656·25 : 621·33

Paper 40

Signalling Equipment (Westinghouse Brake & Signal Co. Ltd)

D. G. Shipp, BSc, MIEE
Assistant Divisional Manager, Signal and Colliery Division, Westinghouse Brake and Signal Co. Ltd

1. Design Requirements

The problems relating to signalling equipment in 50 cycles traction territory are stated in Paper 10.

To meet these problems, the equipment designs must first ensure there is no significant change in the desired performance for all values of traction interference met during normal traffic running. In addition, the equipment must be protected against damage from abnormal interference such as may result from a traction system fault, when any consequent change in the equipment performance must be in the direction of safety.

The designs shall have acceptable security against defects in any protective devices that may be incorporated to meet these fundamental requirements.

Both D.C. and A.C. equipments have been designed to provide the required discrimination between the wanted signalling supply and the unwanted traction interference voltages.

2. Track Circuits

2.1 *D.C. Single Rail Track Circuits*

A 9 ohm D.C. track relay is used and fig.1 shows how it is made immune to A.C. traction voltages.

The relay characteristics are:—

(*a*) Maximum pick up, 0·61V D.C.
(*b*) Minimum percentage release, 68 per cent.
(*c*) Minimum working energisation, 0·85V D.C.
(*d*) So long as a minimum working energisation of 0·85V D.C. is maintained, there is no significant change in the equipment performance for normal values of traction interference up to 100V. Above this value the relay will safely release due to magnetic saturation.
(*e*) This security is fully maintained against abnormal interference of any value, until ultimately the relay is protected against damage by the circuit fuse if the interference is sustained above 400V.

Primary battery track circuits have been installed using this relay, with equivalent protection provided to the feed circuit by a series choke of 120 ohms impedance to 50 cycles and 0·9 ohm resistance.

When a rectifier is used in place of a battery, however, protection must be provided against the traction interference voltage being rectified to an extent which may augment the normal D.C. feed to a dangerous value.

Fig.2 shows a rectifier fed track circuit providing an output of 5V D.C. from the signalling supply, and in which protection is afforded by a simple filter to exclude the interference voltage, the filter comprising a resistor of special construction connected across the rectifier output and separate chokes in each lead to the track.

For all values of traction interference, including the abnormal value of 400V during a traction system fault, the equipment will neither be damaged nor will the desired performance of the track circuit be changed significantly even though one of the two protective chokes becomes defective but reliance has to be placed, however, on the proper working of the remaining choke.

The alternative arrangement of fig.3 provides complete protection without reliance on the integrity of either the shunt resistor or the series chokes, and so a resistor of simple form and only one choke may be safely used. Protection is now afforded by a normally energised relay that compares the output of the feed rectifier against a fixed reference voltage, and which becomes released to disconnect the feed set from the rails if the rectifier output exceeds a value that could impair the safety of the track circuit operation. Normally, this tripping point corresponds to an abnormal interference of 400V, but full protection is still afforded, although at a lower interference voltage, if defects of any kind occur in the filter elements.

A power-off relay proves the integrity of the reference voltage, and also provides the facility for resetting the circuit by the simple expedient of switching the supply momentarily off and on.

Equipment of the type just described is illustrated in fig.4.

D.C. track circuits up to 500 yards in length have been installed, and provide economical units for use where there is no extraneous D.C. interference.

2.2 *75 cycles Double Rail Track Circuit*

The track is fed from a static frequency converter using magnetic circuit techniques taking energy from the 50 cycles signalling supply and providing a 25 VA output at 8 or 12V, 75 cycles. The output is regulated by a feed resistor.

Fig.5 shows the circuit arrangement employing A.C. impedance bonds of the type illustrated in fig.6 and having the following characteristics:—

(*a*) Rail to rail impedance at 75 cycles, 4·5 ohms minimum.
(*b*) Traction current rating, 200 amps/rail continuous.
(*c*) Weight with oil, 128 lb. (58 Kg.).
(*d*) Saturation level, 15V at 50 cycles.

A standard (non-immunised) D.C. track relay is used with a 2-stage frequency discriminating filter tuned to 75 cycles. The filter condensers are of special construction so that their capacity cannot change to a dangerous value. Security against this and other defects within the filter is ensured by the inclusion of a saturable transformer which limits the level of the A.C. traction interference which can be fed to the circuit from the track.

The relay circuit presents an impedance to the track of 3 ohms at 75 cycles, and the track circuit is normally adjusted to provide an input of 2V to the transformer corresponding to 0·8V D.C. at the relay terminals.

Traction interference up to 4·5V across the impedance bond, due to unbalance between rail currents, does not affect the normal operation of the circuit, and this voltage is not exceeded in normal circumstances.

In abnormal circumstances of a traction fault or severe unbalance between the rail currents, the resulting interference voltage will ultimately cause saturation of the filter input transformer, when the track relay will safely release.

Naturally, the protection against cross-feeds between adjoining track circuits is less complete with this equipment than can be obtained with the 2-phase system to be described in the next Section of this paper.

A satisfactory solution has been found which is particularly applicable when alternate long and short track circuits are required, as would be the case in a series of automatic signals. By arranging these A.C. track circuits alternately with D.C track circuits of the type described in Section 2.1, full protection is secured because the feed to one cannot operate the relay of the other even if the insulation between adjoining track circuits should become defective.

These 75 cycles track circuits have been installed up to 1,500 yards in length adjusted to operate with a minimum ballast resistance of 3 ohms/1,000 yards.

2.3 $83\frac{1}{3}$ *cycles A.C. Track Circuits*

2.3.1 *The Power Supply*

A central generator provides a 2-phase, 4-wire supply circuit throughout the signalling area; one phase is screened and used only for the relay local windings, the other is unscreened and used for the track circuit feeds.

Security against false operation is obtained jointly by limiting the level of interference that can be fed to the two windings of the vane type relay which is employed.

The screening of the 'local' phase provides one of the required limitations, but if this circuit is particularly exposed to interference, a detector is supplied to give a reliable alarm if the interference approaches a dangerous level.

For Westinghouse equipment, a quadrature relationship between the two phases has been selected to permit simple resistors to be used to feed the track circuits, so avoiding the necessity for power-factor correction.

2.3.2 $83\frac{1}{3}$ *cycles A.C. Single Rail Track Circuits*

Fig.7 shows the circuit arrangement of the typical equipment illustrated in fig.8 which is compatible for both A.C. and D.C. traction systems.

A transformer having 30 and 40V alternative outputs feeds the track through a heavy duty resistor, the whole circuit being rated to withstand traction interference to the limits set out in Section 2.3.4.

A relay which is itself tuned to $83\frac{1}{3}$ cycles is fed through a further $83\frac{1}{3}$ cycles pass filter and also a saturable transformer which limits the interference that can be fed to the relay even should defects occur in the filter circuit. This saturable transformer provides the second of the two basic means of security mentioned in Section 2.3.1.

The relay circuit presents an impedance to the track of 18 ohms at $83\frac{1}{3}$ cycles, and the track circuit is normally adjusted to provide 7V at the input to the filter circuit which gives 2·5V at the relay terminals.

Traction interference up to 100V across the input to the filter does not affect the normal operation of the relay, while excessive interference from a traction fault will saturate the transformer and safely release the track circuit relay.

Track circuits of this type have been installed up to 500 yards in length.

2.3.3 $83\frac{1}{3}$ *cycles A.C. Double Rail Track Circuit*

Two arrangements have been developed and installed, one suited for A.C. traction territory where there is negligible extraneous D.C., and the other which is fully compatible for both A.C. and D.C. traction.

For both arrangements, the track feed and relay circuits are the same as those described in Section 2.3.2 for the Single Rail track circuit.

Fig.9 shows the circuit suited for A.C. traction embodying impedance bonds as described in Section 2.2, except they have an additional secondary winding to suit the feed and relay circuits. Because of the rather higher frequency, the bond impedance now has a minimum value of 5 ohms.

For the second arrangement, which is fully compatible for both A.C. and D.C. traction, the circuit of fig.10 is used embodying larger impedance bonds continuously rated at 500 or 1,000 amps/rail as desired. An air gap is now introduced in the magnetic circuit of the bond to prevent magnetic saturation, so a third winding connected to a condenser is added to restore the impedance to 3 ohms at 83⅓ cycles.

The security against interference voltages is the same as that described in Section 2.3.2.

2.3.4 *Track Circuit Feed Resistors*

The feed resistors used for all 83⅓ cycles track circuits are rated to withstand continuously 50V of traction interference, and higher values for shorter periods until, under abnormal fault conditions, the equipment is protected by the circuit fuse.

3. Signalling Equipment other than Track Circuits

3.1 *Introduction*

Two-wire line-side circuits are used, sufficiently balanced to earth that acceptably small transverse voltages appear across the terminal equipment even when there is a traction system short-circuit.

Also, these terminal equipments operate at voltages up to 50 D.C. or 110 A.C. and so are inherently more immune from interference than the lower voltage track circuit apparatus so far described.

Consequently, although the protective measures are often less elaborate than for track circuits, the signalling equipment will be unaffected, even with the line circuits exposed to maximum traction fault current, provided the longitudinal induced voltage in the circuit is limited to the value recommended in the directives of the CCITT as set out in Paper 10.

3.2 *Line-side Relays*

In territory free from extraneous D.C., use is made of D.C. relays immunised to A.C. as fig.1. A typical relay for 24V D.C. operation is then immune to 1,000V, 50 cycles A.C.

When there is extraneous D.C., as in A.C./D.C. traction territory, 2-element A.C. vane type relays are used fed from a 2-phase, 4-wire, 83⅓ cycles supply system as described in Section 2.3.1. The line circuit feeds the relay control winding through a saturable transformer to limit the transverse voltage should earth faults in the cable unbalance the line.

3.3 *Point Machines*

Electric motor worked points are controlled by a relay immunised to 50 cycles A.C. and placed close to the machine so that the final circuit is free from interference.

Alternatively, air worked points are controlled by an A.C. immune electro-pneumatic valve.

3.4 *Signals*

3.4.1 *Colourlight Signals*

An immunised control relay of the type described in Section 3.2 is used, and the length of the exposed circuit to the signal limited to a safe value.

3.4.2 *Searchlight Signals*

When there is no extraneous D.C. interference, a D.C. mechanism may be used immunised on the same principle as fig.1; alternatively, immunisation is secured by connecting a choke and resistance in series with the mechanism, and increasing the control supply voltage appropriately.

In A.C./D.C. traction territory, an 83⅓ cycles A.C. vane mechanism may be used; alternatively, a D.C. mechanism can be retained controlled from an 83⅓ cycles A.C. 2-element vane relay placed close to the signal. In either case the A.C. control windings are fed through a saturable transformer.

3.5 *Remote Control and Indication*

'Westronic' transistorised high speed remote control and indication equipment operating on carrier frequency station to station link has been used successfully in A.C. traction territory.

3.6 *Instruments*

Phase angle and voltage meters for 83⅓ cycles A.C. testing are available, and a special voltmeter with built-in filters has been developed for 75 cycles and 83⅓ cycles circuit testing.

SUMMARY

This paper refers to the design requirements for signalling equipment in 50 cycles A.C. traction territory, and then deals with the circuits and apparatus which have been developed to prevent improper operation of the equipment, or damage to it, by interference from the traction system.

Track circuits are first described, and typical performance information is given for those designed to operate with D.C., 75 cycles or 83⅓ cycles A.C. signalling current fed to the rails, distinguishing between those which are applicable to single-rail return and double-rail return for the traction current.

The signalling line-circuits are then discussed, and a description given of the methods adopted for protecting the equipments which these circuits control.

These two sections of the paper include descriptions of the particular track circuits and line-side equipments suitable for use on systems where both 50 cycles A.C. and D.C. traction are in operation.

ZUSAMMENFASSUNG

Dieser Bericht befasst sich mit Entwurfsbedingungen für die Signalausrüstung im 50 Hz Wechselstrom Gebiet des Eisenbahnnetzes, ferner mit den Stromkreisen und Apparaten welche entwickelt wurden, um mangelhaftes Funktionieren der Ausrüstung durch Störung vom Fahrstrom zu verhindern oder vor Schaden zu schützen.

Zuerst werden die Gleisstromkreise beschrieben. Typische Leistungsangaben werden gemacht für jene, die mit Gleichstrom, 75 Hz oder 83⅓ Hz an den Schienen angelegten Signalstrom arbeiten. Ferner wird unterschieden zwischen Gleisstromkreisen welche für einschienige – bzw. zweischienige Rückleitung des Fahrstromes anwendbar sind.

Im Weiteren werden die Signalstromkreise diskutiert. Eine Beschreibung der angewendeten Methoden um die Ausrüstungen zu schützen welche diese Stromkreise kontrollieren, ist gegeben.

Zwei Abschnitte dieses Berichtes enthalten Beschreibungen spezieller Gleisstromkreise und Streckenausrüstungen, deren Anwendung besonders geeignet ist in Systemem wo beide, 50 Hz Wechselstrombetrieb und Gleichstrombetrieb vorkommen.

RÉSUMÉ

Cet exposé traite des conditions de construction relatives à l'équipement de signalisation sur les lignes électrifiées en courant alternatif 50 Hz, puis des circuits et des appareils qui ont été développés pour empêcher le fonctionnement intempestif de ce matériel ou d'être endommagé par les circuits de traction.

Les circuits de voie sont décrits d'abord et quelques informations sur les performances typiques sont données sur ceux qui sont destinés à fonctionner en courant continu et en courant alternatif 75 Hz ou 83⅓ Hz, le courant de signalisation alimentant les files de rails. Les circuits de voie avec une seule file de rail et avec 2 files de rails pour le courant de traction sont traités séparément.

Puis les circuits de signalisation sont discutés et on décrit les méthodes adoptées pour la protection des équipements controlés par ces circuits.

Les deux parties de ce rapport donnent une description des circuits de voie particuliers et des équipements de ligne qui conviennent aux cas où les systèmes de traction en courant alternatif 50 Hz et en courant continu existent simultanément.

RESUMEN

Este artículo refiere a los requerimientos para el diseño de equipos de señalizacion donde se usa tracción de corriente alternada de 50 c/s, y luego trata con circuitos y aparatos que han sido desarrollados para evitar el funcionamiento impropio o daño al equipo por interferencia del sistema de tracción.

En primer lugar se describe circuitos de via; información típica de actuacion es dada para los circuitos de via diseñados para operación con Corriente Continua, Corriente Alternada de 75 c/s o 83⅓ c/s conectada a los rieles para la señalización, diferenciando entre los que son aplicables a un riel solo de retorno y los de doble riel de retorno para la corriente de tracción.

Son discutidos despues los circuitos de linea de señalización, y una descripción dada de los métodos adaptados para proteger los equipos que son controlados por estos circuitos.

Estas dos seccionas del artículo incluyen descripciones de los circuitos de via y equipos externos de via adequados para uso en ambos sistemas de tracción, Corriente Alternada de 50 c/s y Corriente Continua.

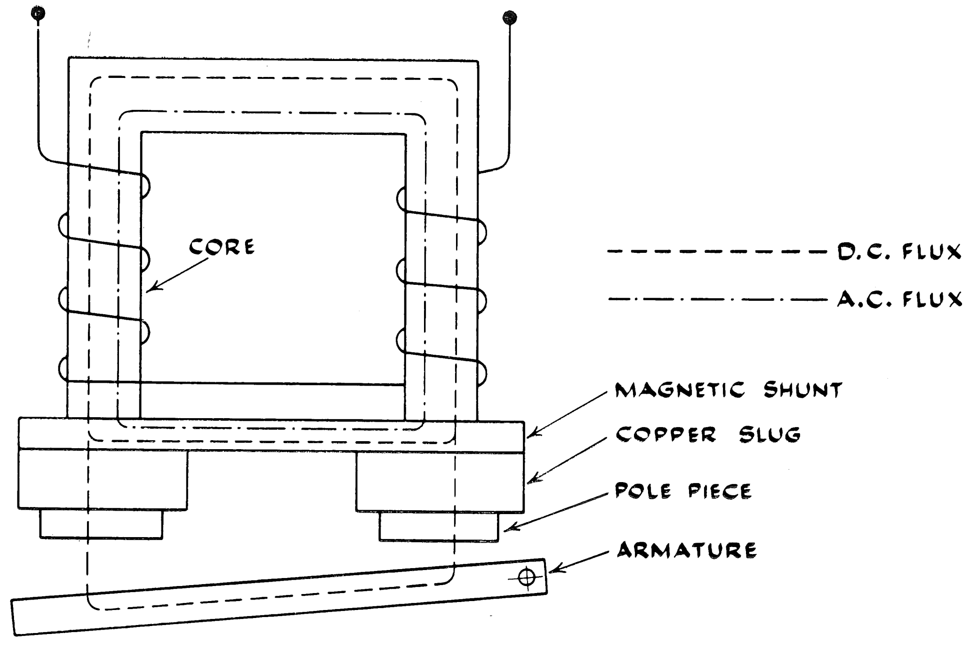

Fig.1 D.C. Relay, A.C. Immune

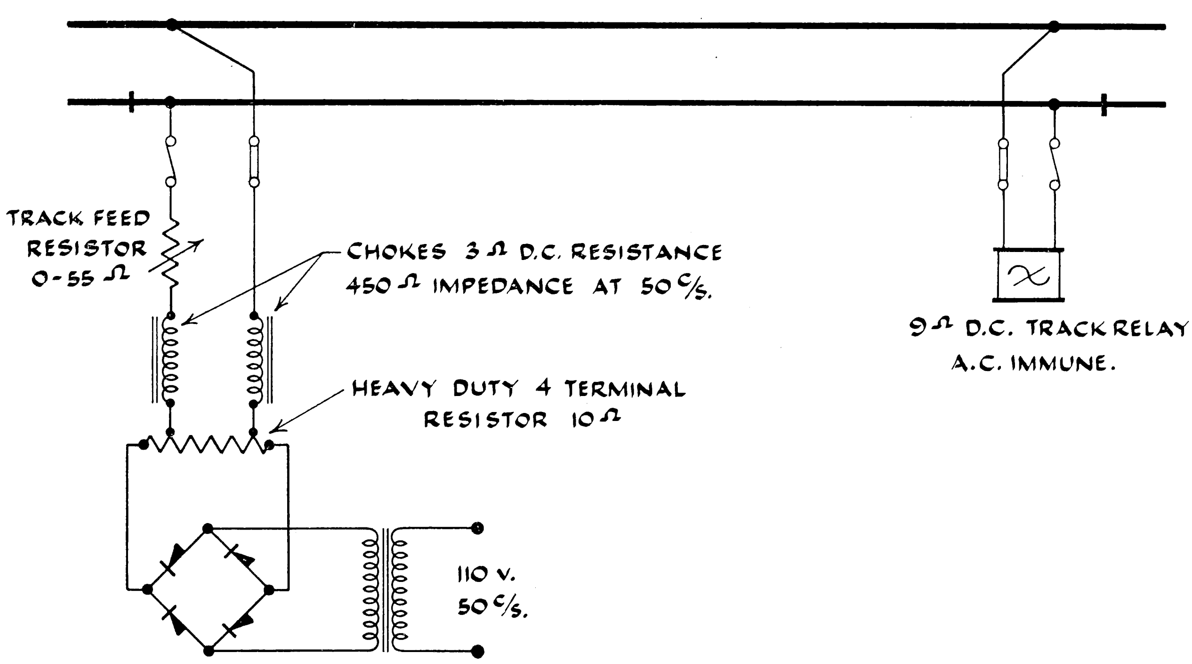

Fig.2 D.C. Single Rail Track Circuit (Patents Pending)

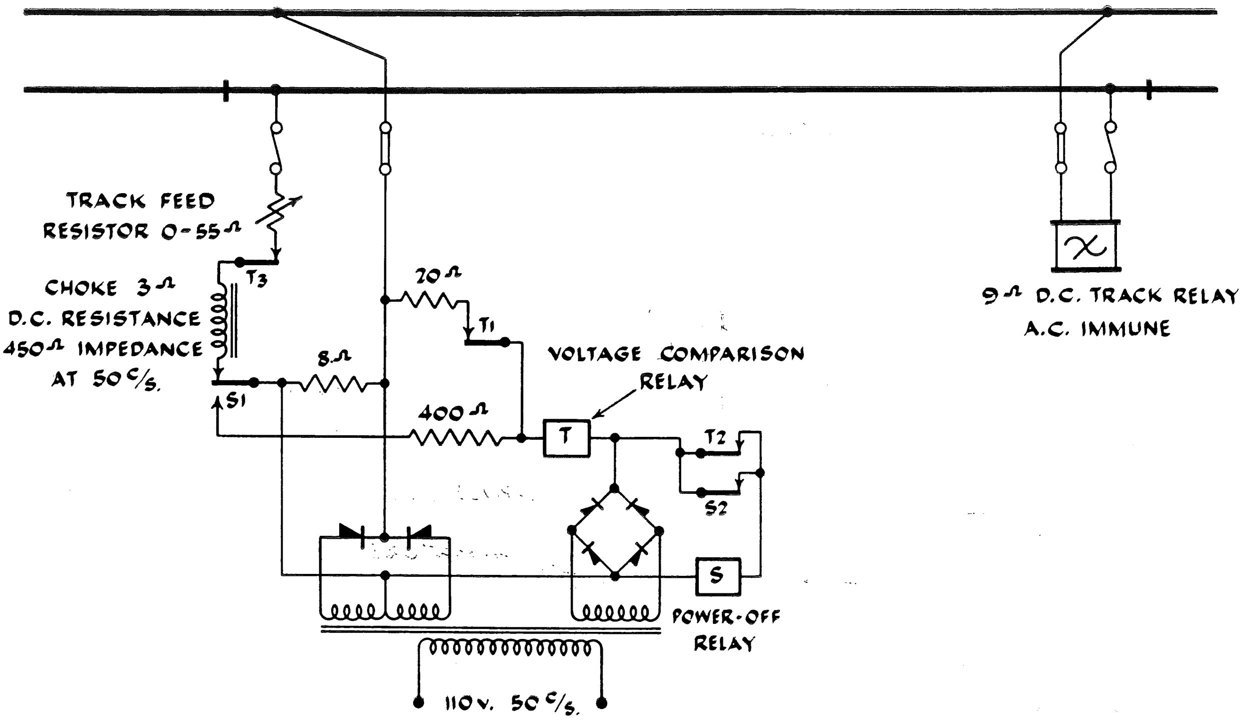

Fig.3 D.C. Single Rail Track Circuit (Brit. Pat. No. 823045)

D.C. Feed Set | Voltage Comparison Relay | Track Feed Resistor | D.C. Track Relay A.C. Immune

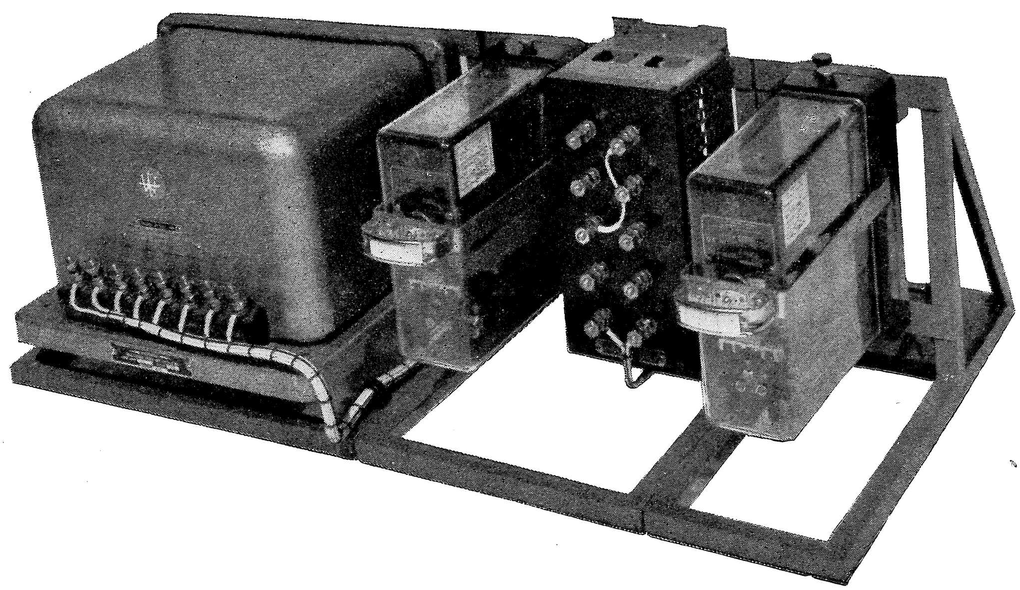

Fig.4 D.C. Single Rail Track Circuit Equipment of Fig.3

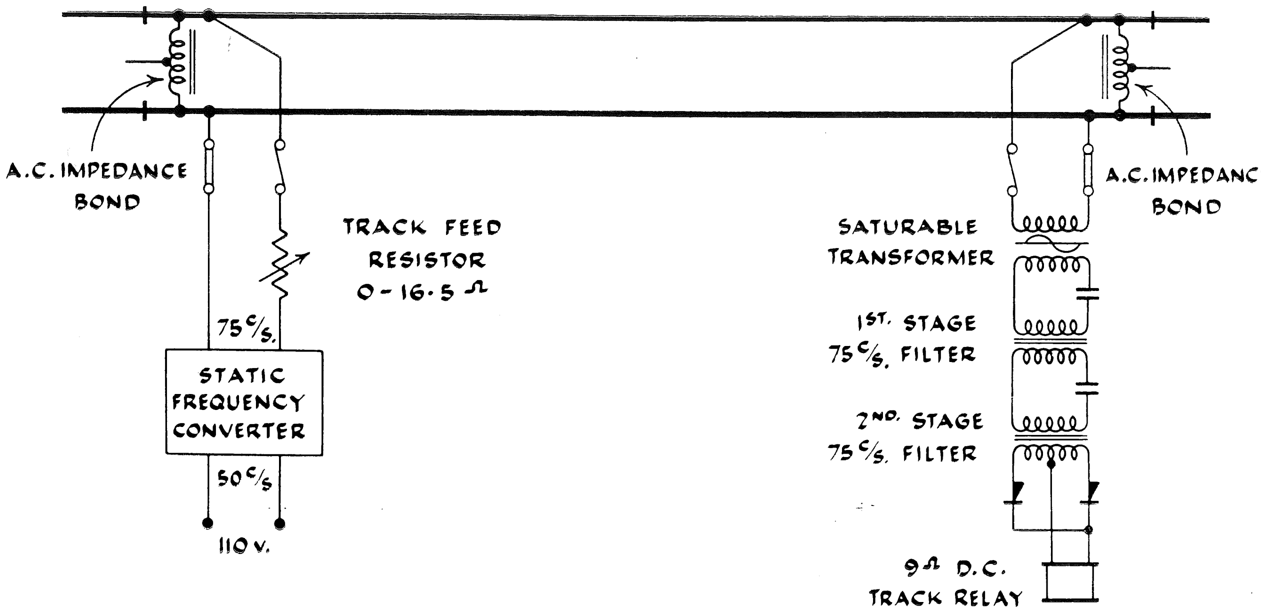

Fig.5 75c/s Double Rail Track Circuit

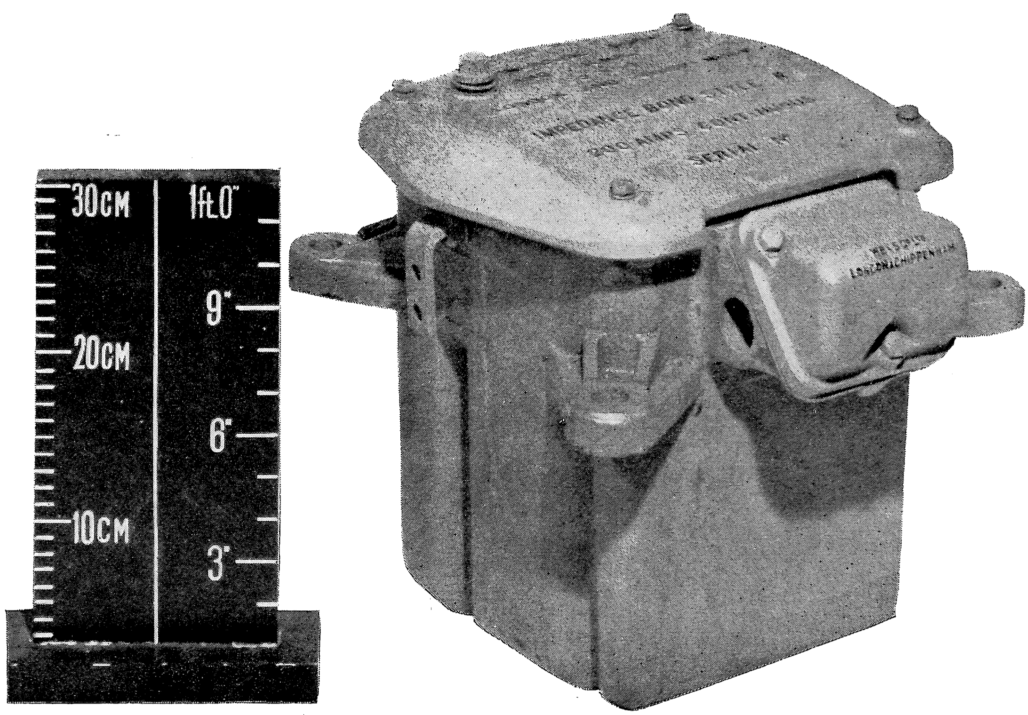

Fig.6 A.C. Impedance Bond

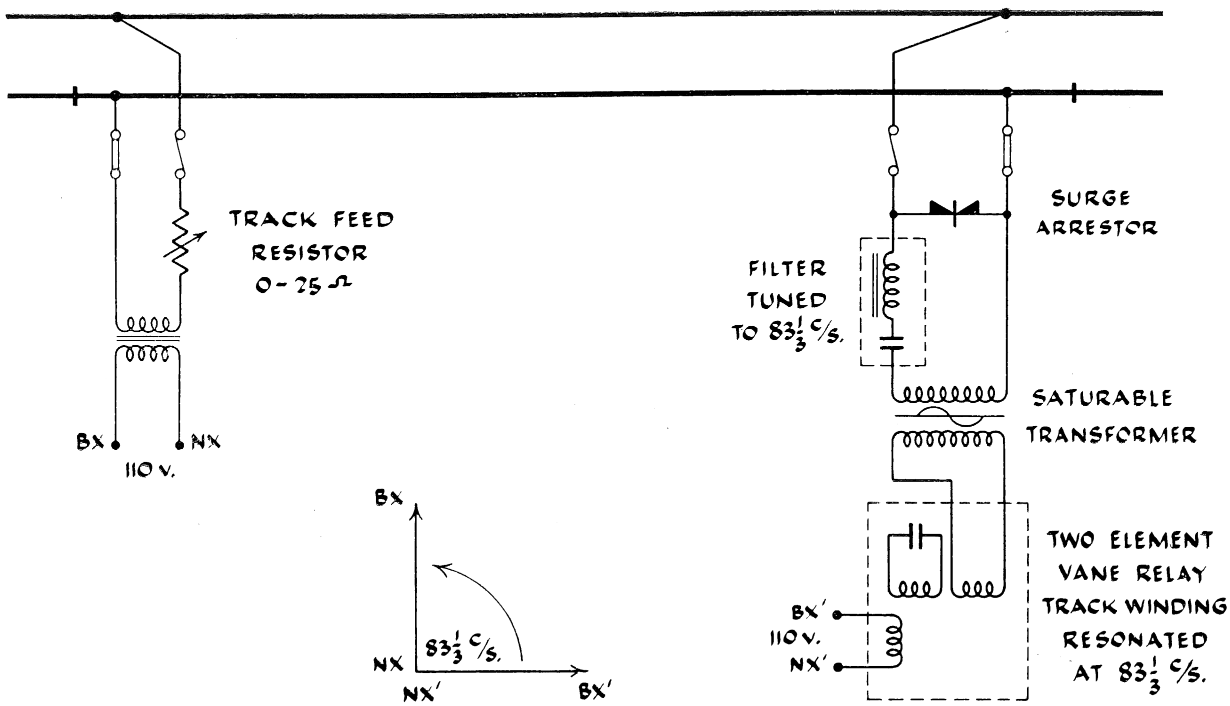

Fig.7 83⅓c/s Single Rail Track Circuit

Track Feed Transformer | Track Feed Resistor | 83⅓c/s Filter | Two Element Vane Relay

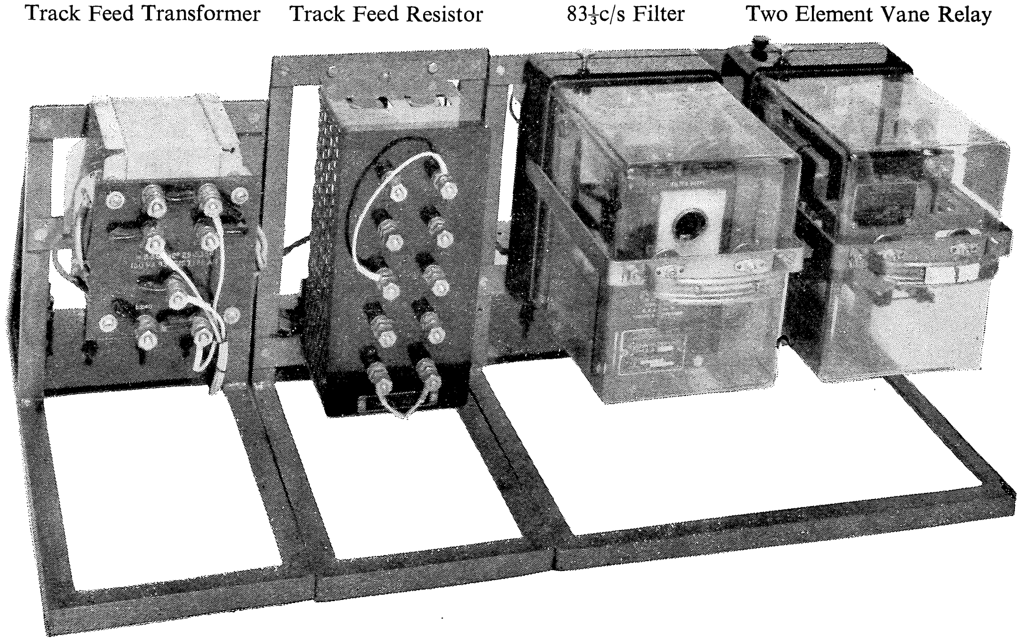

Fig.8 83⅓c/s Single Rail Track Circuit Equipment

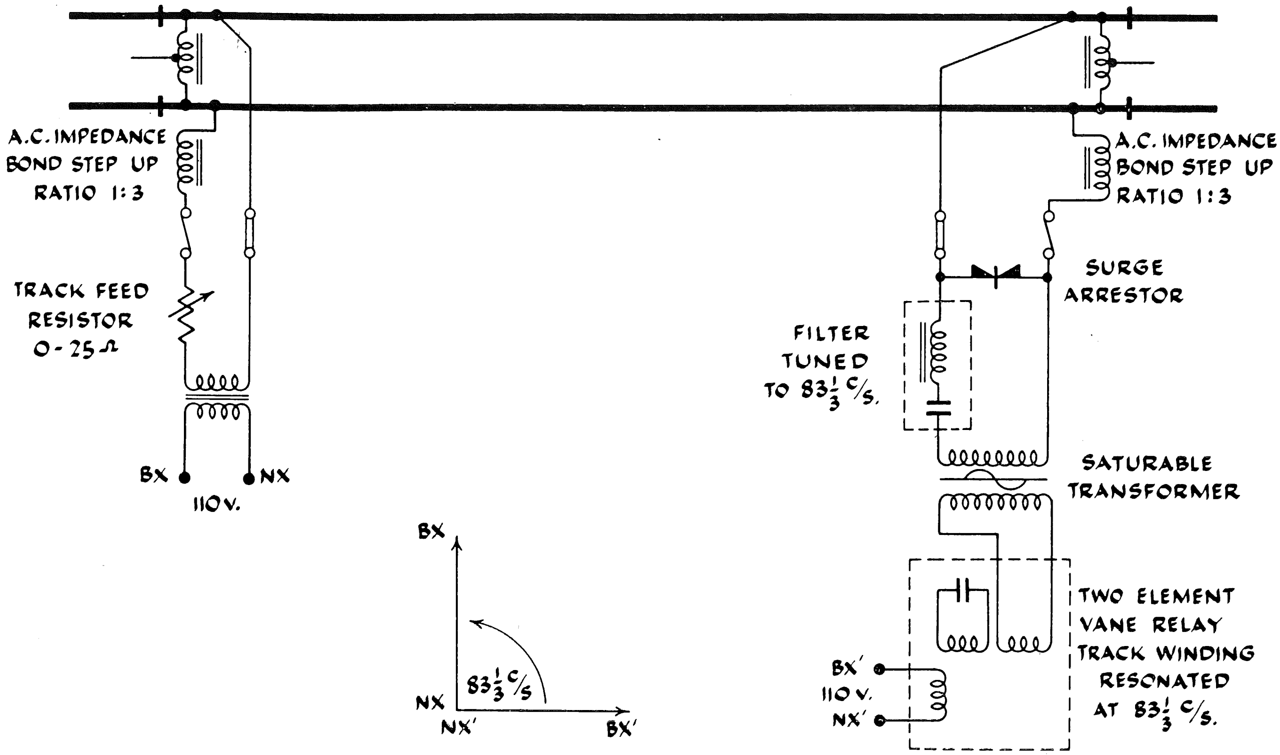

Fig.9 83⅓c/s Double Rail Track Circuit for A.C. Traction Territory

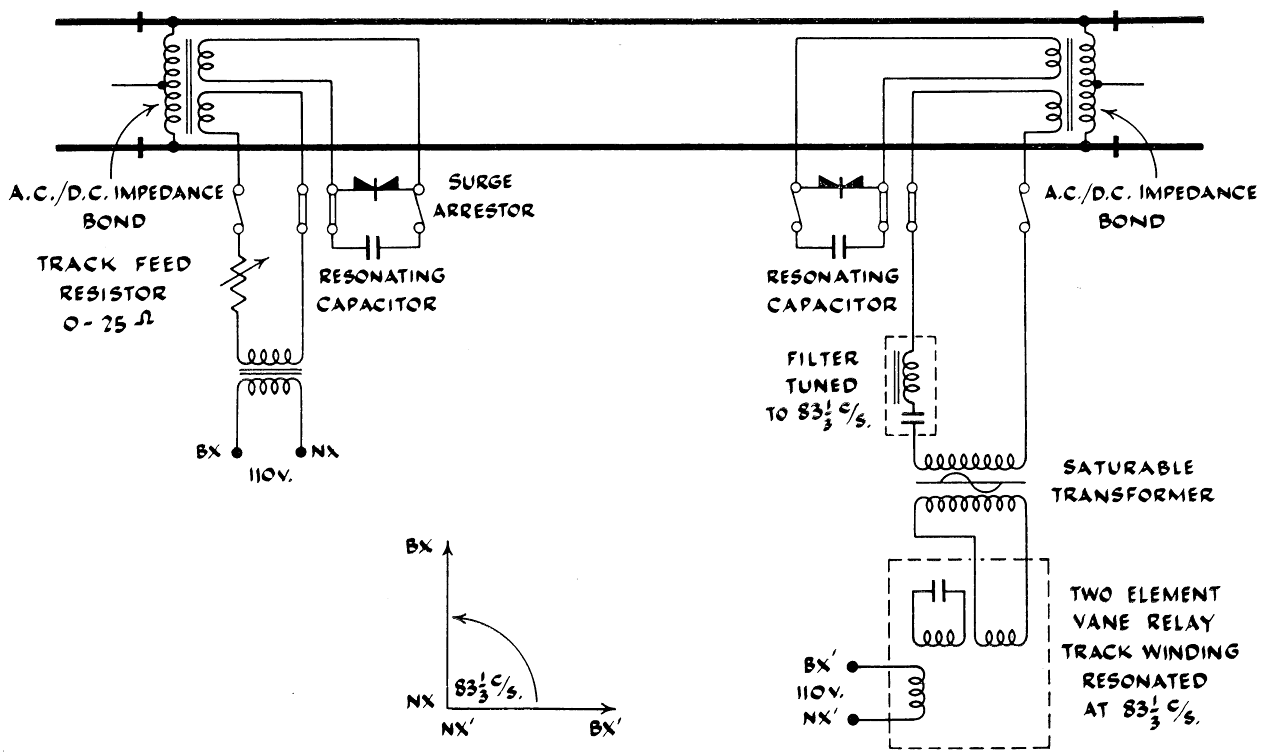

Fig.10 83⅓c/s Double Rail Track Circuit for A.C./D.C. Traction Territory

Printed in Great Britain by Waterlow & Sons Limited