformer negative connections are commoned to the NX 110 there is a complete circuit and current flows through the transformer.

When the train occupies T32, T32 TPR drops cutting the feed to 2 HR which replaces the signal to red. Once the train has cleared T32, the TPR picks, and sends a feed to re-energise 2 HR. This displays a yellow aspect in the signal. The green aspect in 2 signal is controlled by the DR which is fed over 4 HR contacts.

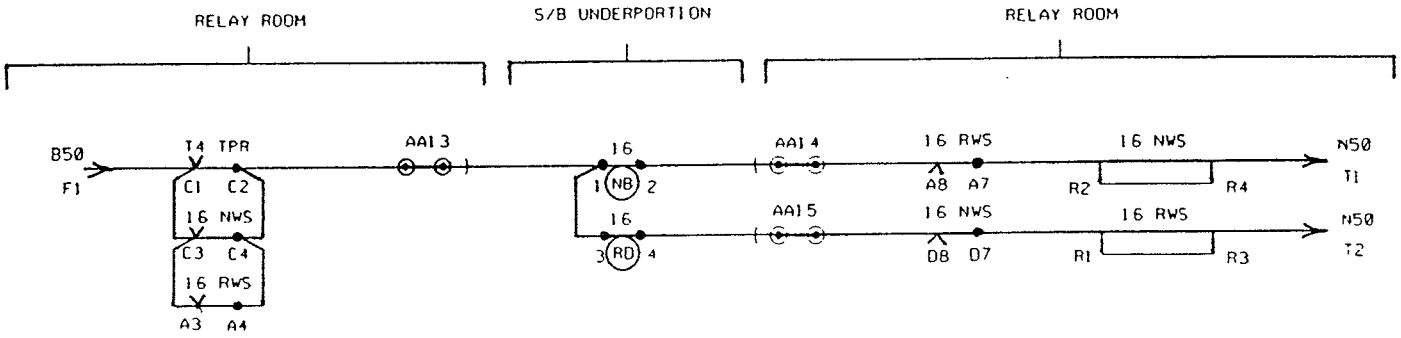
continued

## Point Locking

Track Circuits can also be used to prevent points being moved under a train.




Track Circuit T4 runs through No. 16 points. The control circuit for the points is designed so that with T4 occupied the control relays to throw the points will not operate.




This 'Track Locking' can also be applied to mechanically operated points by fitting electric locks to the point levers. The locks will only allow the point levers to be moved if the track circuit through the points is clear.

continued

## Relay Interlocking

Relays of one sort or another are used in all electrical signalling functions. The plug-in type relay comes into its own when used in relay interlocking.

The term interlocking is used to describe any device, electrical or mechanical which ensures trains can be signalled safely. This means no conflicting routes can be set, signals cannot be cleared until the necessary points have been moved etc.

In the older signal boxes mechanical interlocking is built into the lever frame forming a physical link between levers. This prevents them from being moved if it would cause a dangerous situation. With modern power signal boxes there is no physical connection between the push buttons on the control panel, all the interlocking is connected between the route relays.

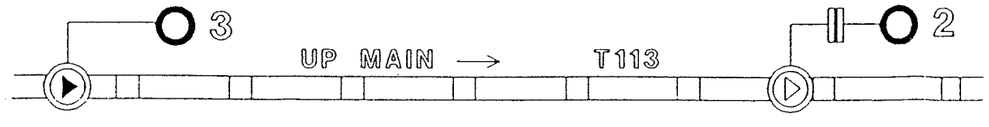
Relay interlocking was first introduced in the 1930's. The only relays available at the time were variations of shelf type relay. Special versions were developed with mechanical interlocking and in order to have the required number of contacts were large in size.

The number of relays required made it desirable to reduce them in size, so the plug-in relay was developed.

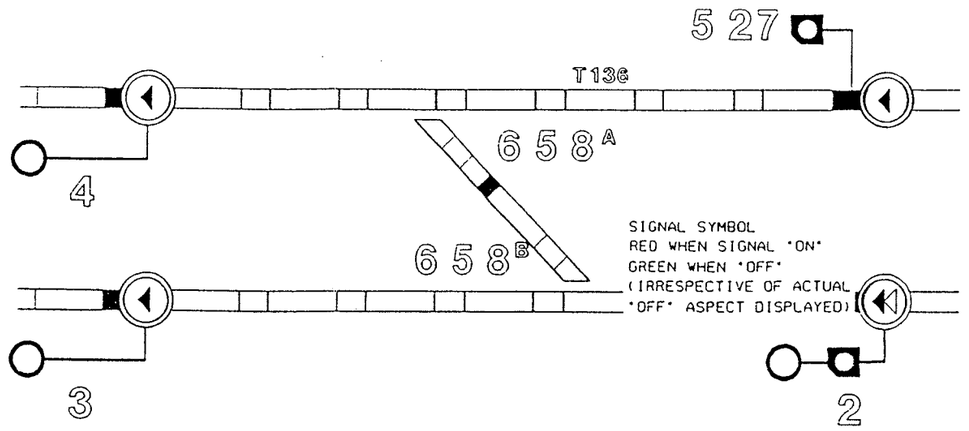
Key relays in a relay interlocking are the route Normal Lock Relay and Reverse Lock Relay.

The diagram below shows part of a control panel.

To signal a train from signal 3 to signal 2, the entrance button on 3 is pressed and released, then the button on 2 is pressed and released. The relays associated with the buttons initiate a sequence of relay operations which culminate with 3 NLR unlatching and 3 RLR energising. These relays are the equivalent of the mechanical signal lever in that with the lever NORMAL the signal is at danger. With the lever REVERSE the signal clears.




The diagram below shows a junction layout.




In this case signal 2 has two sets of route LR's, one for each route. Whichever route is set the route RLR will call 658 points to the required position. This is done through another set of latched relays, the point NLR and RLR.

When the route has been set a series of white lights illuminates between the entrance and exit buttons*. These serve as a reminder to the signalman which route has been set and locked. Once a route is locked, no conflicting routes can be set through or against it.

To replace a signal to danger, the entrance button is pulled. If no train is approaching, the white route lights will also extinguish indicating the route locking is free. If a train is approaching, the signal still returns to red but the route lights remain lit, holding the route for a predetermined period of-time. The reason for this is to prevent a conflicting route from being set until the approaching train has come to a stand.

* Including Overlap where applicable.

continued

## ADDITIONAL SHELF TYPE RELAY INFORMATION

A relay is an electrically operated device for making or breaking circuits, it takes the form of an electro-magnetic circuit consisting of an operating coil or coils which when energised set up a magnetic field causing contacts to be operated.

### Specifications

B.S.S. 1659 (1950) DC neutral track and line relays.

B.S.S. 519 (1950) DC neutral polar line relays.

B.S.S. 1745 (1941) AC track relays double element two position and line relays single element two position.

B.S.S. 561 (1941) AC line relays. Double element three position.

B.S.S. 635 (1935) AC or DC thermal type time element relays.

### DC Relays

(a) Neutral

(b) Polar

(c) Neutral Polar

The flux depends upon the number of turns on the coil and the current flowing through those turns and the pull on the armature is proportional to the square of the flux density in the air gaps.

The drop away on a track relay should not be less than 68% of the pick up value.
(2F/B 9 Ω TR PU, 37ma).

Class A line relay D.A. to PU 60%

Class B line relay D.A. to PU 50%

Class A relay contact gap 0.04 of an inch

Class B relay contact gap 0.10 of an inch

continued

## Neutral relay colouring

A Black coil is metal to carbon contacts. A Red coil is metal to metal one red one black one metal to metal left hand coil and one metal to carbon right hand coil, yellow coil line relay this is used for single line starting signal control.

(a) Blue yoke is a neutral line relay with full wave rectifier.

(b) Red yoke is a neutral line relay class B.

(c) Green yoke is a neutral line relay delayed pick up.

(d) Yellow yoke is a neutral line relay style J lamp proving with resistance.

(e) White yoke is a neutral line relay slow to release.

(f) Black yoke is a neutral line relay class A.

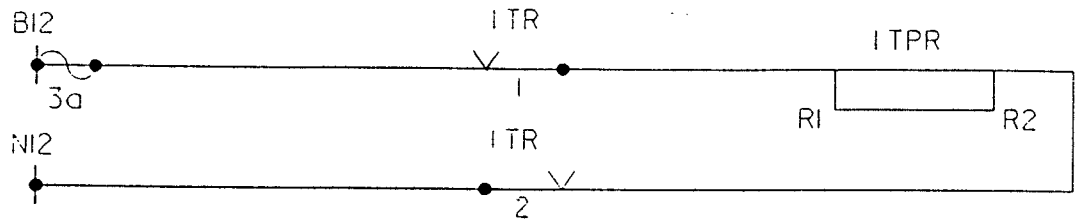
## Polar Relays

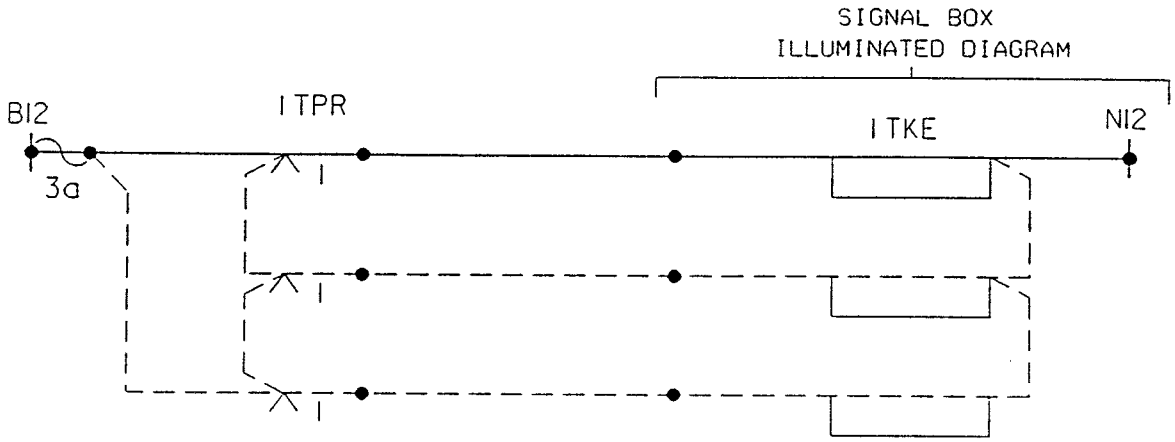
This relay differs from a neutral relay in that the central pivoted soft iron armature fixed between a permanent magnet will detect not only the presence of current but the direction of flow. The permanent magnet performs two functions in that it shifts the poles, which polarises the armature and ensures that the armature returns to the mid position when the coil is de-energised.

## Neutral Polar Relays

As opposed to light current carrying capacity of Polar relays neutral polar relays are capable of using a heavier current and giving a better contact pressure. These relays have three cores the third core being a permanent magnet.

continued



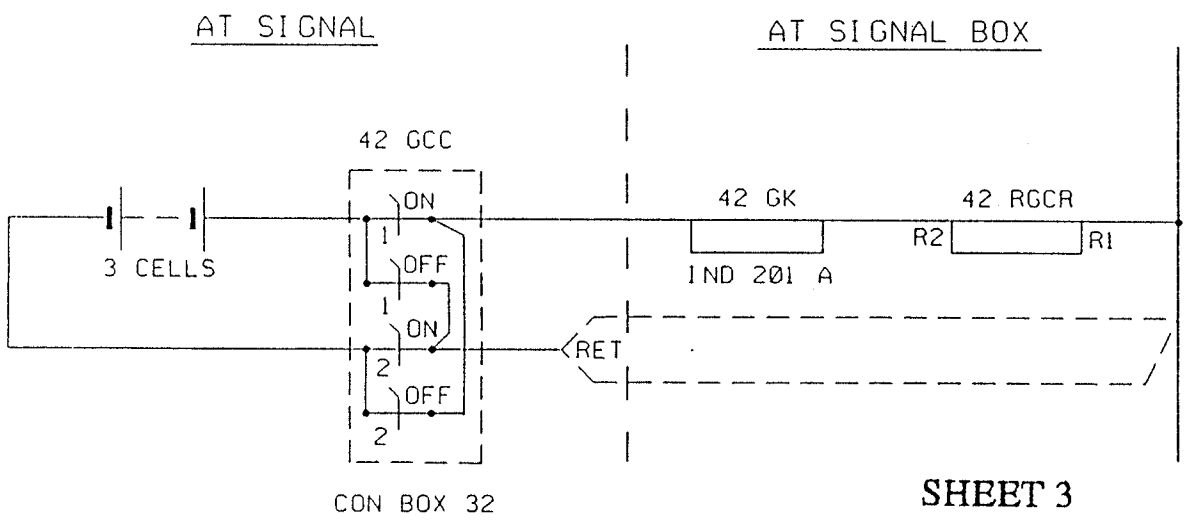

SHEET 10

ANALYSIS

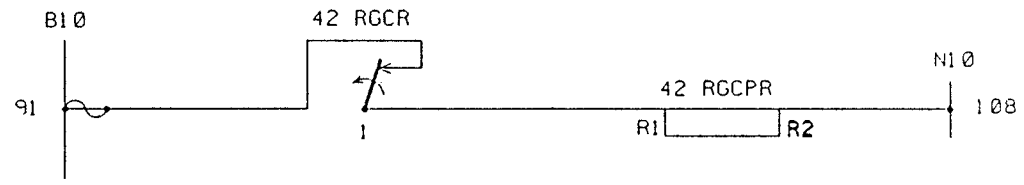
| RELAY | TYPE | RESISTANCE IN OHMS | CONTACTS | CONTROL SHEET NO. | 1 | | 2 | | 3 | | 4 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | F | B | F | B | F | B | F | B |
| 1 TPR | D C NEUTRAL | 1000 | 4F/8 | 10 | | 10 | | | 21 | | 22 | 22 |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**EXAMPLE "A"**

continued




SHEET 3

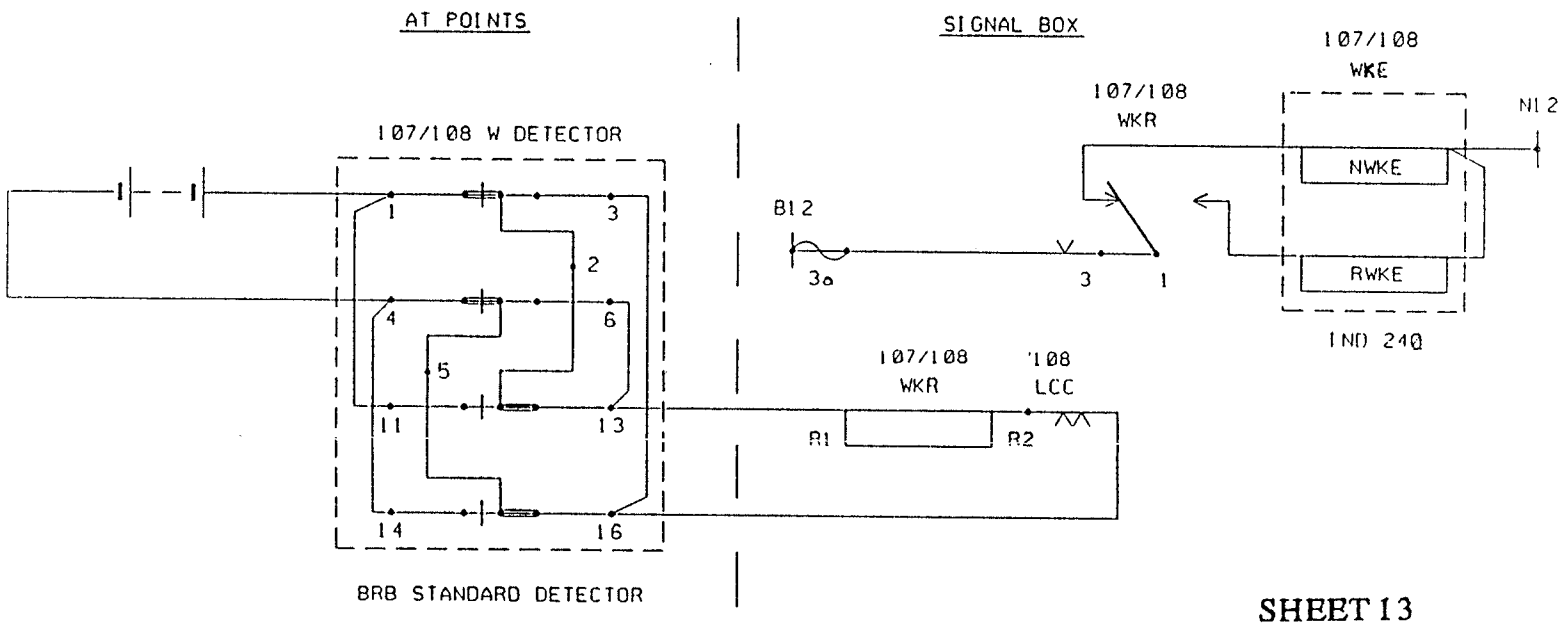



ANALYSIS

SHEET 4

| RELAY | TYPE | RESISTANCE IN OHMS | CONTACTS | CONTROL | 1 | |
|---|---|---|---|---|---|---|
| | | | | | N | R |
| 42 RGCR | DC POLOR-IZED MI | 250 | 1 N/R | 3 | | 4 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

EXAMPLE "B"



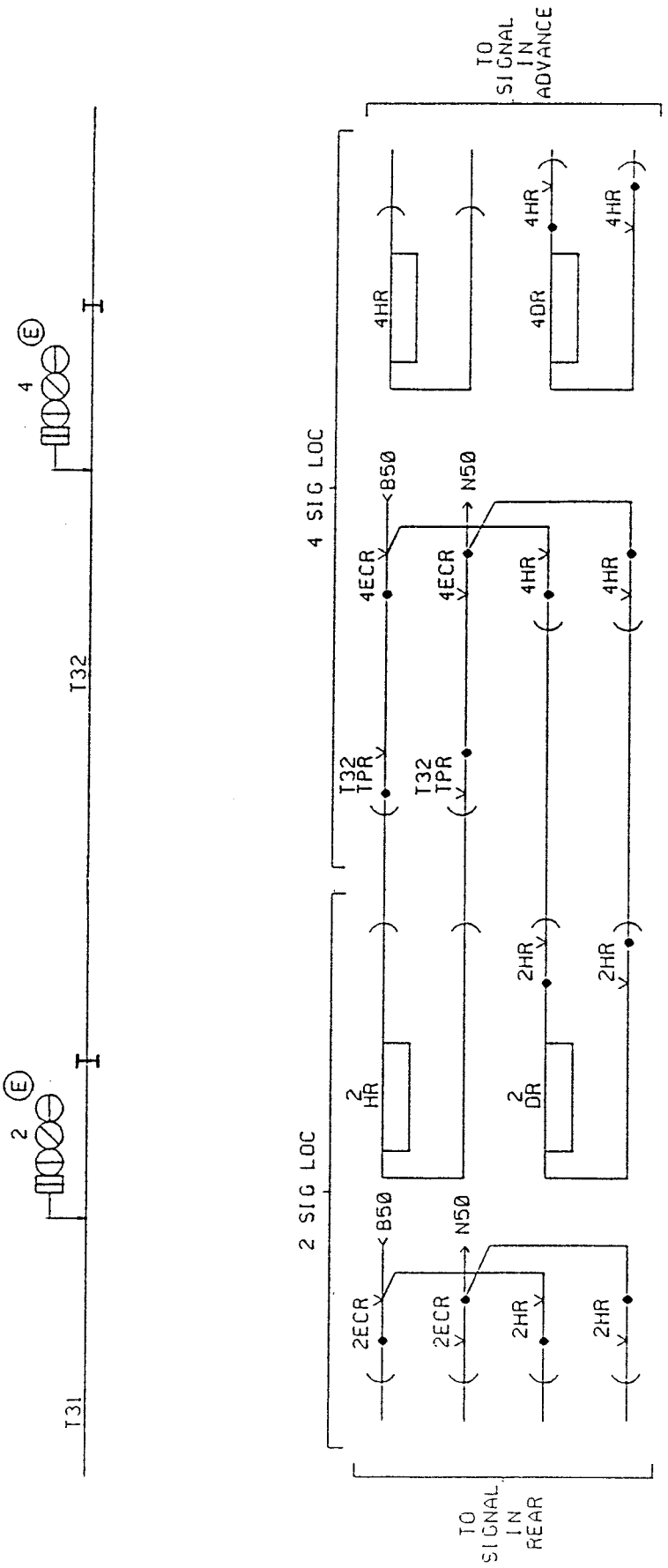

SHEET 13

| RELAY | TYPE | RESISTANCE IN OHMS | CONTACTS | CONTROL SHEET NO. | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | N | R | N | R | F | B | F | B | F | B | F | B | N | R | N | R |
| 107/108 WKR | D.C. NEUTRAL POLAR | 1000 | 4F/B. 4N/R | 13 | 13 | 13 | | | 13 | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | |

continued

EXAMPLE "C"

## RELAYS & THEIR USES




end