Type RR 3000 Series Multiplex System

Handbook

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TYPE RR3000 SERIES MULTIPLEX SYSTEM

HANDBOOK

Contents:

GEC-GENERAL SIGNAL LTD.,
ELSTREE WAY,
BOREHAMWOOD,
HERTFORDSHIRE,
ENGLAND.

Issue 2

1.0 INTRODUCTION TO THE SYSTEM

1.0.1 CONTENTS

1.1 <u>Glossary of terms</u>

The following expressions are used in this manual with particular meanings in connection with type RR equipment.

CHANNEL	-	A path for the transmission of a single item of information (e.g. a control, or an indication).
CORE	-	An individual conductor in a cable
DUPLEX	-	Two-way
FREQUENCY-DIVISION MULTIPLEX	-	A multiplex arrangement in which channels are separated by being allocated signals of different frequencies
LINE, LINE-PAIR	-	A pair of electrical conductors used for the transmission of signals
MULTIPLEX	-	An arrangement for carrying many channels on a single line
REED	-	A mechanically-vibrating element,
SECTIONALISATION	-	Splitting of the line into isolated lengths, connected together only by transformers or amplifiers.
SIMPLEX	-	One-way
SYSTEM	-	All those channels carried in one line-pair, or all the equipment associated with them.

1.2 Frequency-division Multiplex

The GEC-General Signal type RR3000 series Reed system is a frequency-division multiplex system. That is to say, it is a means of connecting many circuits over a distance using a single pair of conductors; a specific frequency is allocated to each circuit, and a signal of this frequency is transmitted along the pair when the circuit is complete. Many signals of different frequencies are therefore transmitted along the pair, and the signal for a particular circuit or channel is separated out at the receiver end of the pair by means of a suitable filter.

The type RR3000 series system can carry up to 63 circuits in one pair of conductors, over an unlimited distance. Since these circuits would normally require a pair each, it will be seen that a great saving in cable can be obtained, especially if the distance being covered is considerable.

The equipment is essentially simplex (i.e., one-way) in operation, although duplex (two-way) systems can be employed under certain circumstances. The transmitters and receivers for the various channels do not have to be grouped at the ends of the line; any channel can be connected into, and out of, the line at any point along its length, as required. Also, the equipment for a channel can be removed without affecting the operation of the rest of the system, so that, for instance, if a fault develops on a channel, it can be serviced without disturbing the rest of the system. The equipment is therefore very flexible in operation.

Type RR3000 series equipment is not fail-safe to the standard required for vital circuits in railway signalling. Its application is in the conveyance of information of a less vital nature such as track circuit and signal indication for display on the control panel. It may also be used for transmitting the controls and indications associated with a remote interlocking.

1.3 The Basic Type RR3000 Series System

1.3.1 Each channel employs an independent transmitter which generates a signal at the particular frequency allocated to that channel when a contact is made in an external control circuit. The frequency is determined by a Reed filter, as described below. The output of each transmitter is connected across a load resistor, and the transmitters are connected together so that all the resistors are in series with each other and with the line (see fig. 1.3.1 - 1). Any transmitter may be placed at any point along the line, and is always connected with its resistor in series with one leg of the line.

1.3.1 (contd)

Each channel also has an independent receiver, consisting of a Reed filter and an amplifier. The Reed filter is a band-pass filter, which passes only the frequency allocated to the particular channel and excludes all others, and is connected with its input across the line (see fig.1.3.1-1). Its output drives the amplifier, which provides a direct voltage when a signal is present at its input. This voltage is used to drive a relay, and it will therefore be seen that the relay is energised only when a signal of the correct frequency is present on the line.

Thus, closure of the contact in the control circuit of the transmitter for a channel causes the relay driven by the corresponding receiver to be energised (exactly as if the circuit was made through directly, with its own pair of conductors). The operation of any channel is completely independent of any other channel on the same pair.

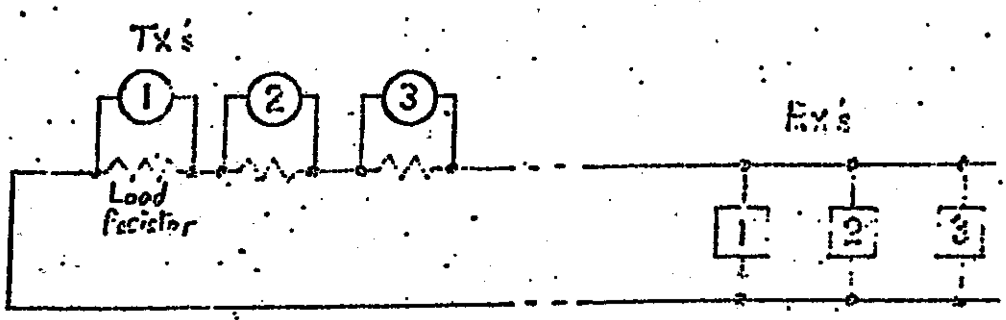


Fig. 1.3.1 - 1: Typical Reed System.

1.3.2 From the above, it will be seen that the frequencies of both transmitters and receivers depend upon the Reed filter. So that many frequencies at close spacing may be used, this filter must have a highly accurate and highly stable pass frequency. The necessary accuracy and stability is obtained by using mechanical resonance on the tuning-fork principle. (The filter is described in detail in section 2.2 below). Its selectivity is such that the system can be operated with frequencies at a spacing of 4Hz or less, so that a very large number of channels can be accommodated in a small range of frequencies.

The range of actual frequencies used is determined by the mechanical characteristics of the Reed filter, and is normally between 300Hz and 1 kHz. The frequencies are chosen within this range in such a way as to minimise effects due to intermodulation between channels, and to external interference from 50Hz mains. 63 frequencies are available for system functions and 2 additional frequencies may be used as universal spares.

1.3.3 For operation over long distances, amplification of the signals is required at intermediate points. This is provided by means of the Reed line amplifier, described in section 2 below. The spacing between amplifiers is determined by the attenuation caused by the type of cable used; when the system is operated over standard signalling cable, it can be up to 4km. Large groups of transmitters or receivers at a location also load the line heavily, and the line amplifier is used in this case also to prevent loss of signal level.

Induction from 50Hz power line and other high voltage sources can give rise to interference in the Reed line. To prevent such currents being transmitted along the full length of the line, it is often desirable to sectionalise it, either by means of the line amplifier, or by means of the Reed line isolating transformer if no amplification is required.

Provided, then, that amplifiers are used at suitable intervals along the line, and that the line is sectionalised as may be necessary, Type RR Reed systems can be operated over virtually unlimited distances. Where many pairs in a multicore cable carry Reed signals, crosstalk between pairs may become significant over large distances, and can be minimised by regular transposition or twisting of the individual pairs, and by selection of the cores used.

1.3.4 The type RR system, therefore, offers great flexibility of application. It can be operated over long distances, and individual signals can be connected into or out of the line at any point along its length - not merely at the ends of the line. The system is designed so that units associated with individual channels can be removed, for repair, etc., without affecting the operation of other channels on the same pair, and this gives it a considerable advantage over time-division multiplex and other electronic systems, in which failure of a single unit often causes failure of the entire system.

2.0 THE EQUIPMENT

2.0.1 Contents.

2.1 GENERAL

2.1.1 Physical Construction of Units

GEC-General Signal type RR3000 series Reed equipment is designed to conform physically with other standard railway signalling equipment. Transmitters, receivers and transmitter repeaters are designed to be mounted on standard miniature plug-boards, and occupy the same space as a relay, except only that the receiver is deeper than a relay (the dimensions are 8.41 in x 5.50 in x 2.19 in, so that the unit projects 0.88 in below the plug-board). Other units are designed to be mounted directly on racks, in the space required for one or more plug-boards (as described in the appropriate sections following). The equipment is therefore suitable for mounting in relay rooms and location cupboards.

2.1.2 Ambient Conditions

Type RR3000 series Reed equipment is designed to operate in ambient temperatures over the range -20°C to 70°C, in conditions of high humidity and in corrosive atmospheres. The units are treated to prevent fungus growth and corrosion under tropical conditions.

Cupboards and relay rooms housing Reed equipment should be ventilated, as all units, especially power supplies and line amplifiers, generate a small amount of heat.

2.1.3 The type RR3000 series Reed system can be operated over a pair of conductors in most types of cable, and does not require a matched or balanced transmission line. Pairs of cores in standard railway signalling cable, and pairs of conductors on an overhead pole route, are both suitable for carrying Reed signals. The resistance of the conductors determines the attenuation of the signal, and hence the spacings at which line amplifiers are necessary. Transposed or twisted pairs can be used to reduce 'crosstalk' effects between pairs in the cable or on the same route (see part 3), and sectionalisation can be employed to reduce interference effects (see section 2.8).

2.1.4 Frequencies

65 frequencies of which 2 are used as universal spares are available. Each frequency is allocated a channel number for ease of reference: for example frequency 879.5Hz is channel f1. A list of frequencies and channel numbers is given in section 5.2.

2.2 THE REED FILTERS

2.2.1 The reed filters are the basis of the type RR3000 series system. These are band-pass filters with exceptionally stable characteristics and a well defined pass frequency determined by mechanical resonance on the tuning fork principle. Two types of filter are employed. The transmitter filter contains a single reed, and the receiver filter a double reed arrangement.

2.2.2 The basic reed is a short bar of a special alloy, clamped at one end and shaped so as to vibrate at a specific frequency, which is set during manufacture by adjusting the thickness near the clamping point. It is placed so that it lies along the axis of a coil, with its free end between the poles of a permanent magnet as shown schematically below:

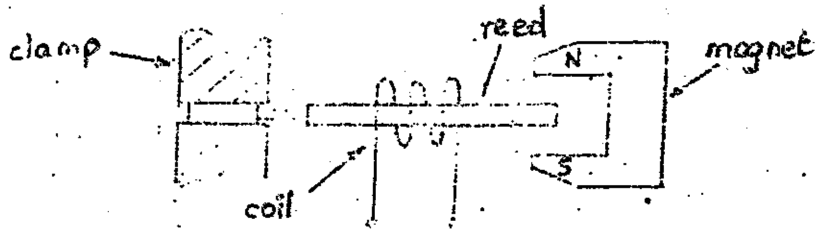


Fig. 2.2-1: Basic Reed

If a current flows in the coil, the reed is magnetised, and it is therefore displaced by the field of the permanent magnet, by an amount depending on its mechanical stiffness. If the current is made to vary sinusoidally, the reed will vibrate in the field. At non-resonant frequencies, the amplitude of this vibration is small, but if the frequency of the current flowing in the coil is the same as the frequency of free mechanical vibration of the reed, the amplitude becomes large. Alternatively, if the assembly is vibrated mechanically, the reed will also vibrate between the poles of the magnet, causing a voltage to appear between the terminals of the coil. This voltage will be small unless the frequency of the impressed vibration is the same as the resonant frequency of the reed, in which case it will become much larger (by a factor of several hundred in practice).

2.2.3 The transmitter filter uses one tuned reed and one dummy reed. Figure 2.3.1 shows the principal features of this filter. When the frequency of the applied signal is outside the pass band of the tuned reed, the filter is in a state of balance, and "unbalanced" at resonance when the frequencies coincide. In the balanced condition the emf at the input divides and appears in equal proportions across each of the primary windings P1 and P2 which have equal constants and are arranged in additive series connection. The emf which is induced in each of the secondary windings S1 and S2 by transformer

2.2.3 (contd)

action, as a result of an input signal whose frequency is out-of-band, is equal in amplitude but opposing in phase relationship and therefore cancels. At resonance, however, the balance of the system is disturbed and a large voltage appears at the output.

This filter is used in the feedback loop of an oscillator to control the frequency of oscillation and thus provides the basis of a very stable transmitter.

2.2.4 The receiver reed filter consists of two vibratory reed assemblies tuned to the same frequency, fastened together. The clamp for the reed takes the form of a brass block on which the coil and the permanent magnet are mounted. In the complete filter, the mounting blocks of the two assemblies are joined by a rigid connection plate, and the whole is suspended in its case on resilient mountings.

The complete arrangement is as shown:

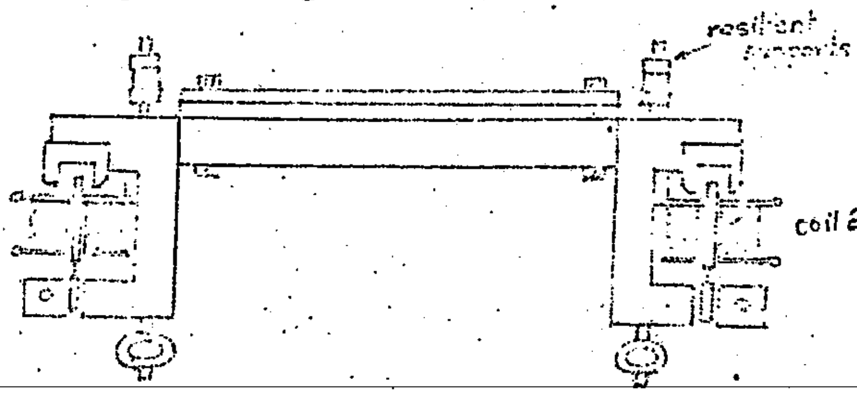


Fig. 2.2-2 Complete assembly of Receiver Reed Filter

It will be seen that the unit has two pairs of terminals, one pair for each reed coil.

Suppose now that an a.c. current flows in coil 1. If its frequency is the same as that of the reeds, then reed 1 will be excited to vibrate with large amplitude. Since the whole assembly is suspended on resilient mounting, the vibration will be acoustically coupled only through to reed 2, which will vibrate in sympathy since it is tuned to the same frequency. This in turn will cause a large voltage to appear between the terminals of coil 2. If the frequency of the current in coil 1 is not in tune with the reeds, the vibration of reed 1 will be small and the energy coupled from one reed to the other will also be small, and the voltage produced across coil 2 will be negligible. The device can therefore be seen to act as a band-pass filter; only signals having the frequency to which the reeds have been tuned are coupled through from coil 1 to coil 2. Typical figures for an actual Reed filter are as follows: for an input of 300mV across the terminals of coil 1, the output voltage across coil 2 would be 125mV (on-tune).

2.2.5 The frequency of free vibration of a reed is determined by its physical characteristics; in particular, by the thickness of the neck near the clamping point, and by the properties of the material used. Faults which cause the frequency of a reed to alter, while allowing it to continue vibrating, can thus only arise as a result of mechanical damage to the reed and are therefore rare. However, if one reed in a filter was so affected, the two reeds in the filter would now have different resonant frequencies. Only if the frequencies of both reeds shifted by exactly the same amount could the filter respond to a frequency other than that to which it was originally tuned, and the probability of this occurring is very small.

The receiver Reed filter is thus a fail-safe device in that, under fault conditions, it will not respond to a frequency other than that to which it was originally tuned. Any fault which does occur will indicate its presence by causing a decrease in, or loss of, output voltage.

2.3. THE TRANSMITTER

2.3.1 Description

The type 3000 series Reed transmitter and amplifier is contained within a standard B.R.B. miniature relay case and is pluggable into a relay plugboard. It therefore occupies the same space as a relay .

The circuit of the complete transmitter is shown in fig. 2.3 - 1; it consists of a feedback oscillator, in which the single Reed filter (see section 2.2.3) acts as the frequency-discriminating element in the feedback path, and an output stage. In order for the signal from the oscillator to be coupled to the output stage so that the transmitter gives an output, an external connection must be made between two terminals on the unit; the output can thus be controlled by a relay or switch contact.

In normal practice, a resistor is connected in one leg of the line and the output of the unit is then connected across the resistor (see section 1). The resistor is usually a 24 ohm, 1 watt, metal oxide film type, crimped directly onto the plugboard terminals. Thus, if a transmitter in a system is removed from its plugboard, the line circuit remains complete through the resistor, and the rest of the system can continue to operate normally. This feature is an important part of the flexibility of type RR systems and enables maintenance to be carried out on one or more channels in a system without disturbance to the remaining channels.

Transmitters are identified by means of blue coloured labels.

2.3.2 Electrical Characteristics

The terminals on the unit are numbered as on the plugboard in exactly the same way as miniature relay terminals.

A smoothed and stabilised d.c. power supply at 12V is required, connected between terminals D5 (negative) and D3 (positive). The current consumption of one transmitter is 50mA.

The output from the unit appears between terminals D1 and D6, across which terminals the output resistor (see section 2.3.1 above) is connected. When the d.c. supply voltage is 12V, the output voltage should lie between 590mV and 680mV (rms.), with an output resistor of 24 ohm.

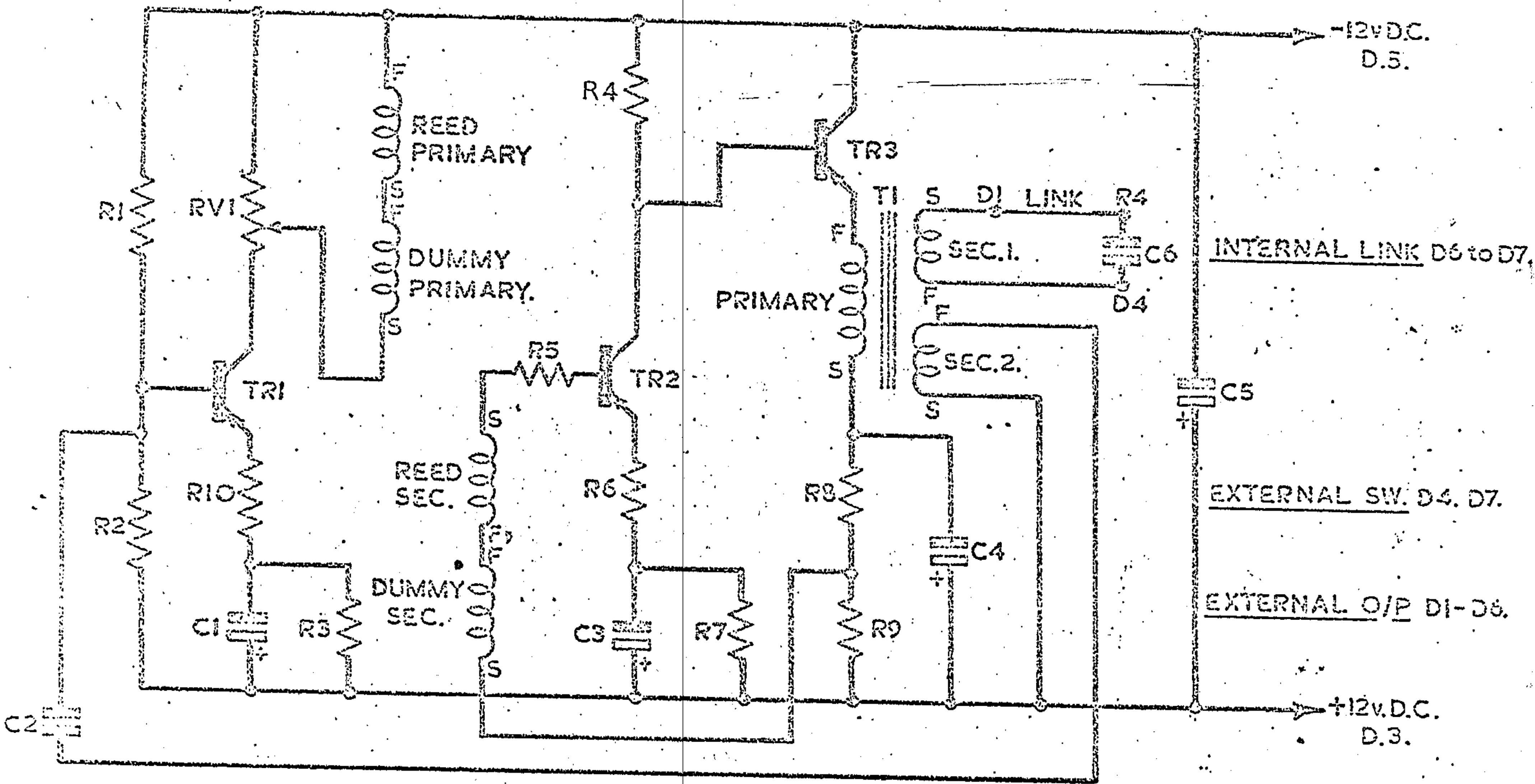


FIG. 2,3-1

CIRCUIT DIAGRAM OF THE TYPE RR3000 SERIES TRANSMITTER

2.3.2 (contd)

For normal operation the unit is controlled by a switch or relay contact connected between terminals D4 and D7. The unit gives full output when this contact is closed and no output when the contact is opened.

When the unit is switched off (not transmitting), the impedance looking into the output is sufficiently high to be negligible in parallel with the 24 ohm output resistor; when it becomes switched on, this impedance drops to become a resistance of about 5.0 ohm.

2.4. THE RECEIVER

2.4.1 Description

The type RR3000 series receiver consists of a Reed filter in the type RR2000 range and a receiver amplifier type RR3000. The two units clip together, and are held by a retaining screw, to form a single unit which plugs into a BRB standard miniature relay plugboard, and occupies the same space as a relay.

The circuit of the complete receiver is shown in fig.2.4 - 1. The input of the Reed filter (see section 2.2.4) is connected across the line. The relay is only energised when the appropriate signal is present on the line, and, because of the fail-safe characteristics of the receiver Reed filter, spurious energisation by other signals, even under fault conditions, is impossible.

Since receivers are connected in parallel with the line they can be removed from the system without affecting the operation of other channels in the same system.

Receiver filters are identified by means of yellow coloured labels and type RR3000 amplifiers by pink coloured labels.

2.4.2 Electrical Characteristics

The receiver requires a smoothed and stabilised d.c.power supply at 12V, from which it draws 100mA (when energised and driving a relay); the positive supply is connected to terminal D1, and the negative to A1, as shown in fig 2.4 - 1.

The input from the line is connected between terminals A4 and D4, which are connected inside the unit directly to the input reed coil in the filter. If the frequency and amplitude is correct, the internal relay is energised.

When the d.c. supply voltage is 12.0V, the signal level at which the relay just becomes energised is not more than 95mV, and the signal level at which it just drops away again is at least 63mV (provided, of course, that the frequency of the signal is the same as that of the filter).

The input impedance of the unit is the impedance of the input reed coil. At frequencies other than that of the filter, this impedance consists of a resistive component of 360 ohm and inductive component of 400mH in series; at the filter frequency, the impedance is approximately 730 ohm, and its phase is indeterminate.

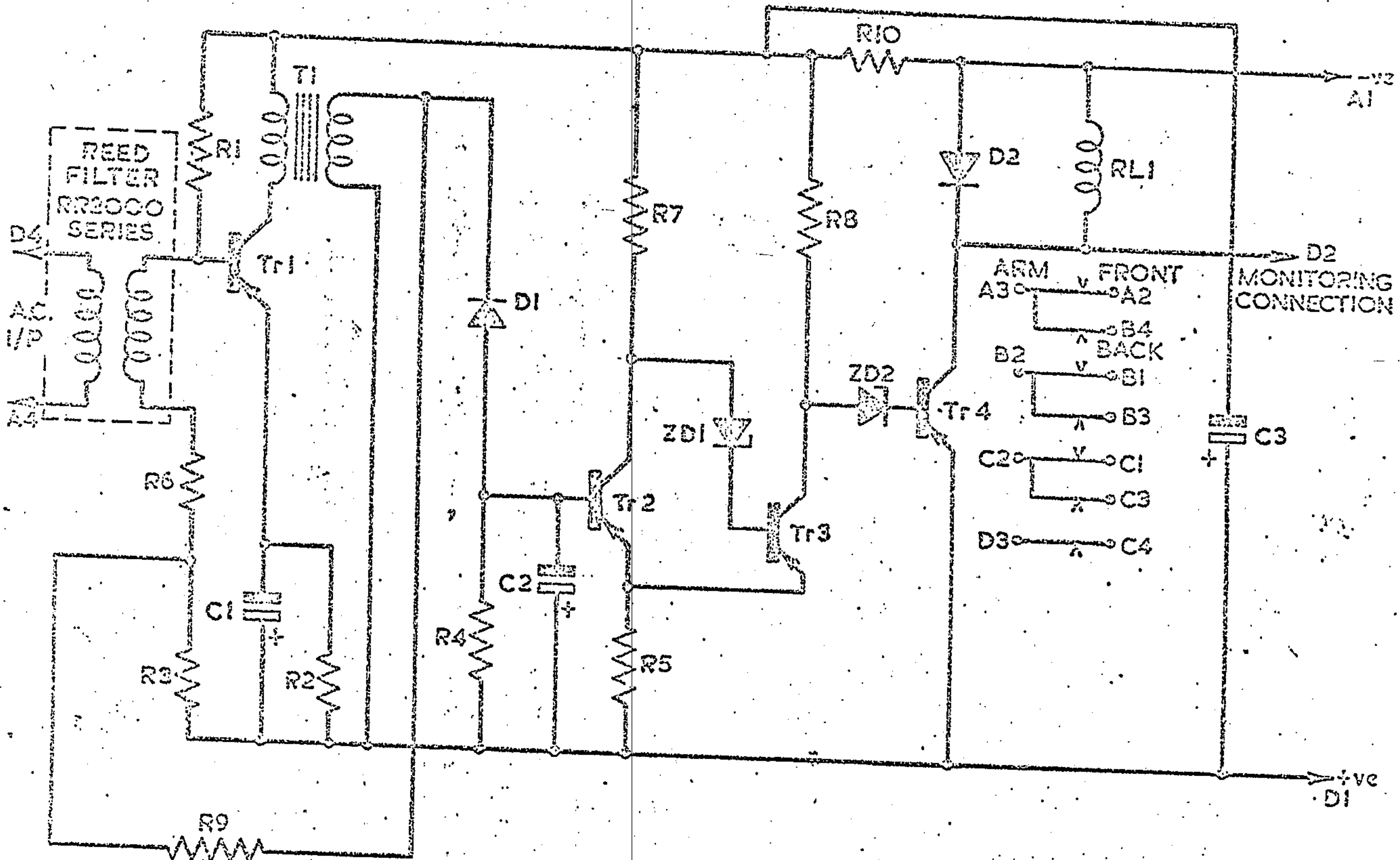


FIG. 2.4-1

CIRCUIT DIAGRAM OF THE TYPE RR3000 AMPLIFIER.
(RECEIVER)

2.5 THE REED FOLLOWER RELAY

The Reed receiver operates a Reed follower relay which is contained within the amplifier portion. It affords 3F/B 1B contacts which are suitable for the switching of indication lamps or operation of repeater relays as required. All contacts are brought out to plugboard terminal positions. Diagram 2.4-1 shows these terminals and also the coil connections.

The 12 volt supply is connected to terminals A1 and D1 (D1 positive). For test purposes a connection is brought out from the positive side of the relay coil to terminal D2 on the plugboard. With the normal power supply switched on, by linking terminals D1 and D2, the relay can be energised without the presence of the reed signal. It is important to note that no other supplies are to be connected to the unit. The voltage on the relay coil may at any time be measured by connecting an Avometer, set to 25Volt d.c. range, across terminals A1 and D2 (D2 positive).

2.6 THE TRANSMITTER REPEATER UNIT (T.R.U.)

2.6.1 Description

In large installations of Reed equipment controls are transmitted from the relay room over many different systems (i.e. in many different pairs) from the one point, and the same Reed frequencies are used in the various systems. In order to economise in transmitters at such an installation, the transmitter repeater unit is used. It is driven by the transmitter and provides four separate switched outputs at the transmitter frequency which can be used for four separate systems. Since one transmitter can drive up to seven repeater units, it will be seen that up to twenty-eight systems can be fed from a single set of transmitters, one for each frequency.

The outputs from the T.R.U. are switched by external contacts, such as relays or switches, and each output is connected across a resistor of 24 ohm connected in series with the particular system which it feeds, in exactly the same way as a transmitter output. The outputs are completely isolated from each other, so that there is no possibility of unwanted connections between systems, or of interference from one system to another.

The unit plugs into a BHB standard miniature plug-board, and is the same size as a miniature relay. It is distinguished by green coloured labels.

2.6.2 Electrical Characteristics

A circuit diagram is shown in fig 2.6-1. The unit requires a smoothed and stabilised d.c.supply at 12V, connected between terminals D2 (positive) and D1, and draws 200mA.

The input is obtained from the output of a transmitter and is connected to terminals A1 and A2. The four outputs appear between terminals A3-A8, B3-B8, C3-C8 and D3-D8, and they are individually controlled by switches connected between A5-A7, B5-B7, C5-C7 and D5-D7 respectively. As previously stated a 24 ohm resistor is connected externally across each output.

The voltage and power gain of the unit from its input to each output is virtually unity so that the signal levels at its outputs are the same as the output level for a transmitter (see section 2.3.2).

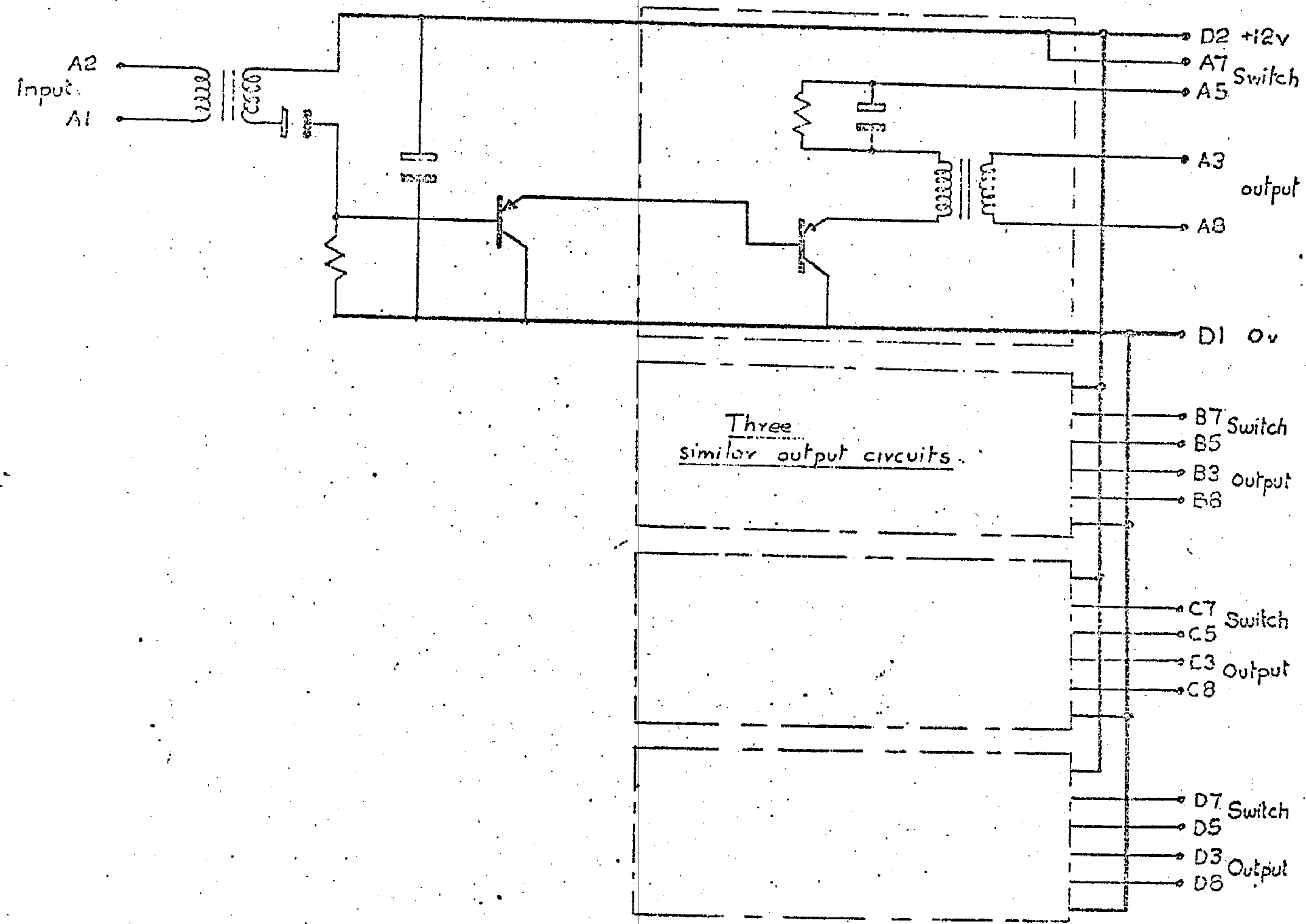


Fig. 2.6-1 Transmitter Repeater Unit Circuit RR 3990.

2.7 THE LINE AMPLIFIER

2.7.1 Description

For transmission over long distances, amplification is required at intermediate points to counteract the attenuation caused by the resistance of the line. This is provided by means of the Reed line amplifier, of which the circuit is shown in fig. 2.7.1. This is a uni-directional amplifier with negative feedback which can be adjusted to set the voltage gain. An outline of the unit is shown in section 5.2.

The unit is designed to be mounted on racks or in cupboards and occupies the space required for four standard miniature plugboards. It has its own built-in rectifying and smoothing circuit and requires an a.c. power supply at 24-28V rms. which can be obtained from 110V a.c. mains by means of the reed line amplifier supply transformer (see 5.2-7). Alternatively it may be operated from an independent 24Volt d.c. supply.

All the external connections to the amplifier, together with the link that sets the gain, are made to a comb with eleven 2BA terminals on it which connect to the terminals on the amplifier itself. If the amplifier should fail for any reason it can thus be replaced without disturbing connections to the comb which can be disconnected intact from the amplifier.

2.7.2 Electrical Characteristics

The input terminals to the amplifier are terminals 2 & 6. The incoming line is connected to terminals 1 and 6 on the contact comb, and either a link or a resistor is connected between terminals 1 and 2 on the comb. The value of the resistor can be selected, so as to give fine control over the signal level at the output from the amplifier.

The a.c.power supply is connected to terminals 10 and 11. If a d.c. supply is used instead, this is connected also to terminals 10 and 11. No polarity need be observed. The output appears between terminals 7 and 9. The feedback connection is made through a link between terminal 6 and one of the terminals 5,4 and 3, and can be adjusted, so as to give coarse control over the voltage gain, as follows:

Link between terminals	% feedback	Voltage gain	Input impedance
6 - 5	100%	1.0	1300 ohm *
6 - 4	75%	1.35	1150 ohm *
6 - 3	50%	1.9	900 ohm *

* typical values.

2.7.2 (contd)

The gain and input impedance are independent of frequency within the Reed spectrum. At 50Hz, however, the input impedance is considerably lower and tends to cause attenuation of such voltages which may be induced in the line, so reducing this amplitude along the system.

The output impedance of the amplifier is typically 40 ohm, both at Reed frequencies and at 50Hz.

2.7.3 Line Sectionalisation

Sectionalisation prevents lethal voltages which would otherwise develop in the Reed system as a result of interference from paralleled high voltage circuits.

Since the amplifier contains transformers in both input and output circuits (see fig.2.7-1), it sectionalises the line where it is inserted. If sectionalisation is required without amplification, the isolating transformer, described in section 2.8 below, may be used for this purpose instead.

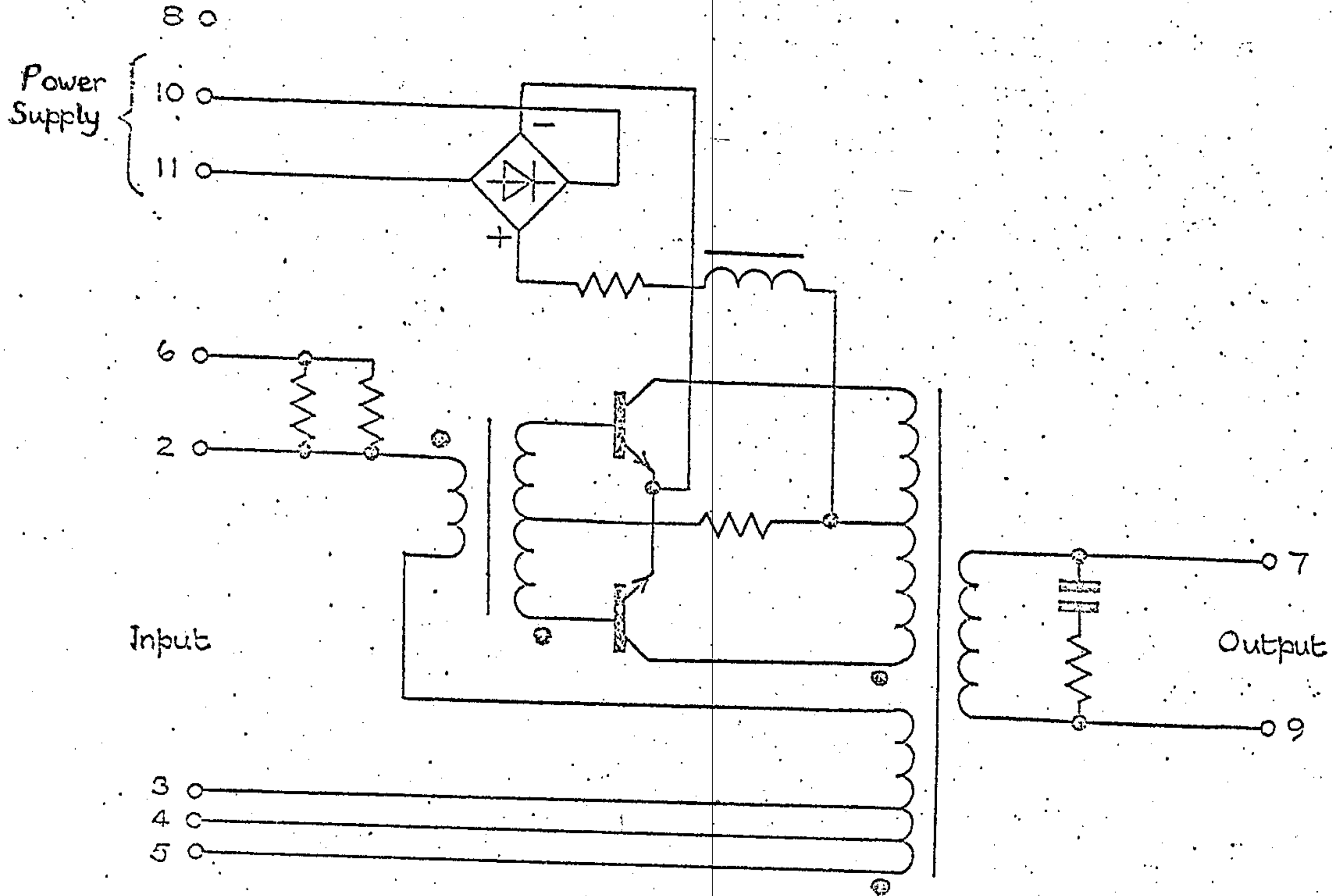


Fig. 2.7-1 : Line Amplifier Circuit (RR8101)

2.8. THE LINE ISOLATING TRANSFORMER

2.8.1 Sectionalising the Line

In systems operating over long distances it is usually necessary to divide the line into isolated sections. This sectionalisation is achieved in type RR systems by means of the line isolating transformer type RR8200, which permits the passage of the Reed signals along the system but attenuates 50Hz currents due to interference from mains or a.c. traction supplies. It should be noted that the line amplifier (see section 2.7) also acts as a sectionalising device. Thus, in a typical system where line amplifiers are required every 4km and the line is to be divided into 2km sections (for example), amplifiers and isolating transformers would be alternated, as shown in fig.2.8-1:

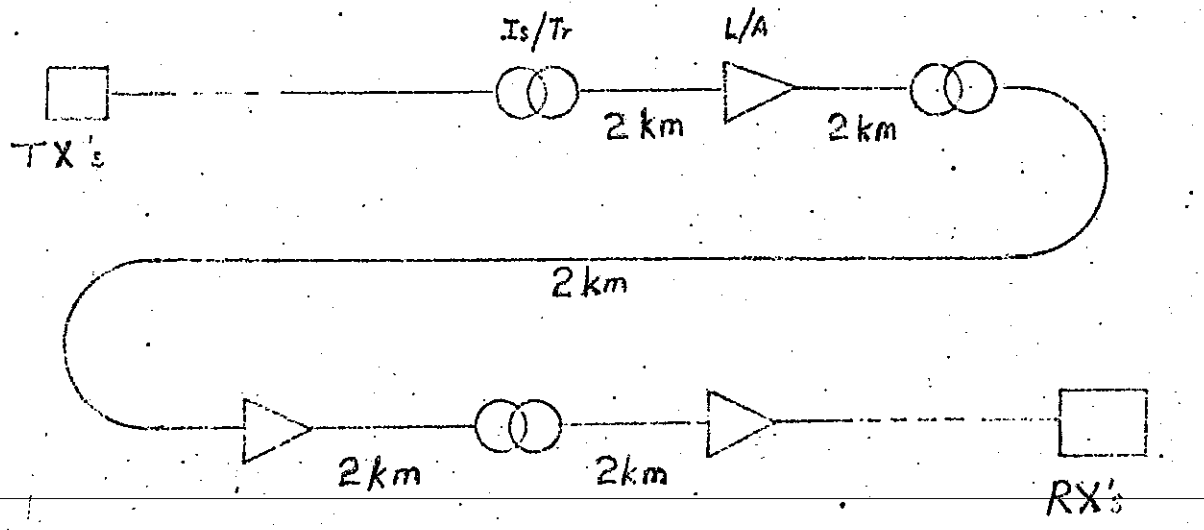


Fig. 2.8-1: Sectionalisation of a Typical System.

2.8.2 Electrical Characteristics

The line isolating transformer is attached to a plate which enables it to be mounted in the space occupied by a standard miniature plug-board in a relay-room or cupboard.

Six 2BA terminals, numbered T1 - T2 and t1 - t4, are arranged on the front of the transformer. T1 and T2 are connected to the primary winding, and are used for the section of line coming from the transmitter end of the system; t1 - t4 are connected to the secondary winding and used for the receiver end section of the line. The turns ratios between the various secondary taps and the primary winding are as follows:

Secondary terminals	Turns ratio
t1 - t2	1 : 1
t1 - t3	1 : 1.2
t1 - t4	1 : 1.4

2.8.2 (contd)

The taps are used to adjust the signal level, to compensate for the attenuation due to the resistance of the line. The amount of voltage gain that can be obtained in this way is limited because, as the turns ratio is increased, so the line impedance looking into the transformer primary winding decreases.

The transformer presents a low impedance to 50Hz and attenuates induced voltages from nearby industrial supplies by virtue of its shunting effect in the line. Such interference is likely to occur only in the event of system line faults.

2.9. POWER SUPPLY UNITS

2.9.1 Description

Reed transmitters and receivers, and also transmitter repeaters, require d.c. power supplies at 12V. These are generated from 110V a.c. mains by three types of unit, each with a different current rating, which are used for local installations of various sizes. Line amplifiers normally derive their power supplies from the line amplifier supply transformer (see section 2.7.1), which also works from 110V a.c. mains. The only external supplies to cupboards and relay rooms required for Reed equipment, therefore, are 110V mains supplies.

The signal levels at the outputs of transmitters and receivers change if the power supply voltage is changed. It is, therefore, desirable to limit the excursion of voltage from the d.c. power supplies to prevent failure of the units.

This requirement is met by one of three different arrangements which are available to suit various load conditions. First, a simple stabiliser which is fed from a 50 Volt location cupboard rectifier set, see figure 2.9-1(a). Secondly a transistor stabilised P.S.U., see figure (b). For very heavy loads a constant voltage transformer rectifier smoothing circuit must be used, see fig.(c).

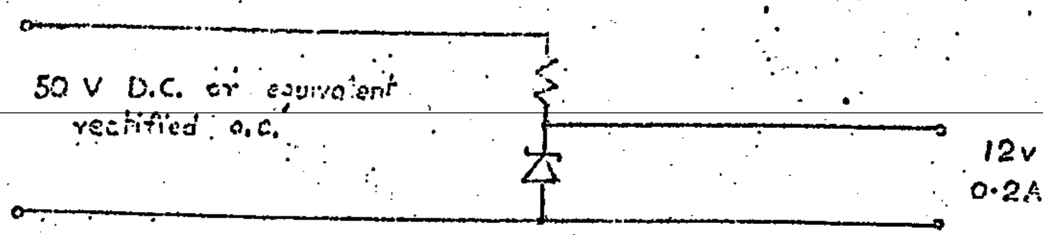


Fig 2.9-1 (a) Circuit of Reed Power Supply RR9410

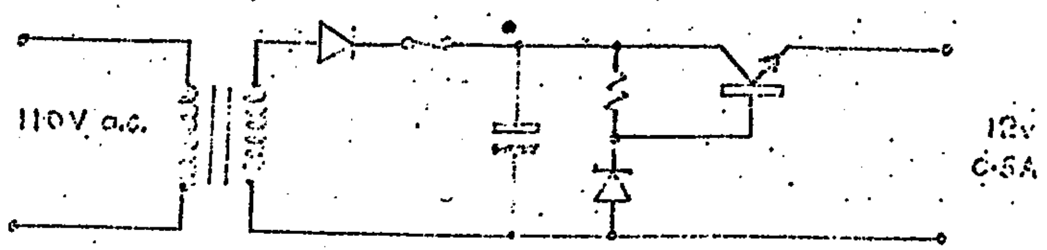


Fig 2.9-1 (b) Circuit of Reed Power Supply RR9420

2.9.1 (contd)

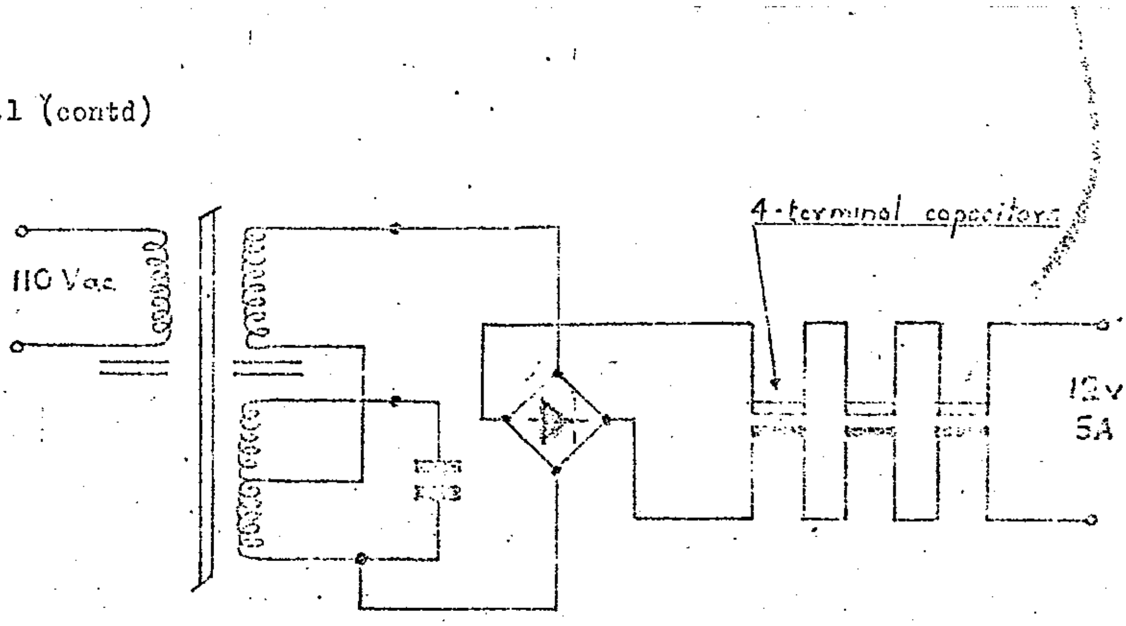


Fig 2.9-1 (c) Circuit of Reed Power Supply RR9131

The three types of d.c. supply give maximum currents of 200mA, 500mA and 5A, at 12V d.c., respectively, and are used according to the power requirements at each location. Where there is equipment belonging to several systems at a location, a separate supply unit must be provided for each system so that transmitters and receivers belonging to different systems are never fed from the same supply unit.

2.9.2 Electrical Characteristics

The three types of d.c. power supply units are designated RR9410, RR9420 and RR9131. The RR9410 unit is normally supplied with rectified 50 volt from the location power supply unit, and the RR9420 and RR9131 units are fed from 110V a.c. mains. The tolerance of the supply voltage variation is ± 15%.

Type	RR9410	RR9420	RR9131
Full load current	200mA	500mA	5A
Max.ripple at full load (peak to peak)	200mV	300mV	700mV
Permissible range of output voltage	12.0-13.5	12.0-13.5	12.0-13.5

The units are all designed to be mounted directly on relay room or location cupboard racks, in the same way as standard miniature plug-boards. The RR9410 and RR9420 each require the same space as one plug-board, and the RR9131 requires the same space as three. Outlines of these units are given on Figures 5.2-4, 5.2-5 and 6.

2.10. A.C. IMMUNISATION

Interference induced from high voltage sources such as overhead lines into a healthy F.D.M. line does not give rise to reed system maloperation. This can only be brought about through the mechanism of multiple line faults which may produce unwanted signals. The probability of such faults occuring is extremely small and has not occurred during several years of extensive reed application in a.c. electrified traction areas.

For non-vital applications therefore, it is not necessary to immunise the equipment.

3.0 APPLICATION OF THE EQUIPMENT

3.0.1 Contents

3.1 DESIGN OF TYPE RR SYSTEMS

3.1.1 Type RR Systems

In the previous two sections, the basic principles of type RR 3000 series equipment have been described, together with the individual units. In this section it will be shown how the units are combined to form complete systems.

As well as circuits which are of a vital nature requiring fully final-safe standards, there are a number of other circuits such as the control of ground frame releases, emergency auto replacement, track indications and the like which are not. For these circuits F.D.M. equipment with a high degree of reliability but with a less rigorous insistance on failure in a particular mode is required. The type RR 3000 series equipment has been engineered to fulfil this requirement. It comprises a single tuned-reed transmitter and a composite unit, containing an electronic amplifier and a follower relay, which is used in conjunction with a vital, double tuned, receiver filter of the RR 2000 series. The use of double-tuned receiver filters facilitates a large number of channels in a system because of their highly selective frequency discrimination.

There are two options open to the user in the application of type RR 3000 series equipment. Firstly, it may be used to convey controls and indications between interlockings or between lineside apparatus and the relay room; and, secondly can be included with fully vital channels in a hybrid system, provided the less-vital channels are also equipped with type RR 1000 series transmitters.

3.1.2 Requirements for all Systems

The following considerations apply to all type RR systems. They are concerned with the basic parameters of the equipment, and not with safety features.

3.1.2.1 The Line Pair

Broadly speaking type RR equipment will function using virtually any pair of conductors as the line, and in particular, does <u>not</u> require a matched transmission line. Because the input/output circuits of all the units include transformers (see section 2), it is not advisable to use a pair in which a steady d.c. is present without taking special precautions to isolate the equipment.

In general, pairs of conductors in standard railway signalling and telecommunications cables and on overhead pole routes are suitable for Reed systems. In cables, twisted pairs can be used with advantage to minimise 'crosstalk' on long systems (longer than 25 km). On pole routes, it should be noted that galvanised-iron conductors have a high resistance which severely limits the maximum possible distance between amplifiers, so that such conductors are unsuitable, and copper should be used instead.

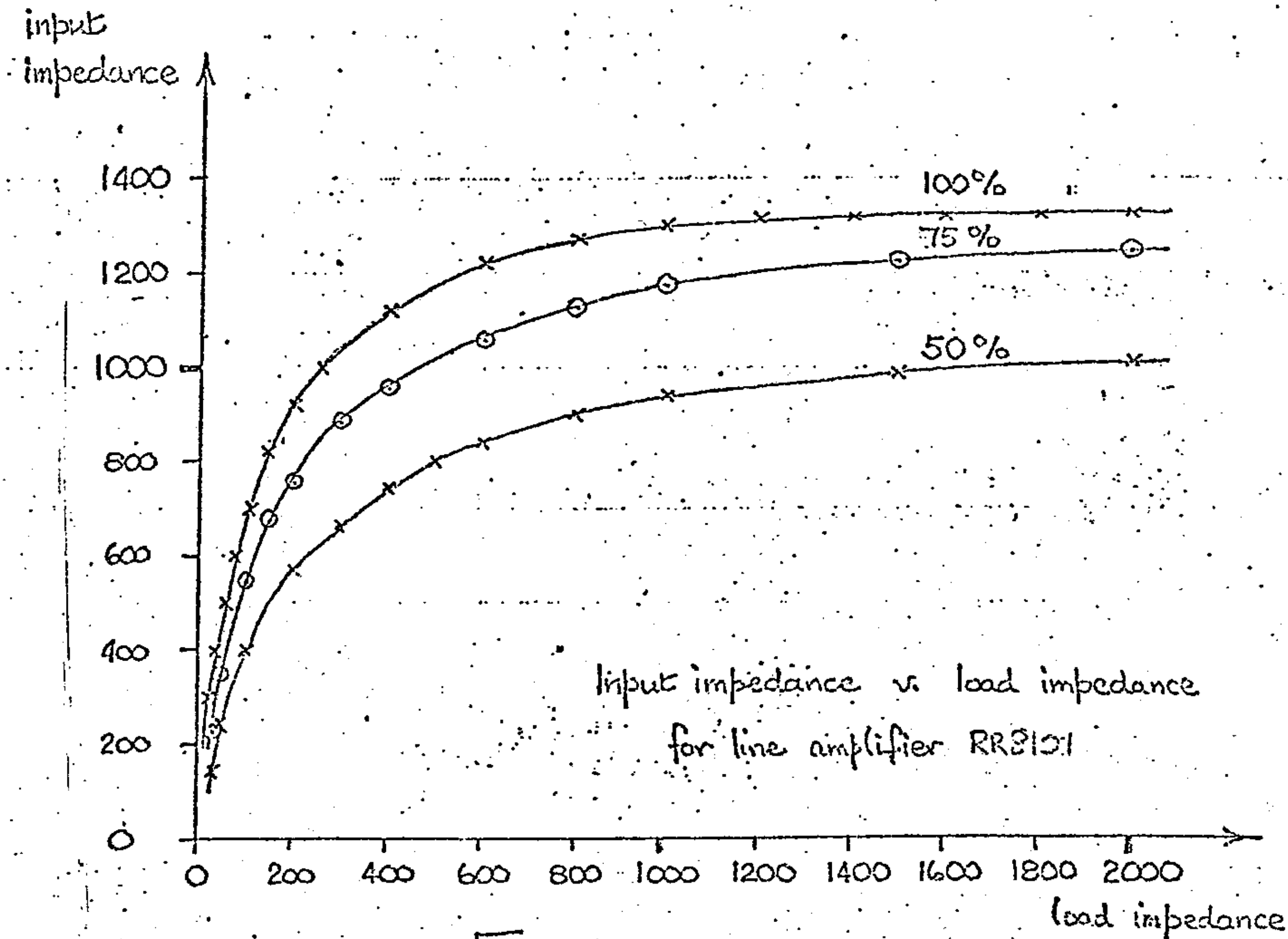


FIG. 3.1–1

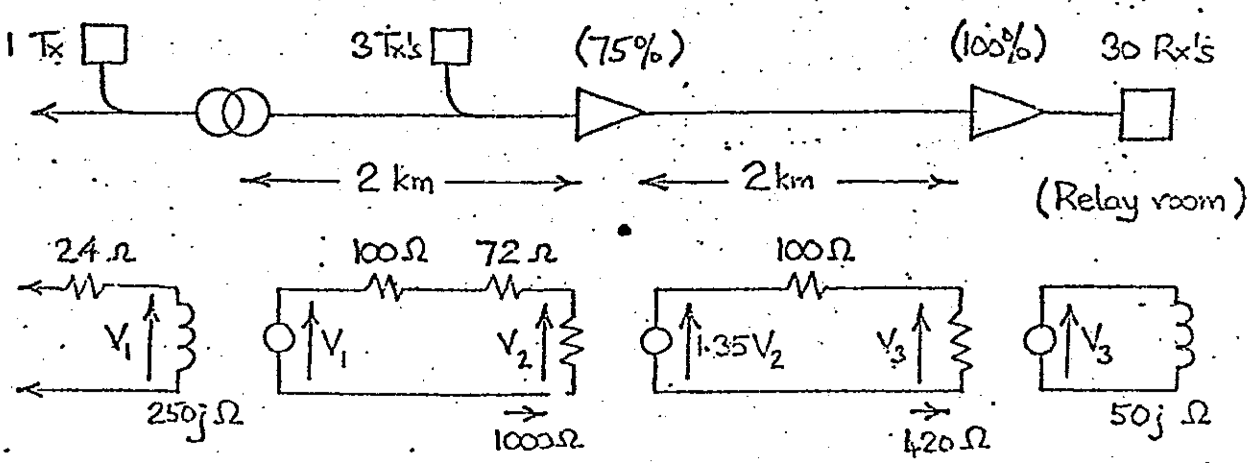


FIG. 3.1–2

Equivalent circuit of part of a typical system (controls), in cable having a resistance of 50 Ω/km loop.

3.2 INSTALLATION AND COMMISSIONING

3.2.1 Installation of the Equipment

This section gives the procedures that are required on site when a large concentration of Type RR equipment is being installed.

Particular attention is drawn to the requirements for the wiring of connections between units, as they affect the reliability of the systems.

3.2.1.1 Wiring of Equipment in Relay Rooms.

The recommended cable is 250V grade, PCP/VIR insulated to class MC1 B.R.872A. In general, twin twisted pair 9/0.3mm should be used and all circuits should be as short as possible, particularly the links between adjacent transmitters or receivers.

The type RR9131 power supply unit is rated at 5 amp and is, therefore, suitable for supplying all the transmitters or receivers of a system where they are grouped at the extremity of the system. Each power supply unit is provided with three sets of output terminals to enable the load to be shared by up to 6 bus-bar circuits.

If transmitter repeater units (TRUS) are used, a maximum of 25 should be fed from one RR9131 power supply unit. Not more than 5 TRUs should be connected to a spur.

For small concentrations of equipment, up to a full load of 0.5 Amp. , the RR9420 power unit may be used. In instances where there is a local 50 Volt d.c. source, the RR9410 power supply which is suitable for loads up to 0.2 Amp., may be used. (see section 3.1.2.9 for details of these items)

Connections between associated transmitter repeater units and their master transmitters are to be twin twisted screened cable 14/0.2mm. All screens on cables from a particular transmitter are to be connected together with the final connections taken to a free independent earth.

3.2.1.2 Wiring of Equipment in Location Cases.

All wiring should be in 9/0.3mm single core, 250V grade, PVP/VIR insulated to class MC1 B.R.872A. Wire runs should be as short as possible and arranged in a logical order.

Each cable from the power unit to the first transmitter or receiver unit must be no longer than 3m, and must be twin twisted-pair 9/0.3mm. The looping wires between transmitters or receivers must be as short as possible, and preferably in 1/1.0mm cable.

3.2.1.3 Checking the Line before Plugging in Units or Connecting Line Amplifiers

Normal cable testing techniques should be used to ensure that the line, be it either overhead or multicore, is free from earths and high resistance joints.

Where approved crimp terminals rather than slotted links with their associated nuts and washers are used for line connections at interlockings and location cases, it is necessary to carry out normal cable continuity and insulation testing before units are plugged in and connections made to line amplifiers and isolation transformers.

At this stage it is useful to ensure that good telephone communication exists between each Reed location and the relay room, as this is absolutely essential for the setting up of the Reed systems.

3.2.1.4 Preliminary Testing in the Relay Room and Locations before Plugging in Units

Check the wiring of the Reed systems, noting in particular that the correct polarities have been observed on the plugboards for the power supply connections. This is most important as incorrect polarity will damage or destroy the amplifiers. Ensure that the number of plugboards connected to one power supply does not exceed the maximum number scheduled. If standby supplies are provided check for correct polarities on plugboards.

3.2.1.5 Plugging in Units and Associated Testing

After satisfactorily carrying out the preliminary testing, transmitters, TRUs, and receivers may be plugged in and the power switched on. Check that all line amplifiers are working and that they are set to 100% and that isolating transformers are on the 1:1 tap. Switch on each transmitter by temporarily shorting terminals D4 and D7 and check that each output is between 0.59 and 0.68 volts a.c. Ensure after testing that each transmitter is switched off.

Check the master transmitter outputs in a similar manner. The switching contacts on each TRU should also be temporarily shorted out and the outputs observed.

3.2.2 Setting up the Systems

3.2.2.1 The object of setting up the systems is to ensure that each Reed receiver is operated within the optimum input voltage levels of 270 to 350mV. When small systems are to be set up, it is in order to switch on one channel at a time and observe the input volts to a particular receiver, but on large systems it is essential to switch on all channels which are normally energised. Consequently, to obtain an individual channel level it is necessary to use the appropriate receiver filter and for convenience, a filter adaptor (see section 4.2.1, noting that the intermediate line amplifier is unnecessary during setting up). The reading obtained corresponding to the optimum input level should be between 110 and 150mV.

3.2.2.2 System levels may be adjusted by the following methods:

(a) Line Amplifier

By changing the feedback tap and, if finer adjustment is necessary, by adding suitable resistance in series with the input circuit. Suitable resistors would be a metal oxide glass encapsulated type rating 1 watt with a range of values between 68 and 820 ohms.

(b) Isolating Transformer

By changing the tap on the secondary winding.

System channel levels are adjusted by working progressively away from the relay room. A system may be divided into sections, each section being terminated with either a line amplifier or an isolating transformer.

In the typical indication system shown in fig. 3.2.2-1, adjustment of the isolating transformer at location A will alter the received levels from all the transmitters in section 2 (and to a lesser extent from the preceding sections). Adjust this isolating transformer at location A until the received levels in the relay room from transmitters in section 2 are correct and follow a similar procedure progressively for all other sections, i.e. line amplifier at location C to be adjusted for correct received levels from transmitters in section 3 etc., until the system is completed and all receiver levels are correctly set.

In the typical control system shown in fig. 3.2.2-2, adjustment of the isolating transformer at location A should be made to ensure correct input levels to the receivers in section 2; in this instance a check must be made to ensure that the receivers at location B are also correctly fed. A similar procedure is to be followed for all other sections i.e. line amplifier at location B to be adjusted for correct received levels in section 3 etc.

It is important to keep the gain of both line amplifiers and isolating transformers as low as possible, i.e. to compensate for losses in previous line section, and this is particularly important in long systems where there may be many sections between the first field unit and the relay room. For indication systems of this type, it is convenient to switch on in the field a high and low frequency (possibly f6 and f47) transmitter, checking and adjusting these levels progressively section by section back to the relay room. Conversely, with a control system of this type, having switched on the appropriate high and low frequency transmitters, check and adjust these levels section by section progressively away from the relay room to the first field units. These individual channel levels in each section should be adjusted to lie between 270 and 350mV.

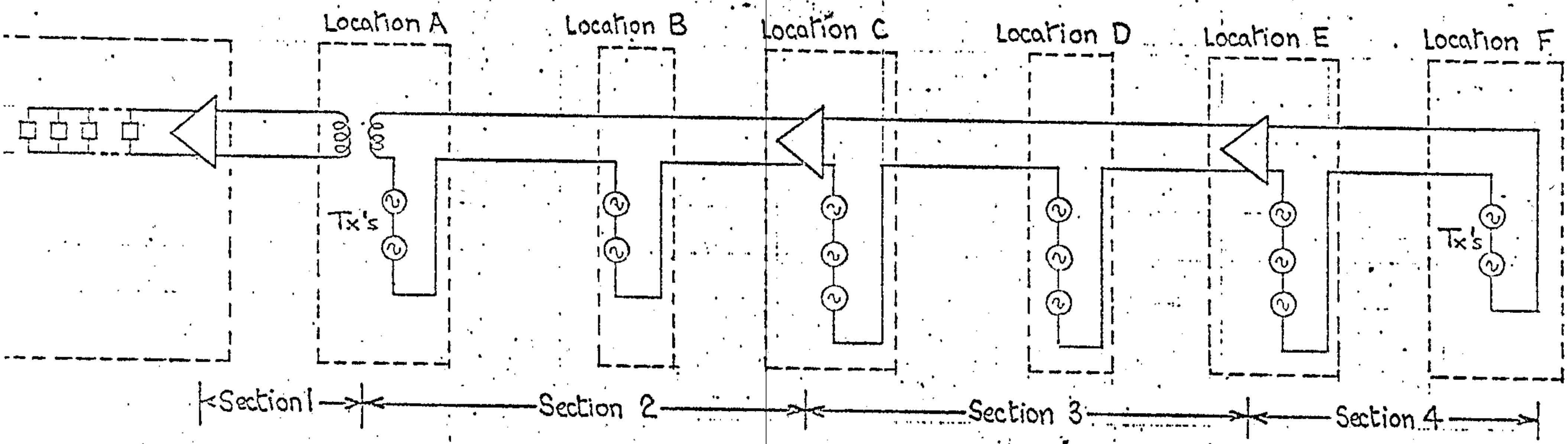


Fig. 3.2.2-1
Typical Indication System.

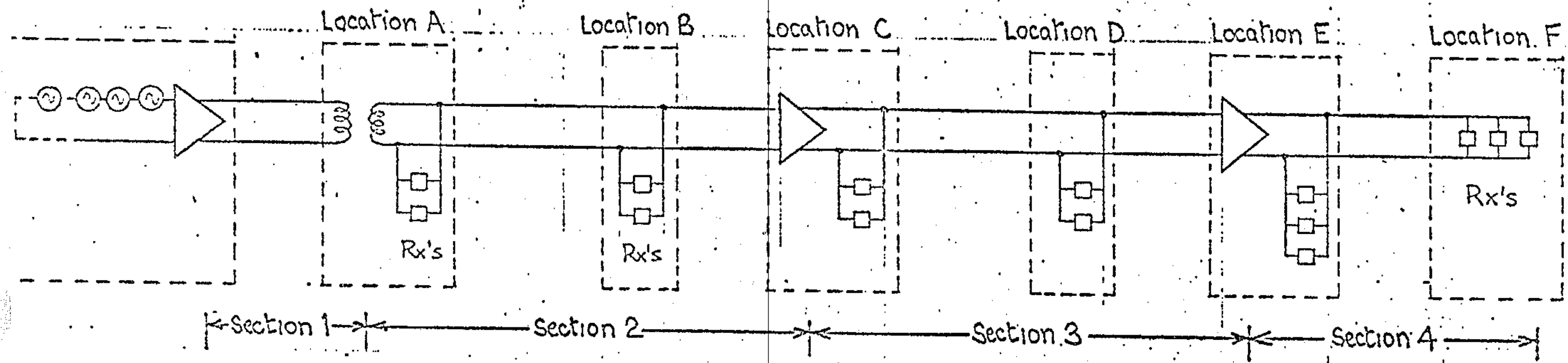


Fig. 3.22-2.
Typical Control System.

3.2.2.3 When a fairly large system has to be set up, all channels which are normally energised should be switched on with at least one in every six functions at a particular location being either fed or energised. Check receiver levels both in the relay room and in the field; although at this stage these will probably be low, they may indicate the state of system and enable faults to be located and rectified. Set the received channel levels for the switched-on functions section by section.

3.2.2.4 Duplex Systems are set by switching on one channel at a time and observing the input level at the particular receiver. If there are no line amplifiers provided, then the system will have been designed to ensure adequate receiver input levels; however each received channel level may be reduced if necessary, by the addition of series resistance between the appropriate receiver and the line.

3.2.2.5 The final test is to ensure that each receiver operates correctly when switched on and off again.

All transmitters are to be switched on. One team proceeding from the relay room observes receivers in the field as the relay room team switches off individual transmitters, and also switches each transmitter in the field in turn for the inside team to observe the receivers at their end.

Following the successful completion of these tests the Reed systems should be cleared of all test straps and will then be available for through signalling testing.

3.1.2.1 cont.

Whatever type of line is employed, its series resistance per unit length, considered in conjunction with the input resistance and voltage gain of the line amplifier, determines the maximum spacing at which amplifiers will be required in a system. For example the resistance of 1/1.13mm copper conductors as used in standard railway signalling cable is approximately 50 ohm/km loop; the total resistance of a 2 km section of line in this cable would therefore be 100 ohm. The input impedance of the amplifier depends upon the load connected across its output and the setting of the feedback tap (see section 2.7) and is shown in fig. 3.1-1

Each transmitter is connected in parallel with a resistor of 24 ohms in order to maintain line continuity when a transmitter is withdrawn from its plugboard, and all such resistors are connected in series with the line (see section 1.2.1).

Each receiver appears as an impedance of the order of 1500 ohms in parallel with the line to Reed frequencies other than its own. To its own frequency, it appears as an impedance of 750 ohms in parallel with the line.

The line isolating transformer has a nominal ratio of 1:1. The primary inductance appears as a load of j200 ohms connected across the line.

The level of the output signal from a transmitter is nominally 600mV. So as to allow an adequate margin, systems should be designed so that the levels at the input terminals of all receivers are each approximately 300 mV.

Using the various figures quoted above, it will be seen that a complete type RR system can, if necessary, be designed by basic network calculations. This procedure is necessary whenever a special case arises; for instance, if the use of a non-standard type of cable is being considered, or if a possible duplex system is being investigated. As an illustration, an equivalent circuit for a typical type RR system, based on the above figures, is shown in fig. 3.1-2.

However, for many standard systems it is possible to derive a set of rules for design, and these can then be used satisfactorily in the majority of cases without the need for detailed calculations; calculation can be used as a check wherever any doubt arises. The rules are set out in sections 3.1.2.2. to 3.1.2.10 below

3.1.2.2 <u>Line Levels and Isolation</u>

If it is proposed to use conductor pairs for type RR systems in cables shared with telecommunications circuits, attention is drawn to the peak transmission level of up to 30V, for a full system, which is likely to produce unacceptably high crosstalk levels in the telecommunications circuits. In certain circumstances it may be possible to reduce the line voltage.

3.1.2.2 (contd)

In a.c. electrified areas where the Reed systems are in lineside cable or where close parallelism with supply authority overhead lines occurs, the system should be sectionalised by means of line amplifiers or isolating transformers, as appropriate, every 2 km or at such distances as the safety requirements of the C.C.I.T.T. regulations dictate. Amplifiers and transformers may be used alternately at successive isolating points, bearing in mind the rules for additional line amplifiers given below (section 3.1.2.3.), but transformers should not be used at successive isolating points because of their loading effect on the line.

In sections where there is no traction or H.V. supply interference, the spacing of line amplifiers depends upon the type of conductor; for typically 1/1.13mm conductors in signalling cable, the maximum advisable spacing is 4 km; for 40 lb. conductors on poles routes, it is 10 km. Basically, a loop resistance of 200 ohm per section should be aimed for.

3.1.2.3 Guidance for use of Additional Line Amplifier.

An additional line amplifier should be inserted into the system or substituted for a line transformer in accordance with the following rules.

a) If the number of transmitters which would have occurred in the input to one line amplifier or between two line amplifiers would have been 25 or more then an additional line amplifier should be introduced so as to reduce the number to below 25.

An exception is made in the case of the initial line amplifier of a control system situated in the relay room or location housing all the transmitters of the system.

b) If more than 4 transmitters would have occurred on the input of one isolating transformer is between the previous amplifier and the isolating transformer, the transformer is replaced by an amplifier.

c) If more than 17 receivers would have been connected on the output of an amplifier, or between one amplifier and the next amplifier, additional line amplifiers should be introduced.

An exception is made in the case of the final line amplifier of an indication system situated at the relay room or location housing all the receivers on the system.

d) If more than 4 receivers would have been connected on the output of a line transformer or between it and the next amplifier ahead, replace the transformer with a line amplifier, and observe (c) above.

e) Where receivers are distributed along a section, the attentuation of the cable must be considered when determining the number and disposition of line amplifiers.

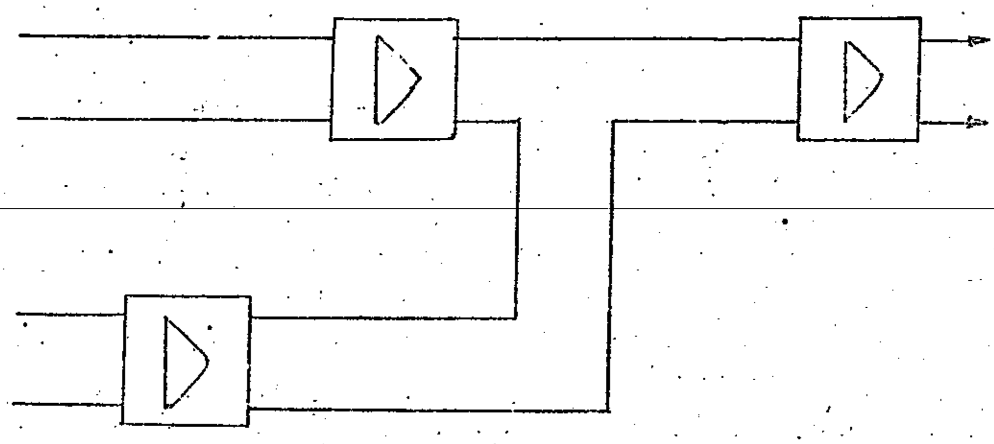
3.1.2.4 Terminal Amplifiers for Control and Indication Systems.

An amplifier is always interposed between the incoming line and the receivers of an indication system. Similarly a line amplifier is used between the transmitters or TRUs of a control system and the outgoing line.

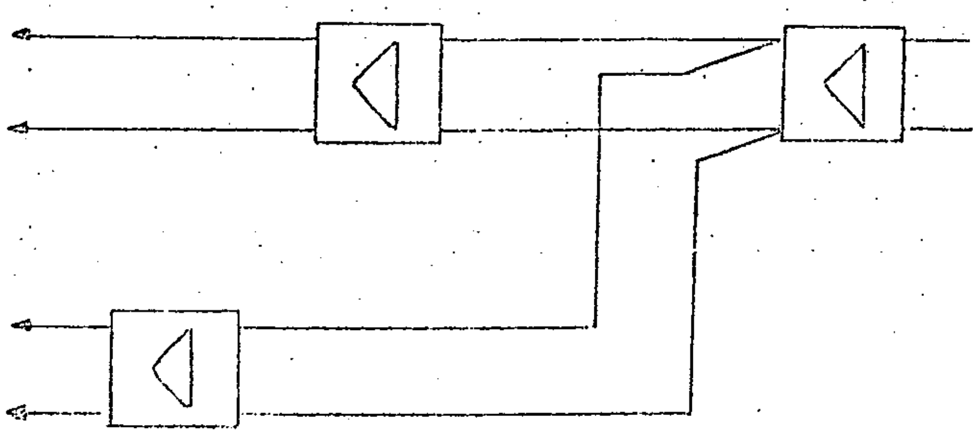
The nearest isolation point to the terminal line amplifier of an indication system should also be fitted with a line amplifier and not an isolating transformer.

3.1.2.5 Branched Systems

There are many possible configurations of systems having one or more branches, and they cannot be treated in detail in a standard set of rules. Very short branches can sometimes be treated as part of the main system, i.e., just as a group of transmitters or receivers in one place. Long branches should however be isolated from the main system by amplifiers. Note that the output impedance of the amplifier is very low (about 40 ohms) and it can, therefore, readily be connected in series with the branch, to the input of a second amplifier feeding the main system, thus:



Converging Systems



Diverging Systems

3.1.2.6 Use of Transmitter Repeater Units

In large interlockings where transmitter repeater units are used, up to seven can be fed from a single standard Reed transmitter; this economises in Reed transmitters. The connections from the transmitter should be in twin screened cable (e.g., twin 14/.2mm, braided - screen), with all screens earthed at one end only to a single independent low-resistance earth; this is necessary to avoid coupling between the T.R.U. input and its four outputs. For the same reason, the four output pairs should not be closely bundled together.

3.1.2.7 Transmitter Switching Circuit

There is no restriction on the length of the transmitter switching circuit (see section 2.3), within the same relay room or location cupboard.

Connections outside the relay room or cupboard isolated from other sources of interference must be limited to a distance of 50m.

3.1.2.8 Receiver Outputs

The receiver's follower relay is enclosed within the amplifier container, and external connections from the relay contacts are made by means of plugboard terminals in the normal way.

3.1.2.9 Power Supplies

One 5 amp Reed power supply unit type RR9131 is sufficient to supply all the transmitters or receivers of a system at the relay room. The connections should be made in the manner described in section 3.2.1.

Type RR9420 Reed power supply units will normally be used in location cases and will supply up to the following numbers of transmitters and receivers.

Number of Transmitters	Together with Number of Receivers
10	-
8	1
6	2
4	3
2	4
-	5

The type RR9410 Reed power supply unit will supply either four transmitters or two receivers, from a 50 Volt d.c. source.

Separate power supply units should be provided for each Reed system.

All d.c. supply leads should be as short as possible and the instructions in section 3.2. should be followed.

3.1.2.10 Selection of Frequencies

The response of line amplifiers is linear throughout the frequency range used in type RR Reed systems. The response of isolating transformers, however, varies with frequency such as to produce a measurable effect in long systems. High frequencies are transmitted with slightly less attenuation than lower frequencies. This effect is the opposite of that which would be expected from a plain length of cable. On systems using isolating transformers it is advisable to counter this effect by applying the following rules.

(i) Systems should be designed so that channels with higher frequencies work to points further from the control point;

(ii) Where the full number of available channels is not required for a system, those in the middle of the frequency band should be used in preference to those near its ends;

(iii) Within individual sections, frequencies should be grouped as closely as possible;

(iv) A few spare frequencies should be left unused throughout the range, so that, if additions are required after installation, they can be made without infringing the above rules.

Note that a list of frequencies and their associated channel numbers is to be found in section 5.

3.1.2.11 Lightning Protection

When considering the provision of lightning protection, it is advisable to weigh the cost of full protection against the anticipated risk to the equipment; only in regions with very high incidence of electrical storms is provision of full protection considered as being necessary.

For full protection, surge diverters such as AEI type 16A and Reed surge protection units type RR8400 are connected into every line pair entering a location or relay room, and, in addition, surge diverters alone are connected to every other circuit entering; any unprotected core whatsoever can provide a possible route into the location for surges. This degree of protection would normally only be required where overhead lines are used.

Where conditions are less extreme, it is sufficient for non-vital type RR systems to provide surge diverters only, and where systems run entirely in cable, it may be considered possible to dispense with these as well.

3.1.3. Requirements to Minimise Crosstalk and System Noise

Spurious signals can occur as a result of crosstalk between systems where lines run adjacent to one another, and also as a result of intermodulation between the various frequencies in a system (and between system frequencies and harmonics of the mains frequency, at places where the latter are induced into the line, either from power distribution cables or from a.c. traction systems). To protect against their effects, the additonal rules set out below must be observed.

3.1.3.1. Multicore Cables

It is recommended that a standard multicore signalling cable to British Railways specification BR 872 A be used for the line. Other cables may be used but in all cases the following conditions must be observed.

a) The cable must be of a type in which successive layers of cores are laid with opposite directions of rotation (i.e. NOT 'unilay').

b) No system must use two cores in different layers in the cable.

c) Where line-pairs for successive systems lie adjacent to one another within a layer, alternate pairs of the series should be transposed at a break point approximately midway between line sectionalising points throughout. The principle is illustrated in fig. 3.1.3-1 below:

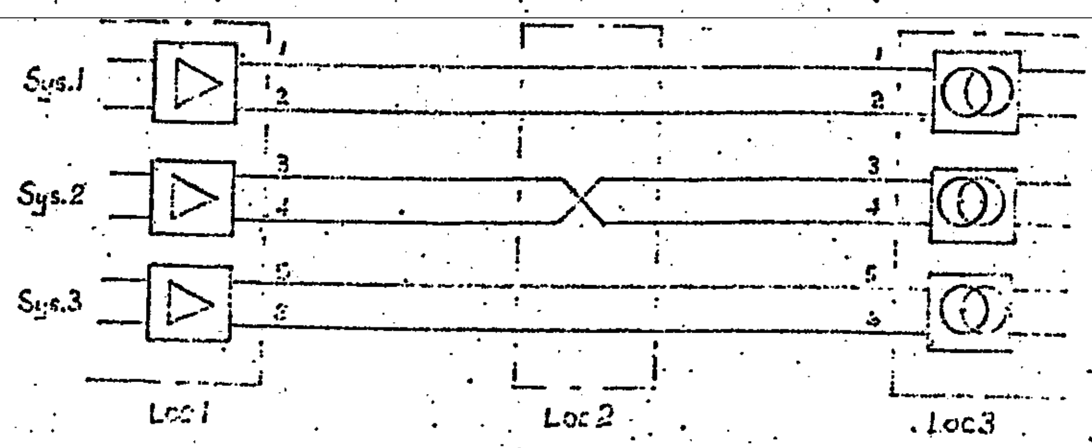


Fig. 3.1.3 - 1: Typical Transposition in Multicore Cable

3.1.3.1. (contd)

In the illustration, system 1, 2 and 3 occupy cores 1 to 6, which are successive cores in one layer of a cable, as shown. All three systems are sectionalised at location 1, and again at location 3, and a cable break also occurs at location 2, which lies approximately half-way between locations 1 and 3. At this point, system 2 only is transposed, so that core 3 coming from location 1 is connected to core 4 going to location 3, and vice versa. This has the effect of making crosstalk voltages induced by each system into the others cancel out in each half-section. The transposition point should be as near the middle of the section as possible, and in any case not more than 400m from the mid-point.

3.1.3.2 Overhead Lines

Overhead lines are acceptable, except in a.c. electrified territory. A standard scheme of transpositions must be used to minimise crosstalk in cases where there is more than one at intervals not greater than 10 km.

Composite systems, partly in cable and partly in overhead lines, are acceptable provided the appropriate rules are observed for the individual sections.

3.1.3.3 Line Levels

Line levels are controlled for two reasons. Firstly, if the receiver filter is over-energised the input reed may be unduly stressed and this may lead to its early failure, and secondly, when the input drops below a certain level, the threshold of sensitivity, the receiver will no longer respond. It is, therefore, in the user's own interests to set the signal levels at the receivers to the preferred value;this is in the range 270 to 350mV.

4. MAINTENANCE AND FAULT FINDING INSTRUCTIONS

4.0.1 Contents

4.1 INTRODUCTION TO MAINTENANCE

The Type RR System is built up of plug-in easily replaced units, and site maintenance, apart from the routine monitoring of the performance of the system, involves only the speedy tracing of the unit causing any fault which occurs, and its replacement to ensure rapid restoration of the system to normal operation.

Fault finding and rectification within the units themselves is a workshop function and should not be attempted on site. It is important that the fault report on any unit replaced in the course of maintenance should give as much detail as possible regarding the symptoms and circumstances of the failure.

The detachable amplifier portion of the receiver is a common unit for all frequencies, and the number of spare receiver amplifiers to be held will be related to the total number of receivers in the installation, probably varying from 5% in large installations to 10% in smaller ones.

Transmitters and the filter portion of receivers can only be replaced by an identical unit of the same frequency and type number, a non-interchangeability pin code ensuring this feature. Consequently it will be necessary to hold at least one transmitter and receiver filter of each frequency used on the installation.

To reduce this quantity of spares an alternative approach may be considered permissible on some installations. Two universal spare channels, f71 and f72, are available either of which may be used to replace a failed channel until such time as repaired or new units are obtained. Additional holes must be drilled in the plugboards to allow these spare channels to be used. Details are given in section 5.2.

All type RR equipment should be stored under dry conditions and when handled and transported, should be treated with similar respect to that given to safety relays. Until actually installed, the equipment should continue to be housed in the individual packs in which it is supplied. Labels on the packs fully identify the contents.

4.2 TAKING MEASUREMENTS

The most suitable instruments for taking measurements on Type RR systems are the Model 8 Avometer and a transistorised voltmeter similar to the Farnell Instruments Ltd. type TM1 or the Levell Transistorised A.C. Microvoltmeter type TM3A. A heavy duty technician's Avometer should only be used in emergency, and then only for taking d.c. measurements and the a.c. output of the transmitter or T.R.U.

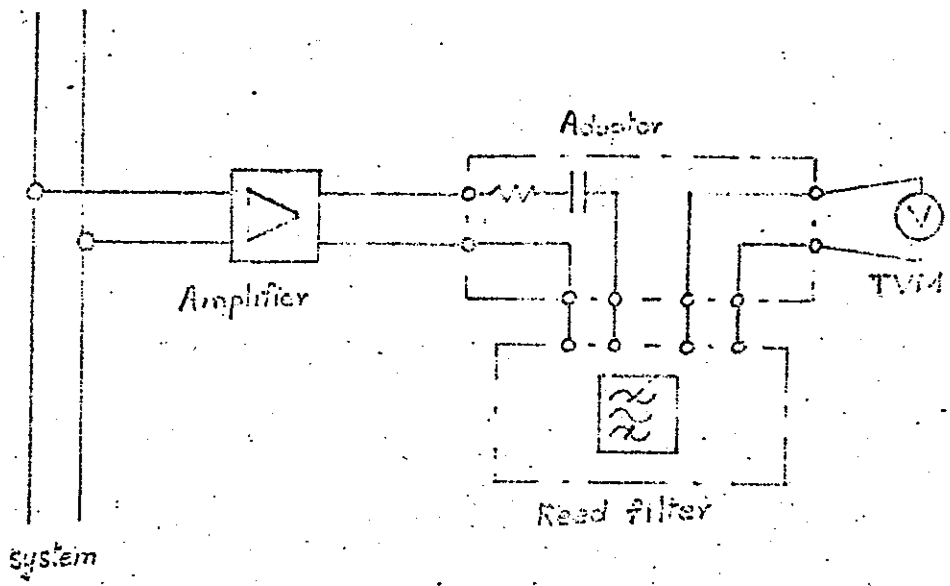
4.2.1 Line Measurements

Measurements of line voltage on the input and output of line amplifiers and line transformers can be taken using the 10-volt a.c. scale of a Model 8 Avometer. The loading of this range of the meter also makes it suitable for taking direct readings of line voltages with no other load on the line at that point, or for measuring the output voltage of an amplifier or transformer whose output terminals have been disconnected from the line. The reading obtained will have little exact significance, and with most working systems will be a rapidly varying one between 1 and 3 volts. It is, however, useful as an indicator of the presence of normal line signal.

Voltage measurements of individual frequencies on the line are only possible by using a Reed filter. A receiver filter, preferably with previously determined input/output calibration, can be used for this purpose, with a transistor voltmeter connected to the secondary side of the filter. To reduce the loading on the system, it is sometimes desirable to interpose a line amplifier set at 100% feed back between the line and the filter. To facilitate connections to the filter, a filter adaptor is provided. This takes the form of a dummy amplifier, and mounts on top of the filter to form a complete plug-in unit, in the same way as a normal receiver amplifier. However, the filter adaptor only contains links which connect the line input from the plugboard to the primary Reed filter coil, and the secondary coil to a pair of terminals on the front of the unit, to which the transistorised voltmeter can be conveniently connected (In the case of a.c. immunised systems, the adaptor provided also contains a resistor and a capacitor, in series with the input from the line, to represent the fuse and capacitor used for immunisation in the receiver amplifier which is used in this case (see section 2.10.), and to attenuate the signal by the same amount, so that readings obtained with the amplifier correspond exactly to those occurring in the working system).

4.2.1 (cont.)

The complete arrangement is as shown:



A T.V.M. reading between 112mV and 145mV is for an energised channel. Caution should be observed in interpreting low values of signal due to noise generated within the system, or crosstalk from adjacent systems. If the readings are less than 6mV from the filter (equivalent to 15mV on line), the possibility that a significant proportion of this reading is due to stray pick-up or noise within the instrument should not be disregarded.

4.2.2. D.C. Supply

The d.c. supply to transmitters and receivers (and T.R.Us. if provided) may be measured on the 25-volt scale of the Model 8 Avometer, and should read between 12 and 13.5 volts.

4.2.3 Input to Power Supply Units

The a.c. supply to power supply units may be measured on the 250-volt scale of the Model 8 Avometer. The reading should be between 93 and 127 volts. For the RR9420 unit the d.c.supply may be measured on the 100 volt scale and should be between 43 and 57 volts.

4.2.4 A.C. Supply to Line Amplifiers

The a.c. supply to line amplifiers should be measured on amplifier terminals 10 and 11 using the 100-volt scale of the Model 8 Avometer. The reading should lie between 22 and 26 volts if the 24 volt tap is in use, and between 26 and 30 volts if the 28 volt tap is in use.

When a d.c. supply to the line amplifier is used instead, the Avometer should be set to the 100-volt d.c. range and connected to terminals 10 and 11. The reading should lie between 22 and 26 volts.

4.2.5 Transmitter and T.R.U. Output

Measurements should always be made across the line resistor which is associated with the transmitter or T.R.U. and is mounted directly behind the plugboard. Using the 1 or 1.5 volt scale of the transistorised voltmeter or the 2.5 volt A.C. scale of the Model 8 Avometer, the reading should be between 0.59 and 0.68 volts A.C. when the D.C. input to the transmitter on terminals D3 and D5 is 12 volts. If the D.C. input voltage is above 12 volts the A.C. output will rise correspondingly to give an upper limit of 0.75 volts A.C. with 13.5 volts D.C. input. The corresponding limits for the T.R.U. are 0.57 to 0.69 volts at 12 volts D.C. input with an approximate limit of 0.77 volts with 13.5 volts D.C. input.

It should be noted that the reading across the line resistor is not appreciably affected by other channels which may be operating in the same system.

4.2.6 Receiver Output and Follower Relay Input

When a suitable signal appears on the line the receiver amplifier output causes the internal relay to be energised. The relay voltage, which should be nominally 12 volts, may be measured across terminals A1 and D2 of the receiver plugboard using the 25-volt rangeof the Model 8 Avometer or Technician's Avometer.

4.2.7 Receiver Background Voltage

'Background' is the signal which can pass through the Reed filter from the line when the corresponding transmitter is switched off. It arises from the effect of all the other frequencies present in the system, and from crosstalk from other systems. It is measured in the same way as that for taking line levels; (see section 4.2.1.).

Because of the switching effect of the amplifier circuit no voltage will appear on the relay until the threshold value is reached.

4.3 PROCEDURE FOR CHECKING UNITS WITH SUSPECTED FAULTS

4.3.1 Checking a Transmitter

Step 1 - Measure output on line resistor

If correct - Unit O.K.
If low or zero - go to step 2.

Step 2 - Measure d.c. supply on terminals D3 (+) and D5

If correct - go to step 3
If low or zero - check power supply unit.

Step 3 - Remove the transmitter from plugboard and replace the same unit. Measure output on line resistor.

If correct - Unit O.K., but examine and if necessary clean plugboard contacts.
If low or zero - go to step 4.

Step 4 - Remove the transmitter from the plugboard and measure between plugboard contacts D4 and D7 on the x1 resistance range of the Avometer.

If zero ohms - Unit faulty
If high reading - Unit probably O.K., but examine switching circuit for open circuit or high resistance contact.

It may be an advantage to carry out the above routine using a separate test plugboard drilled to receive all pin codes. Such a plugboard should be wired with a 12-volt smoothed constant voltage d.c. supply on terminals D3 (+) and D5 and an output resistor, 24 ohms, wired across terminals D1, D6. A switch should be wired between D4 and D7. The switch should normally be 'on' for the above tests.

4.3.2 Checking a Transmitter Repeater Unit (T.R.U.)

Step 1 - Measure each output on corresponding line resistor.

If correct - Unit O.K.
If low or zero on all outputs - go to step 2.

Step 2 - Measure d.c. supply on terminals D2 (+) and D1

If correct - go to step 3
If low or zero - check fuses in power supply circuit and corresponding power supply unit.

Step 3 - Remove T.R.U. from the plugboard and replace the same unit. Measure each output on corresponding line resistor.

If correct on all outputs - unit O.K., but examine and if necessary clean plugboard contacts.
If low or zero on one or more outputs - go to step 4.

Step 4 - Remove the T.R.U. from the plugboard and measure with x1 resistance range of the Model 8 Avometer between plugboard contacts A5-A7, B5-B7, C5-C7 and D5 - D7 as appropriate to check for continuity of switching circuit, when low or zero output has been measured on the A,B,C or D banks respectively.

If zero ohms - switching circuit and line correct. Go to step 5.
If high reading - examine switching circuit.

Step 5 - Replace T.R.U. with another unit of the same type. Check for correct outputs. Report defective unit for workshop repair.

4.3.3 Checking a Receiver (Where Amplifier is type RR3000)

Step 1 - Check as far as possible for an input to the receiver. This cannot be done directly on a working system, so check if possible the corresponding transmitter for output, and the final line amplifier for line signal output. If this cannot be done at this stage, assume an input and go to step 2.

Step 2 - Measure d.c. output to follower relay on plugboard terminals D2 (+) and A1.

If correct - Filter O.K.
If low or zero - go to step 3.

Step 3 - Remove the receiver from its plugboard and then return it. Again measure d.c. output to the follower relay on plugboard terminals D2 (+) and A1.

If correct - Filter O.K. but examine and if necessary clean the plugboard contacts.
If low or zero - go to step 4.

Step 4 - Measure d.c. supply on plugboard terminals D1 (+) and A1 (-)

If correct - go to step 5
If low or zero - check power supply unit.

Step 5 - Remove receiver from plugboard, replace receiver amplifier type RR3000 with a spare unit of the same type, and replace receiver on plugboard. Measure d.c. output to follower relay on plugboard terminals D2 (+) and A1.

If correct - original receiver amplifier was faulty. Report fault and return unit for workshop repair.
If low or zero - go to step 6.

Step 6 - Remove receiver and replace receiver filter with a spare unit of the same type reference. Return complete receiver to the plugboard. Note that the type reference identifies the particular channel frequency, and any other filter will not plug into the plugboard. Measure d.c. output to follower relay on plugboard terminals D2 (+) and A1.

If correct - Original receiver filter was faulty. Report fault and return unit for workshop repair. Go to step 7.
If low or zero - It will be necessary to check associated transmitter and the intervening line circuit of the system. See also alternative below.

4.3.3 (cont)

Step 7 - Recheck with original receiver amplifier and new filter. Measure d.c. output to follower relay on plugboard terminals A1 (-) and D1 (+).

If correct - Original receiver amplifier was O.K. Return spare to stock.
If low or zero - Original receiver amplifier was faulty. Replace with good spare receiver amplifier and report fault and return faulty unit for workshop repair.

4.3.4 Checking a Power Supply Unit

Step 1 - Measure d.c. output on load.

If correct - Unit O.K.
If low or zero - go to step 2.

Step 2 - Measure a.c. or d.c. input as applicable.

If correct - Unit faulty. Report fault and return unit for workshop repair.
If low or zero - Check supply fuse and replace if necessary. Check main power supply.

4.3.5 Checking a Line Amplifier

Step 1 - Check whether an a.c. immunisation unit (see section 2.10), is fitted to the amplifier.

If no, go to Step 2.
If yes, short the immunisation unit out by connecting links from terminal 1 to terminal 11, 6 to 16 and 9 to 19 on it. Check whether the fault has now cleared.
If yes, the immunisation unit is faulty and requires changing and returning for workshop repair.
If no, remove the three links and go to step 2.

Step 2 - Check that the correct power supply is present between terminal 10 and 11. Note that a d.c. supply may be provided as a stand-by for a normal a.c. supply.

If yes, go to step 3.
If no, check the supply connections, the fuses and the main supply,.

4.3.5 (cont.)

Step 3 - Measure the d.c. voltage appearing across the 5 ohm (or 4.7 ohm) resistor on the amplifier baseplate.

If it lies between 5V and 8V, go to step 4.
If it is outside this range, a transistor in the amplifier is probably defective, and the amplifier requires replacing (note that, if the transistors are functioning correctly, they are both warm; if one is faulty, it can often be felt to be cold).

Step 4 - Measure the input from the line between terminals 1 and 6, and the amplifier input between terminals 2 and 6. Check that these two readings correspond, making allowance for the resistor or link connected between terminals 1 and 2.

If both are normal, go to step 5.
If the line signal (1 and 6) is normal and the input (2 and 6) low, the resistor or link requires replacing WITH ONE OF THE SAME VALUE; note that possession of the system will normally be required before this can be done.
If the line signal (1 and 6) is low, go to step 7.

Step 5 - Measure the amplifier output between terminals 7 and 9, and check that it corresponds with the input reading between 2 and 6, making allowance for the setting of the feedback link between terminal 6 and one of 5, 4 and 3. The approximate values of gain to be expected are:

link between terminals	gain
6 - 5 (100%)	1
6 - 4 (75%)	1.3
6 - 3 (50%)	2

If the readings correspond, the amplifier is O.K. and the fault lies elsewhere.
If the output is low or zero, go to step 6.

4.3.5 (cont.)

Step 6 - Remove outgoing leads from terminals 7 and 9. Connect a 200 ohm resistor and the Model 8 Avometer on its 10V a.c. scale across terminals 7 and 9, and measure line output voltage.

If it is normal, fault is not in line amplifier. Restore line connection to terminals 7 and 9, making sure that the lines have not been reversed. Proceed to check the line section ahead and the next line amplifier.

If it is low or zero, change the line amplifier and go to step 8.

Step 7 - Remove the coupler from the amplifier and measure the input from the line between terminals 1 and 6 on the coupler, using the 10V a.c. scale of the Model 8 Avometer.

If it is now normal, change the amplifier and go to step 8.

If it is still low or zero, the fault is probably in the preceding line section or previous line amplifier.

Step 8 - Check that the fault has now cleared. If it has not, go back to step 4.

4.4 CHECKING THE REED SYSTEMS

4.4.1 Reed System Faults

Reed failure will normally become evident either:

(i) through the apparent failure of one or more indications to respond as expected when a route is set up or other function operated, or

(ii) through the unexpected appearance of an incorrect indication or group of indications unrelated to any function being operated, or known train movement.

However, it should be appreciated that such symptoms may just as easily arise due to a failure of the signalling equipment itself, and the Reed system may still be correctly performing its function.

Failures of the first type, i.e. failure to respond to controls, may be due to a failure of the signalling equipment in the signal box, a failure of the Reed control system, a failure of the signalling equipment in the field, or a failure of the Reed indications system.

Failures of the second type, i.e. the appearance of spurious indications, will normally be due to failures of signalling equipment in the field or of the Reed indication system, but in certain instances may also be due to a control system failure.

It is necessary to adopt a logical approach to narrow down the possible causes of failure, bearing in mind that all likely possibilities in the relay room should be checked before proceeding into the field.

First priority is to check whether the fault is in the Reed equipment or the signalling equipment, and, if it is in the Reed, whether it is in the control or the indication system. It will normally be possible to check in this way by operating controls and observing the corresponding indications on the control panel, before carryfng out tests in the field.

In addition to failure being classifiable by the likelihood that either indication or control systems, or only indication systems, are affected, they may also be classified as follows.

4.4.1.1 Single-Channel Faults

Failure of an individual control or indication or possibly two or three such controls or indications without there being any obvious geographical or technical association between them.

If the fault is on the Reed system, control or indication, then it is most likely to be associated with a particular Reed channel, and the transmitter, receiver, or individual power supply unit associated with that channel should be checked.

4.4.1.2 Geographical Group Faults

Failure of a group of channels associated with a particular location, while channels to nearer and more distant locations were still operating, would suggest a failure of the signalling equipment, or of the Reed power supplies at that location.

4.4.1.3 System Group Faults

Failure of a group of channels related sequentially in a particular system, would normally indicate failure of common equipment or of the line. Checking should commence with the line amplifier and its power supply at the last location to which the system appears to be working, since a failed line amplifier will permit the system to work up to its input, but may fail the system beyond its output, (although, under certain circumstances, a system may continue to work beyond a failed line amplifier, because of the equipment's tolerance of a wide range of line levels).

The line itself should be checked carefully, with attention being paid to through-crimps and terminals.

An open line would:

(i) fail in the box, all channels originating beyond the line amplifier or isolating transformer on the box side of the break;

(ii) fail in the field, all channels terminating beyond the break.

A short-circuited line would:

(i) fail in the box, all channels originating beyond the fault;

(ii) fail in the field, all channels terminating beyond the amplifier on the box side of the short.

4.4.1.4 Complete System Faults

The failure of all channels on a system can be due to failure of:

(a) power supplies feeding transmitters/receivers for that system in the box;

(b) the line amplifier in the box;

(c) a line amplifier or its power supply in the field;

(d) the transmission line or connections in the part of the line which carries all the functions in the system. (Beware of intermittent faults, which can be caused by faulty crimps, terminals, etc.).

4.4.1.5 Multi-System Faults

If all systems fail simultaneously, check the main power supply. Failure of several systems in one geographical direction would indicate a local power failure, or a severed cable; it can be located by checking which functions are still working.

In installations employing master transmitters and T.R.U's, failure of the same channel number in just three systems would indicate a fault in the appropriate T.R.U. in the relay room; failure of the same channel number in many systems would indicate a master transmitter fault.

If a group of functions in the same geographical location, but on different systems, fails, check the local power supplies, and the possibility of lightning or similar damage.

4.4.2 Summary Chart - System Fault Finding

This chart is arranged to show the quickest way to the most likely cause of failure. Decide first which category of fault fits the circumstances and then check units in the order suggested, continuing until the faulty unit or condition is discovered and replaced or rectified. If none of the suggested checks reveals the fault, consider the next most likely category, and so on. Refer to section 4.4 for details of unit checking.

REMEMBER, The Reed will show you SIGNALLING FAILURES.
IT IS NOT NECESSARILY THE REED WHICH IS AT FAULT.

	Indication Only Faults	Indication or Control Faults: Indication System	Indication or Control Faults: Control System
INDIVIDUAL FAULT.	In Box 1 Check Receiver In Field 2 Check Transmitter 3 Check Power Supply Unit.	In Box 2 Check Receiver In Field 3 Check Transmitter 4 Check Power Supply Unit.	In Box 1 Check Master Transmitter/TRU In Field 5 Check Receiver. 6 Check Power Supply Unit.
GEOGRAPHICAL GROUP FAULT.	In Box 1 Check that the failed receivers or transmitters do not have any common circuitry or power supply which could be the cause. In Field 2 Check Location Power Supply Units. 3 Check Transmitters. If several faulty, look for signs of lightning damage.	In Box (1 as in first column) In Field 2 Check Location Power Supply Units. 3 Check Transmitters. If several faulty, look for signs of lightning damage.	In Box (1 as in first column) In Field 4 Check Receivers.

<table>
<tr><th rowspan="2"></th><th rowspan="2">Indication Only Faults</th><th colspan="2">Indication or Control Faults</th></tr>
<tr><th>Indication System</th><th>Control System</th></tr>
<tr><td rowspan="4">SYSTEM GROUP FAULT</td><td><u>In Field</u></td><td><u>In Field</u></td><td><u>In Field</u></td></tr>
<tr><td colspan="3">1 Go to line amplifier on box side of first failed indication or control receiver. Check line amplifier and power supply. Check for open circuit line.</td></tr>
<tr><td colspan="2">2 Check next line amplifier out from box for open circuit on output.</td><td>2 Check next line amplifier out from box for short circuit on input.</td></tr>
<tr><td>3 Check line for open circuit.</td><td>3 Check line for open circuit.</td><td>3 Check line for open circuit or short circuit beyond last operating control receiver.</td></tr>
<tr><td rowspan="3">SYSTEM FAULT</td><td><u>In Box</u>
1 Check power supply unit feeding system receivers</td><td></td><td><u>In Box</u>
1 Check for discontinuity in line circuit connecting output resistors of T.R.Us.</td></tr>
<tr><td rowspan="2"><u>In Field</u>
2 Work outwards from box checking line amplifiers, amplifiers power supply units, & line continuity until the first transmitter is reached or the fault found.</td><td colspan="2"><u>In Box</u>
2 Check power supply unit feeding system receivers</td></tr>
<tr><td colspan="2"><u>In Field</u>   <u>In Field</u>
3 Work outward from box checking line amplifiers line amplifier power supply units and line continuity until the first transmitter * is reached or the fault found.
(* receiver in the case of control systems)</td></tr>
<tr><td>ALL-SYSTEM FAILURES (COMPLETE)</td><td colspan="3">1 Check for major power supply failure in box or in field.
2 Check for severed multicore cable affecting all systems.
3 Check power supply to line amplifiers at box and at all locations where these occur on all systems.</td></tr>
<tr><td>(PART)</td><td></td><td></td><td>4 If same channel number fail in all systems, check master transmitt power supply.
If same channel number fail in some systems only, check T.R.U. power supplies.</td></tr>
</table>

5.0 Spares and Re-ordering References

5.0.1 Contents

5.1 SPARES

5.1.1 Spares for Transmitters and Receivers

The detachable amplifier portion of the receiver is a common unit for all frequencies, and the number of spare amplifiers to be held will be related to the total number of receivers in the installation, probably varying from 5% in large installations to 10% in smaller ones.

The transmitter and the filter portion of a receiver can only be replaced by an identical unit of the same frequency and type number; this is ensured by a non-interchangeability pin code (as for standard signalling relays etc.). Consequently it is necessary to hold at least one spare receiver filter and transmitter for each frequency used in the installation.

Where plugboards have been drilled to allow for the use of universal spare channels (f71, f72), one transmitter and one receiver filter of each of these frequencies may be held to replace those of a failed channel whilst repairs are made or replacements obtained. Additional quantities of these channels may be held, but strict control must be exercised to ensure that only one of each channel be used in any one system.

5.1.2 Storage and Transport

All type RR equipment should be stored under dry conditions, and, when being handled and transported, should be treated with the same respect given to safety relays. Until actually installed, the equipment should continue to be housed in the individual packs in which it is supplied; labels on the packs fully identify the contents.

5.2 REFERENCES FOR ORDERING SPARES AND REPLACEMENTS

This section relates only to complete units supplied by GEC-General Signal Ltd. The RR type reference, which is generally an adequate and complete description of the article, should be quoted on all correspondence, enquiries or orders.

Reference should be made to section 2 for detailed description of the units.

5.2.1 Transmitters

The transmitter is described in section 2.3. It has blue coloured labels. The order reference depends upon frequency. The order references, frequencies and pin-codes for the various channels are given in the following table.

Order Ref.	Frequency No.	Frequency Hz.	Period Secs. x 10^{-9}	Code	Pins
RR3010	f1	879.5	1137009	7061	A D E G H L Q
RR3020	f2	876	1141552	7063	A D E G K L Q
RR3030	f3	887.5	1126760	7065	A D E H K L Q
RR3040	f4	803.25	1244942	7067	A D F G H L Q
RR3050	f5	797.75	1253525	7069	A D F G K L Q
RR3060	f6	792.75	1261431	7071	A D F H K L Q
RR3070	f7	788.25	1268633	7073	A D G H J L Q
RR3080	f8	784.25	1275103	7075	A D G J K L Q
RR3090	f9	779.75	1282462	7077	A D E F G M Q
RR3100	f10	774.75	1290738	7079	A D E F J M Q
RR3110	f11	768.75	1300813	7081	A D E F L M Q
RR3120	f12	811.75	1231906	7083	A D E G J M Q
RR3130	f13	714	1400560	7085	A D E G L M Q
RR3140	f14	711	1406469	7087	A D E H K M Q
RR3150	f15	706.5	1415428	7089	A D E J K M Q
RR3160	f16	702.5	1423487	7091	A D E K L M Q
RR3170	f17	697.5	1433691	7093	A D F G J M Q
RR3180	f18	692	1445086	7095	A D F G L M Q
RR3190	f19	687	1455604	7097	A D F H K M Q
RR3200	f20	682.5	1465201	7099	A D F J K M Q
RR3210	f21	678.5	1473839	7101	A D F K L M Q
RR3220	f22	674	1483679	7103	A D G H K M Q
RR3230	f23	667	1499250	7105	A D G J K M Q
RR3240	f24	622.25	1607071	7107	A D G K L M Q
RR3250	f25	616.25	1622718	7109	A D H J L M Q
RR3260	f26	611.75	1634654	7111	A D J K L M Q
RR3270	f27	607.75	1645413	7113	A D E F H N Q
RR3280	f28	598.25	1671541	7115	A D E F K N Q
RR3290	f29	587.75	1701403	7117	A D E F M N Q
RR3300	f30	574.75	1739886	7119	A D E G J N Q
RR3310	f31	569.75	1755155	7121	A D E G L N Q
RR3320	f32	525	1904762	7123	A D E H J N Q

5.2.1 (cont.)

Order Ref.	Frequency No.	Frequency Hz.	Period Secs.x 10^{-9}	Code	Pins
RR3330	f33	519.5	1924927	7125	A D E H L N Q
RR3340	f34	514.5	1943634	7127	A D E J K N Q
RR3350	f35	510	1960784	7129	A D E J M N Q
RR3360	f36	505	1980198	7131	A D E K M N Q
RR3370	f37	499.5	2002002	7133	A D F G H N Q
RR3380	f38	493.5	2026342	7135	A D F G K N Q
RR3390	f39	488	2049180	7137	A D F G M N Q
RR3400	f40	483	2070393	7139	A D F H K N Q
RR3410	f41	478.5	2089864	7141	A D F H M N Q
RR3420	f42	473.5	2111932	7143	A D F J L N Q
RR3430	f43	468	2136752	7145	A D F K L N Q
RR3440	f44	463	2159827	7147	A D F L M N Q
RR3450	f45	415.25	2408188	7149	A D G H K N Q
RR3460	f46	424.75	2354326	7151	A D G H M N Q
RR3470	f47	419.75	2382370	7153	A D G J L N Q
RR3480	f48	410.25	2437538	7155	A D G K L N Q
RR3490	f49	404.75	2470661	7157	A D G L M N Q
RR3500	f50	399.75	2501563	7159	A D H J L N Q
RR3510	f51	395.25	2530044	7161	A D H K L N Q
*RR3710	f71	757.75	1319696	7360	A P Q
+RR3720	f72	458.5	2181025	7360	A P Q
RR3810	f81	383.25	2609262	7221	A E G K M N Q
RR3820	f82	430.25	2324230	7223	A E H J K N Q
RR3830	f83	446	2242152	7225	A E H J M N Q
~~RR3840~~	~~f84~~	~~533.75~~	~~1873534~~	~~7227~~	~~A E H K M N Q~~
RR3850	f85	544	1838235	7229	A E J K L N Q
RR3860	f86	632	1582280	7231	A E J L M N Q
RR3870	f87	719	1390821	7233	A F G H J L Q
RR3880	f88	736.75	1357313	7235	A F G J K L Q
RR3890	f89	748.25	1336451	7237	A F G H J M Q
RR3900	f90	815.25	1226620	7239	A F G H L M Q
RR3910	f91	836.5	1195460	7241	A F G J L M Q
RR3920	f92	842	1187650	7243	A F H J K M Q

Note:

* Universal spare for use only on systems where this is acceptable and plugboards are drilled to correspond. Colour coded RED.

\+ Universal spare for use only on systems where this is acceptable and plugboards are drilled to correspond. Colour coded WHITE.

5.2.2 Receivers

The receiver is described in section 2.4.

5.2.2.1 Receiver Amplifier (detachable top portion of complete unit) - order reference type RR3000. The correct type must be used; the electrical connections to the unit would prevent a unit of the wrong type from functioning, if it were to be plugged in accidentally. The amplifier has pink coloured labels.

5.2.2.2 Receiver Filter (lower portion of complete unit) - order reference depends upon frequency. The order references, frequencies and pin-codes for the various channels are given in the following table. The filter has yellow coloured labels.

Order Ref.	Frequency No.	Frequency Hz.	Period Secs. x 10^{-9}	Code	Pins
RR2010	f1	879.5	1137009	1062	D E G J L
RR2020	f2	876	1141552	1064	D E H J L
RR2030	f3	887.5	1126760	1066	D E J K L
RR2040	f4	803.25	1244942	1068	D F G J L
RR2050	f5	797.75	1253525	1070	D F H J L
RR2060	f6	792.75	1261431	1072	D F J K L
RR2070	f7	788.25	1268633	1074	D G H K L
RR2080	f8	784.25	1275103	1076	D H J K L
RR2090	f9	779.75	1282462	1078	D E F H M
RR2100	f10	774.75	1290738	1080	D E F K M
RR2110	f11	768.75	1300813	1082	D E G H M
RR2120	f12	811.75	1231906	1084	D E G K M
RR2130	f13	714	1400560	1086	D E H J M
RR2140	f14	711	1406469	1088	D E H L M
RR2150	f15	706.5	1415428	1090	D E J L M
RR2160	f16	702.5	1423487	1092	D F G H M
RR2170	f17	697.5	1433691	1094	D F G K M
RR2180	f18	692	1445086	1096	D F H J M
RR2190	f19	687	1455604	1098	D F H L M
RR2200	f20	682.5	1465201	1100	D F J L M
RR2210	f21	678.5	1473839	1102	D G H J M
RR2220	f22	674	1483679	1104	D G H L M
RR2230	f23	667	1499250	1106	D G J L M
RR2240	f24	622.25	1607071	1108	D H J K M
RR2250	f25	616.25	1622718	1110	D H K L M
RR2260	f26	611.75	1634654	1112	D E F G N
RR2270	f27	607.75	1645413	1114	D E F J N
RR2280	f28	598.25	1671541	1116	D E F L N
RR2290	f29	587.75	1701403	1118	D E G H N
RR2300	f30	574.75	1739886	1120	D E G K N
RR2310	f31	569.75	1755155	1122	D E G M N
RR2320	f32	525	1904762	1124	D E H K N
RR2330	f33	519.5	1924927	1126	D E H M N
RR2340	f34	514.5	1943634	1128	D E J L N
RR2350	f35	510	1960784	1130	D E K L N

5.2.2.2 (cont)

Order Ref.	Frequency No.	Hz.	Period Secs.x 10^{-9}	Code	Pins
RR2360	f36	505	1980198	1132	D E L M N
RR2370	f37	499.5	2002002	1134	D F G J N
RR2380	f38	493.5	2026342	1136	D F G L N
RR2390	f39	488	2049180	1138	D F H J N
RR2400	f40	483	2070393	1140	D F H L N
RR2410	f41	478.5	2089864	1142	D F J K N
RR2420	f42	473.5	2111932	1144	D F J M N
RR2430	f43	468	2136752	1146	D F K M N
RR2440	f44	463	2159827	1148	D G H J N
RR2450	f45	415.25	2408188	1150	D G H L N
RR2460	f46	424.75	2354326	1152	D G J K N
RR2470	f47	419.75	2382370	1154	D G J M N
RR2480	f48	410.25	2437538	1156	D G K M N
RR2490	f49	404.75	2470661	1158	D H J K N
RR2500	f50	399.75	2501563	1160	D H J M N
RR2510	f51	395.25	2530044	1162	D H K M N
@*RR2710	f71	757.75	1319696	1360	P Q
@+RR2720	f72	458.5	2181025	1360	P Q
@ RR2810	f81	383.25	2609262	1222	E G L M N
@ RR2820	f82	430.25	2324230	1224	E H J L N
@ RR2830	f83	446	2242152	1226	E H K L N
@ RR2840	f84	533.75	1873534	1228	E H L M N
@ RR2850	f85	544	1838235	1230	E J K M N
@ RR2860	f86	632	1582280	1232	E K L M N
@ RR2870	f87	719	1390821	1234	F G H K L
@ RR2880	f88	736.75	1357313	1236	F H J K L
@ RR2890	f89	748.25	1336451	1238	F G H K M
@ RR2900	f90	815.25	1226620	1240	F G J K M
@ RR2910	f91	836.5	1195460	1242	F G K L M
@ RR2920	f92	842	1187550	1244	F H J L M

Note:

* Universal spare for use only on systems where this is acceptable and plugboards are drilled to correspond. Colour coded RED.

\+ Universal spare for use only on systems where this is acceptable and plugboards are drilled to correspond. Colour coded WHITE.

@ Not for use on vital circuits on systems designed to be immune to 50Hz. interference.

5.2.3 Transmitter Repeater Unit (T.R.U.)

The transmitter repeater unit is described in section 2.6. It has green coloured labels. It is independent of frequency and is mounted in a case similar to that used for the GEC-GS type Z relay, conforming fully to BR 930 relay module size.

Order reference - type RR3990

Pin code 7285 Pins AHJLMNQ

5.2.4 Reed Follower Relay

This relay is integral with the amplifier portion of the receiver.

5.2.5 Plugboards for above

The basic plugboard is the same as for the BR930 series relays, but employs a special retaining clip in the case of the reed receiver.

Basic plugboard moulding: Order ref. D6/26696.

Contact Clip: Order ref. D3/26929.

The plugboard may be supplied pre-drilled for any of the various units described above.

5.2.5.1 Transmitter Plugboard Order Reference.

Unit	Plugboard
RR3010	RZ7361
RR3020	RZ7363
RR3030	RZ7365
RR3040	RZ7367
RR3050	RZ7369
RR3060	RZ7371
RR3070	RZ7373
RR3080	RZ7375
RR3090	RZ7377
RR3100	RZ7379

5.2.5.1 (cont)

Unit	Plugboard
RR3110	RZ7381
RR3120	RZ7383
RR3130	RZ7385
RR3140	RZ7387
RR3150	RZ7389
RR3160	RZ7391
RR3170	RZ7393
RR3180	RZ7395
RR3190	RZ7397
RR3200	RZ7399
RR3210	RZ7401
RR3220	RZ7403
RR3230	RZ7405
RR3240	RZ7407
RR3250	RZ7409
RR3260	RZ7411
RR3270	RZ7413
RR3280	RZ7415
RR3290	RZ7417
RR3300	RZ7419
RR3310	RZ7421
RR3320	RZ7423
RR3330	RZ7425
RR3340	RZ7427
RR3350	RZ7429
RR3360	RZ7431
RR3370	RZ7433
RR3380	RZ7435
RR3390	RZ7437
RR3400	RZ7439
RR3410	RZ7441
RR3420	RZ7443
RR3430	RZ7445
RR3440	RZ7447
RR3450	RZ7449
RR3460	RZ7451
RR3470	RZ7453
RR3480	RZ7455
RR3490	RZ7457
RR3500	RZ7459
RR3510	RZ7461
RR3710) RR3720)	Accepted by any plugboard in this range
RR3810	RZ7521
RR3820	RZ7523
RR3830	RZ7525
RR3840	RZ7527
RR3850	RZ7529
RR3860	RZ7531
RR3870	RZ7533
RR3880	RZ7535
RR3890	RZ7537
RR3900	RZ7539
RR3910	RZ7541
RR3920	RZ7543

5.2.5.2 Receiver Plugboard Order Reference

Unit	Normal	Special to accommodate universal spare
RR2010	RY1062	RY1362
RR2020	RY1064	RY1364
RR2030	RY1066	RY1366
RR2040	RY1068	RY1368
RR2050	RY1070	RY1370
RR2060	RY1072	RY1372
RR2070	RY1074	RY1374
RR2080	RY1076	RY1376
RR2090	RY1078	RY1378
RR2100	RY1080	RY1380
RR2110	RY1082	RY1382
RR2120	RY1084	RY1384
RR2130	RY1086	RY1386
RR2140	RY1088	RY1388
RR2150	RY1090	RY1390
RR2160	RY1092	RY1392
RR2170	RY1094	RY1394
RR2180	RY1096	RY1396
RR2190	RY1098	RY1398
RR2200	RY1100	RY1400
RR2210	RY1102	RY1402
RR2220	RY1104	RY1404
RR2230	RY1106	RY1406
RR2240	RY1108	RY1408
RR2250	RY1110	RY1410
RR2260	RY1112	RY1412
RR2270	RY1114	RY1414
RR2280	RY1116	RY1416
RR2290	RY1118	RY1418
RR2300	RY1120	RY1420
RR2310	RY1122	RY1422
RR2320	RY1124	RY1424
RR2330	RY1126	RY1426
RR2340	RY1128	RY1428
RR2350	RY1130	RY1430
RR2360	RY1132	RY1432
RR2370	RY1134	RY1434
RR2380	RY1136	RY1436
RR2390	RY1138	RY1438
RR2400	RY1140	RY1440
RR2410	RY1142	RY1442
RR2420	RY1144	RY1444
RR2430	RY1146	RY1446
RR2440	RY1148	RY1448
RR2450	RY1150	RY1450
RR2460	RY1152	RY1452
RR2470	RY1154	RY1454
RR2480	RY1156	RY1456
RR2490	RY1158	RY1458
RR2500	RY1160	RY1460
RR2510	RY1162	RY1462

RR2710) Accepted by any plugboard in the special range
RR2720)

5.2.5.2 (cont)

Unit	Normal	Special to accommodate universal spare
RR2810	RY1222	RY1522
RR2820	RY1224	RY1524
RR2830	RY1226	RY1526
RR2840	RY1228	RY1528
RR2850	RY1230	RY1530
RR2860	RY1232	RY1532
RR2870	RY1234	RY1534
RR2880	RY1236	RY1536
RR2890	RY1238	RY1538
RR2900	RY1240	RY1540
RR2910	RY1242	RY1542
RR2920	RY1244	RY1544

Retaining clip for transmitters and T.R.Us: Order Ref: D3/26697.

Retaining clip for receivers: Order Ref: SK.1780890.

Line resistors (one required per transmitter or T.R.U. output) -

Order ref.: Electrosil type TR-6, 24 ohm, 5%, (1W metal-oxide).

5.2.6 Line Amplifier

The line amplifier is described in section 2.7, and an outline is given in fig.5.2-7.
Order ref: type RR8101 (this unit can use either 24V a.c. or 24V d.c. power supplies).

5.2.7 Line Amplifier Supply Transformer

Transformer to supply 1 line amplifier: for outline see fig. 5.2 - 2; 110/28-24-20V, 50Hz, 35VA; order ref type RR9210.

Transformer to supply 10 line amplifiers: for outline see fig. 5.2-1; 110/28-24-20V, 50Hz, 350VA; order ref. type RR9220.

(Type RR9220 may be used as a replacement for type RR9210 for maintenance purposes).

Transformers for other primary voltages can be supplied, but are non-standard.

5.2.8 Line Isolating Transformer

The line isolating transformer is described in section 2.8, and an outline is given in fig. 5.2 - 3.

Order ref: type RR8200.

5.2.9 Power Supplies

The Reed power supplies give a smoothed and stabilised d.c. output voltage of 12.5V and are used to feed transmitters, receivers and transmitter repeater units. There are three types, as follows:

(i) 200mA unit, type ref. RR9410 - will feed up to four transmitters or two receivers.

(ii) 500mA unit, type ref. RR9420 - will feed up to 10 transmitters or 5 receivers.

(iii) 5A unit, type ref. RR9131 - will feed all the transmitters or receivers of a system.

The units are described in detail in section 2.9.

Outlines are shown in Figs. 5.2-4; 5.2-5; 5.2-6.

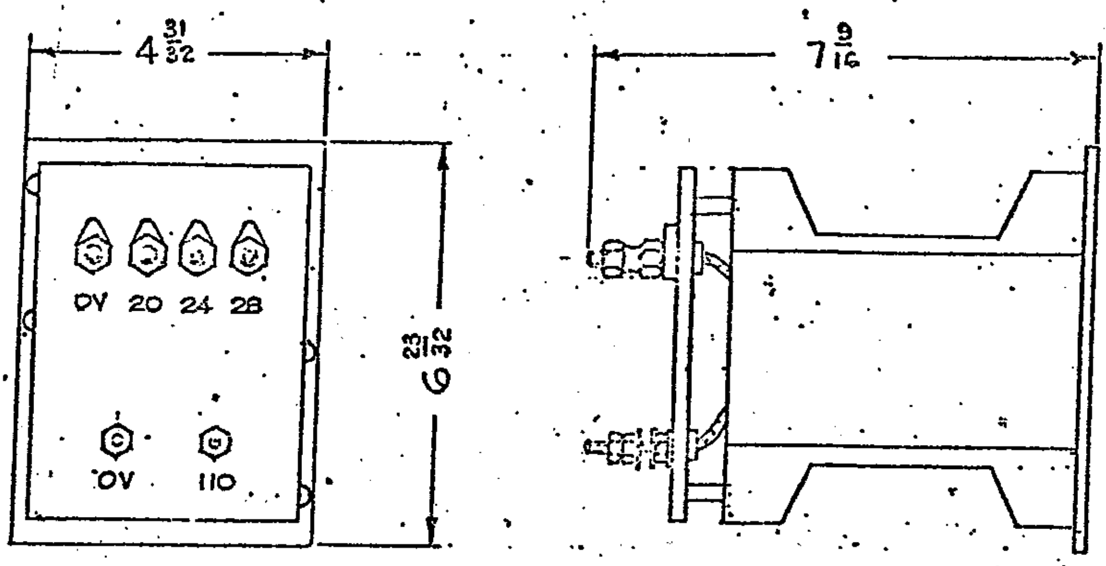


Fig. 5.2-1 : Line Amplifier Supply Transformer, RR 9220

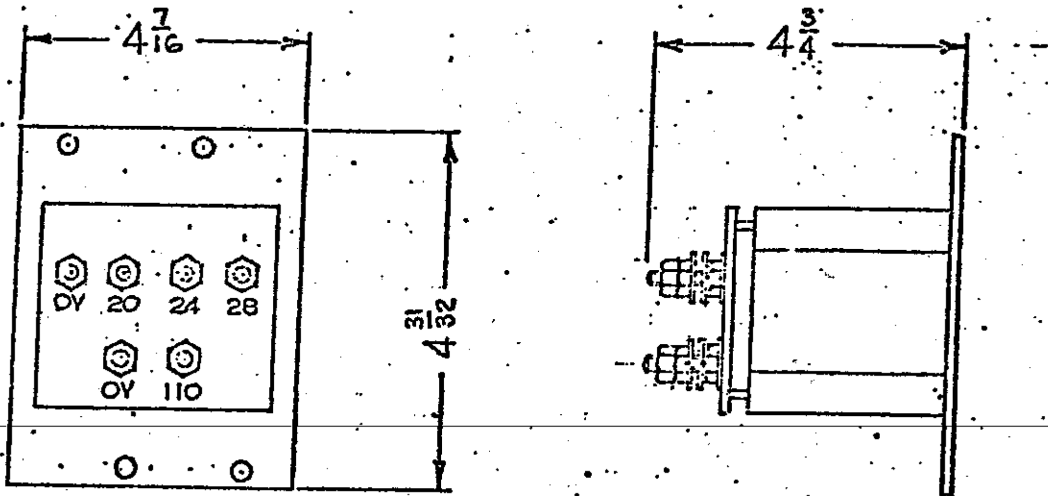


Fig. 5.2-2 : Line Amplifier Supply Transformer, RR 9210

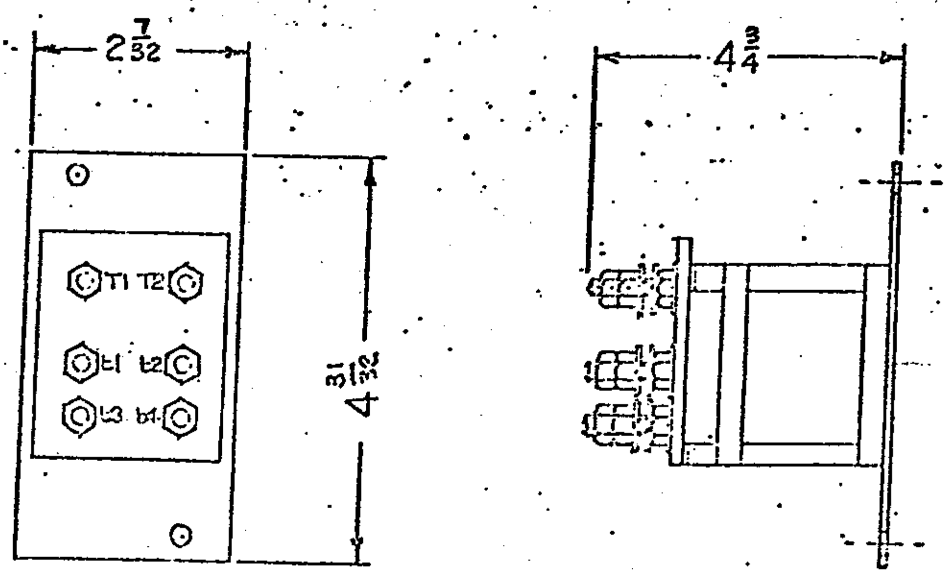


Fig. 5.2-3 : Line Isolating Transformer, RR 8200.

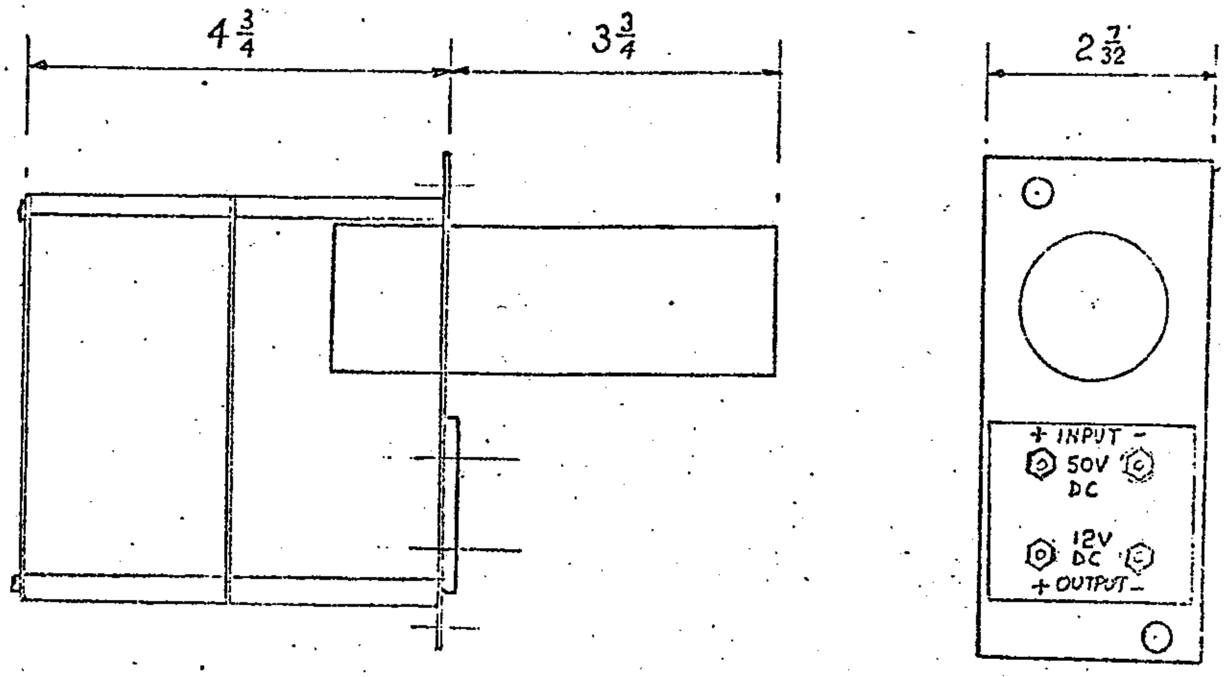


Figure. 5.2-4 Reed Power Supply Unit. Type RR9410. (200mA)

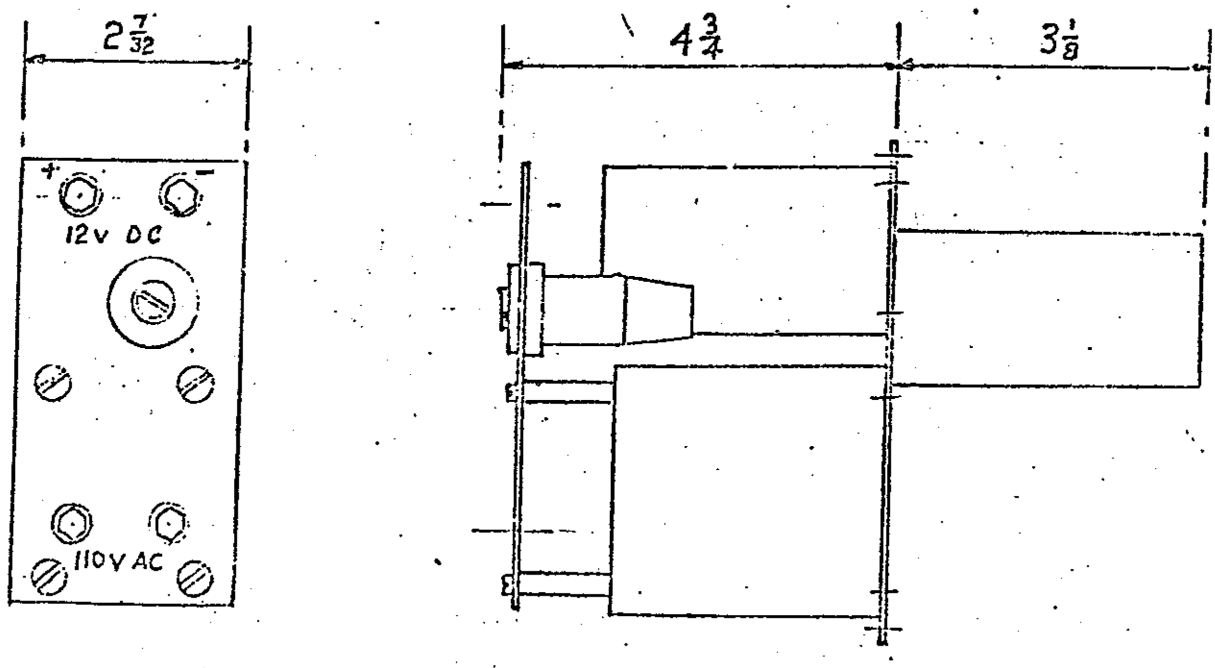


Figure. 5.2-5 Reed Power Supply Unit. Type RR9420. (500mA)

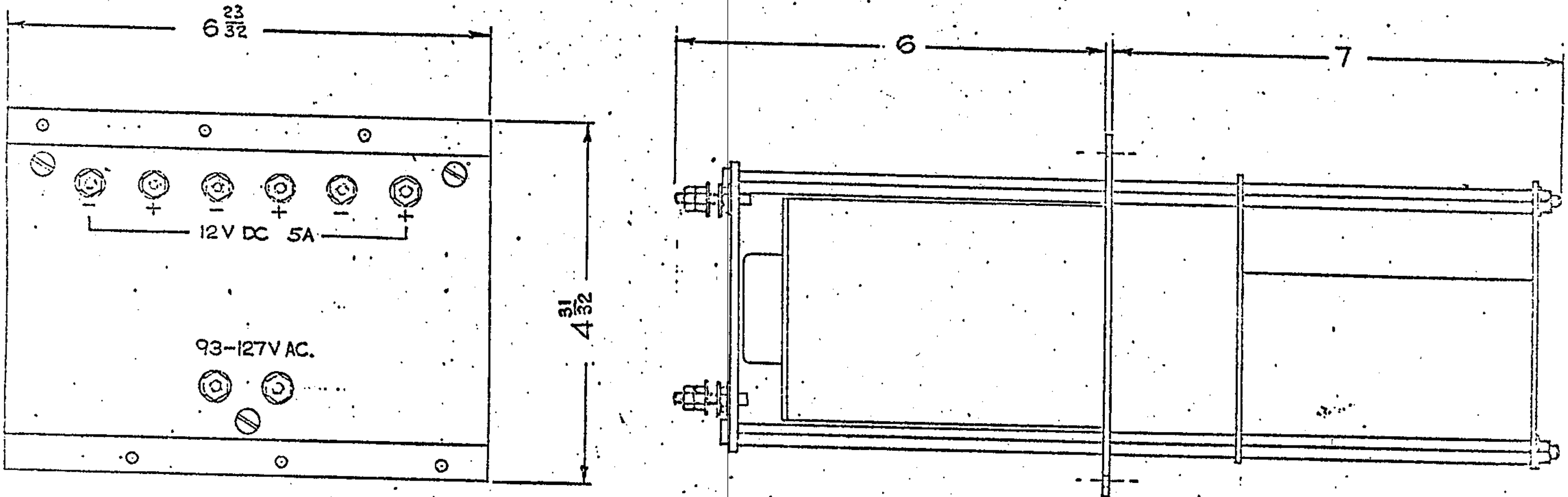


Fig. 5.2.-6 : Reed Power Supply Type RR 9131 (5A).

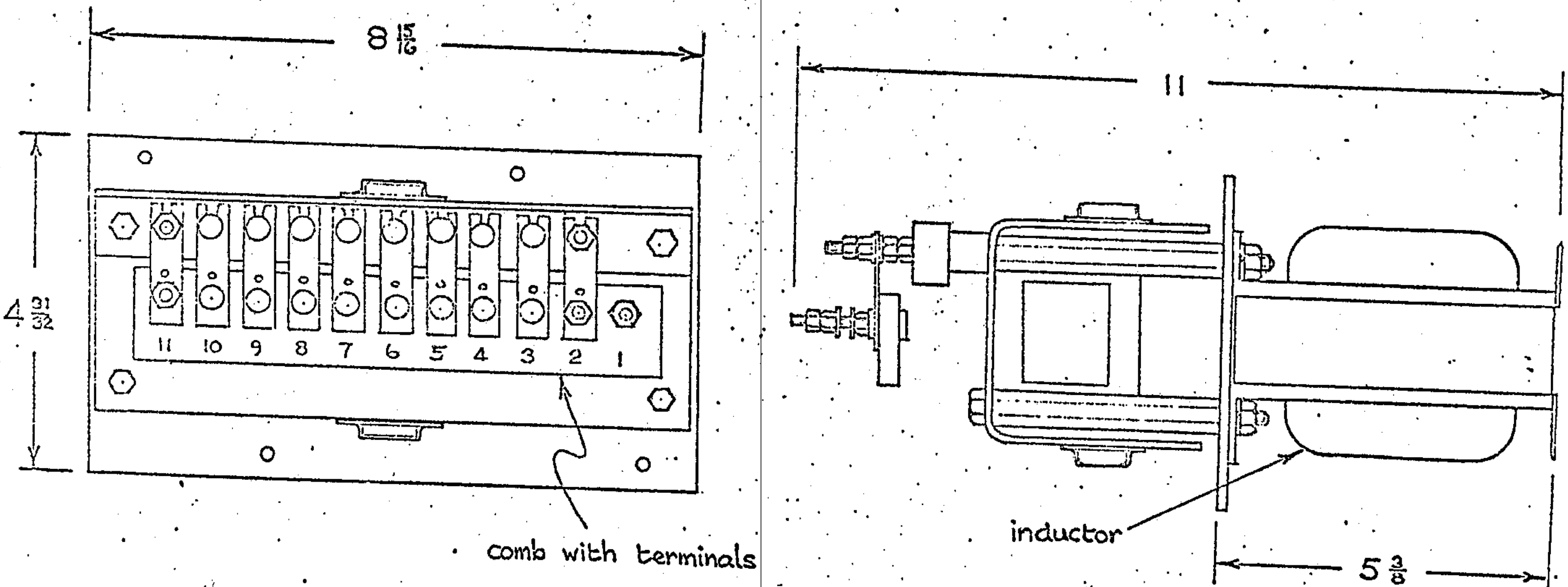


Fig. 5.2-7 : Outline of Line Amplifier RR8101