656·25 : 621·33

Paper 38

Signalling Equipment (A.E.I.-G.R.S.)

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1 Design Considerations

Track circuits, which carry traction current in one or both rails, must be designed so that they cannot show a false clear with any traction frequency voltage across the rails which is possible under worst fault conditions, and also to operate normally unaffected by voltages likely to occur under normal running.

Line side equipment is subject to induced voltages when unbalance occurs in the circuits controlling them, and the general principle adopted has been to control all apparatus by relays adjacent to the apparatus, the relays being protected against operation on traction frequency.

Reference to Paper 10 will show the voltages against which protection is necessary for the various systems of traction return which have been adopted.

2 Track Circuits

2.1 *General*

D.C. Track Circuits provide the simplest form of track circuit available for use on A.C. electrified lines, and are used where only one rail is required for traction return and no D.C. traction interference is anticipated.

Where it is necessary to operate track circuits subject to both A.C. and D.C. interference, or where conversion is to take place from D.C. to A.C. traction, A.C. track circuits operating on a frequency of $83\frac{1}{3}$ cycles are used. These may be of the single or double rail type.

2.2 *D.C. Single Rail Track Circuits*

The track circuit employs an A.E.I. – G.R.S. Type B1 protected D.C. track relay. A relay of this type is protected against operation on A.C. by fitting copper slugs on the cores between the coils and the armature air gap. Magnetic shunt strips are fitted linking the cores between the coils and copper slugs. Fig.1 is a photograph showing the arrangement. Such a relay is guaranteed against pick-up on A.C. at any voltage below 1,000 volts A.C. In practice, it is found that the relay will not pick-up at any value below that at which a flash-over at the coils would take place.

The relay has been designed to meet the standard 68 per cent drop away to pick up ratio and contact openings and pressures required by B.S. 1659. Operating currents are, however, higher and for a 9 ohm relay the maximum pick-up current is 0·082 amps. The D.C. operating characteristics of the relay are not affected by the presence of up to 20 volts A.C. Above this value, the D.C. required to pick up or hold up the relay increases until with over 35 volts across the relay, the relay will release despite normal D.C. working current flowing. This constitutes a failure to safety, but must be avoided within the range of voltages to be expected. For this reason, a series reactor is used to limit the A.C. voltage appearing at the relay. The relative impedance of the reactor and relay changes as the D.C. through the relay is increased, and the resultant A.C. potential on the relay, is shown in fig.2. When the relay is energised by 0·16 amps D.C., 200 volts A.C. across the track will not produce sufficient A.C. voltage across the relay to affect its operating characteristics.

The feed end arrangement is shown in the diagram of the complete track circuit, fig.3. A transformer supplies a full-wave bridge rectifier, the D.C. output voltage being controlled by tappings on the secondary side of the transformer. A reactor of low D.C. resistance together with a variable resistor are included in the feed to the track circuit. The reactor limits the A.C. current fed back from the track to the output side of the transformer-rectifier. Provided the resultant A.C. voltage appearing across the rectifier is small compared with the normal working voltage of the rectifier unit, the D.C. output of the unit is unaffected.

If the A.C. signalling supply is removed from the A.C. side of the rectifier, the rectifier will appear as a half-wave unit connected in parallel across the track circuit. This will consequently produce a D.C. potential across the relay when A.C. appears across the track. The track circuit would then become dependent for its operation on the traction return current and this is clearly undesirable. On tests on the Styal line, it was shown that with 150 volts A.C. across the rails due to traction current and the signalling supply removed from the A.C. side of the rectifier, a D.C. voltage of 5 volts was measured at the relay. To avoid this possibility, a D.C. relay operated from its own rectifier detects the presence of a minimum A.C. voltage across the A.C. side of the main bridge rectifier and front contacts of this relay are inserted in the main feed from the track feed set to the rails. In the event of the signalling supply to the rectifier failing, the relay will release and disconnect potential traction voltages from the rectifier. When the signalling supply is reconnected, no re-setting of the feed set is necessary, the 'power-off' relay picking up automatically. Track circuits of this type are normally limited in length to 1,500 ft for lines with 6·25 kV and to 1,800 ft for lines with 25 kV traction.

The following are typical operating characteristics:—

Feed set rectifier output	0·33 amps
Feed end track volts	6·3 volts
Relay end track volts	6·2 volts
Train shunt	1·5 ohms

Site trials have shown that with 170 volts A.C. across the rails there was no increase in the D.C. output from the feed set and no change in shunt value. A traction short circuit condition failed to cause the relay to 'bob'.

2.3 *Compatible A.C. Track Circuits*

Where it is necessary to operate track circuits subject to both A.C. and D.C. interference, or where conversion is to take place from D.C. to A.C. traction, track circuits operating on a frequency other than the proposed traction frequency are used. The adoption of $83\frac{1}{3}$ cycle A.C. for this purpose and its generation and distribution are covered in Paper 10.

The track circuits to be described were developed for part of the Liverpool Street – Stratford – Shenfield conversion scheme and it was a primary aim to use existing equipment where possible to both reduce cost and simplify the changeover.

The two supplies were chosen with the control phase leading the local phase by 90°. This facilitates the use of double element line relays without series resistors or resistive windings.

2.3.1 *Double Rail Track Circuits*

The existing double rail track circuits are of the auto-bond type and consideration was given to the retention of this arrangement at the new frequency. However, under 50 cycle conditions, a fault giving an open circuit between one side of the track winding of the bond and the running rail, could result in all the return traction current taking the path through the second half of the bond to the centre connection, and this would not be balanced by similar current in the first half. The resultant voltage drop across the half bond would be magnified by the bond ratio and would result in high 50 cycle voltages possibly of the order of 2 kV appearing on circuits to the track relay in the signal box.

To overcome this difficulty, the existing impedance bonds are retained but converted to the resonated connection with the resonating condensers housed adjacent to the track in separate cases and suitably protected by fuses and surge arrestors. The use of resonated bonds has necessitated new feed transformers with lower voltage secondaries and tapped feed reactors. It also became necessary to house track relays in outside locations where the lead resistance would have been too great for them to continue to be housed in the signal box. The circuit is shown in full in fig.4.

Since the impedance bond is normally balanced to traction current, it is not expected that 50 cycle voltages in excess of 2 volts will occur across the relay track coil and no special precautions to discriminate against the unwanted frequency are taken. Tests conducted on the Stratford section under D.C. traction running and on the Colchester – Clacton under 50 cycle traction running, showed that the track circuit behaved normally and was uninfluenced by the traction currents experienced. Under traction short circuit conditions a slight 'bob' of the vane was noted. The following are the operating figures for a typical track circuit of this type:—

Feed transformer output	8 volts, 4·5 amps
Track volts (feed end)	3·4
Resonating capacitor	1·2 μFd
Relay volts	1·1
Train shunt	0·8 ohms

2.3.2 *Single Rail Track Circuits*

The existing single rail track circuits were of the condenser-fed type and this arrangement has been continued as it has the advantage of preventing D.C. saturation of the feed transformer during continued operation of D.C. traction and providing a wattless method of limiting A.C. traction current.

Although the presence of 50 cycle voltages on the track coil are not liable to operate the relay, the magnitude of the rail to rail voltage involved in the case of single rail track circuits were expected to be of the order of 50 volts in the course of normal operation. This would saturate the relay magnetic circuit and a frequency discriminator is therefore interposed between the track circuit and the relay. This reduces the ratio of 50 cycle to $83\frac{1}{3}$ cycle voltage appearing on the relay and limits the total voltage on the relay to an acceptable level of

8 volts output for a 50 cycle input of 50 volts. The discriminator consists of a series type filter with transformer input and output and is entirely safe in the event of component failure. Input voltages much in excess of 50 volts lead to the saturation of the input transformer and consequent limitation of output.

Fig.5 shows the arrangement of this track circuit.

The filter unit has a higher input impedance than the normal track relay, and tests have been made with a parallel resistor of 10 ohms across the relay end of the track to stabilise the track circuit should wide ballast resistance changes take place. In practice, however, the resistor has not been found necessary.

The following are typical operating characteristics:—

Feed transformer output	110 volts, 1·3 amps
Feed capacitor	20 μFds
Track volts	9·0
Relay volts	4·6
Train shunt	4·0 ohms

2.4 *Track Circuit Equipment Supplied or on Order*

Region	*Track Circuit Sets* *D.C. Protected*	*A.C. Single Rail*	*A.C. Double Rail*
Eastern (Liverpool St – Shenfield)	—	273	175
Eastern (Potters Bar)	49	—	—
Eastern (Copper Mill Jct. Temple Mills West)	77	—	—
Eastern (Ripple Lane and Barking – Upminster)	40	285	—
Scottish (Glasgow Suburban)	578	—	—
London Midland (Colwich – Rugby)	640	—	—

3 Line Side Equipment

3.1 *Control and Repeater Circuits*

In order to limit possible induced voltages to values considered safe as discussed in Paper 10, line side circuits are limited in their length of exposure using repeater relays when necessary. All outside apparatus liable to receive unsafe induced voltages is locally fed and its circuit double cut over contacts of protected line relays.

All line circuits are themselves double cut and line fuses have been used in each leg of such circuits to protect against circulating currents.

3.2 *Line Relays*

Line relays used are either of the D.C. neutral type working on 24 volts D.C., or in the case of repeater circuits, they may be of the biassed neutral type. Alternatively $83\frac{1}{3}$ cycle double element 2 or 3 position relays may be used.

D.C. neutral line relays are fitted with copper slugs on the core between the coil and armature air gap and a relay of this type will not pick up when any A.C. voltage up to at least 1,000 volts is applied to it. Biassed-neutral relays are inherently safe from operation on A.C., the only effect of excessive A.C. being to de-magnetise the magnet and prevent the relay picking up on either D.C. or A.C.

A table of characteristics of the relays used is given below:—

D.C. Relays

	Type B1 Line (Protected Neutral)	*Type B1 Line* (Biassed-Neutral)
A.C. volts to pick up	In excess of 1,000	In excess of 1,000 (all rows)
A.C. volts to drop relay when relay energised on D.C. just to pick up ...	170	
A.C. volts to drop relay when energised on D.C. to working volts ...	250	
A.C. volts which will prevent relay picking up on 24 volts D.C.	150	

3.3 *Multi-Unit Colour Light Signals*

It is necessary to restrict the possible induced voltage appearing on the lamps of unwanted aspects of multi-unit colour light signals, and for this reason, the local leads to the signal are kept to the minimum possible length by placing the control relays in locations situated about 12 feet longitudinally from the signal. Where, however, signals are fed from the box, longer local leads are permitted, provided that not more than 20 volts will appear on the 110 volts side of the lamp feed transformer under maximum traction current conditions.

3.4 *Point Machines*

The control relays which are of the protected line type already described, and contactor for the point machines are placed as near as possible to the points concerned to reduce possible induced voltages. The point machines are of the D.C. split field type.

On certain contracts, a D.C. track lock has been added to the machine and this lock is protected by a reactor in series with the operating coil. The lock thus protected was immune to 2 kV A.C.

SUMMARY

Track circuits are normally of the D.C. single rail type with a transformer-rectifier feed set and protecting series reactor. A relay disconnects the feed set from the rails in the event of a signalling power supply failure. The track relay is proof against operation from any A.C. potential less than 1,000 volts.

Conventional A.C. vane type track relays are used where track circuits are to be compatible with both A.C. and D.C. traction systems or where double rail track circuits are necessary. Two independent supplies at $83\frac{1}{3}$ cycles are used, the phase of the supply for the control leading that for the local by 90°. Double rail A.C. track circuits employ resonated impedance bonds with a reactor feed. Single rail track circuits are condenser fed and a filter is used at the relay end to reduce the 50 cycle voltage on the relay control coil.

Line side apparatus is normally fed from an adjacent power supply and is controlled by a line relay of the D.C. neutral or biassed-neutral type. These relays are protected against operation on 1,000 volts A.C. Point Machines are of the D.C. split-field type.

RÉSUMÉ

Les circuits de voie sont normalement à courant continu, isolés sur une file de rails et alimentés par un groupe transformateur-redresseur avec inductances de protection disposées en série. Un relais isole le groupe d'alimentation des files de rails au cas où le courant de signalisation fait défaut. Le relais de voie résiste et ne fonctionne pas intempestivement à toute tension alternative inférieure à 1000 V.

On emploie des relais de voie à ailettes classiques pour courant alternatif là où les circuits de voie doivent fonctionner sous les deux systèmes de traction en courant alternatif et en courant continu ou dans le cas des circuits de voie isolés sur les deux files de rails. On se sert de deux alimentations indépendantes à 83,3 Hz, la phase de la source d'alimentation pour la commande centrale est en avance de 90° par rapport à celle de la source locale. Les circuits de voie avec isolement des deux files de rails emploient des connections inductives résonantes avec une inductance de protection dans le circuit d'alimentation. Les circuits de voie isolés sur une file de rails sont alimentés d'un condensateur et un filtre est employé à l'extremité où se trouve le relais de voie pour réduire la tension de 50 Hz dans la bobine de commande du relais.

Des appareils de voie sont normalement alimentés d'une autre source disponible et sont controlés au moyen d'un relais à courant continu. Une protection adoptée pour ces relais assure qu'ils ne s'excitent pas sous toute tension alternative inférieure à 1000 V. Les moteurs actionnant les aiguilles sont à deux inducteurs.

ZUSAMMENFASSUNG

Die Gleichstrom-Gleisstromkreise sind normalerweise einschienig ausgeführt und werden von einer Transformatoren-Gleichrichter Gruppe gespeist, ferner sind sie mit einer Schutz-Vorschaltdrosselspule versehen. Bei Ausfall der Signalleistung unterbricht ein Relais die Verbindung zwischen Transformatoren-Gleichrichter Gruppe und Schienen. Das Gleisrelais ist gegen Betätigung durch eine Wechselspannung bis zu 1000 Volt geschützt.

In Gleisstromkreisen, die beim Wechselstrom- und Gleichstromzugförderungssystem Anwendung finden, oder wo zweischienige Gleisstromkreise notwendig sind, werden die konventionellen Wechselstrom-Gleisrelais vom Fahnentyp verwendet. Es werden zwei voneinander unabhängige Speisungen mit $83\frac{1}{3}$ Hz verwendet, wobei die Phase des Ueberwachungskreises der Phase der örtlichen Versorgung 90° voreilt. In zweischienigen Wechselstrom-Gleisstromkreisen werden Resonanz-Impedanzverbindungen mit Speisung über Drosselspule verwendet. Einschienige Gleisstromkreise werden über Kondensatoren gespeist, wobei die Relais-Seite mit einem Filter ausgerüstet ist um die 50 Hz Spannung an der Relais-Ueberwachungsspule herabzusetzen.

Der Apparat auf der Schienen-Seite wird normalerweise von einem nahe gelegenen Netzanschluss gespeist und durch ein Gleichstrom-Netzrelais, und zwar entweder durch ein neutrales Relais oder durch ein neutrales vorgespanntes Relais, überwacht. Diese Relais sind gegen Betätigung durch eine Wechselspannung bis zu 1000 Volt geschützt. Die Weichenantriebsätze sind mit Gleichstrom-Doppelfeldmotoren versehen.

SOMARIO

Los circuitos de la vía están normalmente de tipo corriente continua, compuestos de carriles conductores sencillos y alimentados por un grupo transformador con rectificador y bobina de reactancia protectadora, acoplada en serie. Por medio de un relé, se desconecta de los carriles el grupo de alimentación, caso que se haga falta de corriente para el sistema de maniobra. Este relé de vía es a prueba de todo funcionamiento por corriente alterna de potencial menos de 1 000 voltios.

Se emplean los relés de vía clásicos, tipo aletas, de corriente alterna, en lugares donde los circuitos de vía deben estar compatibles con ambos sistemas de tracción, a saber, el sistema de c.a. y el de c.c., en el caso de que se hallan necessarios los circuitos de vía de dos carriles. Dos suministros de corriente independientes de $83\frac{1}{3}$ Hz se utilizan, en el sentido de que la corriente para el mando central muestra un avance de fase de 90° antes la de la regulación local. Los circuitos de vía de c.a. de dos carriles emplean enlaces de impedancia de resonancia, de que la alimentación está por vía de bobina de reactancia. Los circuitos de vía de un solo carril emplean un condensador por la alimentación y un filtro al extremo donde se halla el relé, para reducir el voltaje de la corriente de 50 Hz en la bobina de regulación del relé.

Los aparatos ubicados al lado del ferrocarril se alimentan normalmente por medio de un suministro vecino de energía, y para su mando se halla un relé de línea, tipo c.c., neutro o de protección diferencial. Estos relés incluyen un sistema de protección contra la posibilidad de un funcionamiento por corriente alterna de 1 000 voltios. Los mecanismos de mando de aguja están accionados por motores eléctricos, tipo c.c., con bobina dividida para realizar la inversión del campo.

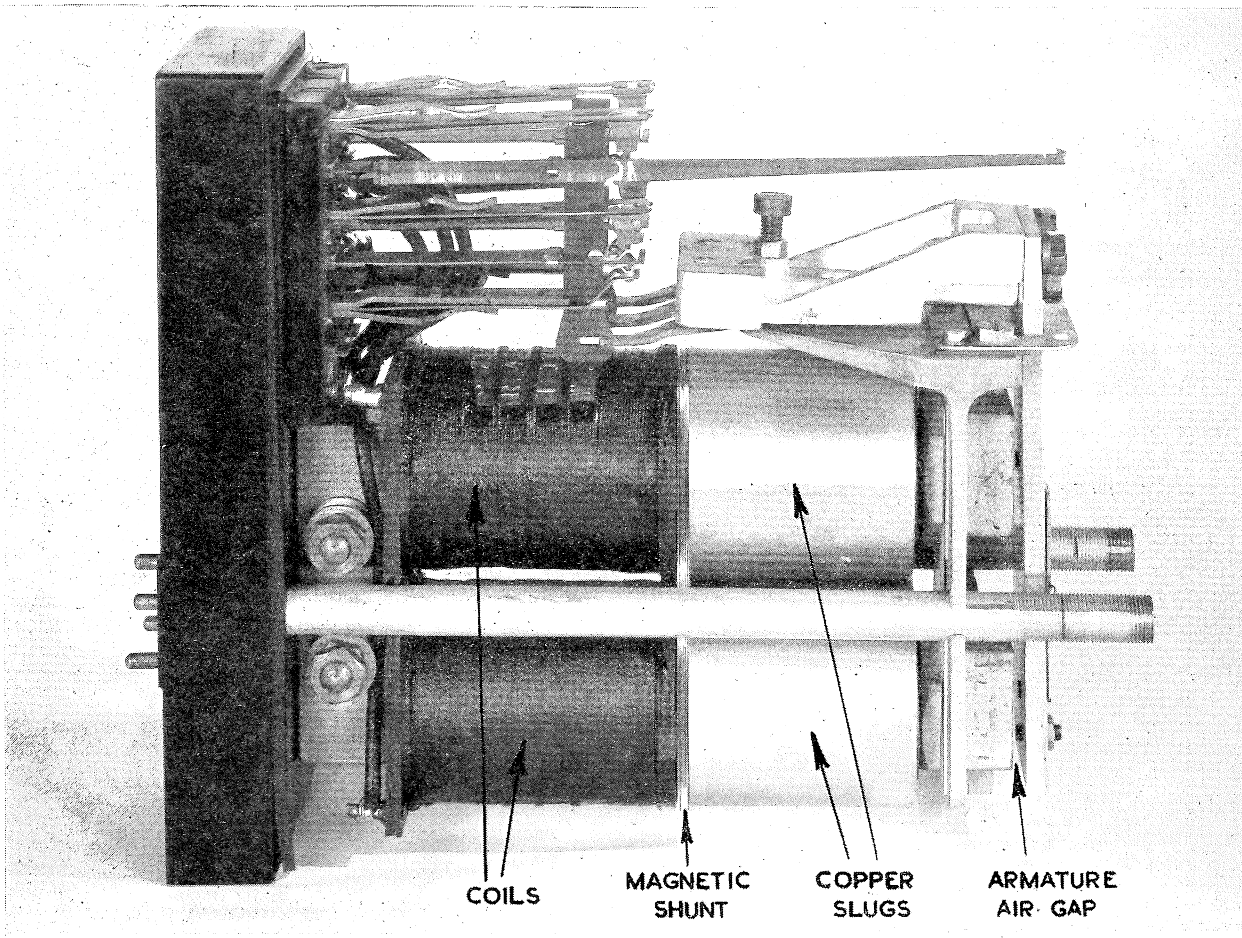

Fig.1 Protected D.C. Track Relay Type B1

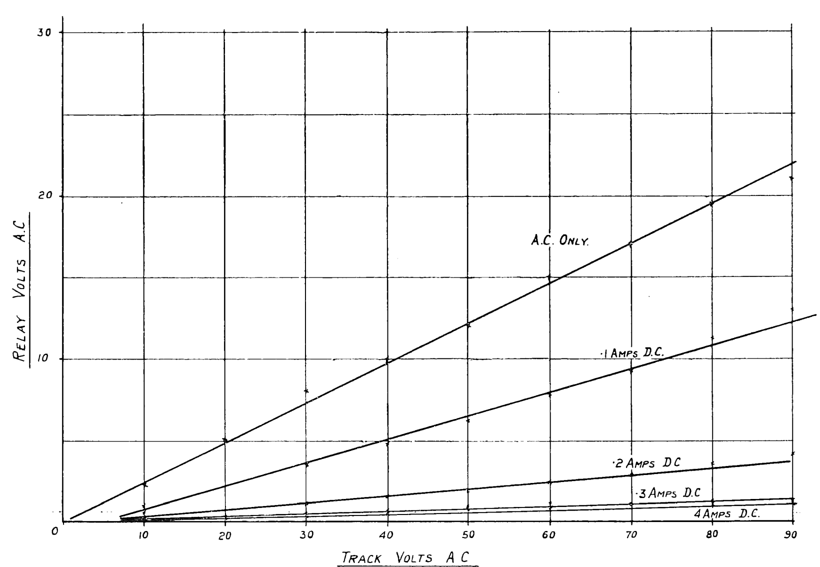

Fig.2 A.C. Volts Across Relay

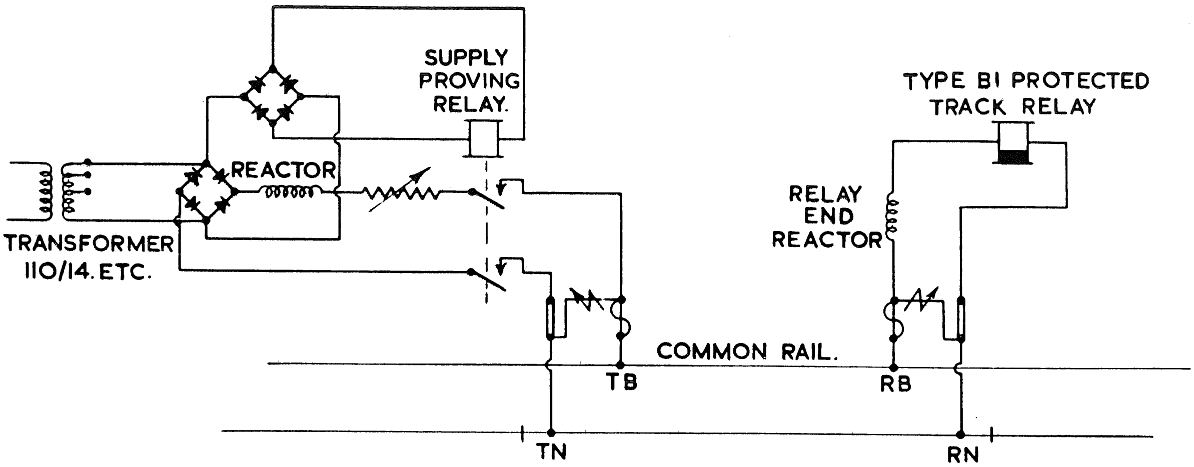

Fig.3 Single Rail Track Circuit for A.C. electrified areas with AEI-GRS Ltd Type P2 Feed Set

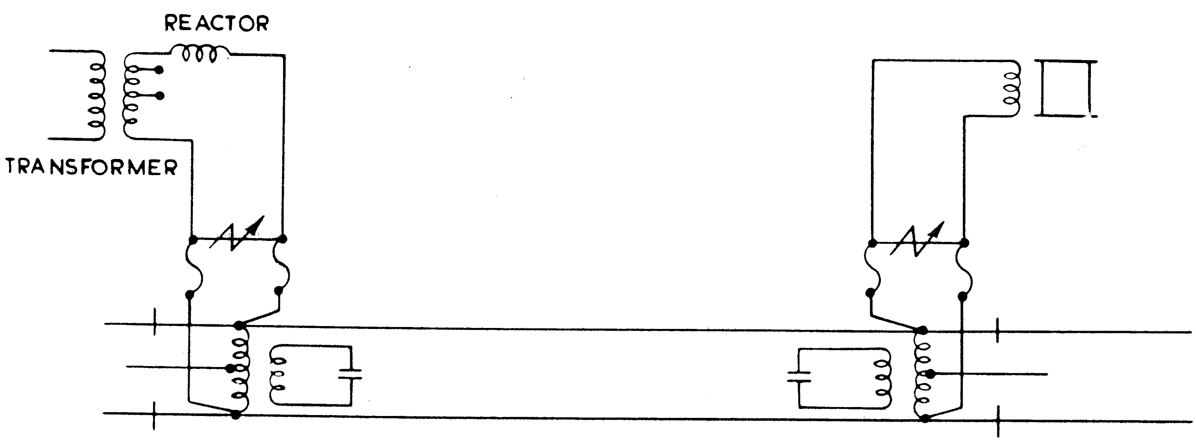

Fig.4 Double Rail 83·3 cycle Track Circuit

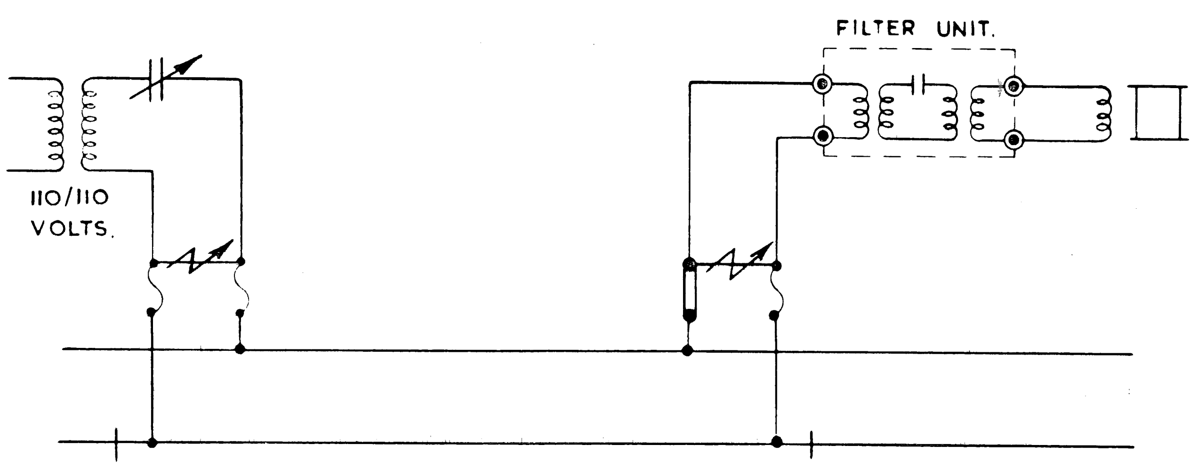

Fig.5 Single Rail 83·3 cycle Track Circuit

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