1st TRAINING REGIMENT

ROYAL SIGNALS

TRADE TRAINING NOTES

Part No. 9A

WIRELESS SET No. C42

RESTRICTED

WIRELESS SET C 42

A V.H.F. F.M. R.T. SET for vehicle installations

A complete technical description of the set and ancillary equipment.

RESTRICTED

ALPHABETICAL INDEX

1st column of numbers indicates text; component layout diagrams are on pages in 2nd column.

BASIC THEORY

F.M. vs A.M.

Intelligence can be recovered from a frequency modulated signal by applying it to a device which is sensitive only to differences in applied frequencies: this device is not dependent on amplitude changes for its output, and may be preceded by another device (called a limiter) which deliberately removes all variations of amplitude. Most forms of interference (atmospheric and man-made) and receiver noise are variations of amplitude, and this process of limiting removes nearly all extraneous noise, provided that the signal is large enough.

LIMITERS

The limiters used in the receiver are pentode amplifiers running with grid current bias but no auto-cathode bias. A large signal is applied (of the order of 50 volts), which produces nearly that much grid-current bias; this means that the stage is working in Class C, and the grid-base is shortened (by reducing the anode and screen voltages) in order to reduce the operating angle still further. (The operating angle is defined as the number of degrees per cycle of the applied voltage during which anode current flows). Thus only the peaks of positive half-cycles are amplified. As the amplitude of the applied signal is increased, the grid-current bias increases, and although a larger absolute amount of signal is amplified, the peaks appearing in the anode circuit are a smaller percentage of the applied voltage, and are narrower - that is, they flow for a shorter time. The net result is a larger current pulse flowing in the anode circuit for a shorter time, and so a roughly equal amount of energy is applied to the anode tuned circuit, whose "flywheel effect" converts this into a signal of roughly equal amplitude.

TRIPLE DETECTION

The requirements of good image rejection (freedom from second channel interference) and adjacent channel selectivity conflict because they require, respectively, a high and a low intermediate frequency. The double superhet (triple detection) provides the answer; the first frequency conversion to a comparatively high I.F. gives good image rejection and a second conversion to a lower I.F. provides adjacent channel selectivity.

POSITIVE AND NEGATIVE TEMPERATURE COEFFICIENT CONDENSERS

In a sealed set like the W.S. C42, the internal temperature can rise 35°C above the ambient (the initial) temperature, which means that the set has to cope with large variations. To prevent detuning of the set when the temperature rises, all tuned circuits except the driver and P.A. anode circuits are provided with temperature-compensating condensers; these have varying coefficients, both positive and negative, and it is important to replace these condensers, when necessary, with an exact equivalent.

FERRITE BEADS

In order to prevent troublesome spurious oscillations, a number of anode and screen leads have been fitted with ferrite beads. These are made of a high permeability material, and function in two distinct ways:-

(i) The "skin effect" is increased, i.e., the tendency of R.F. currents to flow on the surface of the wire is enhanced, and the same current flows in a smaller cross-section of the wire, which then appears to have a higher resistance to R.F., especially to V.H.F. Thus the bead simulates a parasitic stopper.

(ii) The inductance of even a straight piece of wire becomes appreciable at these frequencies, and may resonate in the band in use. In this case the higher permeability of the bead raises the inductance of the wire, and lowers the resonant frequency out of the band in use.

DECIBELS

Power levels can be expressed absolutely (in terms watts or milli-watts), or relatively (in terms of ratio to a given reference power level). If this ratio is expressed logarithmically (to base 10), the units of the resultant expression are Bels; so if the given power is 100 times greater than the reference level, it is said to be 2 bels above the reference level, because log 10 of 100 is 2. The Bel is too large a unit for most practical purposes, and so the decibel is more commonly used; 10 decibels are equal to 1 Bel, so the above ratio could be expressed as 20 decibels (20 DB). This method of expression applies only to power ratios, but voltage ratios and current ratios can be expressed in decibels on the basis of the power ratios which those voltages would produce in a given resistor (the resistor being of the same value in the case of both the voltages or currents being compared. Thus a 2: 1 voltage or current ratio would be equivalent to a power ratio of 4: 1 in any given resistance (since W equals I^2R and $\frac{V^2}{R}$, so this voltage or current ratio could be expressed as 6 DB (log 4 Bels, or 0.6 Bels)

FERRITE REACTOR

Reference to a graph of field strength H against flux density B shows the phenomenon of hysteresis, or an initial reluctance to change the flux density in a changing field strength. Thus an alternating field strength produces a flux density as shown below:-

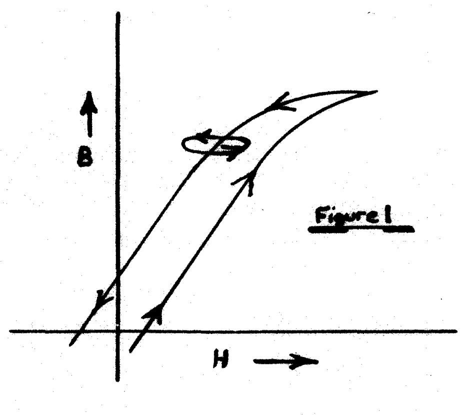


Figure 1

The flux density in the core is not directly proportional to the field strength during a cycle of change of field strength; this ratio of B:H therefore varies according to the variations of field strength, and is defined as the permeability (B/H). If the core is used as the core of the coil in an oscillator, these variations cause changes in the frequency of the oscillator, since the inductance of the coil is a function of the permeability of the core.

In practice, the "secondary" coil is not used indirectly as the oscillator coil, but is tapped across the part of the actual oscillator coil.

The "primary" coil carries the anode current of the modulator valve, variation of which causes variations in the field of strength.

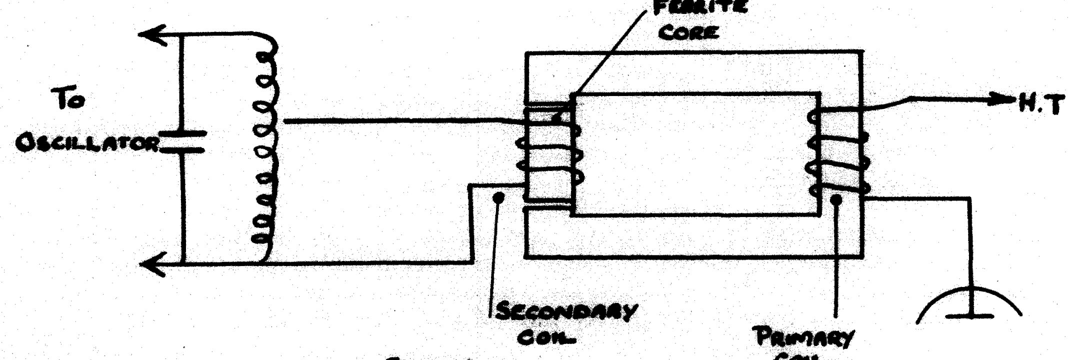
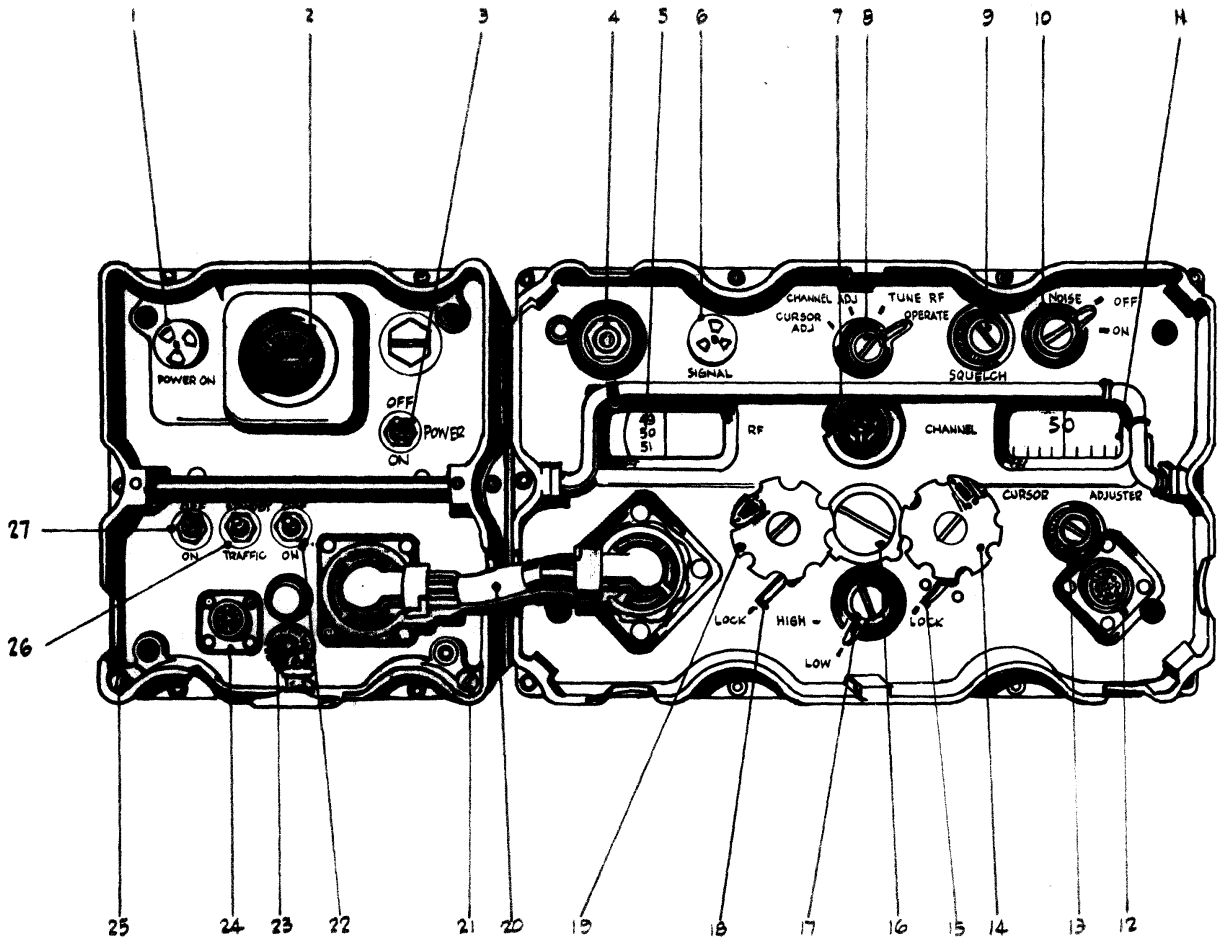


Figure 2

ILLUSTRATION OF C.42 & P.S.U.



KEY

1	POWER ON LAMP.	14	CHANNEL TUNING
2	BATTERY VOLTMETER.	15	LOCKING LEVER.
3	POWER ON-OFF.	16	DIAL LAMP (UNSCREW TO CHANGE).
4	A.T.U CONNECTOR PLUG.	17	HIGH/LOW POWER SWITCH.
5	R.F. SCALE.	18	LOCKING LEVER.
6	SIGNAL LAMP.	19	R.F. TUNING.
7	CENTRE ZERO METER.	20	CONNECTOR.
8	CALIBRATOR SWITCH.	21	SPARE FUSE.
9	SQUELCH CONTROL.	22	I/C ON-OFF.
10	NOISE ON-OFF SWITCH.	23	FUSE IN SUPPLY LINE.
11	CHANNEL SCALE.	24	POWER SUPPLY CONNECTOR.
12	HARNESS CONNECTOR SOCKET.	25	SPARE FUSE.
13	CURSOR	26	STANDBY TRAFFIC.
		27	WIRELESS SET ON-OFF.

FIGURE 3

GENERAL INTRODUCTION TO W.S. C42

W.S.19 and some other wireless sets are to be replaced by newer equipment, such as the C42. Long-range communications will continue to be carried out by High Frequency equipment, but short-range, front-line communications are more suited to Very High Frequency equipment; this is because V.H.F. has several characteristics which suit it well for this purpose:- short range, making for security; surer communication at night; absence of long-range interference; the ability to use frequency Modulation, giving a low interference level (due to the use of limiters) and the advantages of a squelch circuit (receiver silenced in the absence of a signal). In addition, much-needed H.F. channels are left clear for long-range communications; V.H.F. provides, in effect, very many channels, for any one frequency can be shared by a number of nets, provided these are separated by comparatively few miles.

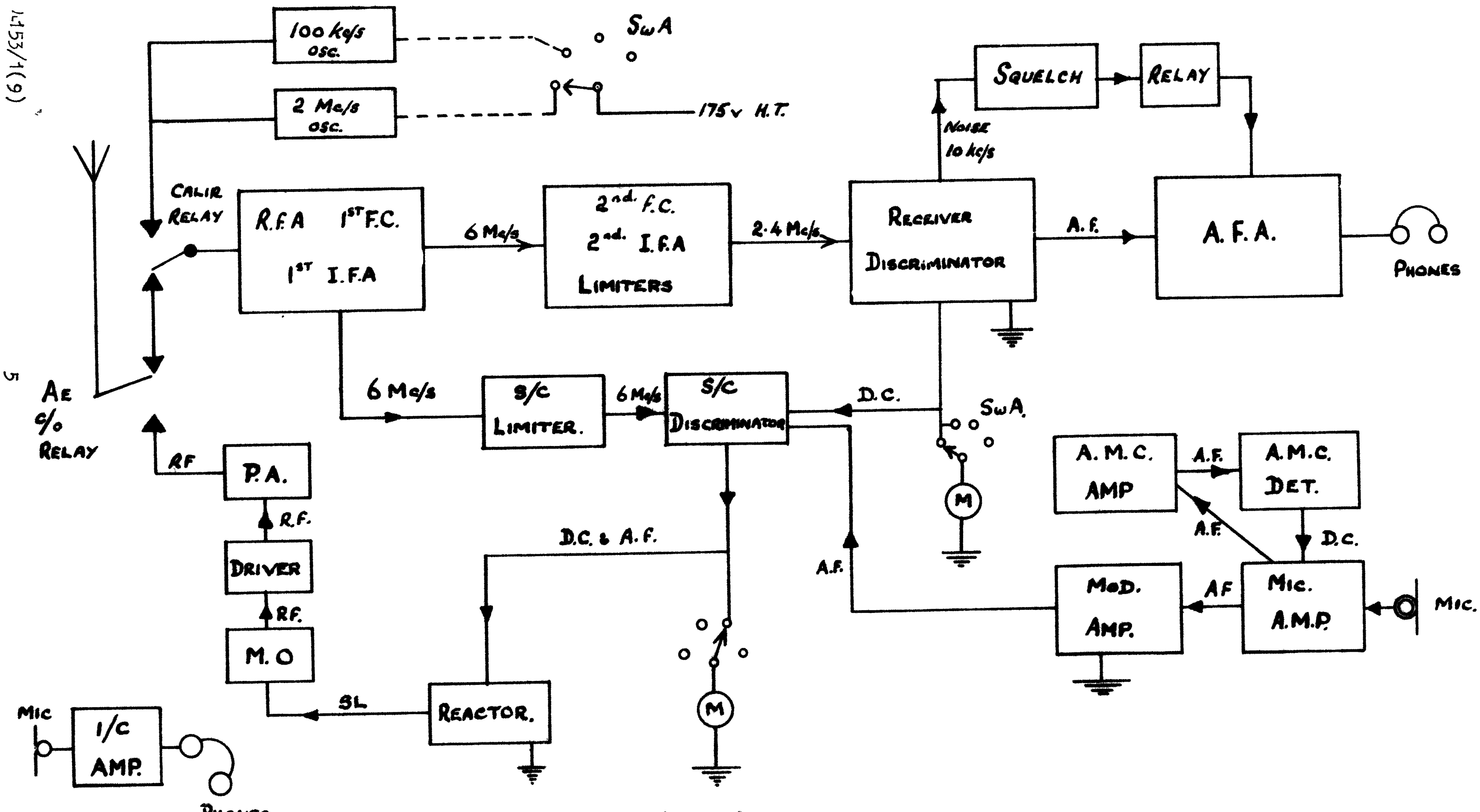
In operation, the C42 might be used in the control vehicle of, say, an armoured unit, working to tank squadron HQs: the C45 (a similar set with a different frequency range) would be used to work with supporting artillery; each tank squadron HQ would work to the tank troops with C42s on another net; inter-tank and tank-to-infantry communication is carried out by B45 and B47 respectively, these sets having different frequency ranges but being otherwise similar.

The C42 and its P.S.U. are built into die cast steel cases designed to fit into special racks in the vehicle. The cases are sealed and secured by Allen Screws, one of which is fitted with a cap, showing if the seal has been broken. An external Aerial Tuning Unit is located at the aerial base, and the set is controlled (apart from the tuning-up procedure) via a Control Harness. In its simplest form, this harness takes the form of a single Junction Box, called J.1, to which are connected an L.T. supply, one or two headsets and remote control cables, if this facility is required. But in a typical tank installation, a more complicated harness is used, controlling two other wireless sets (B45 and B47) and giving full facilities to three crew members, with a fourth in inter-communication at all times; in addition, a tank telephone may be connected to the harness, remote control of any one set is available (up to 1000 yards away), rebroadcast is possible between any two sets, and a loud-speaker-amplifier system can be connected to the harness, leaving a crew member unhampered by a headset.

The tuning-up procedure is extremely simple, and is as follows:- Switch on the P.S.U. (Power, Wireless Set, and Standby/Traffic), and wait at least half a minute (15 minutes, if possible); turn the system switch to Cursor Adjust, set the R.F. tuning dial to near the required frequency and set the Channel tuning dial to the nearest even number of megacycles. Adjust this latter control to give a null reading on the centre-zero meter and alter the Cursor Adjuster to bring the cursor over the appropriate mark on the scale. Switch to Channel Adjust, alter the Channel tuning control to bring the required frequency opposite the cursor, and finally tune accurately for zero meter reading, *then lock the Channel tuning control. Switch to R.F. Tune, and adjust the R.F. tuning control for zero meter reading *then lock this control. Switch to Operate; adjust the squelch control in the usual manner: turn the knob clockwise till the signal lamp lights, and then turn it slowly anti-clockwise till the lamp just goes out. Finally switch to High Power, press the pressel and adjust the Aerial Tuning Unit for maximum meter reading, returning the switch to Low Power unless High Power is required.

* In these cases, the meter needle must move in the same direction as the scale on the top of the knob; there are two wrong null points which give reversed meter movements.

BLOCK DIAGRAM OF C 42



— Figure 4 —

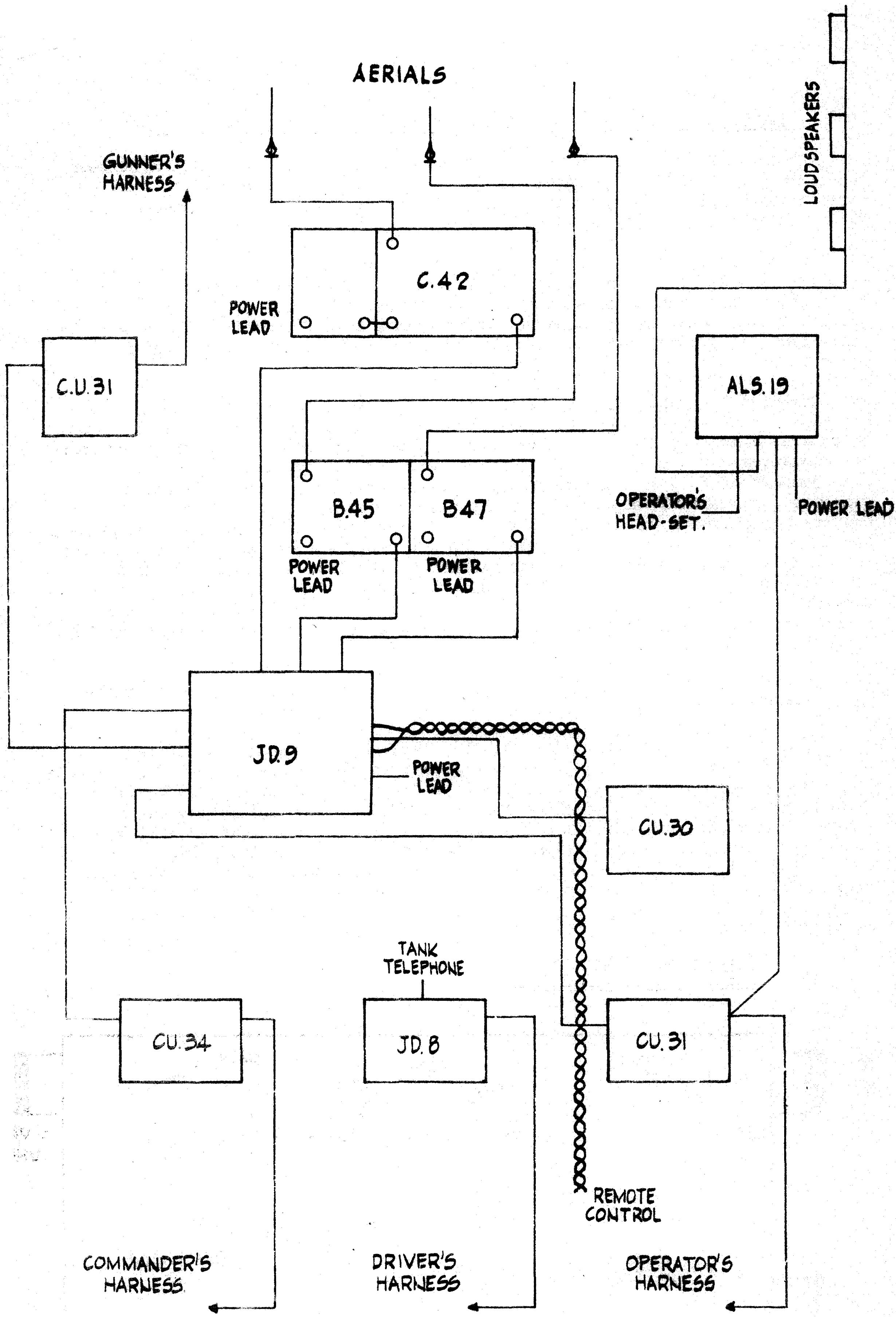
TECHNICAL INTRODUCTION TO SET AND P.S.U., INCLUDING FACILITIES

The C42 is a VHF FM RT transmitter-receiver providing 241 channels each 100 Kc/s wide between 36 and 60 Mc/s, and has a built-in audio amplifier for intercommunication between members of a crew. The complete equipment consists of the set itself, a P.S.U. (24 volts input at 8 amps or 12 volts at 18 amps), an aerial tuning unit and a number of connectors; in addition, a control harness is necessary. The set is built on a number of sub-chassis which are bolted to two main chassis and electrically connected to a wiring harness which connects the units together and to the components on the front panel. Generally speaking, servicing consists on localising a fault to a particular sub-unit and then replacing the unit. The transmitting range varies between a guaranteed minimum of 3 or 4 miles and a maximum of about 35 miles depending on atmospheric conditions, power used, and aerial height, type and siting; the high Power output is at least 15 watts, while Low Power gives between $\frac{1}{4}$ and $\frac{3}{4}$ watts. Two built-in crystal calibrators enable the station to be set up on any specified channel without netting, with an error not greater than 0.01%. Automatic frequency control of the transmitter is provided, and an automatic gain control system in the modulation amplifier section keeps its output fairly constant regardless of the microphone input, thus keeping the deviation close to 15 Kc/s for both soft and loud speech. A squelch circuit in the receiver silences it when there is no signal, and lights a "signal" lamp on arrival of a signal; this circuit can also be used to operate an automatic rebroadcasting system.

The receiver is a double superhet, consisting of an R.F.A., a first mixer and local oscillator, a first I.F.A. working at 6 Mc/s, a second local oscillator and mixer, two I.F.As. working at 2.4 Mc/s together with two limiters, and a Bond (or Weiss) discriminator, which feeds two A.F.As. and the Squelch circuit, which consists of a noise amplifier, a noise rectifier and a D.C. amplifier feeding the squelch relay. The first local oscillator is a very stable V.F.O., fitted with an 8 foot long tuning scale (channel tuning), and the second is crystal-controlled; thus the receiver is altogether very stable.

The transmitter is modulated by a two-stage amplifier, the first stage also feeding another amplifier and a rectifier which biases the first stage, these two stages constituting the modulation control section; the modulator valve modulates the master oscillator by means of a Ferrite reactor. The R.F. stages of the transmitter consist of the Master Oscillator, a Buffer-Driver and a Power Amplifier. Side-tone and automatic frequency control are effected by leaving the receiver running while sending, and applying any D.C. output from the receiver discriminator to the reactor; because of the selectivity of the discriminator, this system can only deal with deviations less than about 80 kc/s, and greater deviations (up to 400 Kc/s) are dealt with by sidechain; this consists of a limiter fed by the 1st I.F.A., and a "wide" discriminator which is connected in series with the "narrow" receiver discriminator, the two outputs in series being applied to the grid of the reactor valve, bringing the M.O. frequency to within 10 Kc/s of its correct value. The R.F. tuning knob controls all the tunable circuits in both transmitter and receiver with the exception of the first local oscillator.

The inter-communication amplifier is a simple two-stage amplifier; both it and the A.F.As. in the receiver have negative feedback to stabilise the output voltage regardless of the number of headphones connected; this will also minimise the distortion in these stages.



CONTROL HARNESS TYPE 'A'

FIGURE. 5.

TECHNICAL INTRODUCTION TO CONTROL HARNESS, INCLUDING FACILITIES

The basic function of the control harnesses is to make connections between the operators' headset or handsets and the wireless set; in addition, they contain a voltage-sensitive relay which, with the P.S.U., forms a simple system for compensating for varying input voltages.

The training harness consists of one junction box, J.1. This box selects either the wireless set or the i/c amp for the two operators, controls their headphone volume, and enables them to call the remote operator, who can call the local operators and employ whichever service they have selected. There are also other facilities available when the J.1 is used in conjunction with other apparatus.

Armoured Fighting Vehicle installations will normally contain the Harness, Type A. This involves two other wireless sets (B45 and B47) comprises a system of control boxes and junction boxes, and provides facilities for 4 crew members:- the commander can select any of the three sets or i/c amp, can put the other crew members on to i/c in an emergency (over-ruling their service selection switches), can monitor any or all of the wireless sets and, by means of a thirty foot cable, can have these facilities outside the stationary vehicle if required; the driver is permanently connected to the i/c amp., and can call the commander; the other two members can select and use any of the four services and can call the commander. In addition, a tank telephone (for infantry use) can be connected to the i/c amp., and a remote operator (up to 1000 yards away) can operate whichever facility the local operator has selected, and can call and be called.

It is possible to connect a loudspeaker system to the harness so that the load-operator (for example) may not be hampered by a headset.

There is also a rebroadcast unit, which extends the facilities of the harness so far described. Rebroadcasting is possible between any two of the sets connected to the harness; if both sets have "rebroadcast" lines from their squelch relays, the change of direction of traffic will be automatic, but if either or both have not this facility, then the direction of traffic will have to be changed manually. The third set can be controlled normally. The other special facility provided by this unit is called "break-in"; the operator can speak or listen to both the two stations on a rebroadcast link. If none of these special facilities are required, the "normal" facility can be selected and the three sets can be controlled and operated normally.

JUNCTION BOX J.1

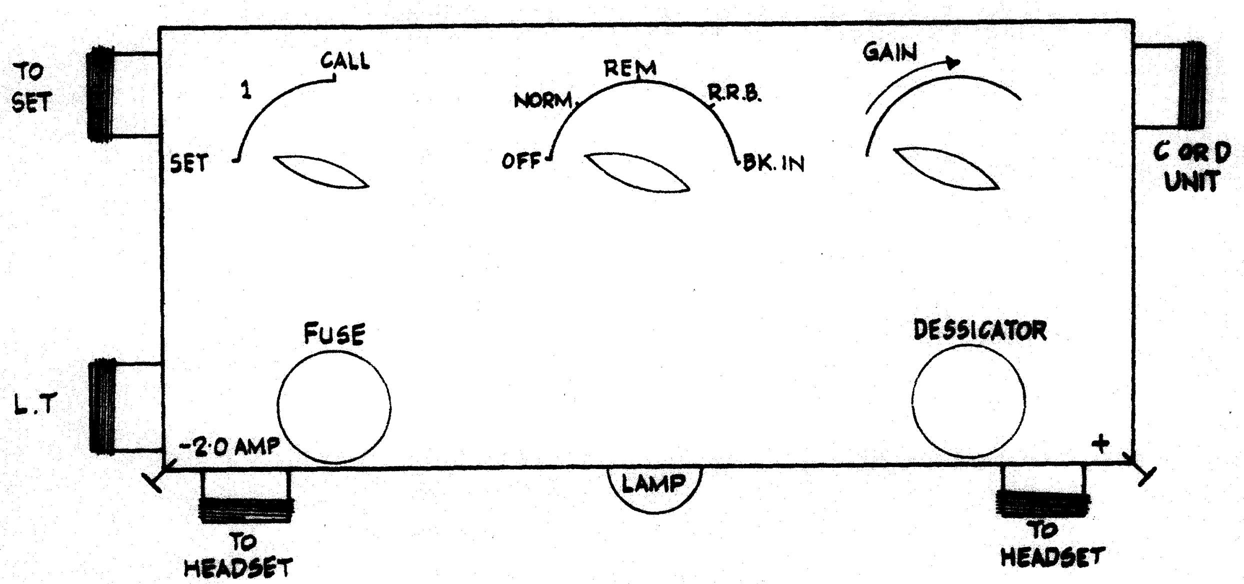


FIGURE. 6.

Valve Table

C.V.	21228 ECH 81	Triode-heptode	Second mixer & local OSC
C.V.	329 or CV 2209	R.F. Pentode	Constant frequency OSC
C.V.	469 EA76	Diode	Discriminator, noise rect.
C.V.	850 6AK5	R.F. Pentode	all other receiver stages
C.V.	133 6C4	Triode	Master Oscillator
C.V.	2243 PSG8	Pentode	Driver
C.V.	2220	Tetrode	Power Amplifier
C.V.	4051 9D6	Pentode	Microphone amplifier
C.V.	469 EA76	Diode	A.M.C. rectifier
C.V.	850 6AK5	Pentode	Modulator, a.m.c. amp., mod o/p
C.V.	850 6AK5	Pentode	Sidechain limiter
C.V.	469 EA76	Diode	Sidechain discriminator
C.V.	850 6AK5	Pentode	I/C amplifiers

TECHNICAL SUMMARY

Frequency range:-	36 - 60 Mc/s in one band
Frequency accuracy:-	0.01%
Frequency stability:-	30 c/s per Mc/s per degree C. 7.5 c/s per Mc/s for 10% change of input
Automatic Frequency control:-	Transmitter drift of 400 kc/s corrected to within 10 kc/s
Transmitter deviation:-	15 kc/s maximum
Automatic modulation control:-	Output is substantially constant for input variation from 10 mv to 200 mv.
Deviation due to hum:-	Less than 100 c/s
Receiver sensitivity:-	Less than $1\frac{1}{4}$ µv produces 10dB quieting
Receiver selectivity:-	64 kc/s at 3dB down; 250 kc/s at 60dB
Second channel rejection:-	Better than 70 dB
I.F. rejection:-	Better than 80 dB
Limiting:-	1dB change in output for input change from 2 µv to 100 µv
Receiver and i/c A.F.As:-	250 mW into 50 ohm load for an input of 1 volt (Rx) or 1/15 volt (i/c amp)
Power Supply Unit:-	24 volt input at 8 amps or 12 volt input at 18 amps: approx 180 watts
Pre-emphasis:-	6dB/octave
De-emphasis:-	3 - 6 dB/octave

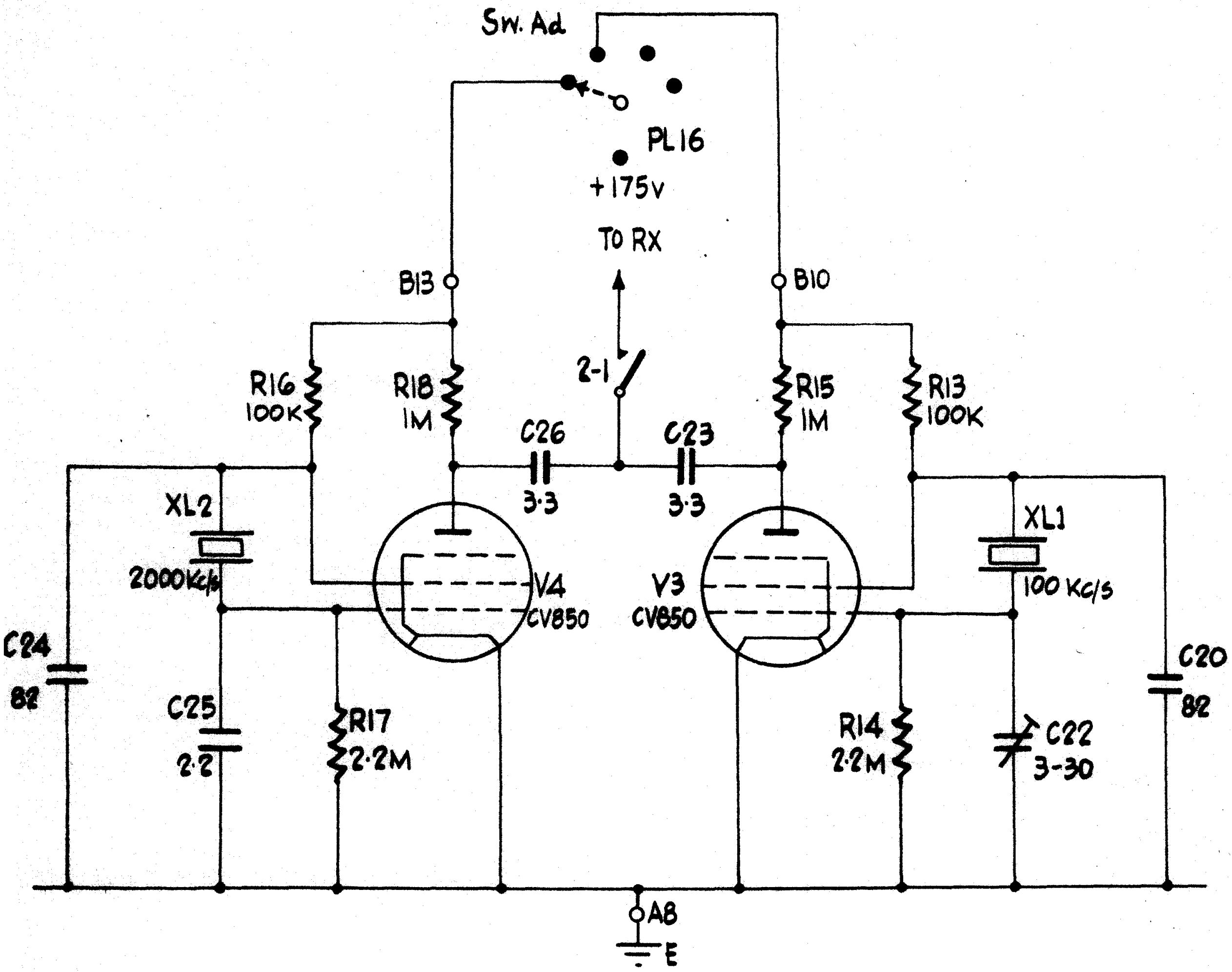


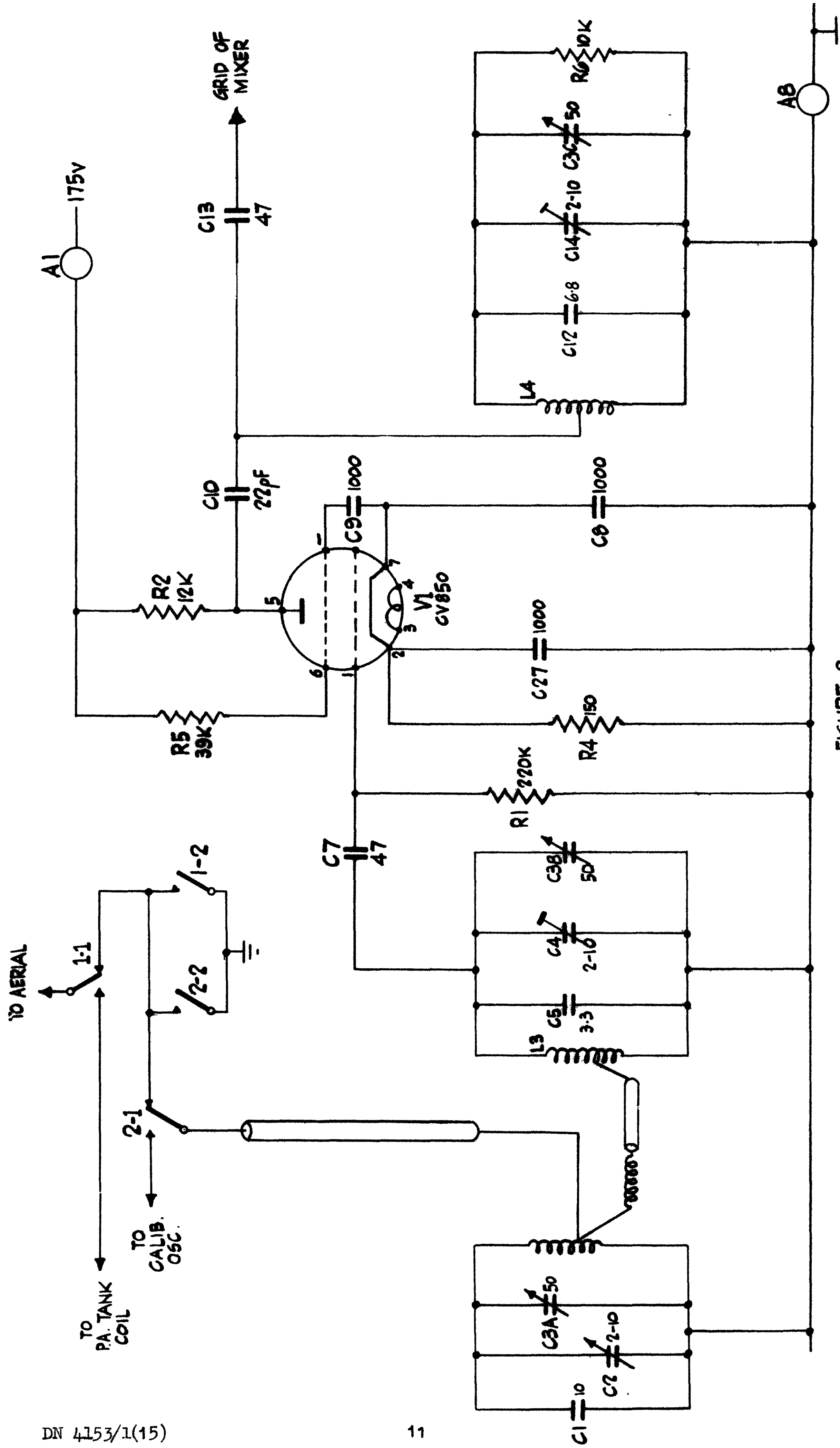
FIGURE. 7.

CALIBRATING CRYSTAL OSCILLATORS

These are both electron-coupled Pierce crystal oscillators: the screens of the valves (which are C.V. 850, 6AK5) are used as the anodes of the oscillators, and the anodes of the valves are used for coupling between the oscillatory circuit and the load being the electron stream of the valve.

R14 and R17 are the grid leaks, giving grid current bias with the capacity of the crystal as the "grid condenser". R13 and R16 are the screen load resistors for developing the output, which is coupled via C23 and C26 to "the Calibrate" relay (2-1). The pairs of condensers connected between earth and either side of the crystals (C20, C22, and C24, C25) result in a phase change of 180° across the crystal (as in the Colpitts oscillator); being in parallel with the crystal, they also affect the frequency slightly, and C22 is made semivariable so that the frequency of the 100 kc/s oscillator may be set exactly to the nominal value. Unlike the normal Colpitts oscillator, the pairs of condensers are not of equal capacity; if the grid condenser is small compared with the screen condenser, the amount of feed-back is reduced, and if the ratio is very large the circuit stops oscillating.

In normal Pierce crystal oscillators, a blocking condenser is used between the oscillator anode (which is nearly at H.T. potential) and the crystal, which has its other end at D.C. earth potential (or less, if grid current bias is being developed); in these cases, however, since the screen potential is much less than the full HT., the blocking condenser is unnecessary.



GRID OF MIXER
A1
175V
C13
47
R6
10K
50
C3C
2-10
C14
6·8
C12
L4
AB
C10
22pF
1000
C9
C8
R2
12K
5
6
1
2
3
4
7
V1
CV850
C27
R5
39K
150
R4
220K
R1
C7
C3B
C4
2-10
C5
3·3
L3
TO AERIAL
1-1
1-2
2-2
2-1
TO CALIB. OSC.
TO P.A. TANK COIL
C3A
C2
C1
10

FIGURE. 8.

R.F. Amplifier

The grid circuit consists of two tuned circuits, top-inductively coupled to give a band-pass effect; the response curve is double-humped, the size of the coupling inductor determining the depth of the trough (actually 3 dB down) and separation between the humps (about 400 kc/s at 36 Mc/s. rising to 900 kc/s at 60 Mc/s). The tuned circuits consist, respectively, of L1 and L3, the inductors; C3A and C3B, the variable sections of the six-gang tuning condenser; C1 and C5, fixed trimmers, C2 and C4, pre-set trimmers. The inductances are located in screened compartments (to prevent any stray inductive coupling) and are coupled together by L2 and a length of coaxial cable; the tapping points on L1 and L3 are chosen to have a suitable impedance to match this 80 ohm coaxial cable.

The input from the aerial tuning unit comes via a coaxial lead, and is also at a low impedance; it is therefore applied to the grid circuit at a point of low impedance, namely at the same points as the coupling inductor and its length of coaxial cable, since the impedances are the same in both cases. The signal passes through the aerial change-over relay and the crystal calibrator relay, both of which will be described later.

The grid of the R.F.A. is fed from a high impedance point, namely, the top of the second tuned circuit. C7 is the grid coupling condenser, and R1 the grid leak; these components provide grid-current bias for the valve when a signal greater than the auto-cathode bias reaches the grid, such as when the receiver monitors the transmitter while sending.

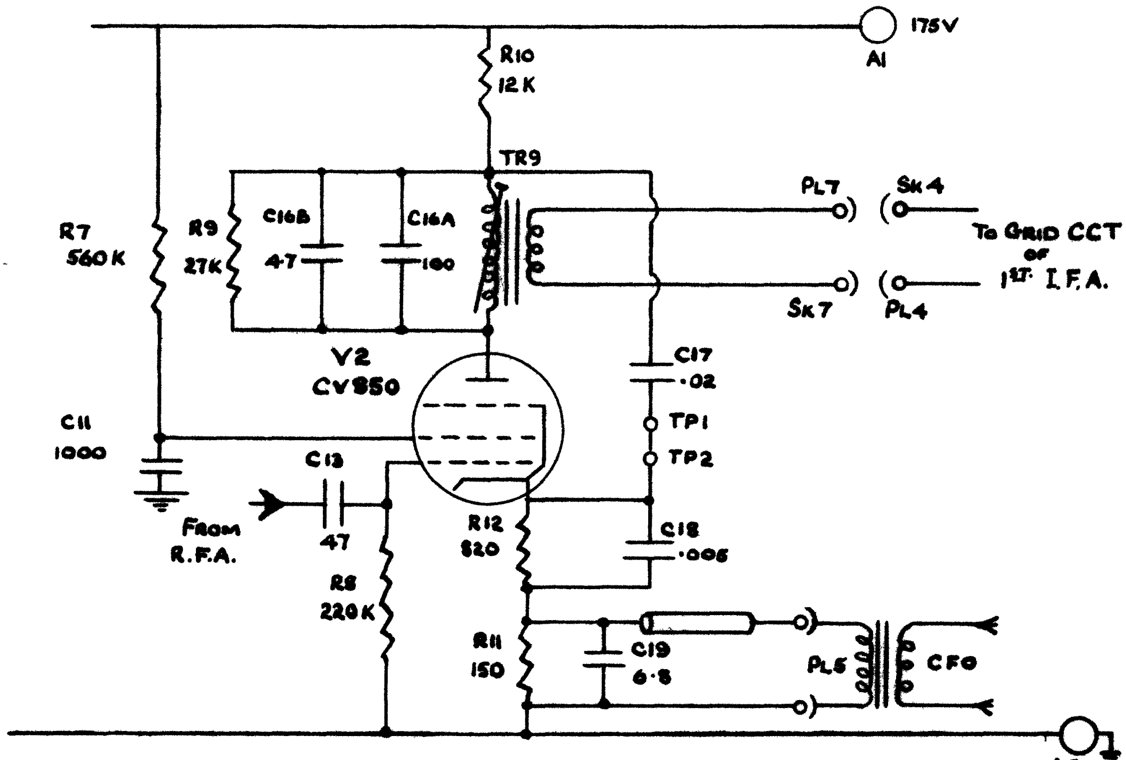
R4 is the auto-cathode bias resistor, decoupled by C8 and C27; this stage is very prone to oscillate; the cathode is brought out to two pins on the base, and both are decoupled to earth.

R5 is the screen dropping resistor; the screen is de-coupled directly to the cathode in order to increase the stability of the stage (the requirement for stability is a low impedance between screen and cathode, not necessarily between screen and earth). The Ferrite bead on the screen lead prevents parasitic oscillations. (see page 1).

R2 is the anode load; the R.F.A. is resistance-capacity coupled to the following tuned circuit, in which L4 is the tuned inductor, C3c is the tuning condenser, C14 is the pre-set trimmer and C12 is the fixed trimmer, the whole being damped by R6, which reduces the "Q" to about a half of its natural value. The anode of the R.F.A. and the grid of the following stage are matched to this tuned circuit by tapping down on the coil.

The bandwidth of this 3rd circuit is about 400 kc/s at 3 db down (at 36 Mc/s) and so the overall response (of this together with the input circuits of the R.F.A.) is approximately flat for a bandwidth of about 400 kc/s, and the R.F.A. has a uniform gain over this bandwidth. The large bandwidth in the receiver input circuit means that the tuning of these circuits is not critical, and the frequency of the master oscillator (which is tuned at the same time) can be passed to the automatic frequency control system, which corrects the frequency to within 10kc/s.

1ST. MIXER



— Figure 9 —

The grid of this stage is coupled to the tuned circuit following the R.F.A. by C13; R8 is the grid leak. R7 is the screen dropper: the screen is decoupled by C11, and has a ferrite bead. Auto-cathode bias is provided by R12, which is decoupled by C18: R11 is the load resistor for the secondary of the output transformer of the 1st local oscillator: C19 in parallel with it bypasses harmonics from the local oscillator. The anode H.T. supply is filtered by R10 and C17; the tuned anode circuit consists of the primary of Tr9, C16A, C16B (which is a negative temperature coefficient condenser), and R9, a damping resistor; the low impedance secondary forms part of the tuned grid circuit of the 1st I.F.A.

During initial alignment, when Tr9 has not yet been tuned, R10 is used as an anode load; the link between TP1 and TP2 is broken (in practice, it is never made) and a diode detector circuit is inserted instead, to measure the overall response of the R.F.A. the lower end of the detector TP2 is returned to the cathode rather than to earth so as to measure only the signal from the R.F.A. which has been further amplified, without including the voltage from the 1st local oscillator which is injected into the cathode circuit.

The input signal is coupled from the R.F.A., which is on the same chassis: the input from the 1st local oscillator comes via a coaxial socket and plug (Sk5, PL5) and a coaxial cable; the 6 Mc/s signal to the 1st I.F.A. passes via PL7 & Sk7, a length of twin flex and Sk4 & PL4. These latter signals are conveyed at low impedance to minimise the effect of stray capacitance on the tuned circuits.

1ST LOCAL OSCILLATOR: THE CONSTANT FREQUENCY OSCILLATOR

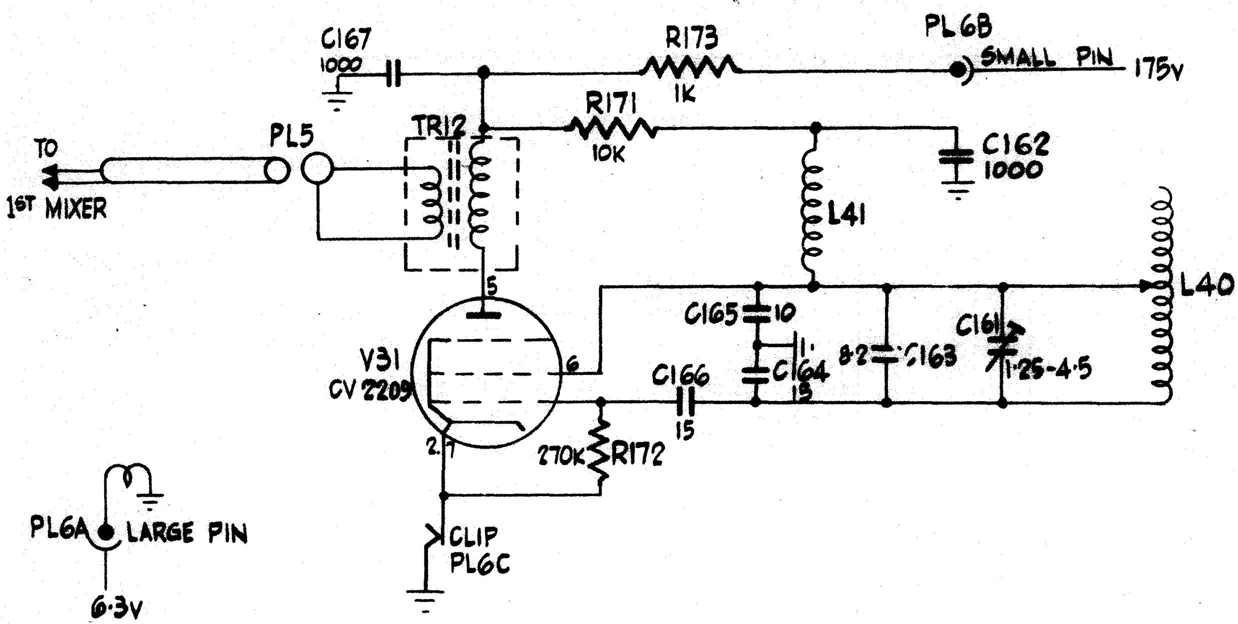


FIGURE. 10.

The 1st local oscillator (or C.F.O.) is an electron coupled Colpitts oscillator: the screen of the valve functions as the oscillator anode, while the output is taken from the valve anode the load being coupled to the frequency-determining circuit, L40, the variable "Inductuner" controlled by the "Channel" control, C161, a pre-set trimmer, C163, a fixed trimmer, C164 and C165 in series with their centre point earthed (these are the "Colpitts condensers"), and C166 in series with the Grid-to-screen capacitance of the valve; the inequality of C164 and C165 results in rather less feedback than if they were equal (reversed inequality would increase the feedback). Grid current bias is developed by C166 and R172; this is the only bias on the stage. L14 is the screen load, for developing feedback.

R173 and C167 filter the H.T. to the stage, and R171 together with C162 filter the screen H.T. supply.

The anode load is the primary of Tr12; it is untuned for two reasons:- firstly, because variable tuning would present tracking difficulties and would spoil the isolation between the load and the frequency-determining circuit (which might result in "pulling"); and secondly because the present tuning demanded for good isolation would need to have an impracticably wide response. The secondary of Tr 12 is connected via P15 to a length of coaxial cable terminating in the R.F. chassis R11, its load resistor (which is also the D.C. path to earth for the 1st mixer cathode circuit).

This stage is contained in a separate chassis which is almost totally enclosed, the only connections to it (beside the coaxial plug already mentioned) are the three power input lines : H.T., L.T. and earth; these are conveyed by a two-pin plug and socket, PL6, which has a clip for the earth return.

The valve used in this stage is a CV.2209 type pentode using 6.3 volt heaters.

1st. I.F. AMPLIFIER

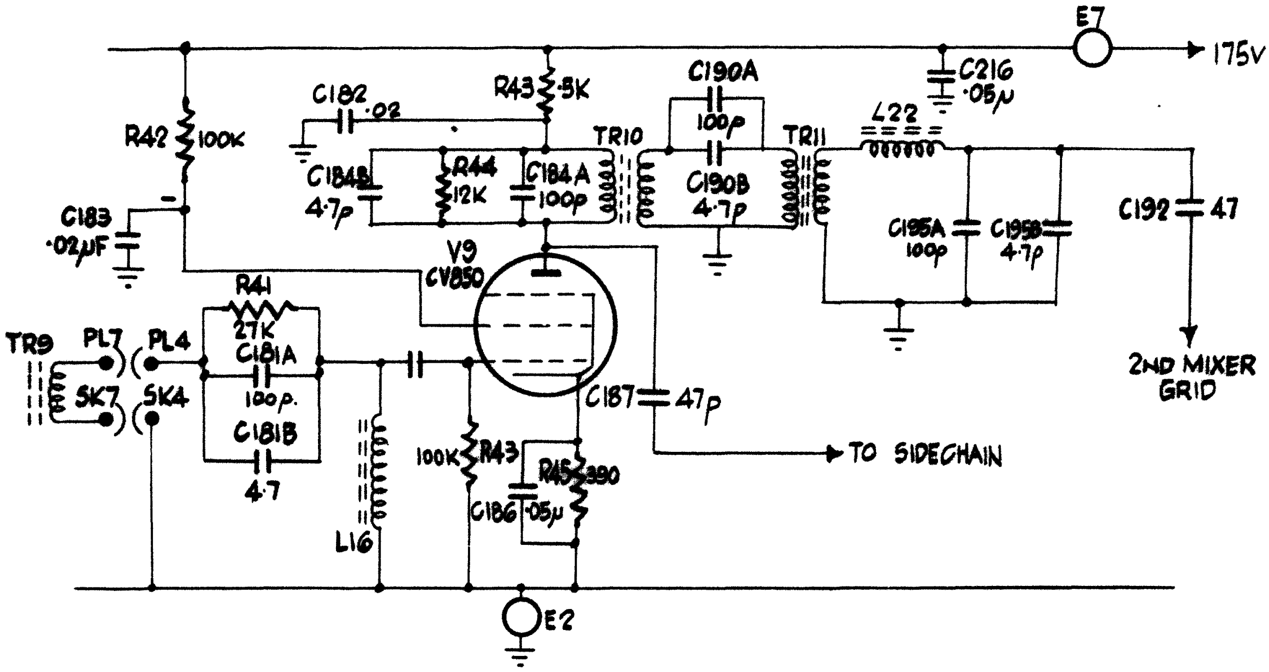


FIGURE. 11.

The tuned grid circuit of the 1st I.F.A. consists of the low impedance secondary of Tr9, C181a, C181b (negative temperature coefficient condenser) and L16, damped by R41: although it appears to be series-tuned, it is really parallel-tuned, with the junction of the two components of the coil (L16, Tr9 secondary) earthed; this steps up the impedance to match the grid of the 1st I.F.A., and incidentally changes the phase (after the manner of the Hartley's oscillator circuit). R43 is the grid leak, and C185, is the grid condenser; these components give grid current bias when a large signal is applied (as during "transmit"). This tuned circuit, together with the tuned anode circuit of the 1st mixer, constitute an over-coupled pair; thus the frequency response between this grid and the previous anode is double-humped, with 200 kc/s peak separation. This wide response, together with the wide response of the R.F.A. enables the automatic frequency control system to cope with frequency errors as large as 400 kc/s. After amplification by the valve, some of the signal is fed via C187 to the sidechain, which completes part of the A.F.C. system; the remaining I.F. circuits, which are more selective, are not included in the A.F.C. circuit.

R45 provides autocathode bias, and is decoupled by C186. The screen (which has a bead) is filtered and decoupled by R42 & C183. The H.T. supply to the whole stage is filtered by R43 & C182.

The anode is coupled to the grid of the 2nd mixer by a chain of three tuned circuits in cascade, in order to obtain the required response curve - narrow, since only the signal and its sidebands have to be accommodated (They are no longer concerned with A.F.C.). The first of the circuits includes the primary of Tr10, tuned by C184b (n.t.c.) C184a, and damped by R44; the second includes the secondary of Tr10, the primary of Tr11, C190b (n.t.c.), C190a; the third includes the secondary of Tr11, L22, (to balance the small secondary of Tr11) C195b (n.t.c.) and C195a.

The valve used in this stage is a CV.850 type pentode using 6.3. volt heaters.

Note

n.t.c. indicates negative temperature co-efficient.

2ND MIXER & 2ND LOCAL OSCILLATOR

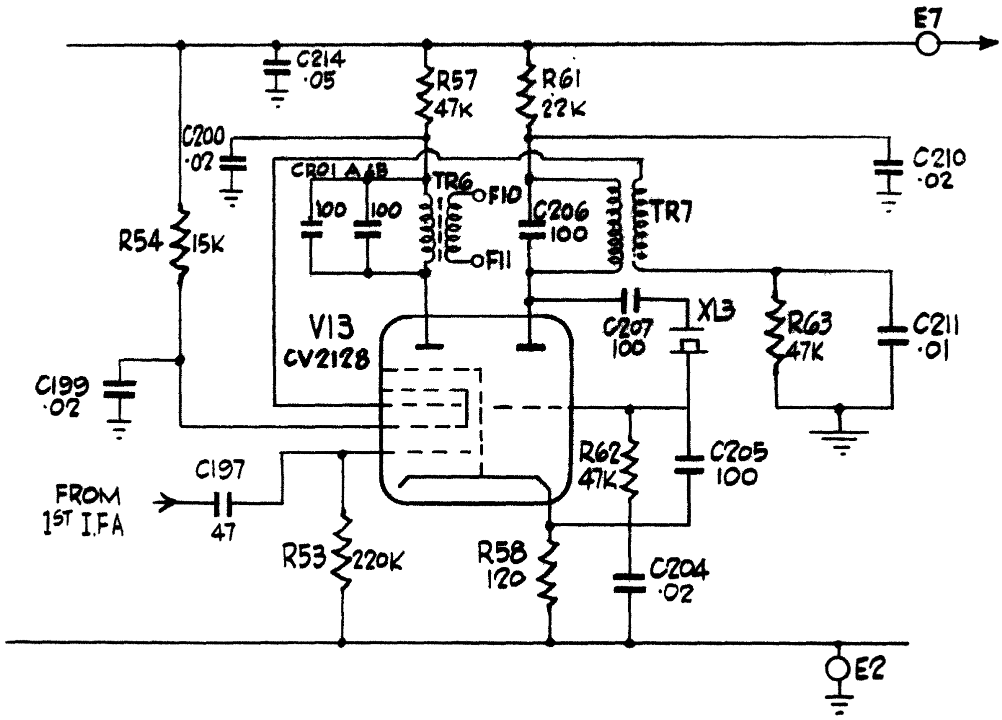


FIGURE 12.

These two stages are incorporated in one valve, a triode heptode, type No. C.V.2128, heated by 6.3 volts A.C.

The 2nd mixer consists of the heptode section; auto cathode bias for the control and signal grids of this part is provided by R58 which is decoupled by C204. The control grid is coupled by C197 to the tuned circuits following the first I.F.A. R53 forms the grid leak resistor. These two components give protective grid current bias when the receiver monitors a relatively large input from the transmitter on "send". The signal grid is transformer-coupled by TR7 to the anode of the 2nd Local Oscillator. The screen dropping resistor is R54 and its decoupler is C199. The anode supply is filtered by R57 and C200, together with C214 which also affects the screen supply. The anode load is the primary of TR6, tuned to 2.4 Mc/s by C201A and C201B.

The 2nd Local Oscillator uses the triode section of the same valve. It operates as a Pierce Crystal type working at 8.4. Mc/s. C207 keeps H.T. off the crystal while C205 determines the amount of feedback. R62 in conjunction with the capacitance of the crystal produces grid current bias (the auto cathode bias on the stage does not affect the triode section since R62 is returned to the cathode). The anode H.T. supply is filtered by C210 and R61, again in conjunction with C214. The anode load is the primary of TR7 tuned to 8.4. Mc/s by C206. The secondary of TR7 is connected to the signal grid of the heptode section, and to earth by R63 and C211 which give grid current bias on the signal grid.

The 2nd intermediate frequency is 2.4 Mc/s and this is obtained from the previous 6 Mc/s I.F. by mixing with an 8.4 Mc/s output (not one of 3.6 Mc/s). This is because there is less possibility of harmonics of the oscillator upsetting reception over the working range of the set. There are only three harmonics of 8.4 Mc/s in the range whereas there are more harmonics of 3.6 Mc/s.

2ND I.F. AMPLIFIER

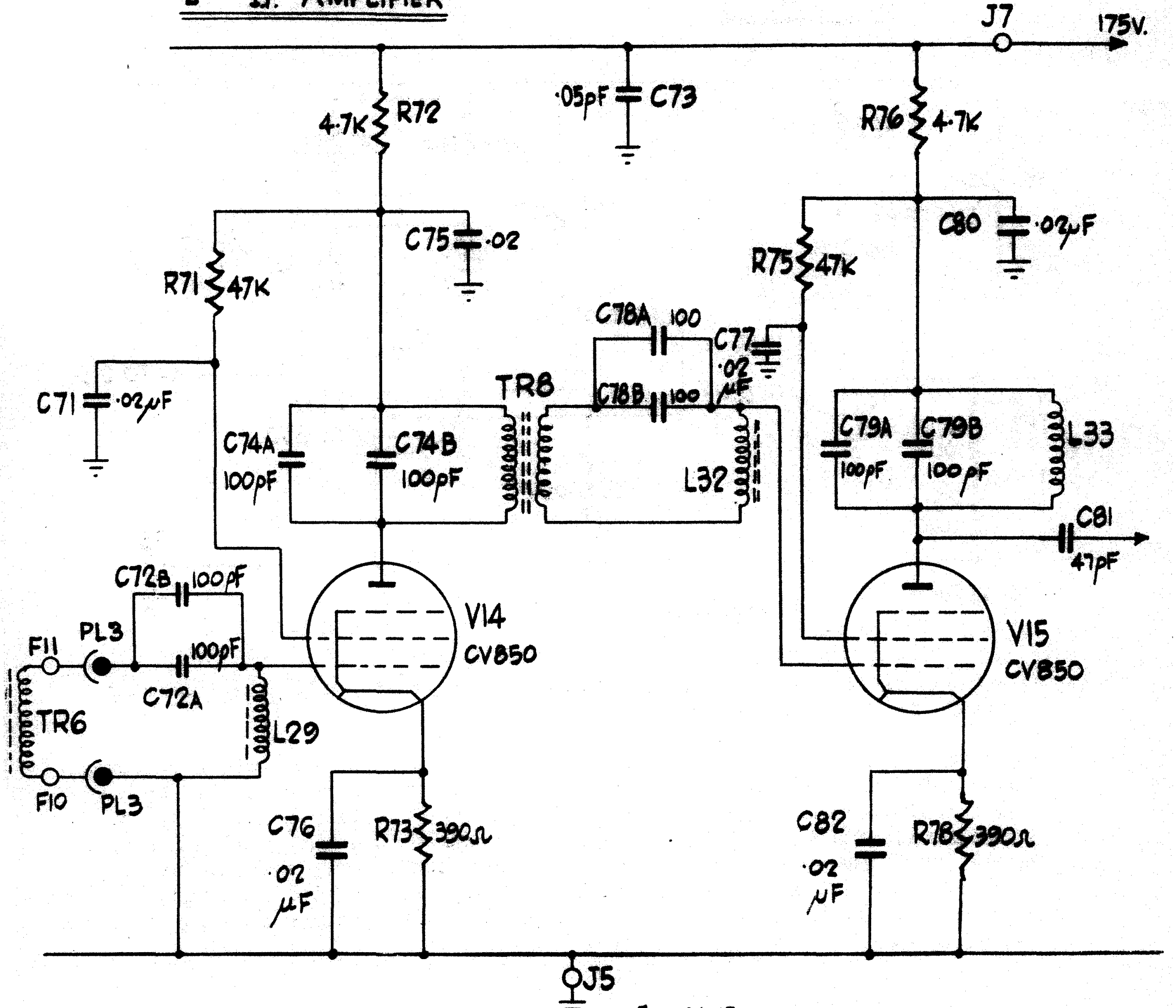


FIGURE. 13

This is a two stage amplifier, using two C.V. 850 type pentodes, both with 6.3 volt heaters.

The grid of the first stage is fed from the anode of the 2nd mixer by TR6 which has a small secondary; to balance this L29 is added in series, the whole is tuned by C72a and C72b (negative temperature coefficient). The screen of the first stage is fed from the H.T. filter R72 & C75 together with C73, and via R71 & C71, the screen dropping resistor and decoupling condenser. Auto-cathode bias is provided by R73 and C76.

The primary of Tr8 forms the anode load and is tuned to the Intermediate Frequency of 2.4 Mc/s by C74a & C74b (N.T.C.).

The secondary is again small and with L32, is tuned by C78a and C78b (N.T.C.) and the voltage developed across it is applied directly to the next stage.

This second stage is identical to the last: R78 & C82 provide auto cathode bias, R75 & C77 are the screen dropping resistor and decoupling condenser and as in the first stage there is a ferrite bead. R76 & C80 form the H.T. filter together with C73. The anode load consists of L33 tuned by C79a & C79b (N.T.C.).

The output from the anode is capacity coupled to the grid of the first limiter, by C81.

THE LIMITERS

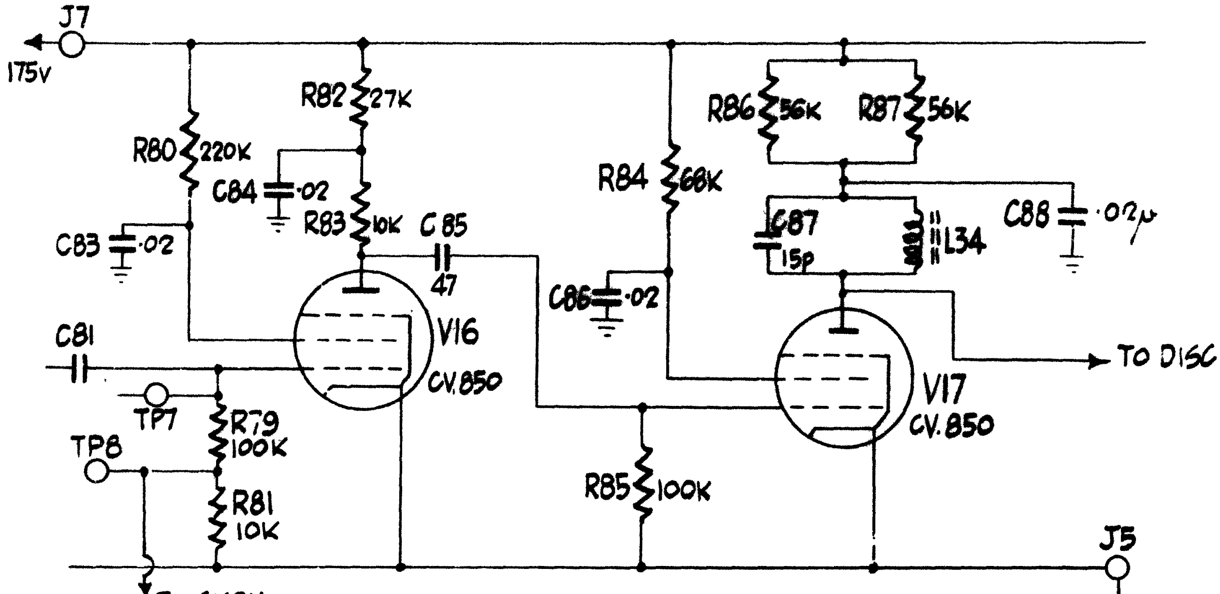


FIGURE. 14.

Limiters are put into an F.M. set to ensure that a signal of constant amplitude is fed to the discriminator.

This is done by operating the valves with low anode and screen voltages, thus shortening the grid base. The valves start with zero bias but, when a signal arrives, grid current flows and the valves are biased back. By using grid current bias in this way the positive peaks of a large amplitude signal are cut off. The short grid base will ensure that no very large negative peak passes through. Thus a constant amplitude output is obtained. A tuned circuit is placed in the anode of the second stage to ensure a sinusoidal input to the discriminator.

The 1st Limiter

This is a C.V. 850 pentode. R79 and R81 are the grid leaks which with C81 give grid current bias when a signal arrives. R80 and C83 are the screen dropping resistor and decoupling condenser. The anode is run at a low voltage and its supply is filtered by R82 and C84. The output is resistance-capacity coupled to the second limiter grid. There is a Ferrite bead on the screen lead.

The 2nd Limiter

R85 is the grid leak and with C85, the coupling condenser, gives grid current bias in the presence of a signal. R84 and C86 are the screen dropping resistor and decoupling condenser. R86 and R87 and C88 filter the H.T. supply to the anode which is run at a low value. L34 and C87 are the tuned anode load, the output being directly coupled to the Bond (or Weiss) discriminator. There is also a Ferrite bead on the screen lead of this stage. Tp 7 is attached to the anode of the second stage of the 2nd I.F.A. From this point we can get overall readings of the performance of the receiver (bandwidth, sensitivity etc.) up to this stage. At Tp 8 we can measure the limiter grid current and thus obtain a measure of the signal strength. Tp 8 is brought out to the front of the set to Sk2h so that the set can be shown to be working as far as the limiters without opening it.

THE BOND DISCRIMINATOR

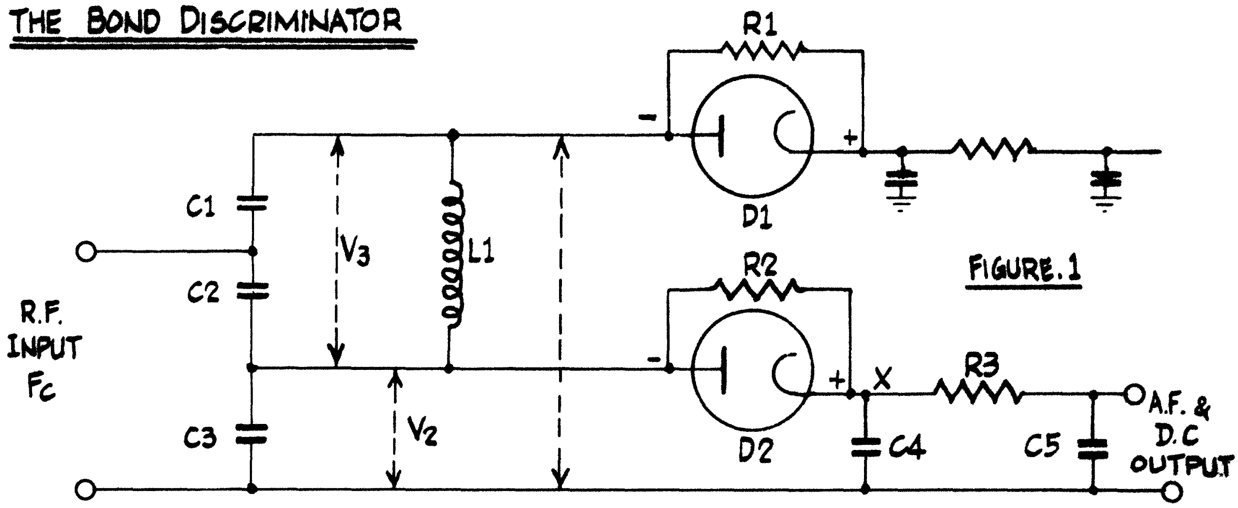


FIGURE 15.

The R.F. input is applied across the parallel tuned circuit (which consists of L1, C1, C2) and C3 in series. In fact it is applied to a tapping on the tuned circuit rather than to the upper end of C1 so that D1 & R1 may not damp the previous circuit (the anode load of the limiter), and the tapping is capacitive to provide a D.C. block for the limiter anode potential.

The R.F. voltage applied to the diode detector D1R1 is V1, and since the point "X" is put at R.F. earth potential by C4, the R.F. voltage applied to D2R2 is V2. Now R1 is equal to R2, so the D.C. potentials developed across R1 & R2 will be proportional to the applied voltages, V1 & V2, and their polarities will be as shown. Since these potentials are connected "back-to-back" through L1 (which has negligible O.C. resistance), the resultant output will be the difference between them, and will be positive or negative according to whether V1 or V2 is greater.

In order to determine how this discriminator operates when a frequency-modulated signal is applied, we must consider the vector relationships between V1, V2 and V3. Consider first the circuit consisting of L1, C1, C2, & C3: the parallel tuned circuit comprising L1, C1 & C2 has a resonant frequency F which is higher than the rest frequency Fr; it is therefore partly inductive, and the voltage across it, V3, leads the current I taken from the generator. The voltage across C3 of course lags I, and these quantities, together with their resultant V1, can be represented in a vector diagram as shown below:-

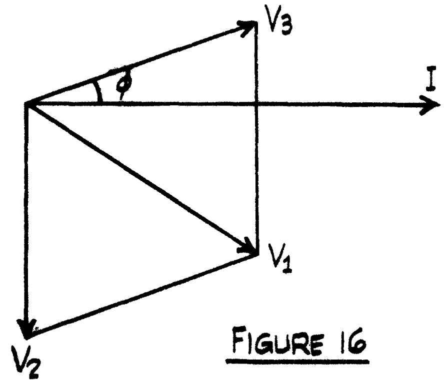


FIGURE 16

In order to get zero output at Fr, V1 and V2 must be equal in magnitude and to achieve this the phase angle of V3 is adjusted by altering the amount of detuning of the tuned circuit: the following diagram shows how the phase angle of a tuned circuit alters on each side of its resonant frequency.

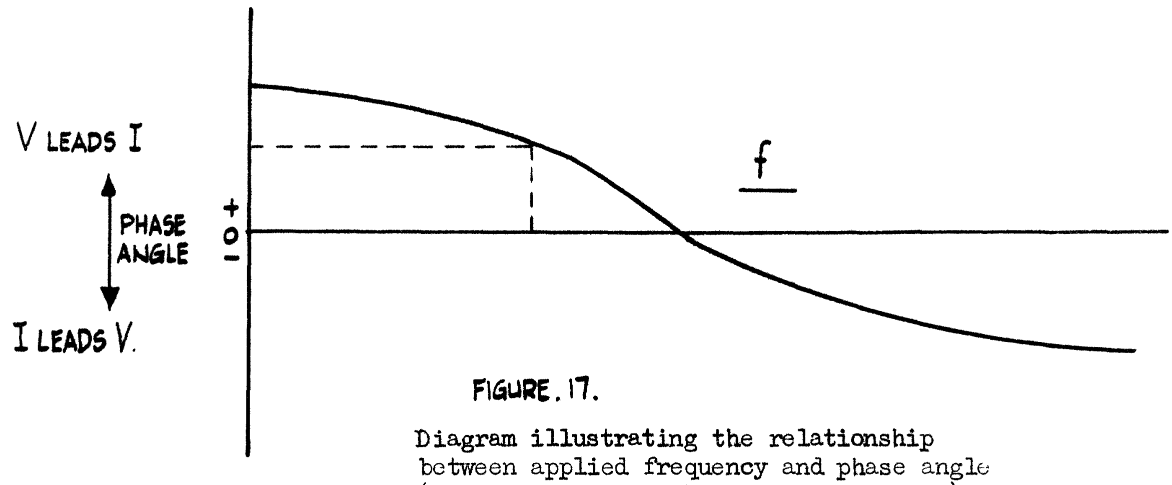


FIGURE. 17.

Diagram illustrating the relationship between applied frequency and phase angle (current leading voltage or vice versa).

If FC is raised, the vector diagram in Figure 16 has to be modified in two respects:- since the tuned circuit in the discriminator is more nearly resonant, the magnitude of V3 is increased somewhat relative to the other voltages, and the phase angle is reduced. Both these changes tend to increase the magnitude of the resultant, V1, as shown below:-

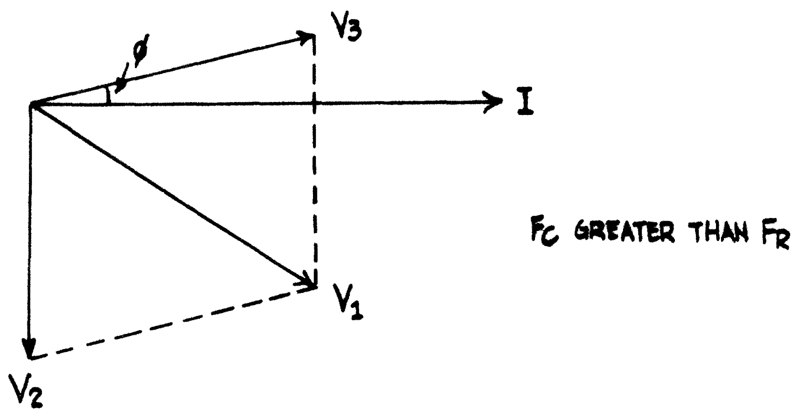


FIGURE 18

Thus V1 exceeds V2, and the resultant output from the diodes is negative. Note that since FC is approaching FO, the current I decreases (tending to decrease V2), and the reactance of C3 decreases (also tending to reduce V2); these factors increase the difference between V1 and V2 (thus increasing the sensitivity of the discriminator) but are too small to have any appreciable effect in practice.

Similarly, when the applied frequency is lowered, the reverse changes take place, and a positive output is obtained.

Note, in Figure 1, that the cathode of D1 is differently connected in the two discriminators used in the set; in the receiver it is directly earthed, while in the sidechain it is earthed for R.F. by the first condenser of the pi-shaped filter (as is the cathode of D2), the other end of the filter being connected to the receiver discriminator (via an L-plus-T-shaped filter), so that their D.C. outputs add together.

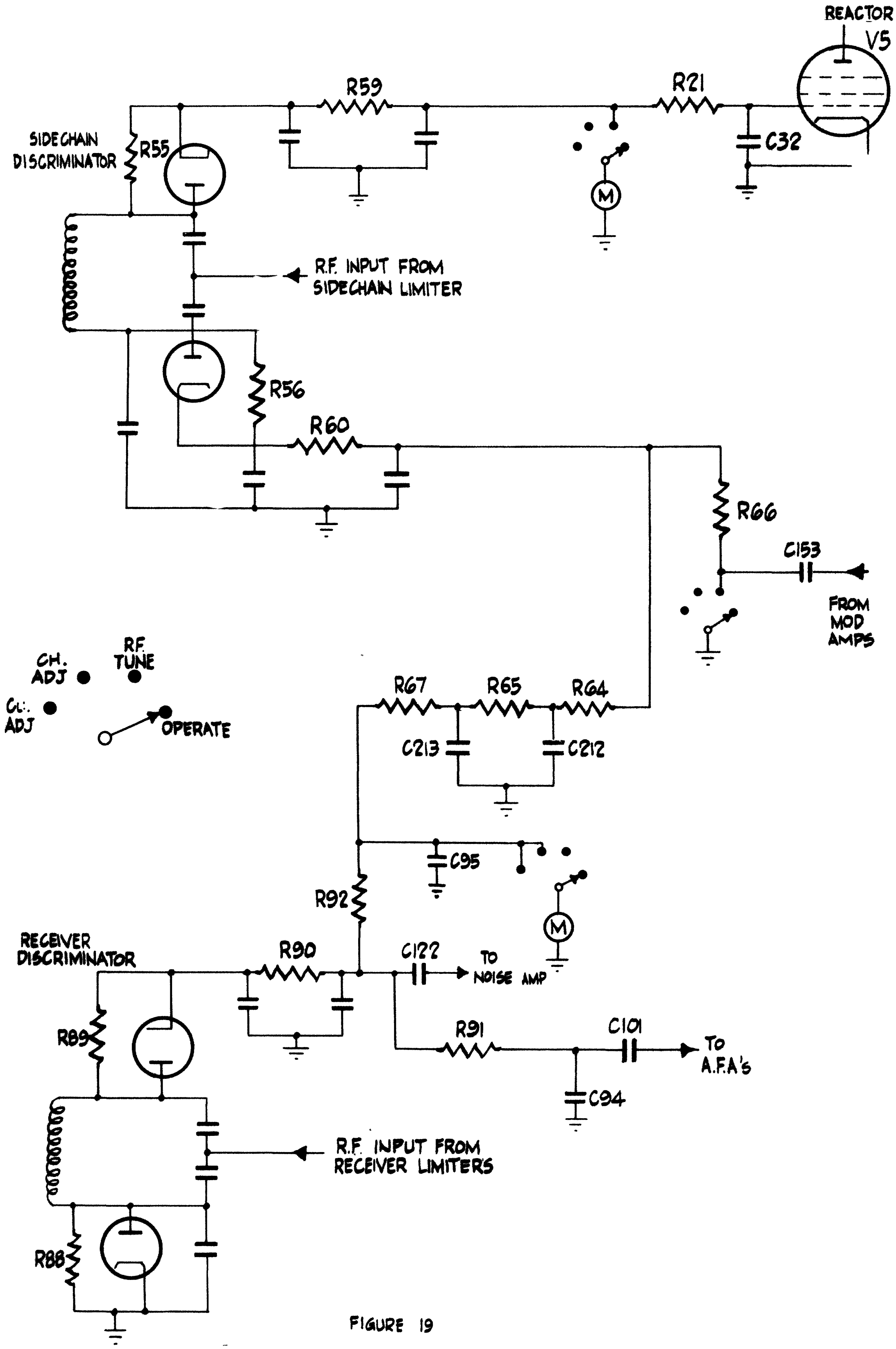

REACTOR
V5
R59
R21
SIDECHAIN DISCRIMINATOR
R55
C32
M
R.F. INPUT FROM SIDECHAIN LIMITER
R56
R60
R66
C153
FROM MOD AMPS
CH. ADJ
R.F. TUNE
CL. ADJ
OPERATE
R67
R65
R64
C213
C212
C95
R92
M
RECEIVER DISCRIMINATOR
R90
C122
TO NOISE AMP
R89
R91
C101
TO A.F.A's
C94
R.F. INPUT FROM RECEIVER LIMITERS
R88

FIGURE 19

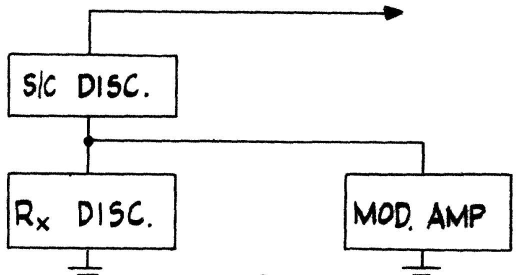


FIGURE. 20.

The above block diagram, together with the circuit diagram on the previous page, shows how the reactor stage is fed with D.C. and A.F. When transmitting and receiving, the receiver is always working, and so both discriminators are being fed with R.F. at the appropriate frequency and are therefore producing D.C. & A.F. outputs according to the amount of drift and A.F. deviation on the applied signal. The receiver discriminator produces its output with respect to earth (one of the diode cathodes is directly earthed), and the sidechain discriminator produces its output with respect to whatever voltage is produced by the other discriminator:- since the receiver discriminator is connected to this circuit via a low-pass filter, only its D.C. output reaches the "earthy" cathode of the sidechain discriminator, together with the A.F. output from the modulation amplifiers, and thus the net output is the sum of the D.C. outputs from the two discriminators together with the output from the modulation amplfiers.

Since this circuit involves four different types of voltage - D.C., A.F., NOISE VOLTAGE (which is A.F. of about 10 Kc/s), and R.F. - the filtering system has to be fairly comprehensive in order to prevent interaction.

(A) R.F. Filters:- the output lines of the two discriminators are filtered by means of the three filters which include R90, R59, and R60.

(B) D.C. Filters:- D.C. is isolated from the three A.F. stages which are connected to this system (the modulation amplifiers, the A.F.As. and the noise amplifier in the squelch circuit) by C153, C101 and C122, respectively.

(C) A.F. Filters:- A T-shaped filter consisting of R65, R57 and C213 is backed at each end by L-shaped filters consisting of R92, C95 and C212: this combination effectively prevents the output from the modulation amplifiers from reaching the A.F.As. and also isolates the A.F. and noise output produced by the receiver discriminator from the reactor stage, V.5.

(D) Noise Filters:- the A.F. filters mentioned above also function as noise filters: in addition, R91 and C94 block noise from the A.F.As.

(E) R21 and C32 filter stray R.F. signal from the reactor grid lead, thus preventing feedback and instability.

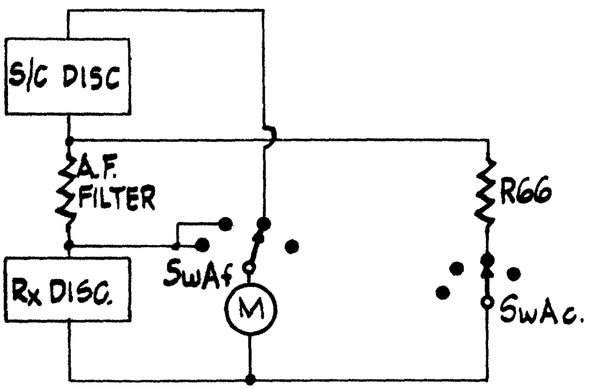


FIGURE. 21.

On "tune R.F." the lower end of R66 is earthed. This bypasses the high impedance due to the receiver discriminator (164 K) and the A.F. filter network (R64,65,67,C212,213 R92,C95) (746 K). The meter reading is thus increased. The output from the receiver discriminator is negligible as it is attenuated by the filter. On the first two positions, this output is taken from the other side of the filter; it is therefore not attenuated.

THE SQUELCH CIRCUIT

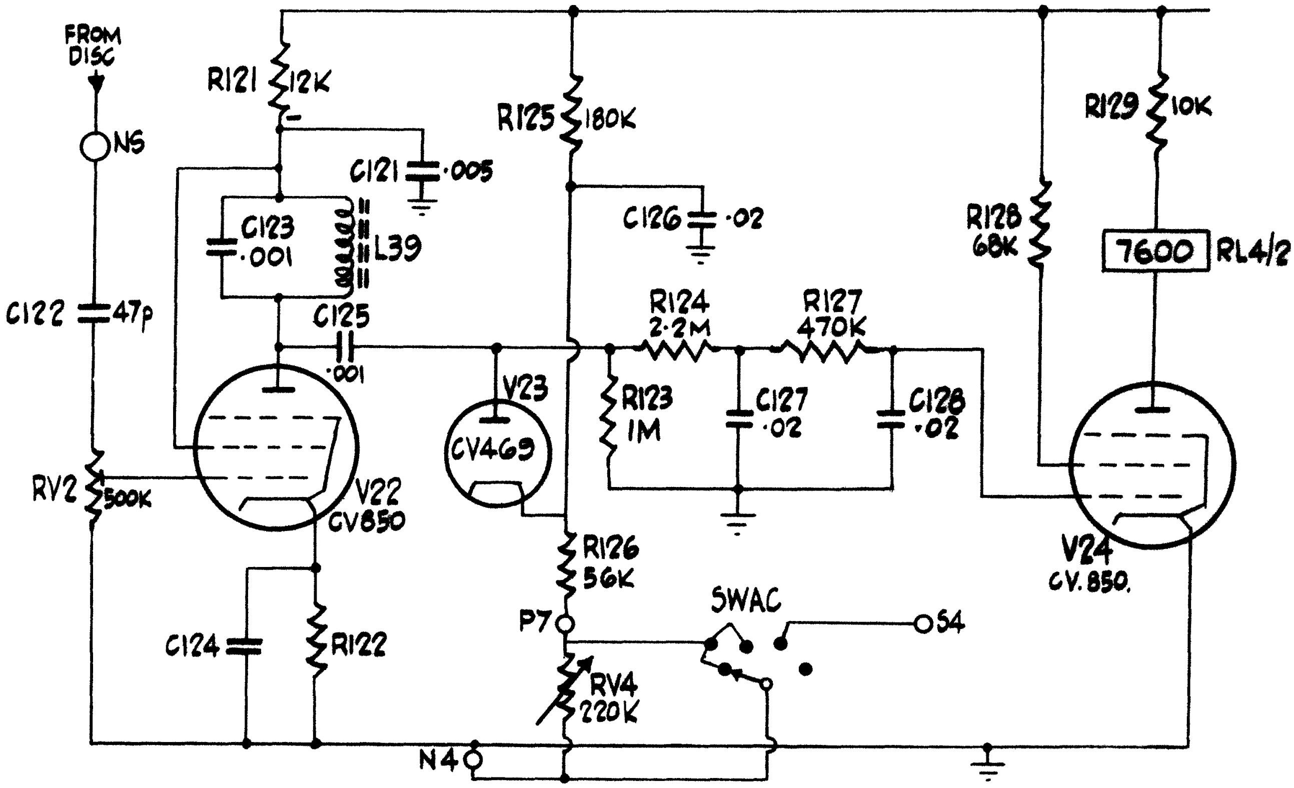


FIGURE. 22.

F.M. Sets produce a noise output in the headphones in the absence of a signal, which is reduced when a signal arrives. This has been found, by experiment, to arise in the SECOND MIXER, a heptode. The squelch circuit mutes the receiver whenever this noise is produced and the arrival of a signal causes the receiver to operate normally, and the signal can then be heard.

THE NOISE AMPLIFIER

The noise signal from the discriminator passes through N5 and through a coupling condenser C122 to RV2: a pre-set control, which applies a pre-determined amount to the grid of the amplifier. R122 and C124 provide auto cathode bias. R121, C121 and a ferrite bead filter the H.T. supply to the anode and screen. L39 forms the anode load tuned to 10 Kc/s. by C123. (the majority of the noise signal occurs around this frequency). The output is capacitively coupled to the next stage.

THE NOISE RECTIFIER

This is a shunt-connected diode, with a variable delay voltage between 40 and 100 volts on its cathode determined by the potentiometer network; R125, R126, and RV4 which can be switched in and out of circuit by SwAc. C126 decouples the diode cathode and the bottom of R125 which drops the H.T. to the delay voltage. Any noise output from the previous stage in excess of this voltage is rectified and developed across R123, the load resistor. It is then filtered by two 'L' shaped filters R124 and C127 and C188, and applied directly as negative D.C. to the grid of the next stage.

THE D.C. AMPLIFIER

Any negative voltage on the grid of this stage due to an output from the rectifier will reduce the anode current, which will then become insufficient to hold the squelch relay in its rest position, that is, closed. The relay (RL4/2) will therefore open, and with one contact earth the anode of the 1st A.F.A. thus muting the headphones while the other extinguishes the signal lamp on the front panel. R128 and R129 filter the anode and screen circuits, and also set the standing anode current in the absence of a signal on the grid.

When any signal arrives the noise ceases, there is no noise voltage to rectify and hence there is no voltage on the grid of the D.C. amplifier. The anode current once more increases and operates the relay reconnecting the anode of the 1st A.F.A. to the H.T. supply. The signal can then be heard in the headphones and the signal lamp relights.

SwAc on the system switch reduces the delay voltage on the noise rectifier on "cursor" and "channel" adjust by shorting out RV4 in the potentiometer network (the variable resistor which is the front panel as the "squelch" control).

The squelch circuit is also used in connection with automatic rebroadcast operation which will be explained later.

The two amplifier valves used in this section are C.V. 850 type pentodes using 6.3 volt heaters, while the noise rectifier is a small pencil diode C.V. 469 which is also the type used in both discriminators and in the Automatic modulation control circuit. These are heated by 4 volt supplies which are, in most cases taken from the 6.3 volt line through a series resistor (but not in the case of the sidechain discriminators).

A high impedance squelch relay is used to match the high anode impedance of the D.C. amplifier which operates it.

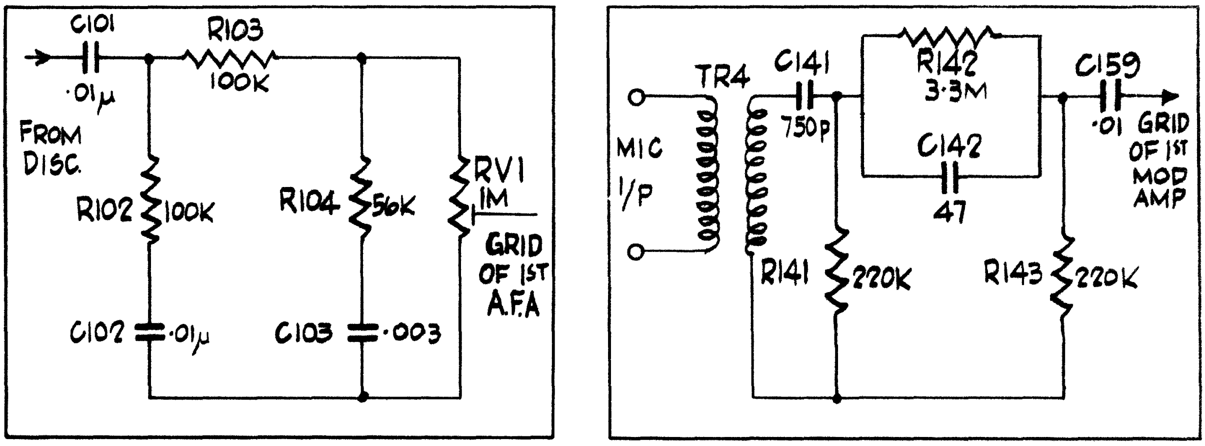
THE PRE-EMPHASIS AND DE-EMPHASIS NETWORKS

The De-emphasis network is situated in the receiver on the input line from the discriminator to the 1st AFA. This network consists of a system of filters arranged so that the network as a whole has a frequency response curve which drops at the high end.

The network is put in to improve the signal to noise ratio of the higher speech frequencies (where there is more noise); It cuts down the response at higher frequencies (at 3Kc/s it is 12 Db below that at 300 c/s). To compensate for this, as far as the signal is concerned another network is provided on the input line from the microphone to the 1st modulation amplifier, known as the Pre-emphasis network, which has a rising characteristic, thus emphasising the higher speech frequencies by having greater response at the top end of the speech range.

In this way the noise is cut down at the high end of the speech band whereas the signal remains constant. Thus the signal to noise ratio is increased at these frequencies.

Both these networks are contained in their own separate screening cans.

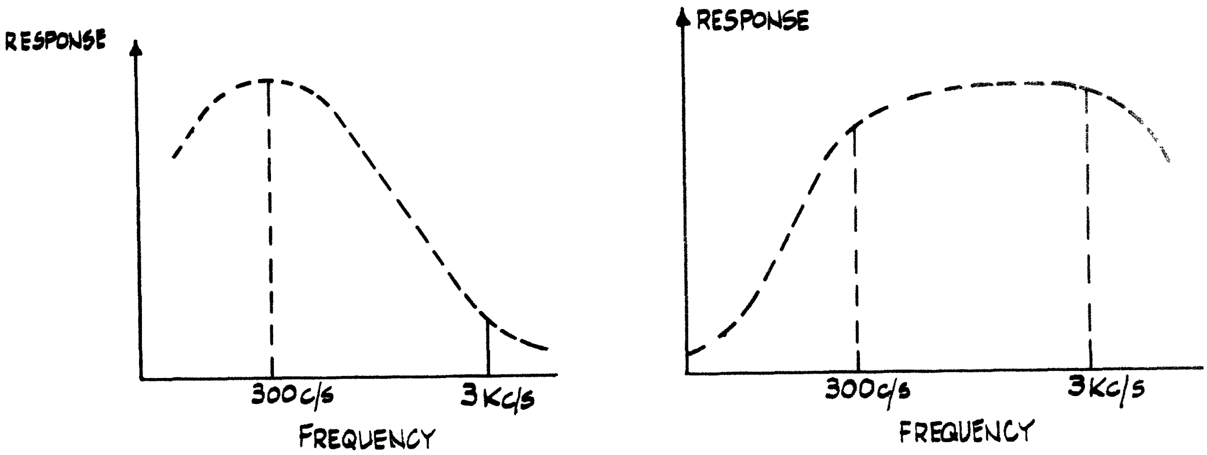


DE-EMPHASIS IN Rx

PRE-EMPHASIS IN Tx

FIGURE 23

It is not necessary to account for frequencies outside the range 3Kc/s down to 300c/s since very nearly all speech frequencies lie within this range.



RESPONSE CURVES

DE-EMPHASIS

PRE-EMPHASIS

FIGURE. 24.

THE AUDIO FREQUENCY AMPLIFIERS

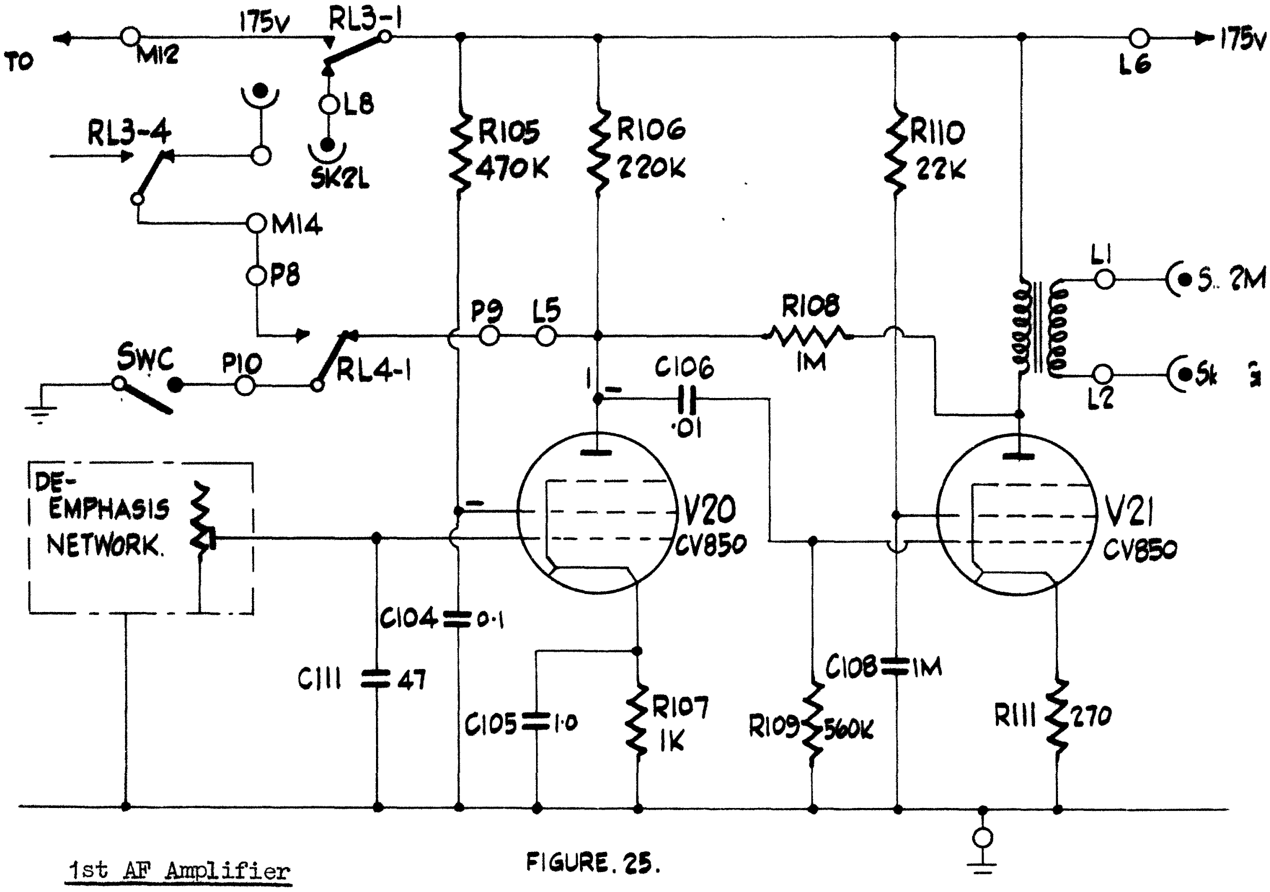


FIGURE. 25.

1st AF Amplifier

The signal is applied to the de-emphasis network, which has just been explained. The terminating resistor of the network is the grid leak of this stage; C111 removes any R.F. which reaches this part of the circuit, during "transmit", or at any other time. R107 and C105 are the autocathode bias components. The screen has a ferrite bead and is decoupled by C104, R105 being the dropping resistor. The anode is resistance-capacity coupled to the next stage by the load resistor R106 and the coupling condenser C106. The anode is also fitted with two ferrite beads.

2nd AF Amplifier

The signal from the first stage is coupled to the grid leak, R109, by C106. R111 is the autocathode bias resistor, which is undecoupled to give current negative feedback on this stage. The screen has a bead, and is decoupled by C108, R110 being the dropping resistor, the anode load is the primary of Tr.1. whose secondary feeds the headphones via the distribution box. R108 provides voltage negative feedback across this stage; this, reduces the output impedance of the stage, improving the regulation of the output voltage when varying numbers of phones are connected.

Squelch Operation

In the absence of signal, the squelch relay releases and the earth connection via SwC is transferred from the rebroadcast line (Sk2E) to the anode of the first AFA. When a signal arrives, the squelch relay operates, un-muting the AFAs and earthing Sk3E; but on "transmit" (when the squelch relay again operates) this earth connection is broken by the send/receiver relay; thus the earth connection is made only while a signal is being received, and is used for automatic rebroadcasting.

Both valves in this section are type C.V. 850.

THE MODULATION AMPLIFIERS

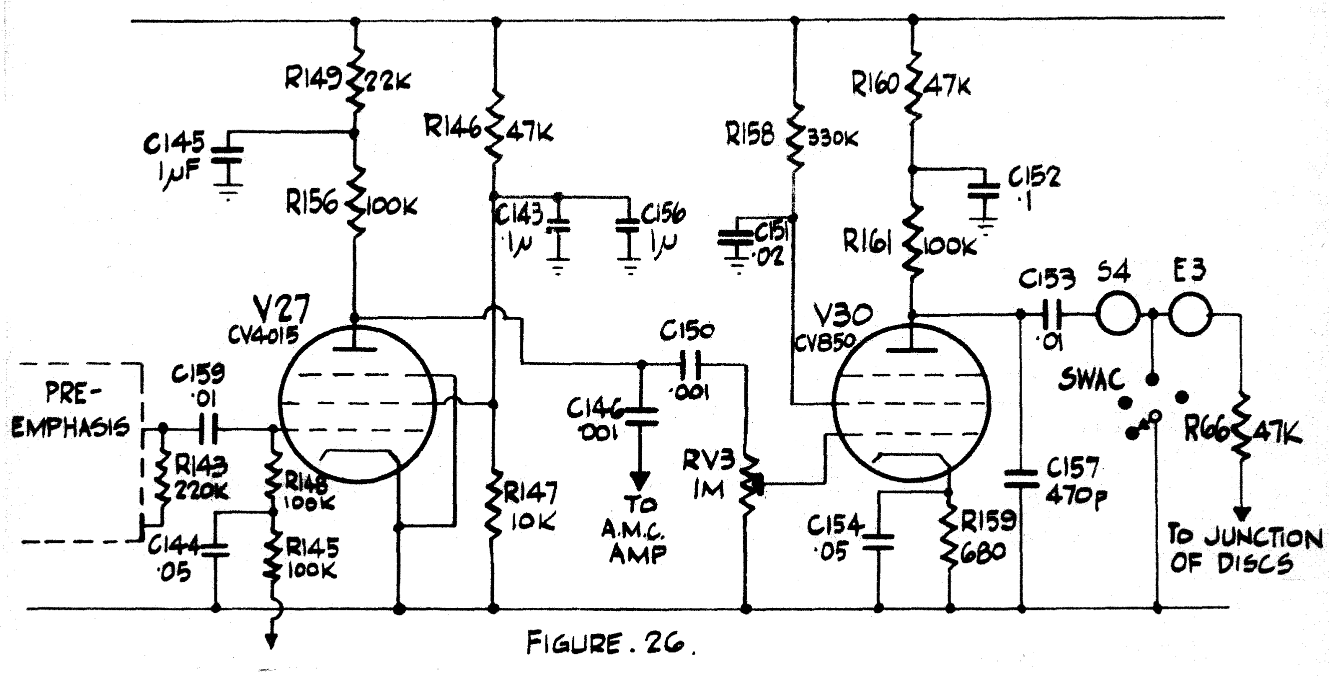


FIGURE. 26.

1st Modulation Amplifier

This stage is fed by the microphone input transformer Tr4, via the Pre-emphasis network. This network is terminated by R143. C159 blocks the negative voltage on the grid of the 1st modulation amplifier from the D.C. path to earth through the Pre-emphasis network. R145, R148 and C144 form a T shaped filter to keep any AF output from the automatic modulation control detector from the grid of the modulation amplifier, where it might cause instability. R148 prevents the microphone signal from being passed to earth by C144. The cathode and suppressor are directly earthed. The screen is supplied from the potentiometer network R146 and R147, which stabilises the voltage supplied to the screen, which is decoupled by C143 and C156. C145 and R149 filter the anode circuit and the anode load is R150. The output is capacitively coupled, via C150, to the grid of the 2nd modulation amplifier and to the automatic modulation control amplifier by C146. The valve is a CV 4015 type pentode whose heater is fed with D.C. to reduce hum.

2nd Modulation Amplifier

RV3 is a preset gain control, which applies a certain amount of the signal to the grid of this stage. R159 and C154 provide auto-cathode bias. The screen dropping resistor is R158 and the decoupling condenser is C151; there is a ferrite bead. The anode H.T. supply is filtered by R160 and C152. R161 is the anode load developing the output voltage which passes through C153, a D.C. block, to the junction of the discriminators. C157 acts as a top cut Filter.

SwAc earths the top of R66 on "tune R.F.". This serves as an attenuation network for the output of the receiver discriminator, which has to be reduced on this position of the system switch, as only the sidechain discriminator is being used to produce the meter reading.

The AF and DC signals from the modulators and receiver discriminator are applied in series with the DC output from the sidechain discriminator, which adds its own DC component, to the grid of the reactor. This loop results not only in automatic frequency control, but also in negative feedback in the modulator, which keeps its percentage deviation linear, and also constant at all frequencies.

The 2nd modulation amplifier is a CV 850 type pentode, fed with 6.3 volts to its heaters. These are only on when the Standby/traffic switch is at traffic, as are those of the 1st mod amp. H.T. is only on when the system switch is set to "tune RF" or on "operate" with the pressel pressed.

AUTOMATIC MODULATION CONTROL

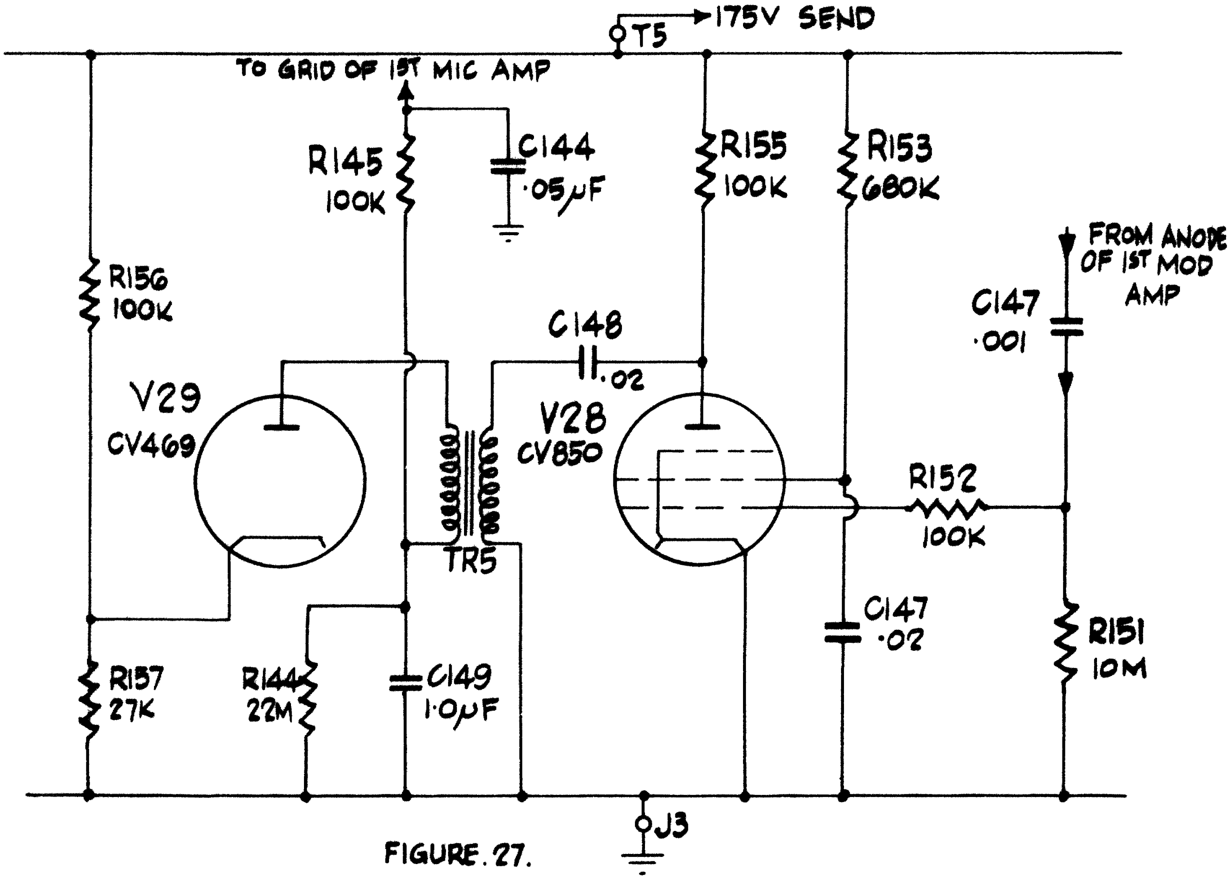


FIGURE. 27.

This circuit ensures that the deviation of the master oscillator is never greater than the specified 15 Kc/s.

AUTOMATIC MODULATION CONTROL AMPLIFIER

This is a CV 850 type pentode. R151 is the grid leak. R152 is a parasitic stopper. The cathode is directly earthed and only grid current bias is provided, by R151 and C146. R153 is the screen dropping resistor and C147 is the decoupling condenser. The anode is resistance capacity coupled by R155 and C148, to the primary of Tr5 which steps up the voltage applied to the rectifier.

AUTOMATIC MODULATION CONTROL RECTIFIER

This is a pencil diode, type No CV 469 with a 4 volt heater. It is connected as a series diode detector with a delay voltage of network formed by R156 and R157. R144 acts as the load resistor, the D.C. developed across it being smoothed by C149. This DC is fed via the 'T' shaped low pass filter R145, R148 and C144 to the grid of the first modulation amplifier (which is a variable mu pentode) thus reducing its gain. Thus if a large signal reaches the anode of the first modulation amplifier which would eventually produce a deviation of the master oscillator greater than the required maximum of 15 Kc/s, it is amplified and rectified by these two stages and produces a negative DC output which reduces the gain of the modulation amplifier tending to keep constant the output of the modulation amplifiers, and therefore the deviation of the master oscillator.

Both A.M.C. valves and the 2nd modulation amplifier are fed with balanced heaters to reduce hum.

THE MODULATOR & MASTER OSCILLATOR

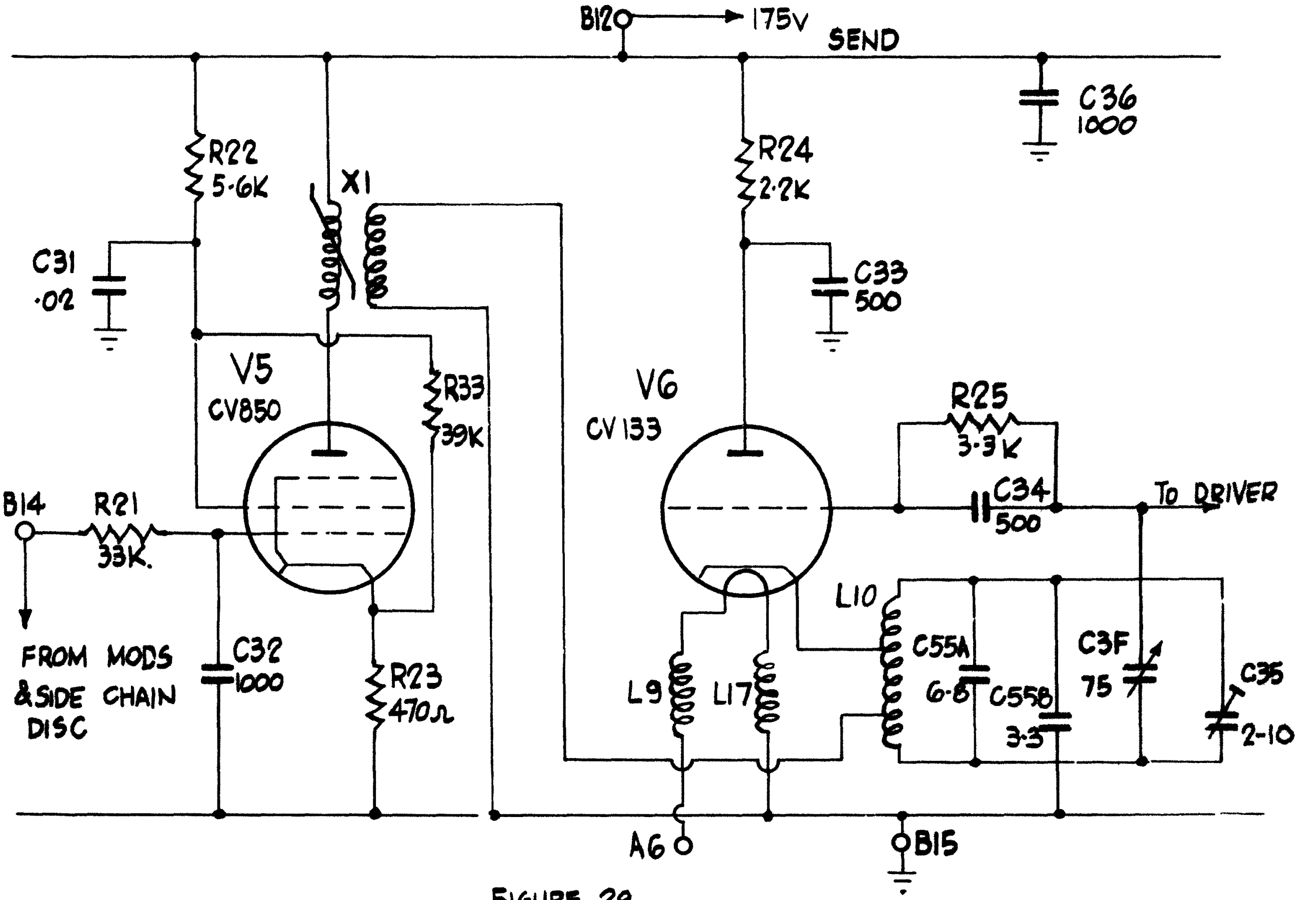


FIGURE. 28.

THE MODULATOR

The valve used is a CV 850 type pentode using 6.3 volt heater.

The D.C. and AF signals from the discriminators and the modulator are applied to the grid via the filter R21 and C32 which removes R.F. from a physically long wire. R23 provides auto-cathode bias and is not decoupled. R33 increases the current through R23 so that the required auto-cathode bias can be obtained with a smaller value of R23 thus reducing the current negative feed-back. The screen supply is dropped and filtered by R22 and C31 in conjunction with a ferrite bead. The primary of the ferrite reactor is connected directly in the anode circuit, while the secondary is tapped across the bottom turn of the Master Oscillator tuning coil.

(The theory of the ferrite reactor is discussed on Page 2).

THE MASTER OSCILLATOR

This is an inverted Hartley type, using a CV 133 type triode with 6.3 volt heaters. L10 is the tuning coil, C55a and C55b (the latter a negative temperature coefficient condenser) are fixed trimmers, while C35 is a pre-set trimmer and C3f is a section of the main tuning 6 - gang condenser. R25 and C34 provide grid current bias.

L9 and L17 are VHF chokes to keep the heater circuit from being at RE earth potential. (If these were not present the heater-cathode capacitance of the valve would be shunted across the lower part of the MO coil). The anode HT supply is filtered by R24 and C33 together with C36. There is no anode load on the valve since the output to the driver is taken from the grid circuit.

H.T. is only switched to these valves when the standby/traffic switch is set to "traffic" and the system switch at "Tune RF", or at "Operate" with the pressel pressed.

THE DRIVER

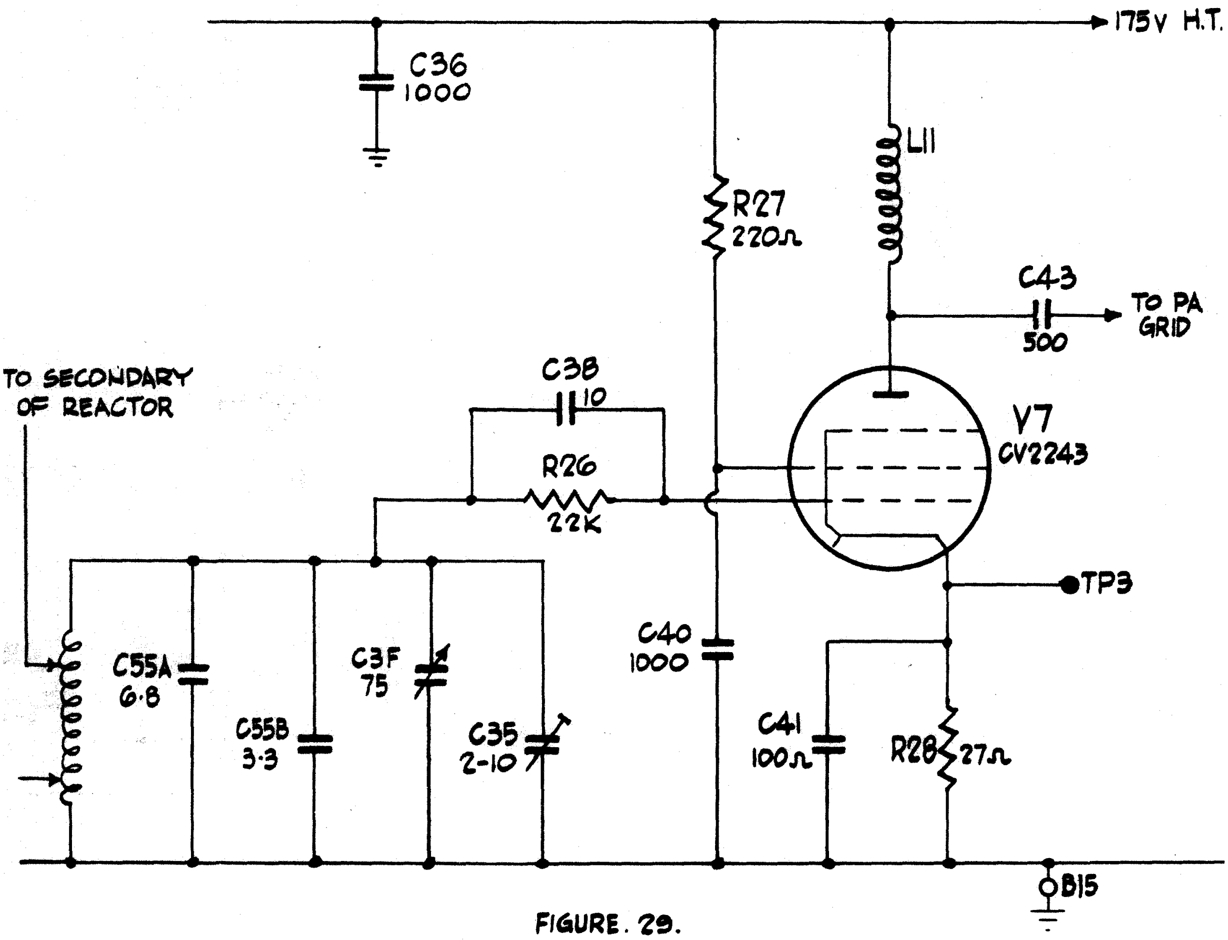


FIGURE. 29.

The master Oscillator tuned circuit is coupled to the driver by C38, R26 being the grid leak. Auto cathode bias is provided by R28 and C41.

The screen HT supply is filtered by C40 and R27. L11 is the anode load which is not tuned. The output is passed via C43 (which blocks H.T.) to the grid of the power amplifier.

The valve is a CV. 2243 type pentode fed with 6.3 volts A.C. but only when the Standby/Traffic switch is set to "Traffic". It is only fed with H.T. when on "tune RF", or on "Operate" with the pressel pressed.

TP3 is in the cathode circuit and thus at this point we can measure the cathode current and test that the transmitter is functioning correctly up to this stage. See page 71.

THE POWER AMPLIFIER

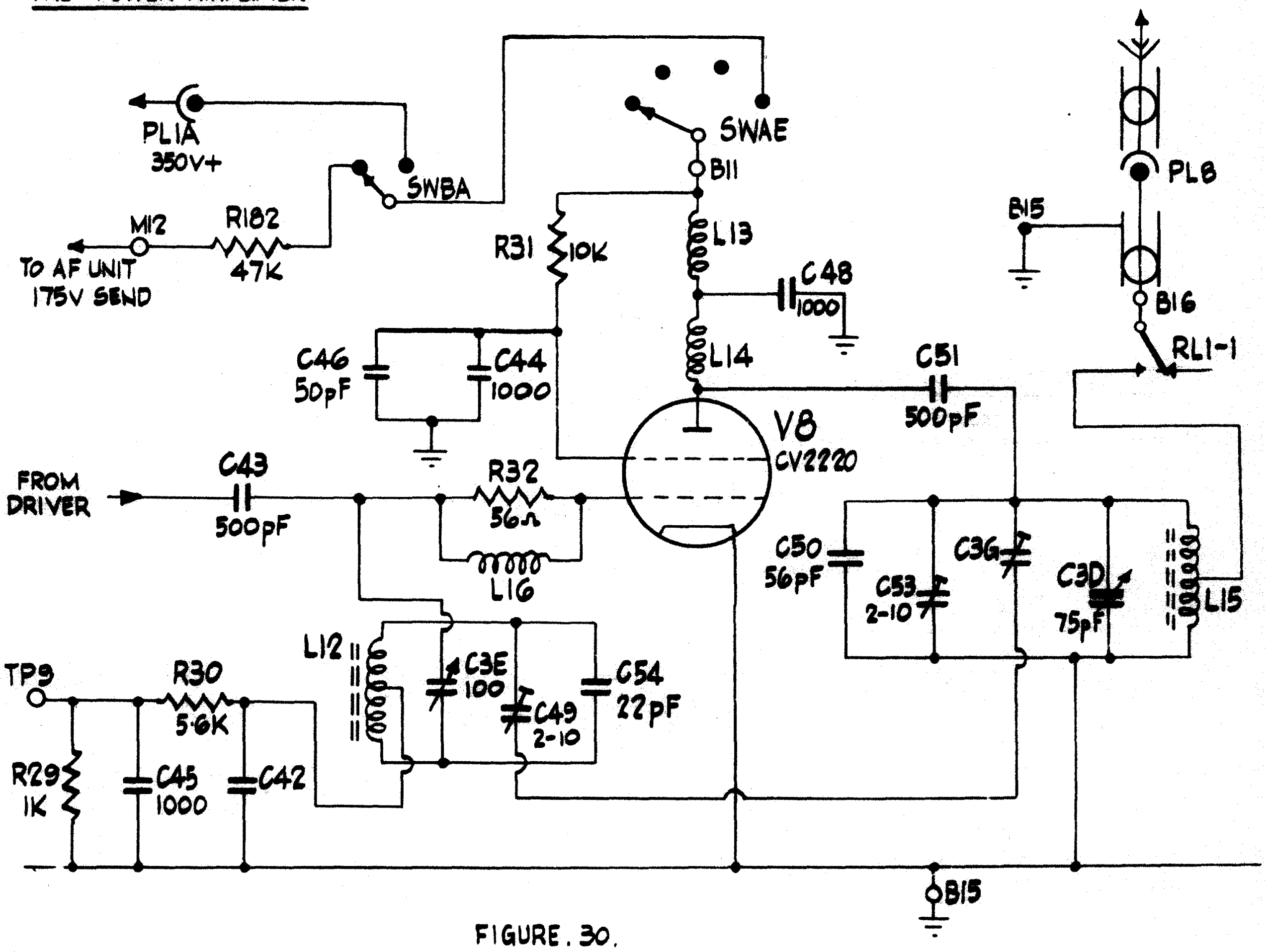


FIGURE. 30.

The valve is a C.V.2220 type tetrode fed with 12 volts A.C., for its heaters. This supply, as in all the other transmitter valves, is only switched on when the Standby/Traffic switch is set to Traffic.

The tuned grid is double ended, the tap on L12 being earthed for R.F. by C42. C54 is a fixed trimmer, C49 a preset trimmer and C3e a section of the 6-gang main tuning condenser.

One end of this tuned circuit is coupled to the grid of the P.A. by L16 and R32, which act as a parasitic stopper and also to the previous stage by C43. The other end is connected to the anode of the P.A. by C3g, the neutralising condenser. A certain amount of R.F. is fed back from the anode to the grid capacitively, through the valve itself. This is undesirable, so R.F. is fed back from the anode to the opposite end of the grid coil so that its phase is reversed by the time it reaches the grid. This is known as neutralising and is effected by C3g. This condenser is not part of the main 6 gang tuner but only given this number owing to its position near the ganged set.

C43, R29 and R30 provide grid current bias, which is the only bias that the P.A. has. Tp 9 provides a means of measuring the grid current and thus the drive. C45 decouples R.F. from this test point, R31 is the screen dropping resistor, C44 the main screen decoupling condenser; this was found to be physically too large to be wired as close to the pin as is desirable and C46 was added to complete the decoupling.

The anode H.T. supply is filtered by L13 and C48. This supply is only on the valve when the system switch is set to operate and the pressel is pressed. (The Master oscillator and the driver only have H.T. switched on when the system switch is in the "tune' R.F." position). On high power the supply to the P.A. is 350 volts and on low power the anode is connected to the normal 175 volt line and a dropping resistor R182 is switched into circuit by SwBa on the High/Low power switch on the front panel.

The output is developed across the anode load L14, which is untuned, and then capacitively coupled to the aerial tank circuit by C51. This circuit consists of L15 (which has a low impedance tapping for coupling the output to the aerial via 80 Ohm coaxial cable), C50, a fixed trimmer, C53, a preset trimmer, and C3d, a section of the main 6 gang tuning condenser. The output from this circuit is directly coupled through the cable to the aerial tuning unit.

The relay contact 1 - 1 is on the aerial change-over relay and connects the aerial to the tank circuit when the pressel is pressed and the system switch is at "operate".

THE SIDECHAIN LIMITER AND DISCRIMINATOR

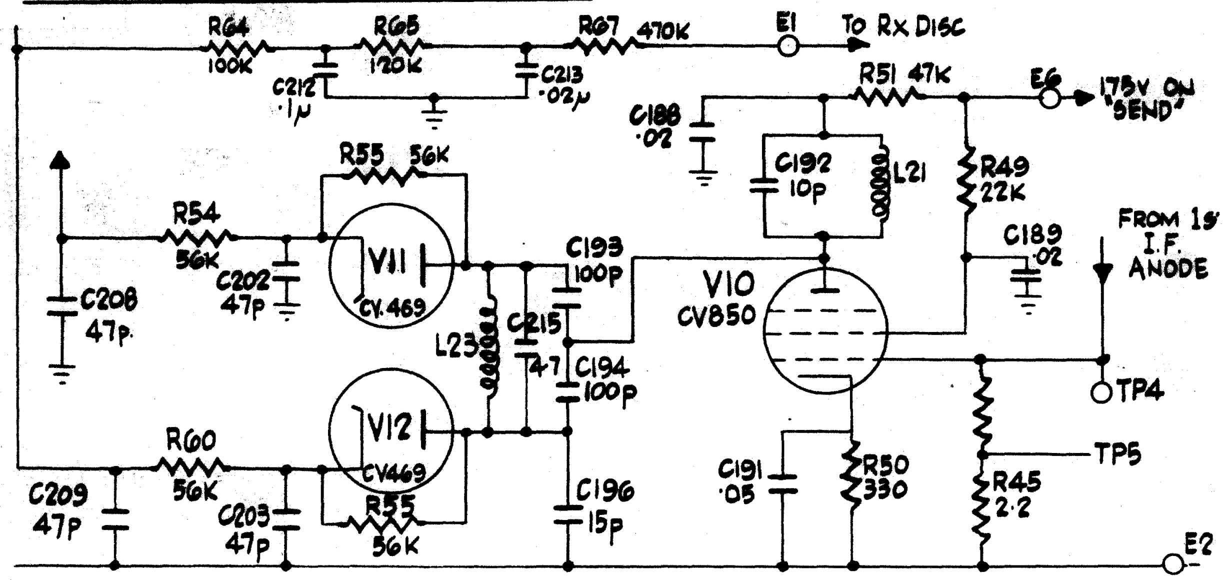


FIGURE. 31

AUTOMATIC FREQUENCY CONTROL

A small fraction of the transmitter output is fed by stray capacitance to the receiver, although its input line is earthed (in fact, to the 1st mixer). This signal passes normally through the receiver until it reaches the narrow discriminator; from here the A.F. portion will pass on through the headphones and give sidetone, and, if the transmitter has drifted for any reason from the set frequency, the discriminator will also produce a D.C. potential which is positive or negative according to whether the transmitter frequency has drifted upwards or downwards. This output is fed through the wide discriminator, which is itself fed through a limiter with part of the signal from the anode of the 1st I.F.A., and hence will add its own component to that of the narrow discriminator if the transmitted signal is off tune. The two outputs are together fed to the grid of the modulator valve and vary the anode current passing through the reactor which proceeds to correct the Master Oscillator frequency drift, leaving an error not greater than 10 Kc/s. The correct polarity of the D.C. is obtained by connecting the "offset" condenser to the appropriate side of the discriminator tuning coil.

The wide discriminator has 1/6th of the sensitivity of the narrow one, and is about 30 times as wide; so its output for all normal amounts of drift will be so small as to be quite negligible. It will however help to bring the Master Oscillator back to a frequency where the receiver discriminator can correct it if the drift has been very great. In this way a swing of up to $\frac{1}{2}$ Mc/s either side can be accounted for and the M.O. frequency corrected. Another use of the wide discriminator, is for tuning the M.O. on to the receiver frequency, when tuning up. The meter is used to give an indication of zero output from this discriminator. The narrow one produces too sharp a null point for easy tuning, and so R66 and SwAc are used to reduce its output to $6\frac{1}{2}\%$ and eliminate any rapid changes in potential. The wide discriminator is fed via a limiter (which is analogous to the 2nd receiver limiter except for having auto cathode bias, produced by R50 and C191) from the anode of the 1st I.F.A. (a point of reasonable signal strength and not too great selectivity). The limiter uses L21 as an anode load, tuned by C192. The anode and screen H.T. supplies are filtered by R51, C188 and R49, C189 respectively. The screen has a bead R47/&/R48 form the grid leak. The discriminator is of the Bond type.

Tp 4 gives the receiver performance up to the 1st I.F.A. anode and Tp 5 gives the side-chain limiter grid current.

THE INTER- COMMUNICATION AMPLIFIER

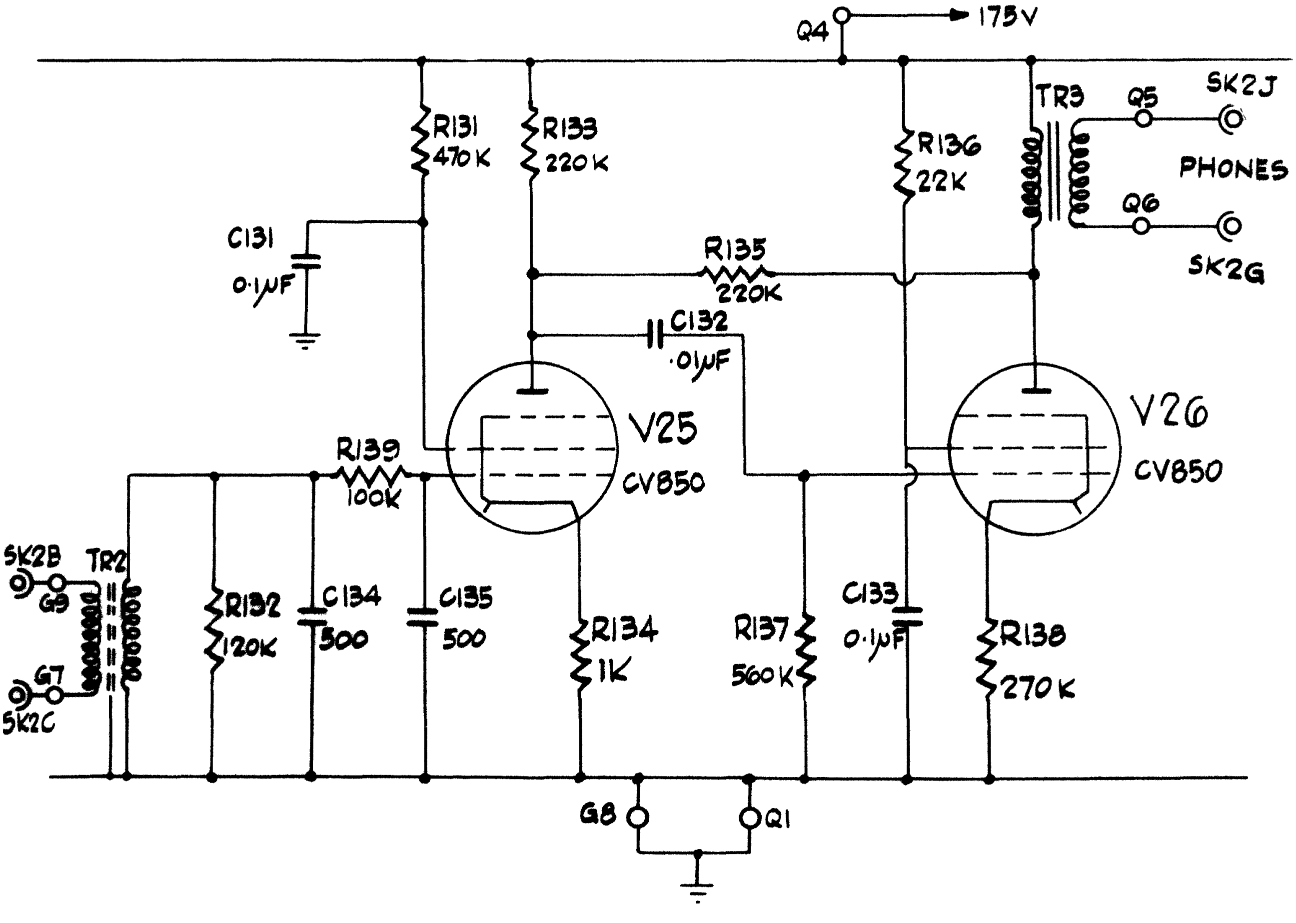


FIGURE. 32

Inter-Communication Amplifier

This is a two stage resistance-capacity coupled amplifier with input and output transformers and using two CV 850 type pentodes with 6.3 volt heaters.

The input transformer works into a load resistor R132 which also serves to damp any resonant responses in the transformer. R139, C134 and C135 form a pi-shaped filter to keep R.F. off the grid of the stage. R134 is the auto-cathode bias resistor, which is not by-passed, giving current negative feedback. C131 is the screen dropping resistor; there is also a Ferrite bead on the screen lead. R133 is the anode load and C132 couples the anode to the next stage.

R137 is the grid leak resistor of the second stage. R138 is the auto-cathode bias resistor, again not bypassed. The screen is decoupled by C133 and R136 is the screen dropping resistor. R135 provide voltage negative feedback across the stage, being connected between the anodes again to improve the regulation of the output. The anode load is the primary of TR3, whose secondary feeds the headphones.

THE POWER SUPPLY UNIT

This is a supply unit vibratory No.12, 24 volt input. It consumes a maximum of 7 amps at 24 volts. There is also a 12 volt input type, which takes a maximum of 17.8 amps and is, therefore, less efficient.

The output of the 24 volt unit is: 12 volts D.C. for the sidechain valves and 1st modulation amplifier, (dropped to 6.3 volts in the set), 6.3 volts centre-tapped for the rest of the modulation amplifier, 6.3 volts for the inter-communication amplifier, 6.3 volts for the receiver valves and for the transmitter, except the P.A. and 1st modulation amplifier and 12 volts for the P.A. (all these latter voltages are A.C.). It also supplies the H.T. voltages; 175 volts for the main line and 350 volts for the Power amplifier on "High power send".

A voltage sensitive relay in the harness type 'A' connects the 24 volt input, after chopping by the vibrator, to high or low voltage tappings on the transformer primary, according to whether the nominally 24 volt input is above or below its stated value.

On the unit there are 4 switches:-

The Main POWER on/off switch which starts the vibrator,
The SET on/off switch which starts the receiver by supplying 6.3 volts to the receiver heaters.
The STANDBY/TRAFFIC switch which starts the transmitter by supplying the heaters of the transmitter valves.
The I/C on/off switch which allows 6.3 volts to pass to the heaters of the intercommunication amplifier valves.
There is one fuse, Fs1, which is rated at 10 amps and each unit carries two spares.
The meter is unusual in that it reads from 15 volts to 30 volts.
This gives greater accuracy for a given scale length.

Some sets are designed to that they can be used with either a 24 volt P.S.U. or with a 12 volt type. They have a switch for changing from one to the other. The more recent models however can only be used with one type of supply unit.

HASH FILTERING

All vibrators create a lot of R.F. interference due to sparking at the contacts. Very exacting standards were laid down for the performance of this supply unit, and so 21 hash filters and three spark suppression devices are incorporated in it. These hash filters each consist of two feedthrough condensers and one R.F. choke. Ten of these L3 - 12 and C9 - 28 are contained in a screening can. The spark control devices consist of two in connection with the voltage control relay (R7 & 8) and one across a relay contact in the 350 volt H.T. line (C8 & R9).

The two screening cans round the filters and round the vibrator itself form a complete screen round the whole vibrating system.

THE POWER SUPPLY UNIT.

D.C INPUT CIRCUIT

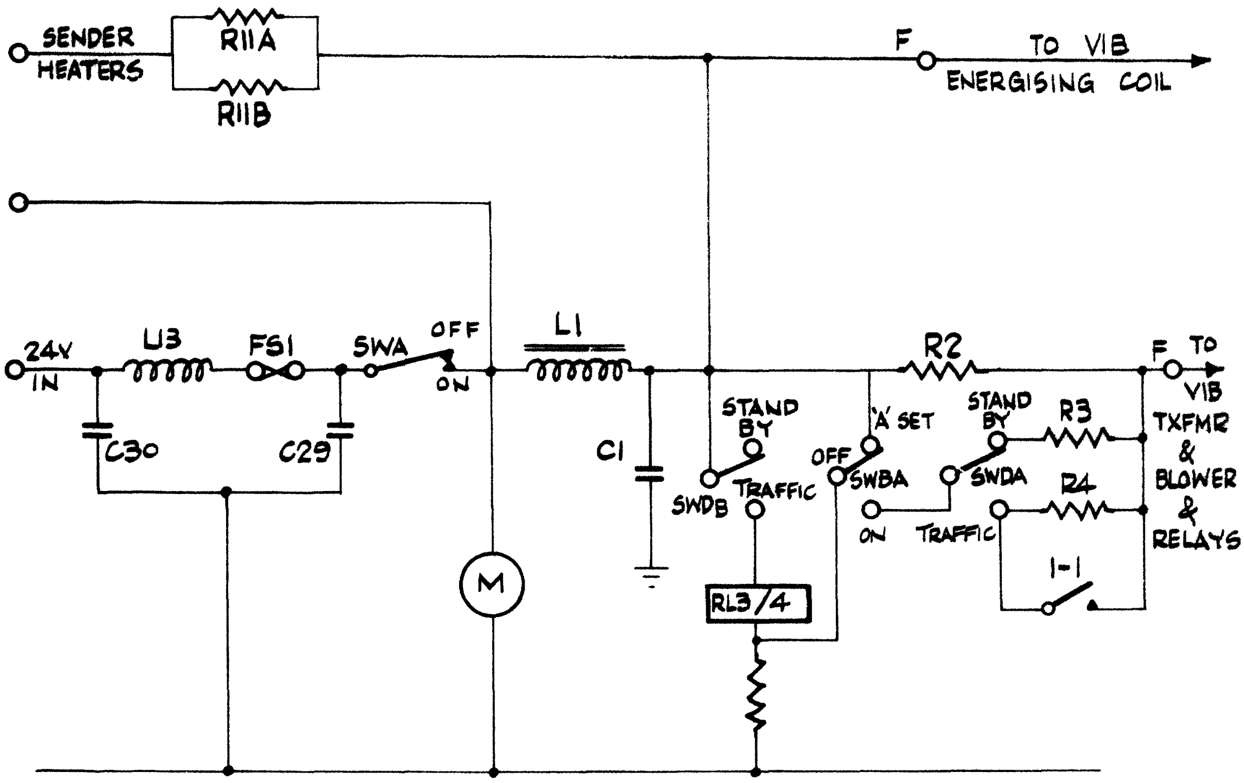


FIGURE 33

Input circuit

Twenty four volts from the 2 pin input plug is applied through the fuse Fsl, rated at 7 or 10 amps, and the pi-shaped filter L13, C30 and C29 to the power on/off switch Sw A which, when closed, allows the 24 volts to flow to the meter, to the battery homing terminal, and, via the "L" shaped filter, L1, C1, to the heater of the 1st modulation amplifier. This line goes via two dropping resistors R11a and R11b (which drop 12 volts) and another resistor R163 (placed in the set) and which drops 6 volts giving an output of 6.3 volts at 0.3 amps D.C. The line through L1 and C1 passes through a hash filter (L4, C11, C12) to the vibrator energising coil and also through R2 and another filter to the transformer primary, the blower motor and the relay circuits. Twenty four volts is also applied, via L1 and C1 to the Traffic/Standby switch so that the relay RL3/4 will operate when this switch B is set to Traffic.

So far only the power on/off switch has been switched on. As a result, the vibrator and transformer are working, and generating the heater and H.T. voltages, the H.T. is passing on to the set but the A.C. heater voltages are only applied to switches and relays, and are not yet connected to the set. The cooling fan is also supplied with 24 volts and will start. Throwing the SET on/off switch to "on" completes the heater circuit of the receiver and connects R3 in parallel with R2 (to keep the input voltage up despite the increased load).

Throwing the Traffic/Standby switch to traffic puts 24 volts on the top end of RL3/4 which will then operate provided the lower end is earthed by having the SET switch to "on". It also connects R4 in parallel with R2 instead of R3 (again to account for the increased load). Three of the contacts of the relay RL3/4 connect the transmitter heater windings to the set while the fourth puts 24 volts on the top end of the low/high power relays so that they will operate when their other ends are earthed by switching the LOW/HIGH switch on the front of the set to "high".

Contact 1 - 1 is a contact of this H.P/L.P. relay and it is used to short out R4, again to account for the increase of load.

Power Supply Unit

The Vibrator.

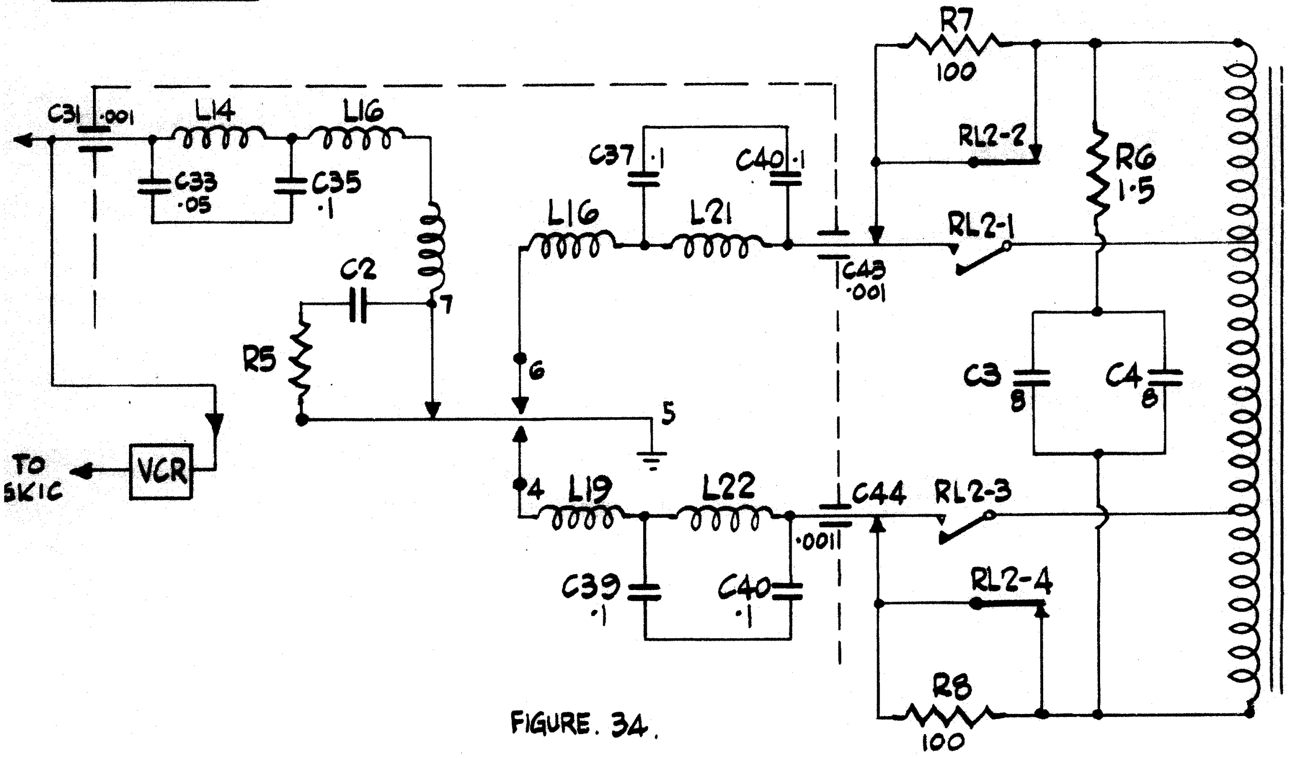


FIGURE. 34.

The Vibrator action

The vibrator is of the synchronous type and is shunt driven. It takes a supply of 24 volts. When this voltage is applied, by throwing the power switch to "on", current flows through the energising coil, via pin 7 of the vibrator, across the contacts, through pin 5 and then down to earth. Since the coil is energised the vibrator reed is attracted (down in this diagram), thus breaking the energising circuit. The reed then contacts onto pin 4 thus earthing the lower end of the transformer primary, causing current to flow through that half. Since the energising current is broken, the reed is released and moves back to its original position, remaking the energising circuit. It will also move slightly past its former position, and earth the top end of the primary, thus reversing the direction of current flow, since the input circuit is remade the cycle will start again; the leads going off to the primary of the transformer, and which are earthed as described, each have a hash filter on them to remove stray R.F. interference (these consist of twin "L" shaped filters. L18, L21, C37, C40, C43 and L19, L22, C38, C41 and C44). The line to the input also has a hash filter on it (L14, L16, C31, C33, and C35).

C2 quenches the sparks across the energising coil contacts and R5 gives the correct time constant. C3 and C4 are buffer condensers to prevent any sudden changes of voltage across the primary, which might cause a peaky and uneven output. R6 gives the correct time constant and prevents a short circuit in the case of a failure of C3 or C4.

The Voltage Control Relay

When the input voltage to the PSU drops below 23.5 volts a voltage sensitive relay in the control harness is released, and by so doing removes the earth line from SK1C. This will cause RL2/4 to release and operate to introduce the input across a smaller primary as follows:-

RL 2-2 and RL 2-4 open, thus putting R7 and R8 in the primary circuit. RL 2-1 and RL 2-3 close, effectively applying the input to the tappings on the primary. By the autotransformer effect there will be a voltage across the outer ends of the primary, now out of the main circuit, which will cause a current to flow through R7 and R8. This circuit is broken by the movement of

RL2-1 and RL2-3 past their rest positions causing the contacts A & B to open. Thus the change over compensating for low voltage input is effected without breaking the heavy primary current and then remaking it.

The Power Supply Unit

The Transformer Secondary

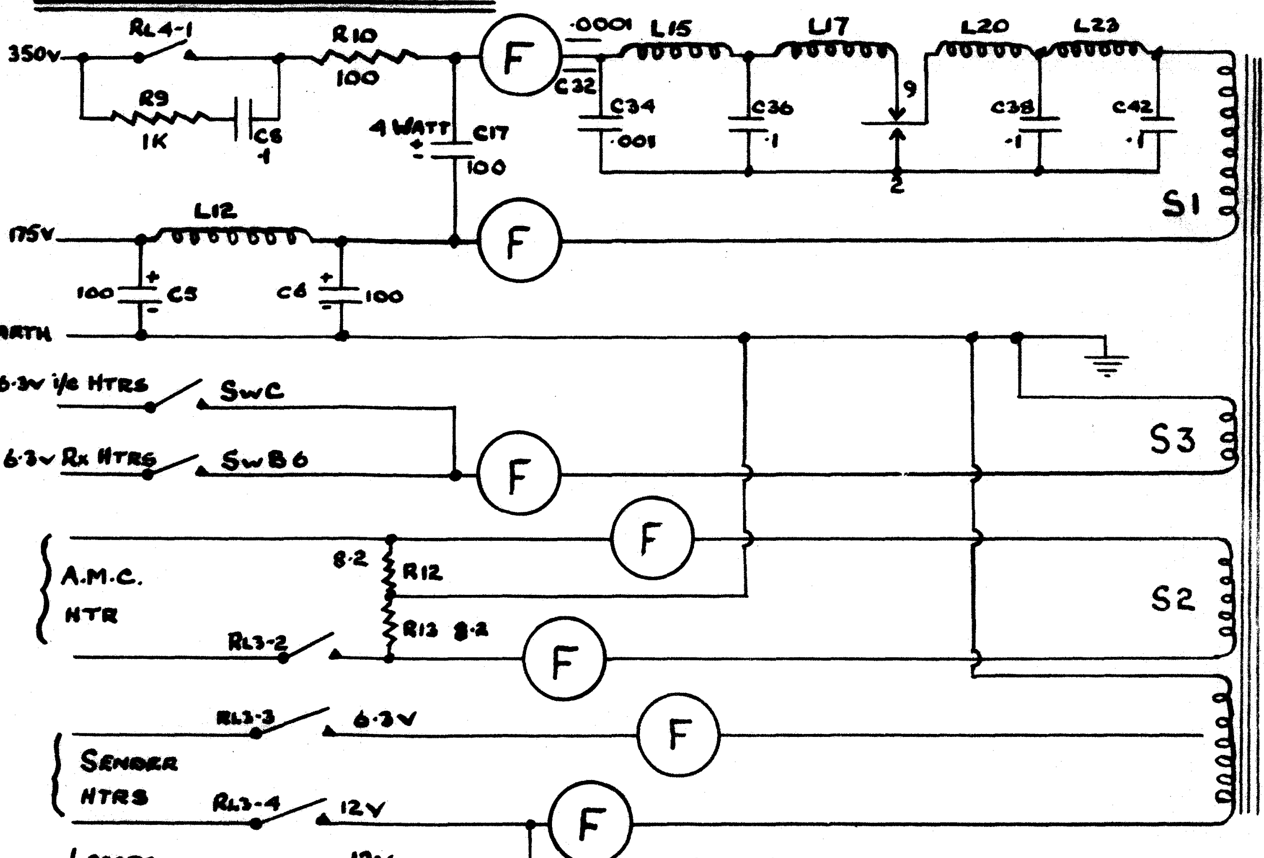


Figure 35

The H.T. winding, S1, produces 175 volts A.C. This is used in a voltage doubling circuit to produce 350 volts D.C. for the anode of the P.A. on "high power send". It is also used in a half wave rectifying circuit to produce 175 volts D.C. for all the other valves and for the P.A. on low power. C6 and C17 are the reservoir condensers; L12 and C5 form a filter to smooth the 175 volts lines. R10 sets the output to 350 volts (the load on this line being light, the voltage will tend to rise). RL4-1 is a contact on the high power relay to switch the 350 volts to the anode of the P.A. C8 quenches any sparks across the gap and R9 gives the correct time constant. The L.T. secondaries are straight forward and produce the heater voltages for all the valves. (12 volts for the P.A. and 6.3 volts for all the others. The 1st modulation amplifier is fed with D.C. from another part of the PSU). The A.M.C. and 2nd modulation amplifier heaters are fed with a balanced voltage to reduce hum.

RL4/1 and RL1/1 are the two relays which operate on high power. RL4/1 completes the 350 volt H.T. line and RL1/1 shorts out the resistors in the input lead to the vibrator, giving maximum input for the maximum load. If it were not for the contact RL3-1 on RL3/4, (which is only actuated when the set is "on" and the standby/traffic switch is to traffic) these latter relays could be actuated and all resistors removed from the input circuit with the set "off", and HT fed to the P.A. without the rest of the transmitter working.

The switch SWB is required to complete the receiver heater circuit, to connect R3 across R2, and to make possible the actuation of RL3/4. These latter two functions could be performed by two separate sections of switch, but it is more convenient to use a single section for both purposes, and simply to switch the 24 volts from the earthy end of the relay. This voltage is developed across R1, which during operation carries the relay current to R3.

The heater voltage to the intercommunication amplifier is switched directly by SwC the i/c "on/off" switch on the front panel of the unit.

Note: **(F) in** the diagram denotes a hash filter, consisting of an R.F. choke and two feedthrough condensers.

WIRELESS CONTROL HARNESS TYPE 'A'

This is the harness normally used in tanks; it comprises three wireless sets (the C42 together with the B45 and B47, which are short-range sets (identical except for their frequency ranges) used for inter-tank and tank-to-infantry communication), and provides facilities for four crew members. The harness consists of a central junction box (Junction, Distribution, No. 9 or J.D.9) to which all other units are connected, a Rebroadcast Unit (Control Unit No. 30), provision for attaching a Tank Telephone (for infantry intercommunication) and a Remote Control Station (up to 1000 yards away, as a gunnery observation point, for example), a control unit each for the gunner and the loader-operator (C.U.31) and a control unit for the commander (C.U.34), together with a control unit for the driver (J.D.8), to which the Tank Telephone is attached. In addition each crew member has a headset connected to his control unit; the loader-operator may, alternatively, use an amplifier and a set of loudspeakers so that he may be unhampered by a headset. Provision is also made for any member to call the commander and he is given a facility where, by pressing an emergency pressel, he puts everyone onto i/c so they can hear him whatever they are doing. This is known as the emergency i/c.

Previous types of control harnesses (such as those including the C.U. No. 2 Mk.II) distribute the phone, microphone and pressel leads from all the sets connected to the harness to all the crew-members' control boxes; the desired service is then selected by the crew-member at that location. Due to the capacitive effects between these many wires (being close together) in the cables of the harness, a certain amount of break-through is experienced between the various services. This drawback is avoided in the type A harness because the three "live" leads from each set are connected to centralised distribution switches situated in the J.D.9, which are controlled by each crew-member's service selection switch and distribute only the required service along the cables of the harness. Thus each cable from J.D.9 to the crew-member's carries only 4 D.C. leads from the service selection switch to the J.D.9 and 3 "signal" leads to the crew-member, instead of 12 "signal" leads; this not only prevents break-through but also results in fewer wires in the cables.

SERVICE DISTRIBUTION IN THE J.D.9

The facilities available to the driver and to the Tank Telephone include intercommunication and the ability to call the commander, and are distributed from the J.D.9 via another control box, the J.D.8; this unit contains the calling switch and gain control for the driver, the calling button for the tank telephone being mounted on that unit: there is no gain control for the tank telephone. The facility of calling the commander, which is available to all other personnel, will be described in detail below.

The loader-operator and the gunner can select any one of the four services (intercommunication and three wireless sets). The selection is made in both cases by means of rotary switches actuated by Ledex motors. These are electro-magnetic devices which stop in a certain pre-determined position; a variety of positions means that the rotary switch wafers can be set in any desired position, as determined by a remotely situated selector switch. This is one of the two methods of having remote control over a central switching system, the other being the relay system by the commander.

LEDEX MOTORS

These are remote operated devised for rotating the selector switches of the gunner and the loader-operator. The motor consists of an electromagnet with a rotary action, together with a pair of contacts which open when the electromagnet reaches the end of its travel; these contacts are connected in series with the D.C. supply to it so that the opening of the contacts de-energises it; on returning to the rest position the electromagnet is re-energised and the cycle is repeated as long as the D.C. is applied. This alternating action is converted into rotation of the switch by means of a rotary ratchet mechanism.

D.C. is supplied to this mechanism via a wiping contact and a slip-ring which has a gap in it; the mechanism repeats, rotating the gapped ring and the selector switching, and stops when the gap is opposite the wiper (breaking the D.C. supply). If more than one wiper is fitted, the mechanism will stop when the gap is opposite whichever wiper was supplying the D.C. It is the crew-member's selector switch which selects the wiper to be used and this determines the position in which the mechanism stops and the service selected.

In this particular mechanism, there are two gapped slip-rings. One is fitted with four wipers for selecting the four services, and the other is fitted with only one; normally, the first is used, but for "emergency i/c" the second is brought into action, the change-over being effected by a section of the "emergency i/c" relay, RL.D/2.

The switch positions are separated by 30°, so there are 12 positions per revolution of the shaft; as there are only four services to be selected, the series "A-B-I-C" is repeated three times per revolution.

For details of motor and switch wiring and contacts see E.M.E.R. TELS L772 Pt.II.

CUT-OUTS

The Ledex motors, consume a considerable amount of current, although normally the current flows for only a short time. If a motor jams, the continued current operates a thermal cut-out (a bi-metallic strip), and the D.C. supply is switched across to the "call" line, removing the D.C. supply from the lamps in the C.U.31's as well as from the Ledex motors; this position of the cut-out is also stable. If the calling switch is now held over, earthing the "call" line, another bi-metallic strip resets the cut-out, and if the "jam" is clear, normal operation continues; but if the motor is still jammed, the continued heavy motor current operates the cut-out again, and the bi-metallic strips are alternately excited by the motor current and the current short-circuited call line; this cycle causes the lamps to go on and off, indicating to the gunner or the loader-operator that the motor has jammed.

The commanders selection of services is achieved by means of relays instead of Ledex motors and rotary switches. The relays are RLG/3, RLH/3, RLJ/3 and RLK/3, and when the J.D.9, is switched on they are supplied with 24 volts D.C. via RL.F-1, which is closed whenever the remote control and calling facility is not in use.

RLG/3 is the monitoring relay, its earthy end is earthed (and the relay operated) by one pole of the monitor on/off switch on the commander's headset, while the other pole switches one of the earpieces from the headphone line of the normal set to the "monitor" line. When this relay operates, its three contacts close, connecting the headphone line from the three sets to the monitor selection switches, via the connecting cable and the resistors R1, R2, R3; the signals passing through them to the commander are attenuated comparatively little, but break-through between the sets (since they can be connected in parallel) is considerably reduced by these isolating resistors. When any or all of the monitor selection switches are closed, the signal to be monitored passes to the monitor gain control, RV2, and then via the second pole of the monitor on/off switch (already described) to the monitoring earpiece.

The other three relays are used in the selection of the main facility required. The Commander's service selection switch, S-Db, S-Dc causes the K relay, the H & J relays and all three relays to operate when the switch is set to B set, A set and C set, respectively; when I/C is selected, none of the relays is energised. Each of the three contacts of each relay works in the same way, the "1" contacts switching the pressel lead, the "2" contacts the headphone lead and "3" the microphone lead; the functioning of the groups of contacts is straightforward. In the diagram below, it can be seen that the H & J contacts (which move together) go to four different points, corresponding to the four services, and the K contact selects one or other of the H or J contacts; thus with these two groups of relays, it is possible to select any one of the four services.

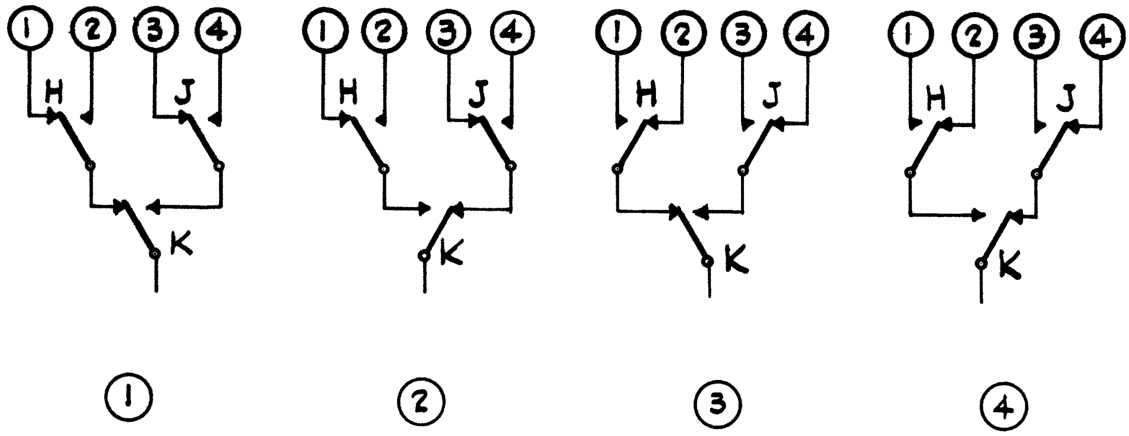


FIGURE. 36.

Pressing the commander's pressel completes the microphone circuit on all four services, but earths the "send/receive relay" line only on A, B, C, because the I/C amp, has no send/receive relay. In the I/C position, the send/receive line from the pressel switch is connected to the earthy end of RL.D/2; the operation of these contacts brings into action the second set of gapped slip-rings and brushes, which connect the loader-operator and gunner to the I/C amp. This can only happen when the emergency pressel is used (by-passing S-Da). Note that the earthing of the lower end of RL.D/2 also entails earthing the input side of the I/C amp. via the feedback condenser C2, which results in the loss of some of the higher frequencies; when RL F-2 is closed (thus completing the feedback loop from output to input of the I/C amp via C2), this earth connection at the lower end of RLD/2 directly earths the input of the I/C amp so that it cannot function at all: this means that calling is not possible when the commander is using "emergency i/c". Pressing the calling switch when the commander's normal pressel is pressed puts the commander on to i/c, and again puts an earth connection on the I/C amp input so a caller can tell that the commander has not heard the call because there is no sidetone.

CALLING

When the call line is earthed, either by a crew-member's calling switch or by RL.B-1 (the remote calling relay), RL.F-2 operates: RL.F-1 then opens and all the commander's selection relays return to their rest positions (putting him on to i/c) and RL.F-2 closes: this connects C2 between the input and output of the I/C amp., which then oscillates and is audible to the commander, and also connects the earthy end of RL.D-2 to earth via the primary of the microphone transformer of the I/C amp: this operates RL.D-1 and RL.D-2, which select the other gapped slip-ring on the two Ledex motors; thus the loader-operator and the gunner are also on i/c and hear the calling tone.

Should the commander be using his pressel at the same time as a crew-member calls, the earth connection on the pressel line short-circuits the microphone transformer of the I/C amp., preventing oscillation; in practice, the earth connection has some resistance, and the result is that the I/C amp. oscillates at a higher frequency. This result is true of the emergency pressel, and of the normal pressel when switched to one of the sets, but when switched to i/c the oscillation is not affected.

REBROADCAST FACILITIES

If the "Normal/Rebroadcast" switch in the J.D.9. is set to "Rebroadcast", the pressel lines of the three sets are disconnected from the selector mechanisms of the three crew-members, and then controlled solely by the rebroadcast unit, the C.U.30., which gives various facilities.

C.U.30.

The following four facilities are provided:-

(1) Normal working: the three pressel leads are re-connected to the sets. Note that this switching is in parallel with the "Normal/Rebroadcast" switch in the J.D.9.

(2) Break-in: any two sets can be connected in parallel and used for simultaneous reception and transmission, the headphone, microphone and pressel leads being correspondingly paired.

(3) Manual rebroadcast: any two sets can be selected for rebroadcasting; the microphone leads of the one are connected to the headphone leads of the other, and one of the pressel leads is earthed according to the direction of traffic (set by another switch).

(4) Automatic rebroadcast: any two sets can be selected, and are connected together as for manual operation except that the pressel lead of one is connected to the "re-broadcast" line of the other. This line is earthed by the squelch relay of the set concerned whenever a signal is being received (provided that the squelch system is properly adjusted), and the direction of traffic is determined by the fact that one or other set is receiving.

Note that in Break-in operating the two pressel lines are each connected to the "Operator's pressel" via rectifiers; this is because, when receiving, each pressel line has a D.C. voltage on it, and if these voltages are unequal the larger voltage will discharge into the smaller.

Note also that for rebroadcast the break-in operation, the third set (the one not selected can be controlled normally by the crew-members, and that on break-in the pair of sets selected can be controlled only by the loader-operator (or by the remote operator, whose headphone, microphone and pressel are connected in parallel with the loader-operator's).

C.U.31

This is used by the gunner and the loader. It includes an input plug and two output sockets, to which are connected the J.D.9. and two headsets respectively (though normally only one headset is used). There is an indicator lamp which lights whenever the J.D.9. is switched on a volume control which sets the level in the headphones, a calling switch (which is spring-biassed) and a four way service selection switch.

J.D.8.

This box distributes intercommunication and calling facilities to the driver and to the Tank Telephone. It has an input plug (to the J.D.9.), a socket for the driver's headset, and a socket for the tank telephone, which is connected via a six-way cable (normally part of the vehicle wiring). The box itself has a calling switch and gain control for the driver; the tank telephone has its own calling button, but no gain control is fitted.

C.U.34

This unit selects which of the wireless sets is to be monitored by the commander, and controls the headphones level of both monitored set or sets and also the main facility chosen. It is connected between the J.D.9 and the commander's headset; it transmits the main headphone lead (via the gain control), RV1), and the three monitoring leads (via the three "monitor on/off" switches and the monitor gain control, RV2), and also the following leads, which pass through uninterrupted:- leads from the three service selection relays and from the monitor on/off relay, a microphone lead and two earth leads.

Commander's handset

In addition to the normal pressel which completes the microphone circuit and also operates the send/receive relay where applicable, there are three other controls: the monitor on/off switch, which operates the monitor on/off relay and also changes one of the earpieces from the main set to the monitoring line; the service selection switch, which controls the relays in the J.D.9.; and the emergency intercommunication pressel, which completes the microphone circuit and also operates the emergency relay RL.D/2, having first rendered the service selection relays inoperative (by S.Bb).

Tank telephone

This is really part of the tank itself rather than the harness; it is connected into the harness at the J.D.9., which also supplies the driver. It consists of a self-winding drum of cable at the far end of which is a hand-set comprising an earphone, a microphone and a pressel, together with a calling button and a five-way terminal board for connection to the harness.

Remote control telephone

This is designed to give receiving and transmitting facilities to a remote operator, together with the ability to call the crew. The calling and sending facilities are obtained by placing high and low resistance bridges across the line, completing the D.C. circuit of two relays in the remote control section of the J.D.9 or the J.1.

Circuit diagram of the remote control telephone:-

Terminals are put on both JD.9 and J1. to take remote lines.

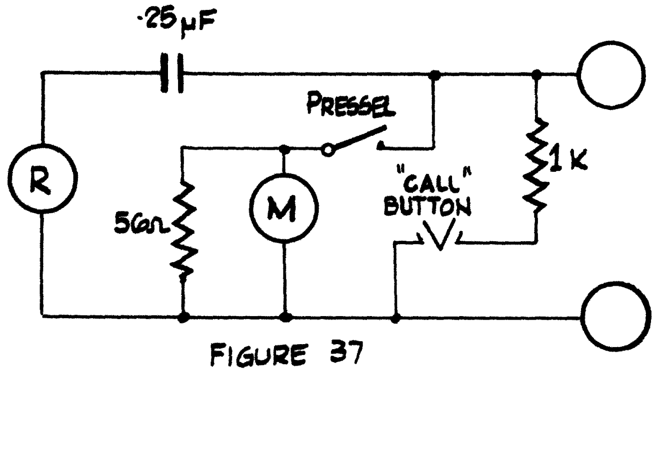


FIGURE 37

HARNESS DIAGRAMS.

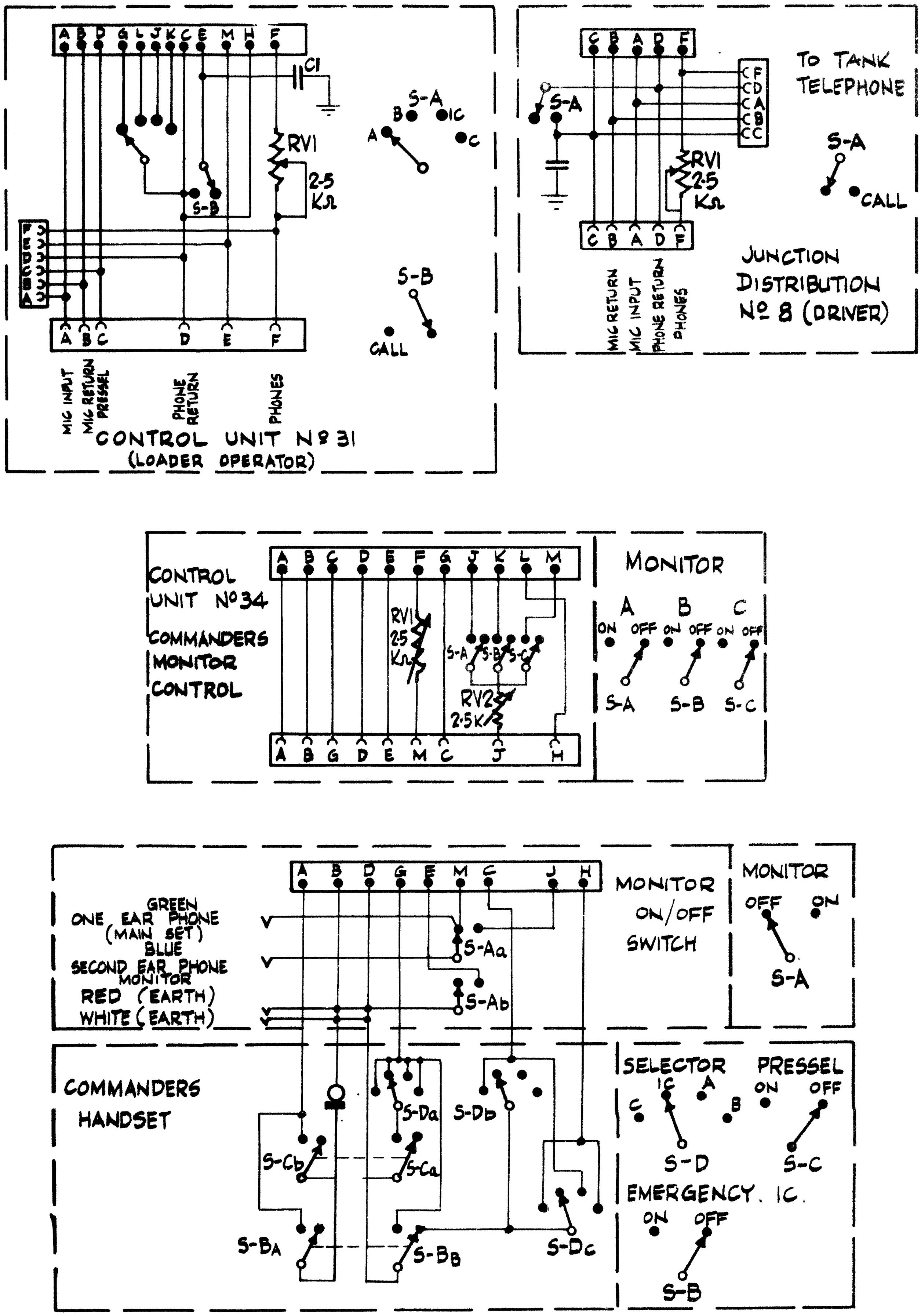


FIGURE 38.

THE TRAINING STATION

For training purposes and other indoor uses, the harness type A is modified. The J.D.9 and other control units are replaced by a single junction box, J.1. This has two sockets for headsets and combines the facilities of normal working, remote working, remote rebroadcast, and "break in". It also enables the i/c amplifier to be used and has a buzzer for calling.

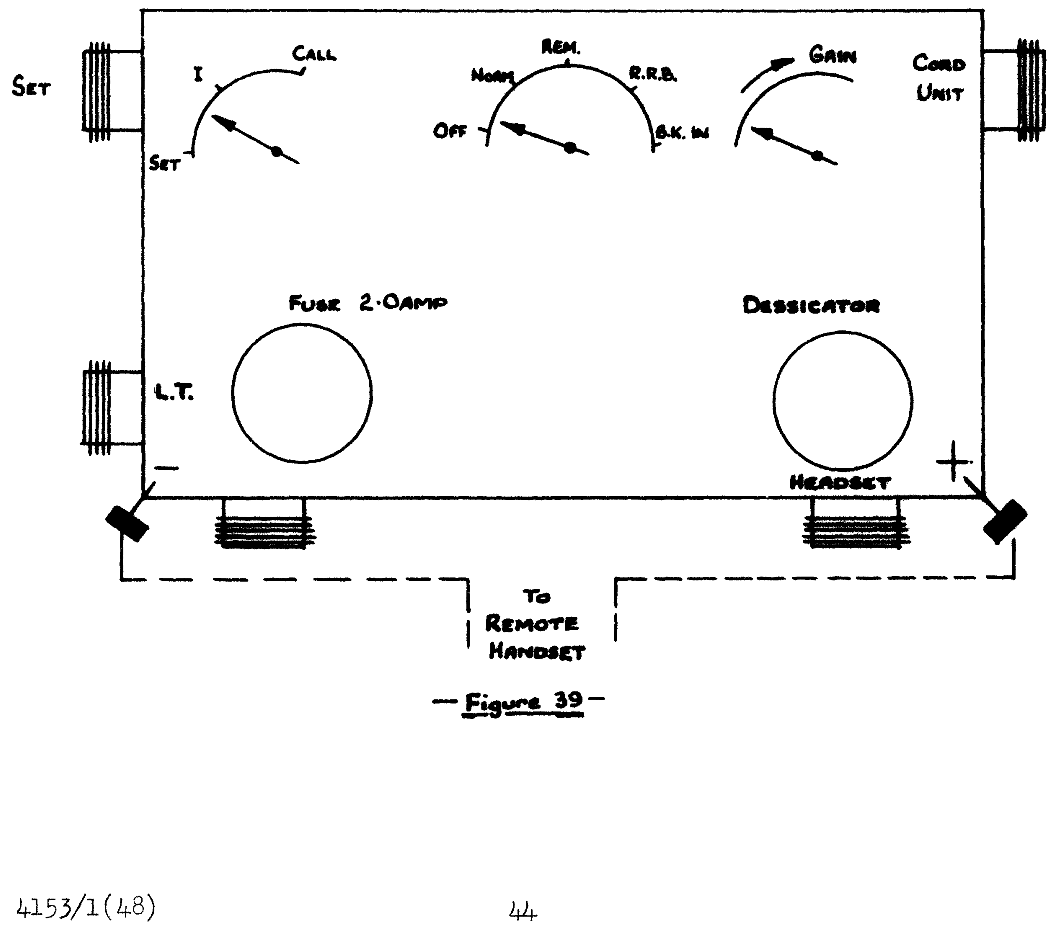
The aerial tuning unit is replaced by an aerial tuning simulator. This is fitted with a meter measuring the R.F. output of the set which enables the set to be loaded. The output is fed into a dummy load so that, without an aerial, the P.A. will not overheat on "high power". A small piece of copper wire about 8 inches long fitted to the "AE" terminal on the simulator will increase transmission range, although the unit is primarily designed for practice in loading and not for set-to-set transmission.

The D.C. input to the P.S.U. comes in via a terminal batten from where also is taken the power for the J.1. This junction box will take about 1.1 amp at 24 volts.

The J.1. is fitted with three switches. One selects either the set or the I/C amplifier or on its third position works the buzzer call. The second is a five position switch selecting the required facility of those mentioned above. The third is a gain control. Apart from these it is also fitted with + and - terminals for use with a remote line, a pilot lamp, a 2 amp fuse and a further 12 point socket, to the two for headsets which is not used in the training station but can be in other arrangements of the control harness.

A silica gel dessicator, with cobalt colouring, is also fitted.

THE J.1.



— Figure 39 —

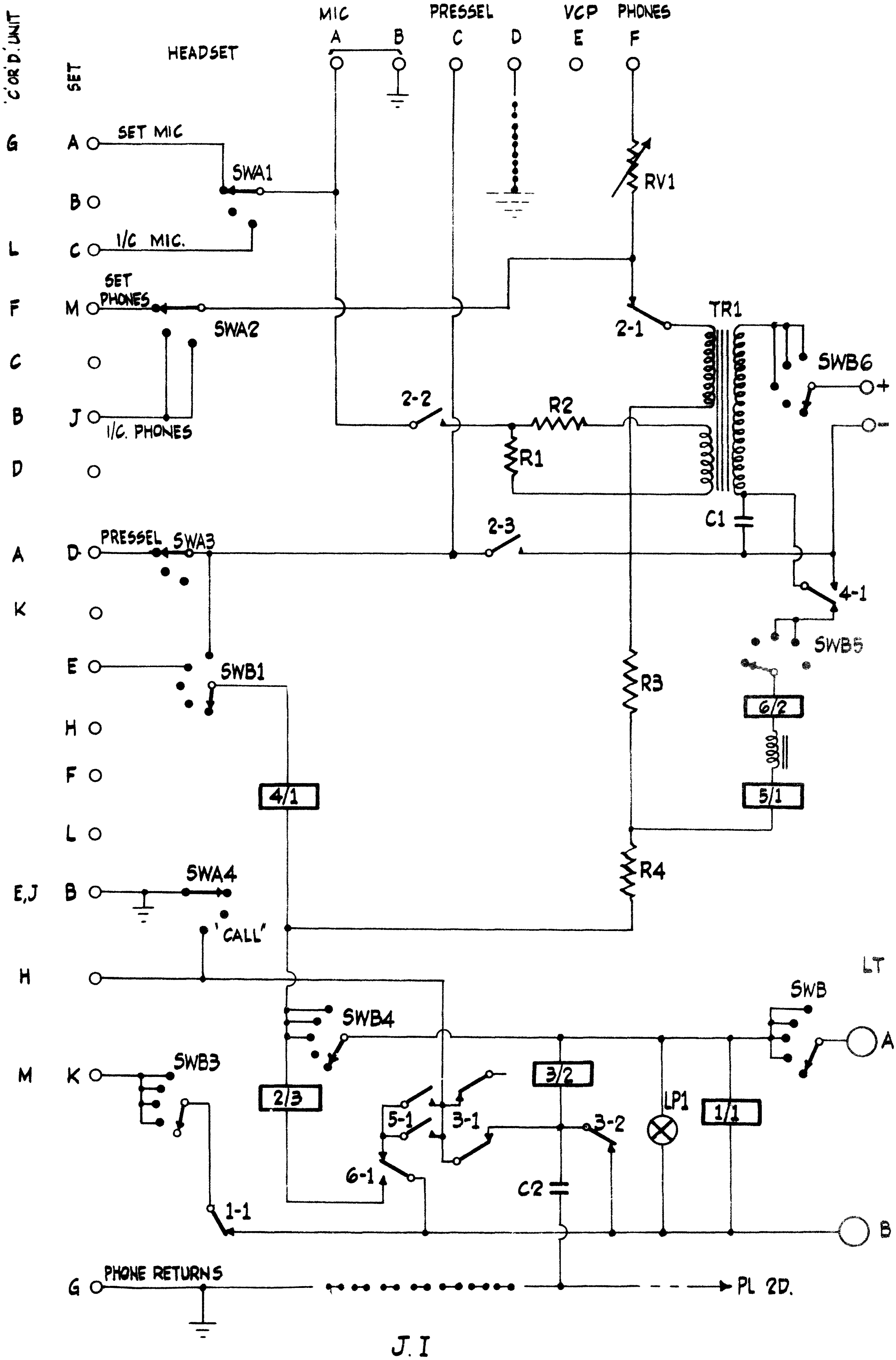
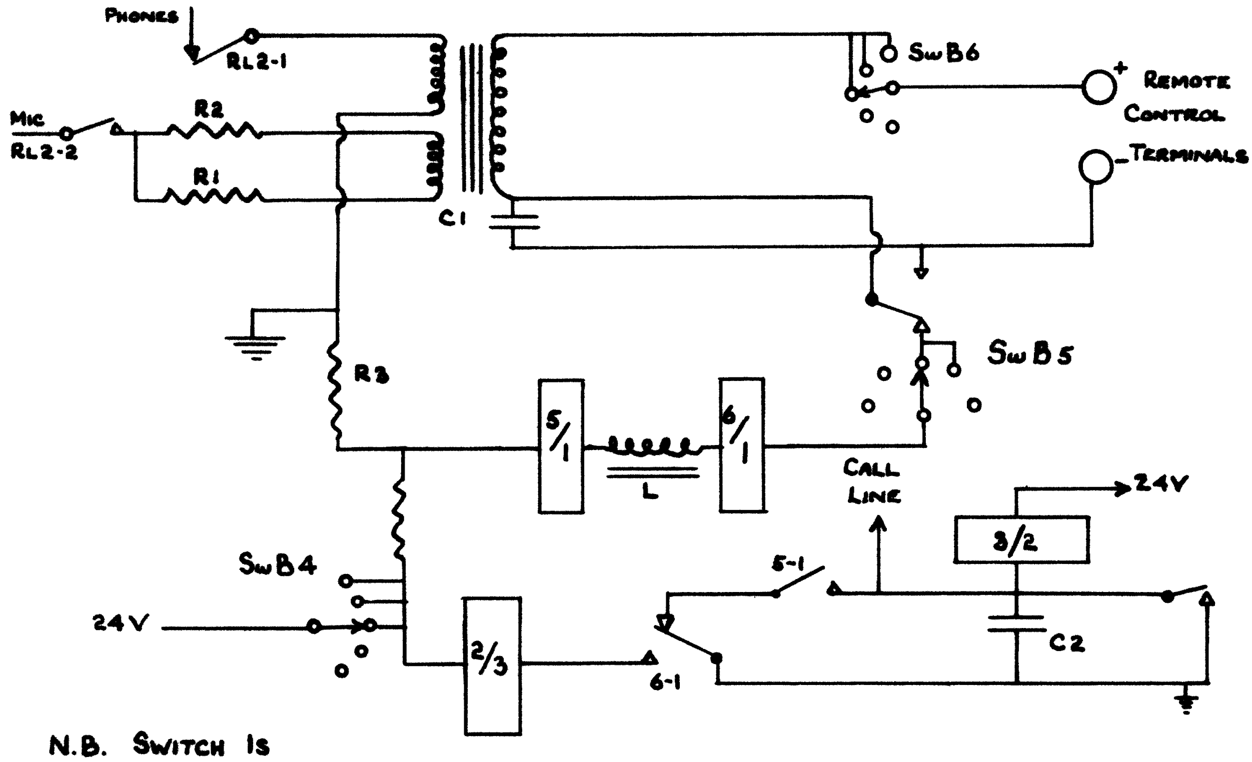

'C' OR 'D' UNIT
SET
HEADSET
MIC
PRESSEL
VCP
PHONES
A
B
C
D
E
F
G
L
M
SET MIC
SWA1
I/C MIC.
SET PHONES
SWA2
I/C. PHONES
PRESSEL
SWA3
SWB1
SWA4
'CALL'
SWB3
SWB4
RV1
TR1
2-1
2-2
2-3
R1
R2
R3
R4
C1
C2
SWB6
SWB5
4-1
6/2
5/1
4/1
2/3
3/2
1/1
5-1
3-1
3-2
6-1
1-1
LP1
LT
SWB
PHONE RETURNS
PL 2D.
J.I

FIGURE. 40.

THE REMOTE CONTROL SYSTEM IN THE J1



N.B. SWITCH IS
SHOWN IN "REMOTE" POSITION

—Figure 41—

The remote control system

When the remote call switch is pressed, a high impedance bridge is connected across the remote line. The current which now flows is sufficient to operate the relay 5/1 but not enough to operate 6/1. (5/1 has a resistance of about 140 ohm, while 6/1 has only 8.8 ohms.) When 5/1 operates the call line is earthed and thus the buzzer sounds.

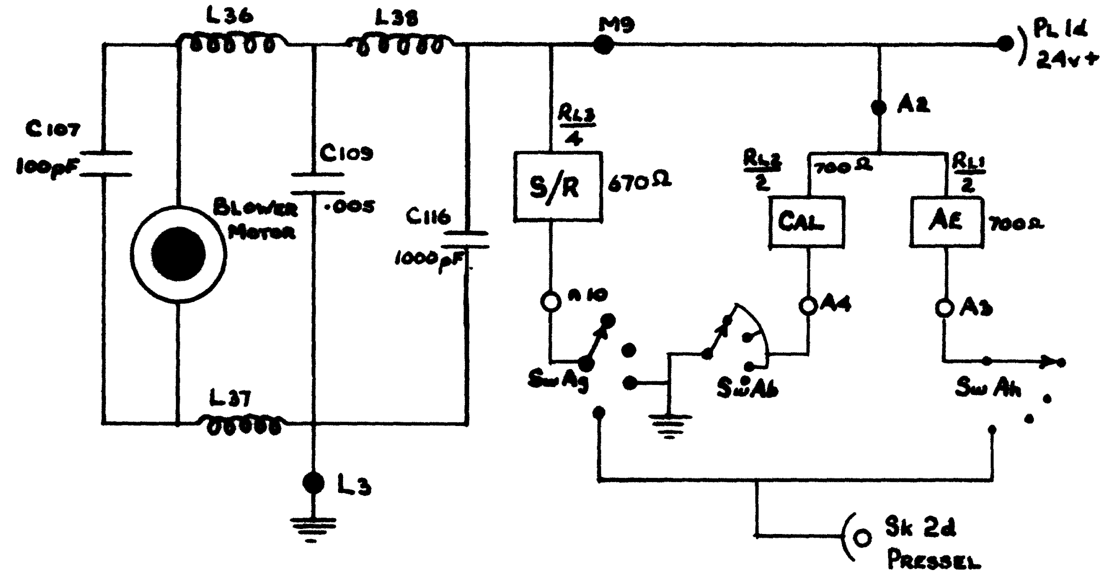
When the pressel is pressed at the remote station a low resistance bridge is placed across the remote line, and thus the current flowing will be greater than in the case of calling. This current will now be sufficient not only to operate 5/1 but 6/1 as well. This will cause contacts 5-1 and 6-1 to change. The earth is removed from the call line by 6-1 and placed instead onto the lower end of RL2/3, this has 24 volts on its upper end provided that the system switch is on any of the last three positions. If this is so relay RL2/3 will operate when the remote pressel is pressed.

Contact 2-1 switches one primary of the transformer out of circuit, contact 2-2 connects the microphone to the other primary, and RL2-3 connects the pressel to the remote terminal. The set may now be completely remote controlled.

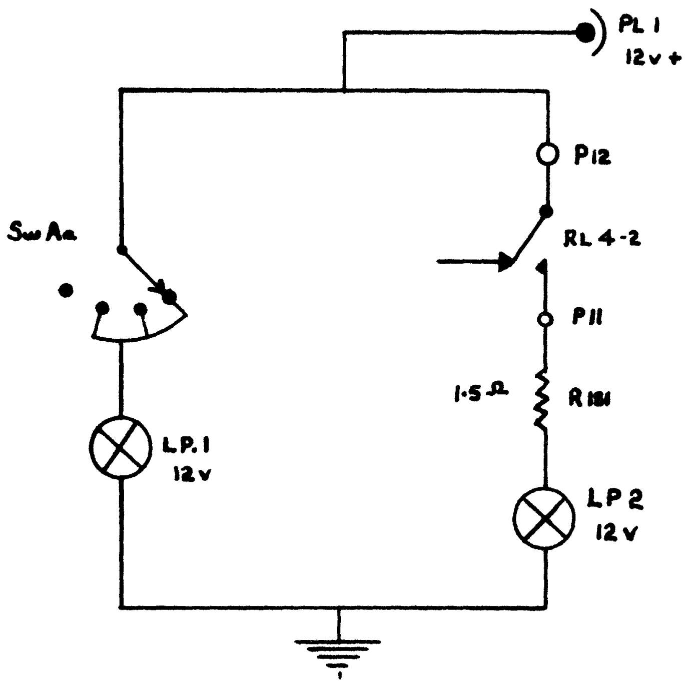
Since the microphones now used in the remote headsets are more sensitive than those for which the transformer was designed, the input was found to be too great. R1 and R2 were therefore put in to reduce this modulating voltage to the right magnitude.

The remote headsets and pressel are connected in parallel with those of the loader operator, and function on the set that he selects.

The remote control system is the same in the type A harness as in the Training Harness. It is incorporated in the J.D.9.



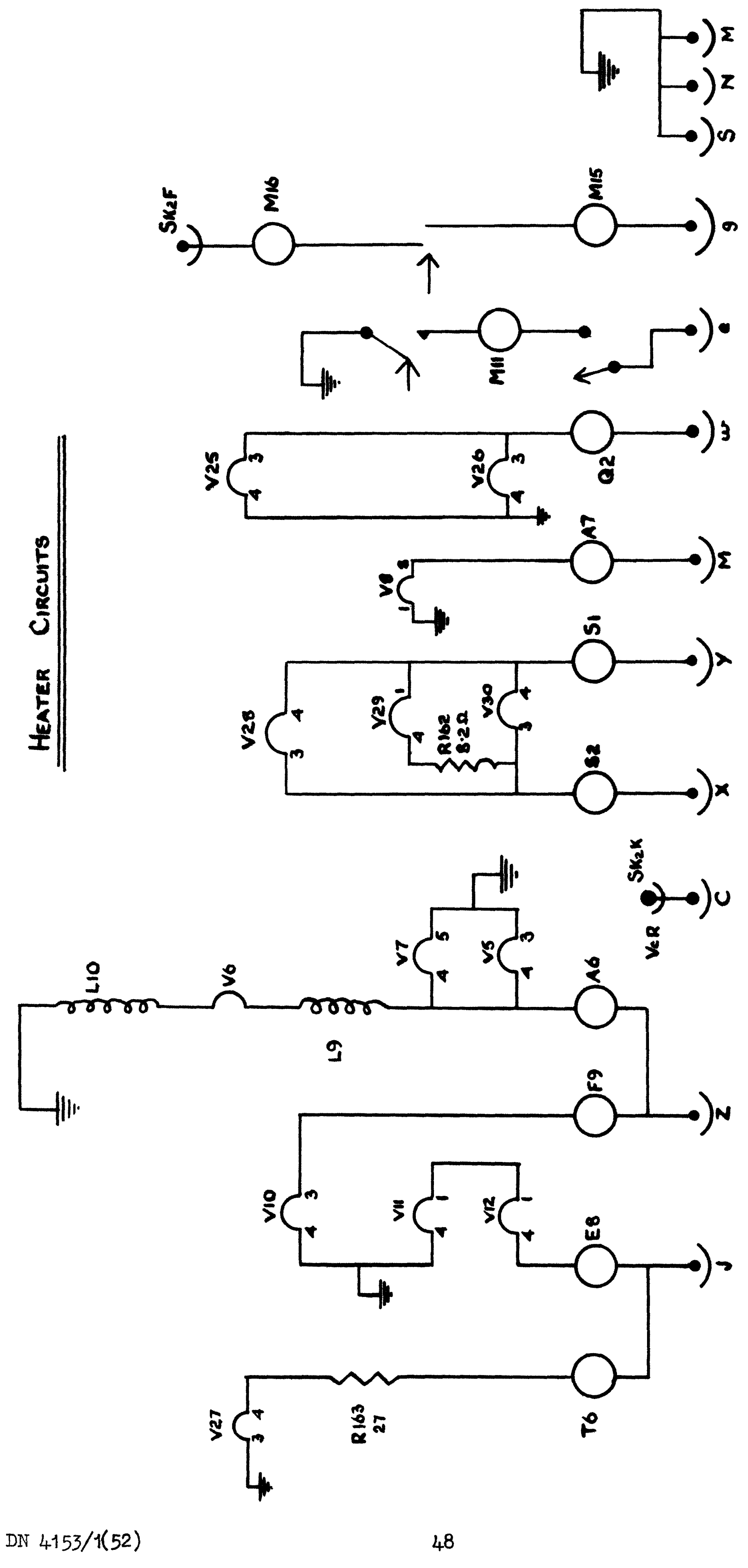
BLOWER & RELAY CCTS.



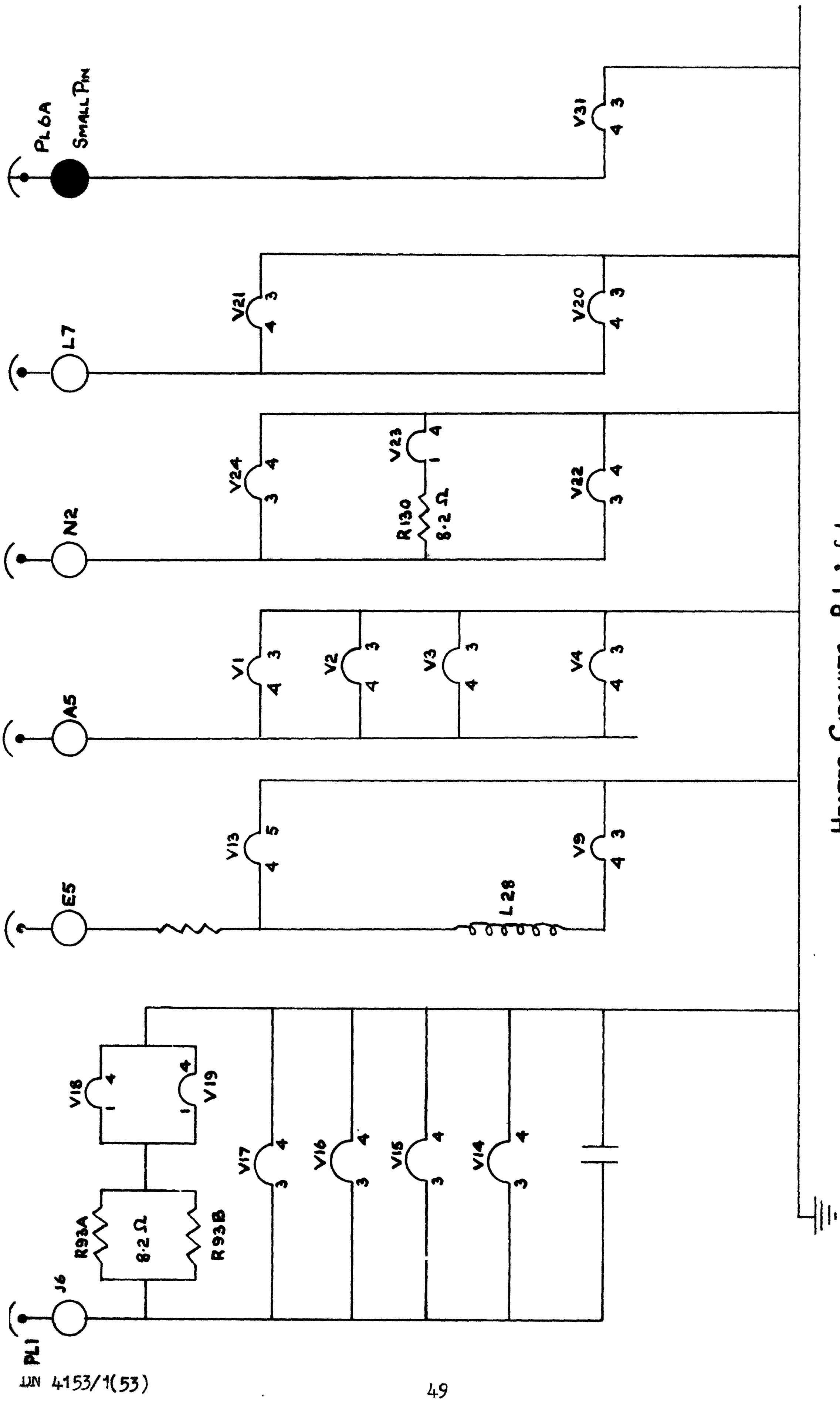
LAMPS C.C.T.

– Figure 42 –

Heater Circuits



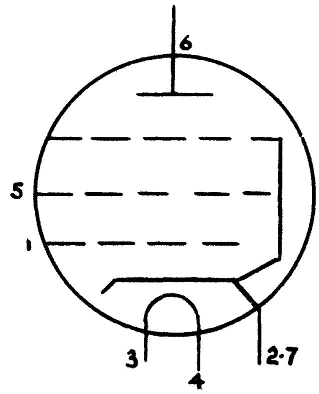
— Figure 43 —



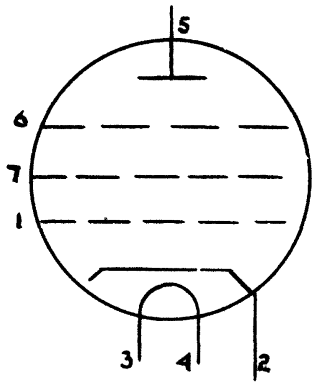
HEATER CIRCUITS P.L & f.L, q.v.

—Figure 44—

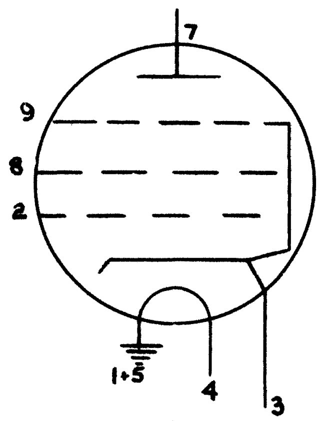
Valve Pin Connections.



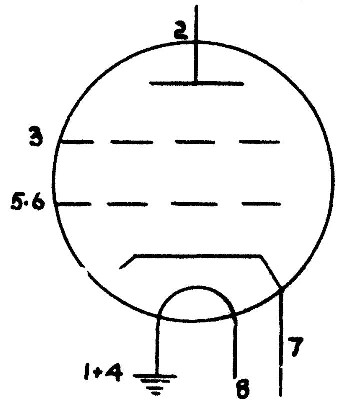
CV 850



CV 4015



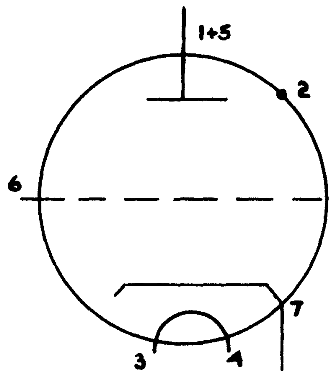
CV 2243



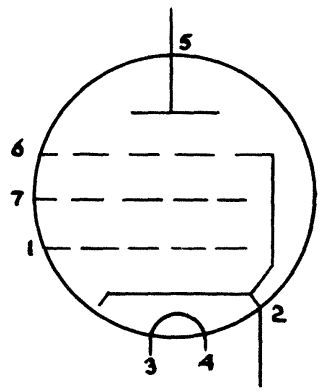
CV 2220

Figure 45

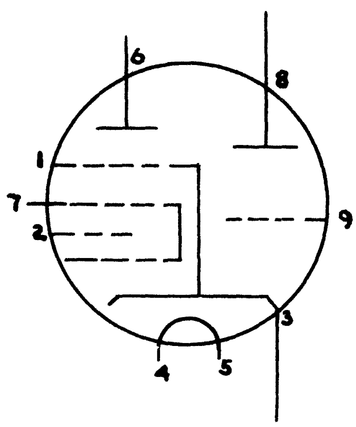
VALVE PIN CONNECTIONS



CV 133



CV 2209



CV 2128

Figure 46

FUNCTIONS OF PANEL CONTROLS

SwA: System switch.	Cursor adjt.	Channel adj.	R.F. Tune	Operate
Section a	Switches 12 volts A.C. to dial lamp			-
b	Operates "Calibrate" relay			-
c	Reduces delay voltage on squelch rectifier		Attenuates Rx disc O/P	-
d	HT to 2 Mc/s Osc.	HT to 100 kc/s osc	-	-
e	-	-	-	HT to PA
f	Meter to Rx discrim.		Meter to S/C disc	-
g	-	-	Operates S/R relay	S/R relay to pressel
h	-	-	-	Ae c/o relay to pressel

SwB: High/Low power switch.

On "High Power": Section a earths PL1e via S/R relay at "send".

Section b changes P.A. HT. supply from 175 volts (via R182) to 350 volts.

SwC: Noise on/off switch.

At "Off" it earths the 1st A.F.A. anode via the squelch relay.

RV4: Squelch control.

Varies the delay voltage on the squelch rectifier.

Cursor Adjust: moves the cursor across scale of 1st L.O.

Channel: The INDUCTUNER, a variable inductance which tunes the 1st LO.

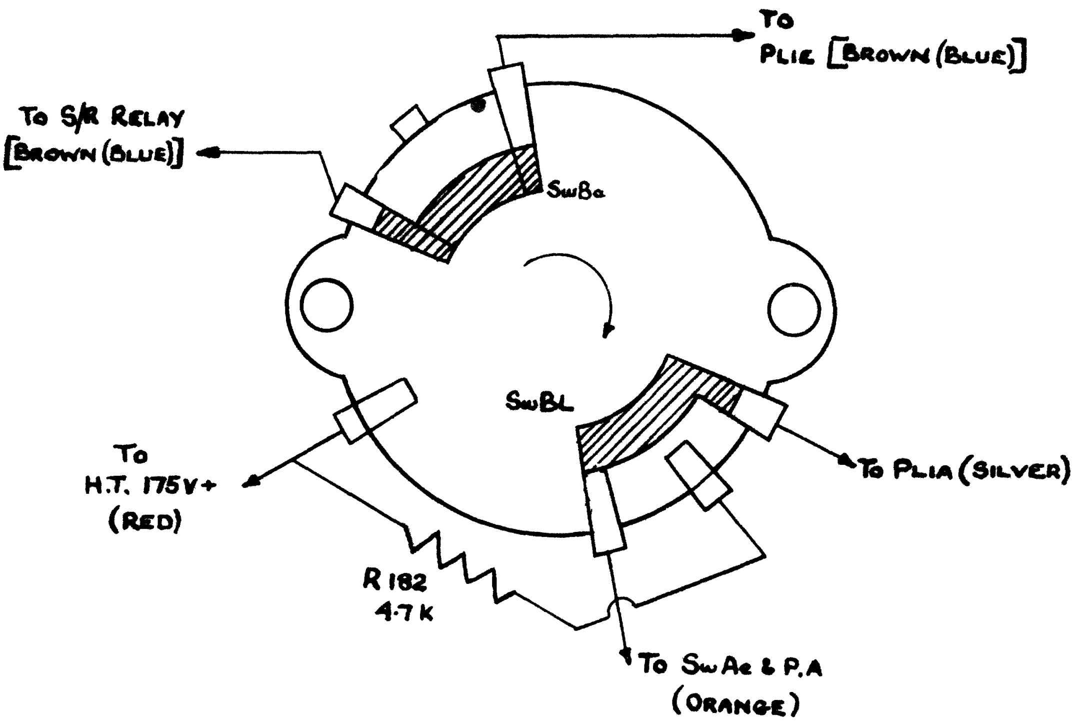
R.F.: a 6 gang condenser which tunes the R.F.A. grid and anode circuits and all the transmitter circuits.

Two LOCKING CONTROLS which lock the 6-gang condenser and inductuner, leaving their knobs to rotate.

Switch Diagrams

HP/LP. SwB Rear View.

(When On H.P.)



Noise On/Off Sw C

(When Off — Rear View)

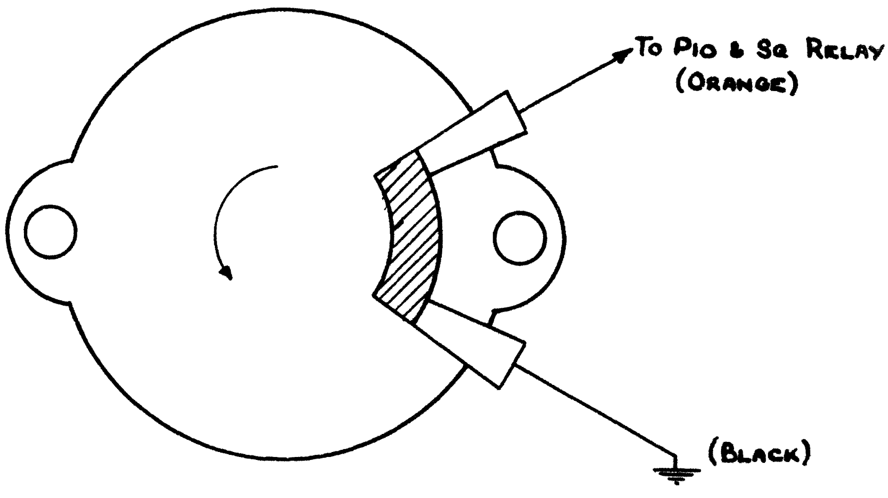
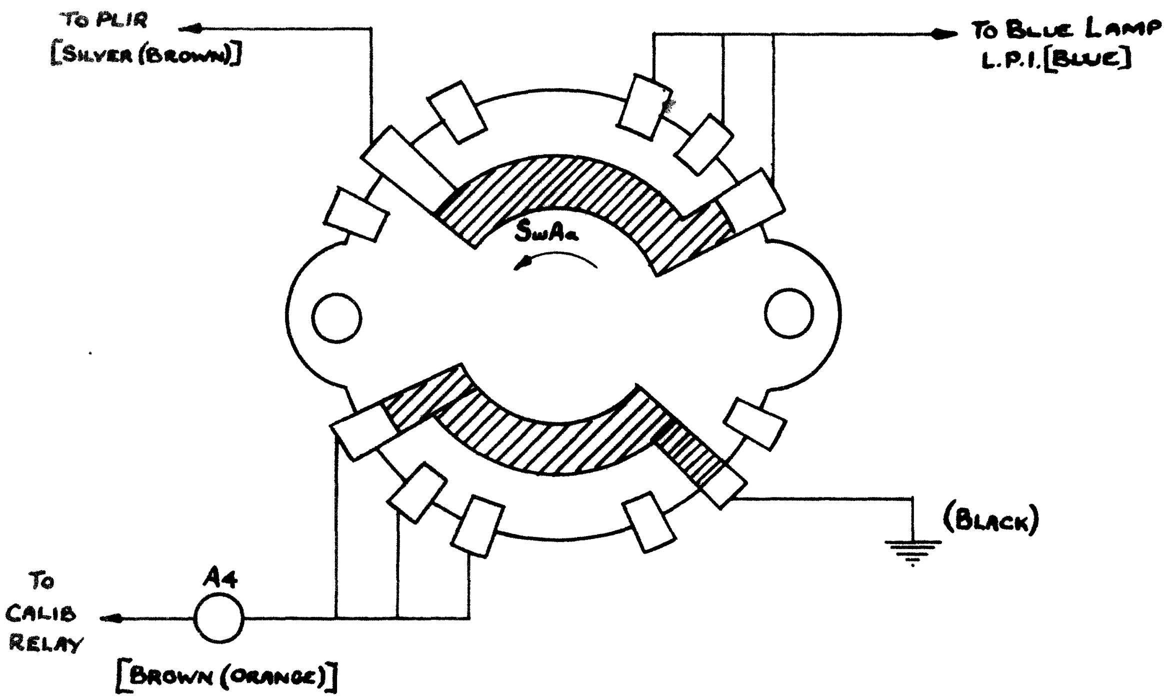


Figure 47.

SWITCH DIAGRAMS

SYSTEM SWITCH —— CURSOR ADJUST —— REAR VIEW



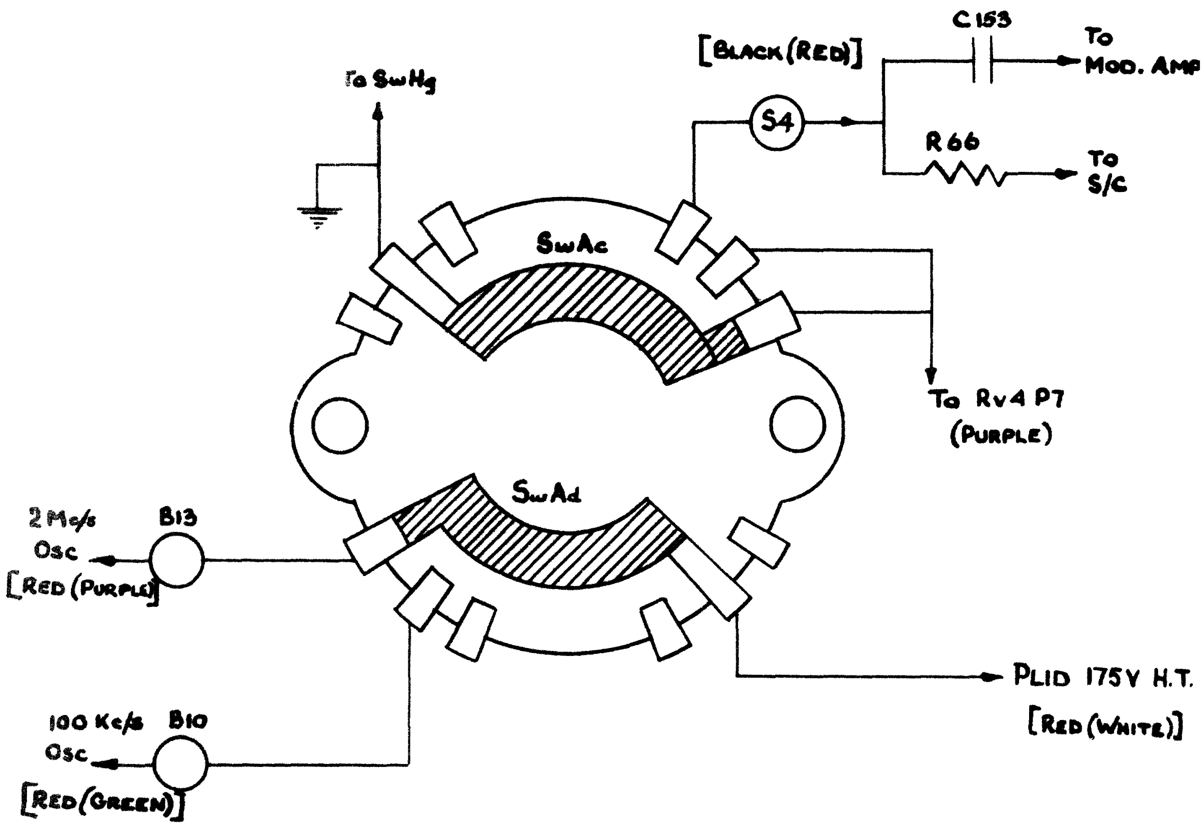


Figure 48

Switch Diagrams

System Switch — Cursor Adjust-Rear View

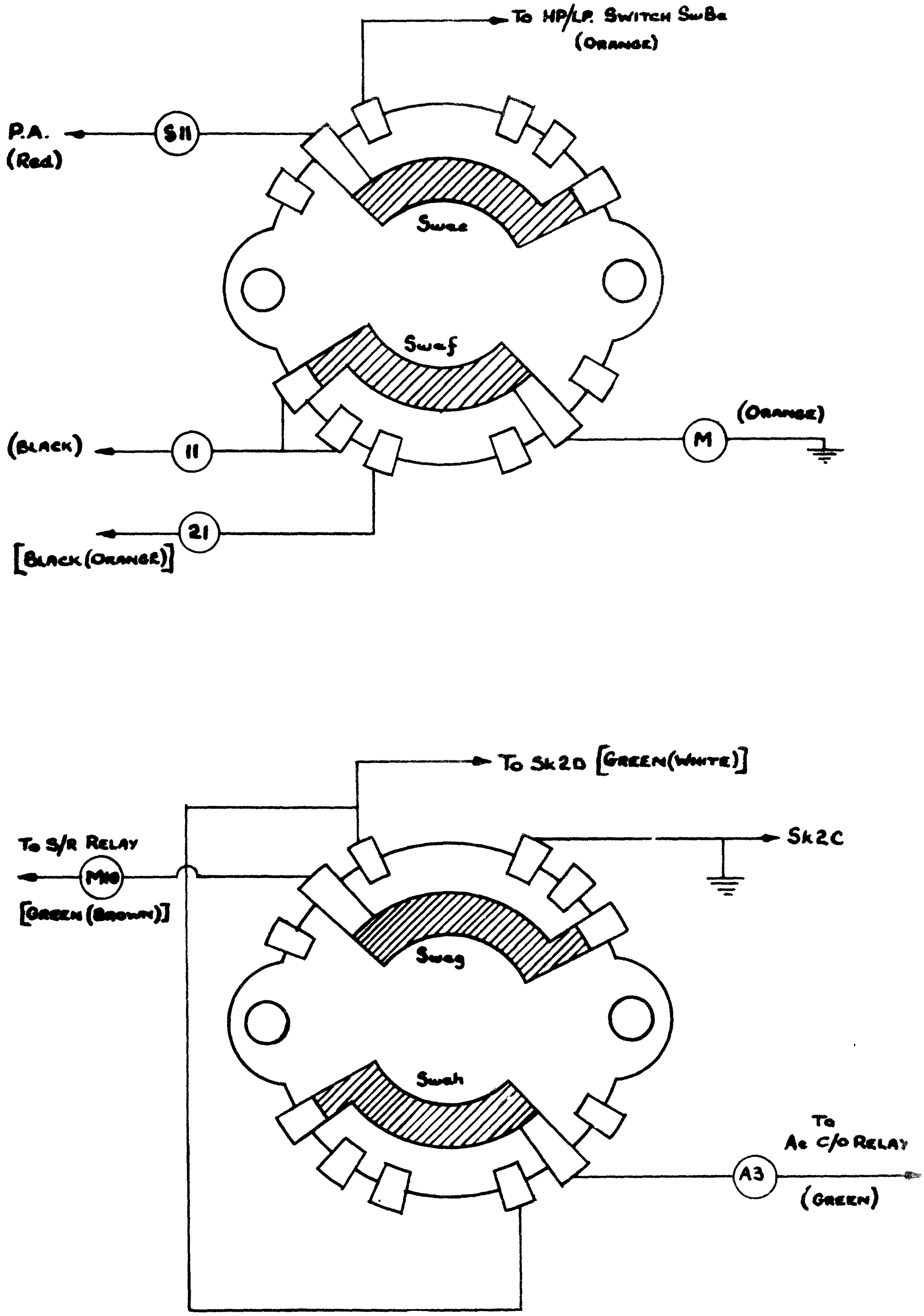


Figure 49

Simplified Switching Diagram. A:- System.

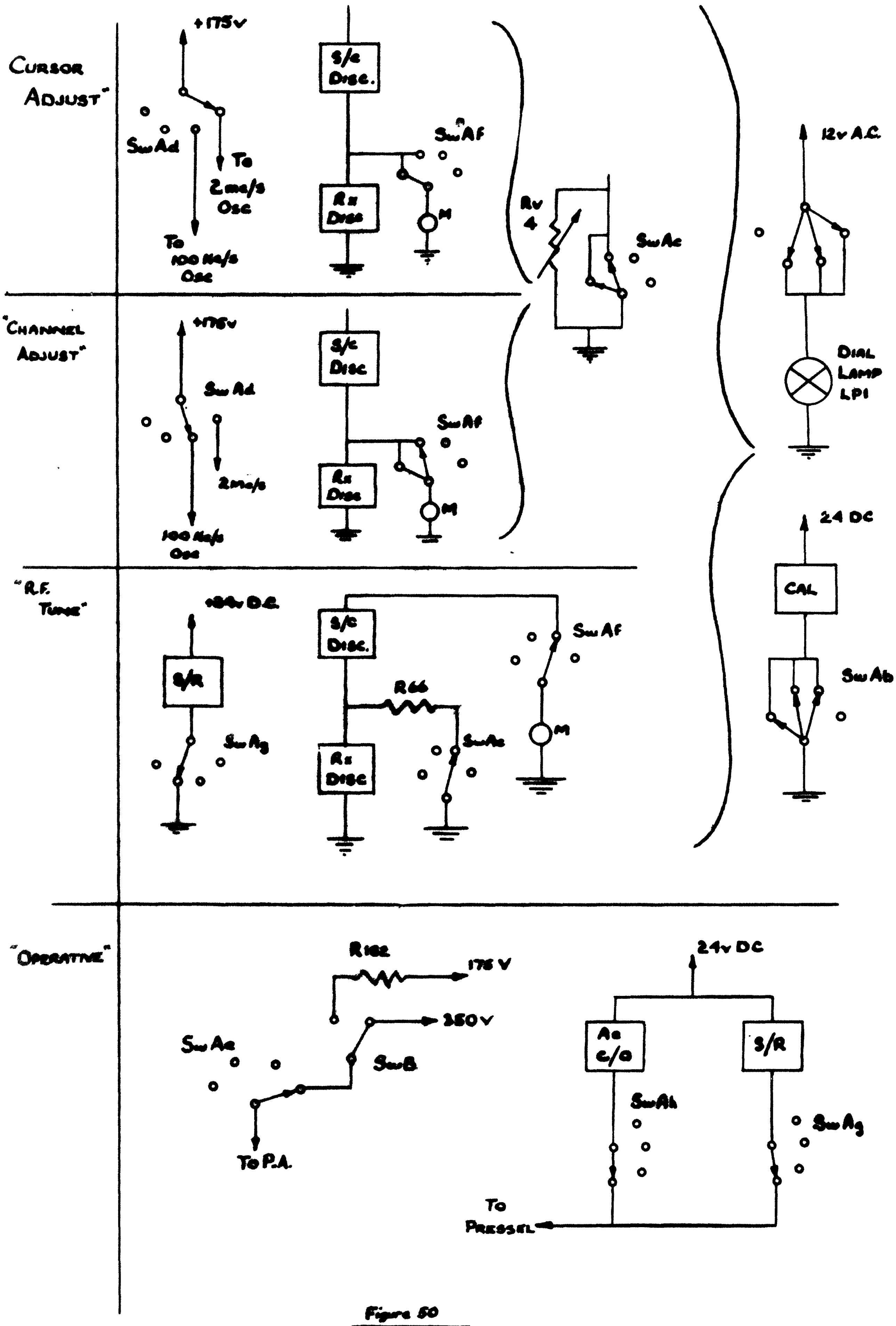


Figure 50

SIMPLIFIED SWITCHING DIAGRAM B :- SQUELCH.

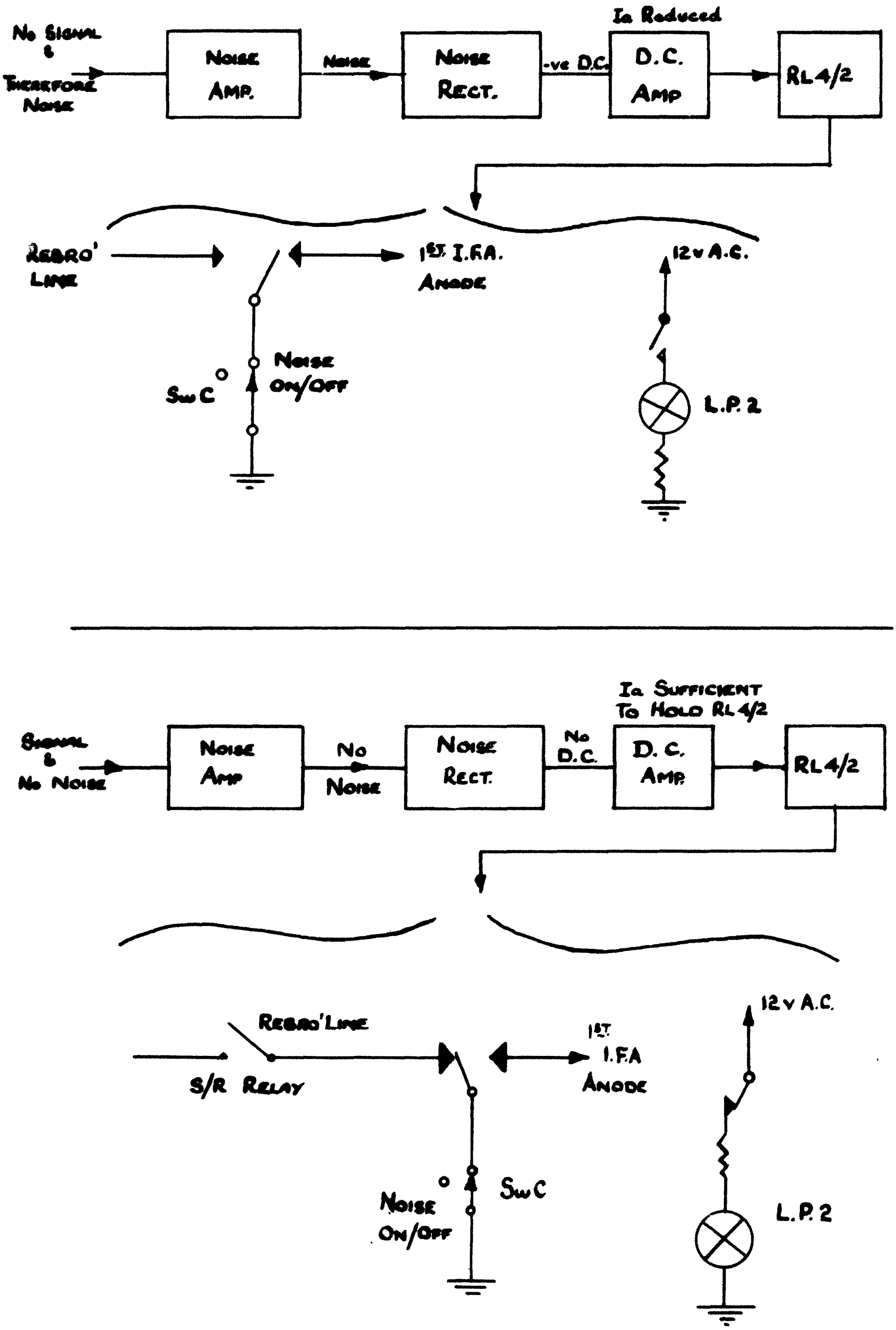
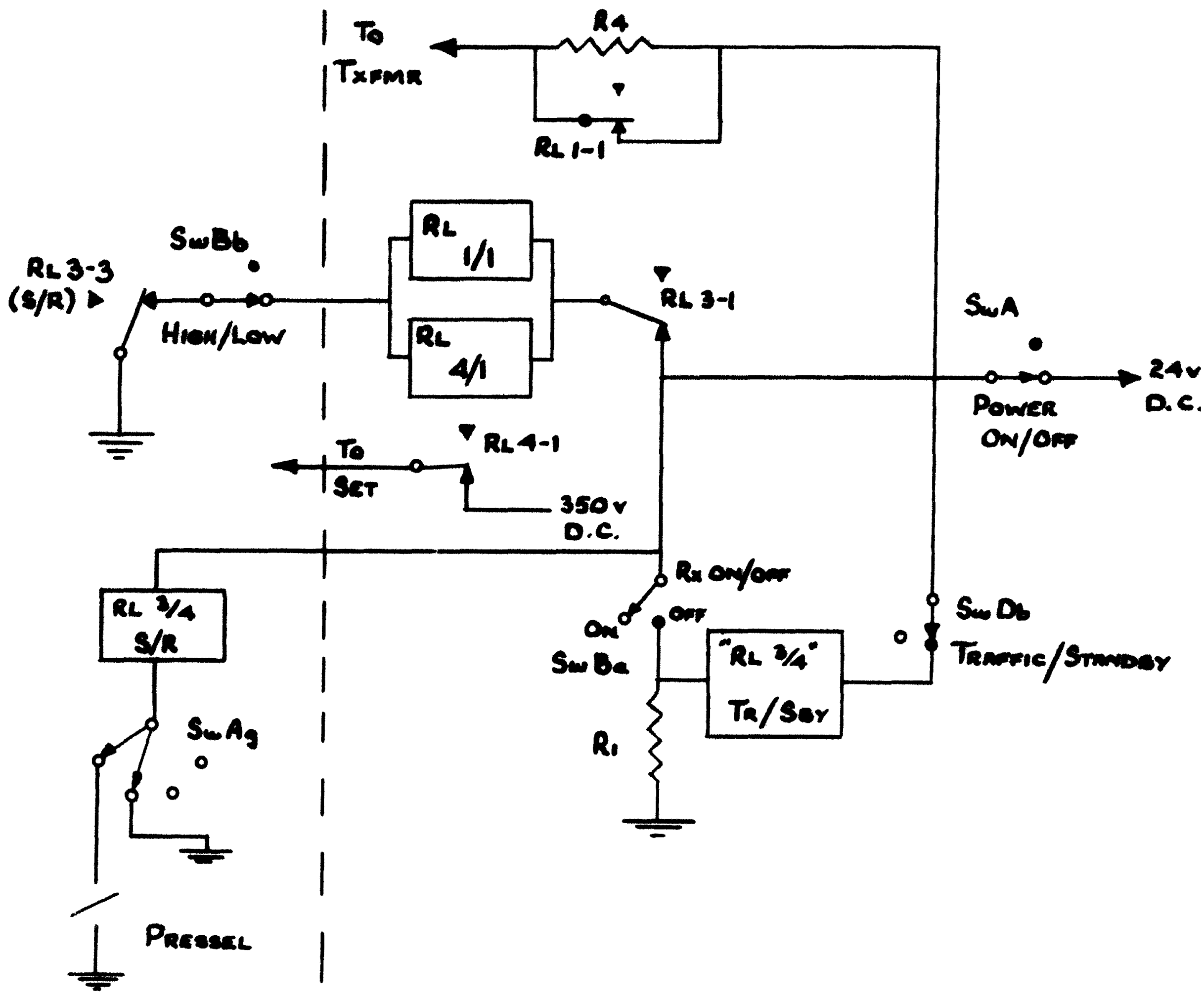


Figure 51

Simplified Switching Diagram – C:— H.P./L.P.



D:— Traffic/Standby

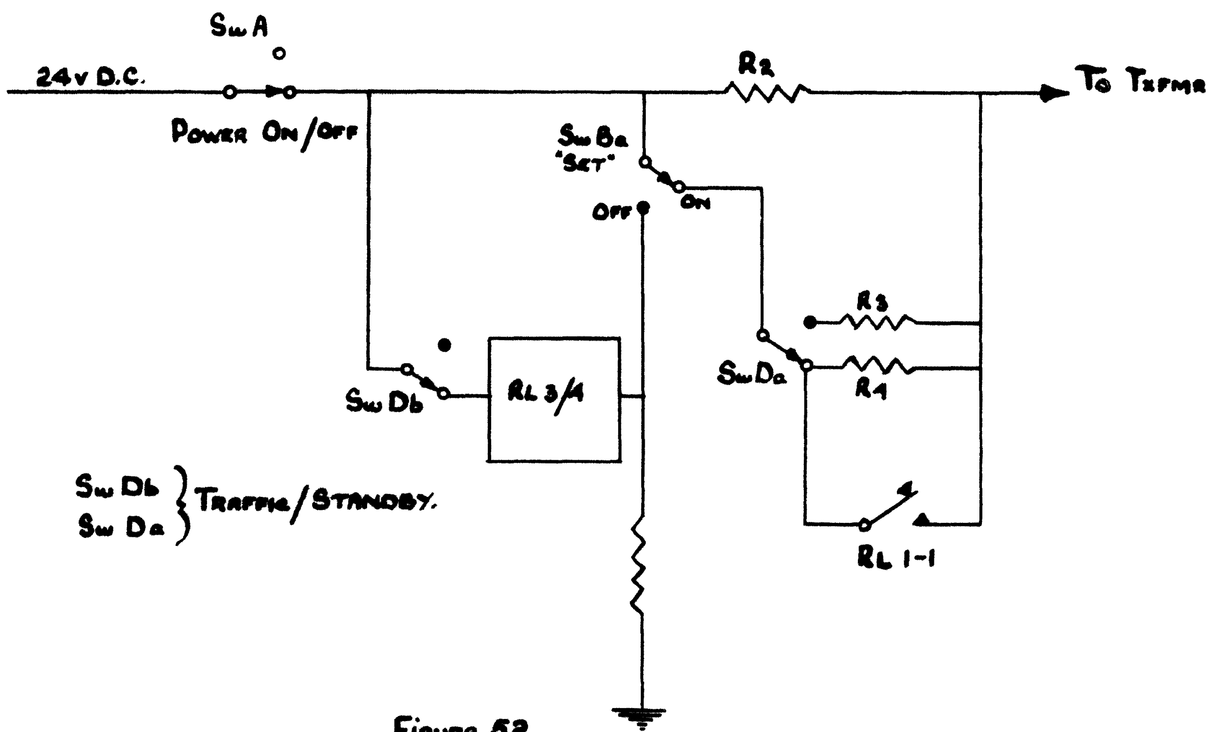


Figure 52

P.S.U. SWITCHING & RELAYS

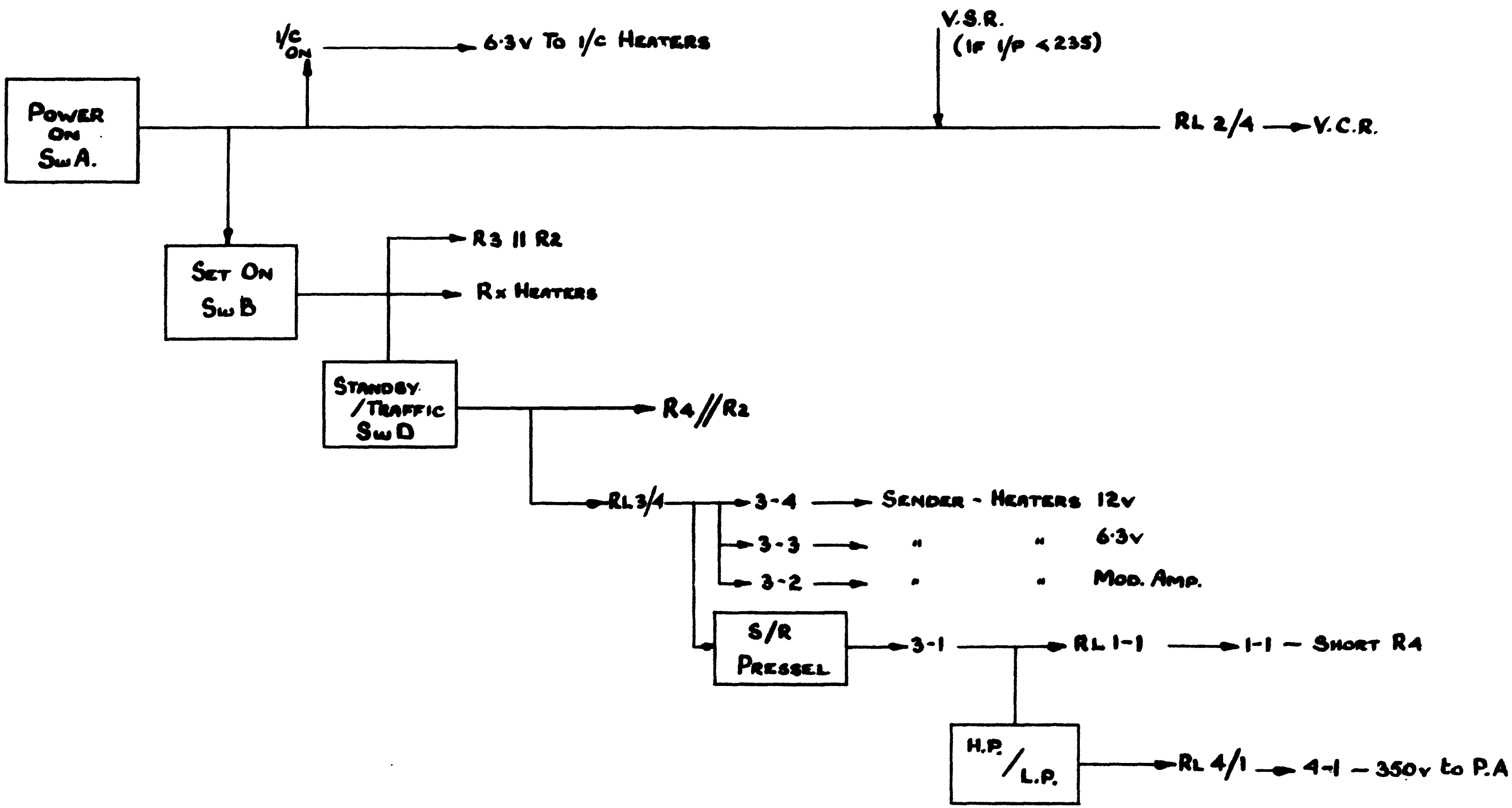


Figure 53

W/SET RELAYS

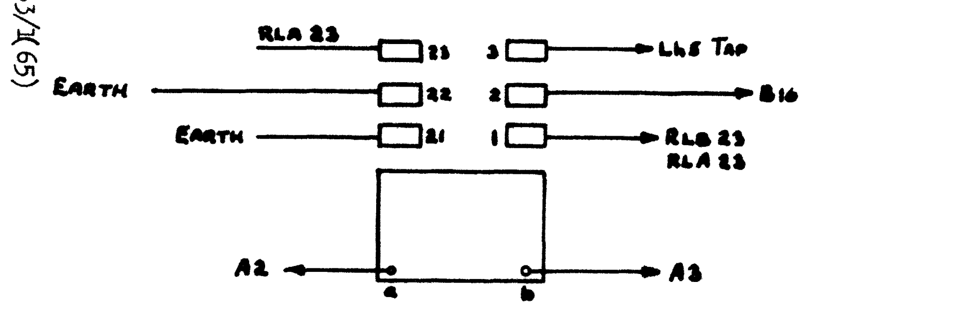
RL 1/2	AE C/O	1-1	AE from earth to P.A. o/p.
		1-2	Earth stray unconnected coax in aerial cct.
RL 2/2	Calib.	2-1	Calib. o/p to R.F.A. grid cct.
		2-2	Earth on AE.
RL 3/4	S/R	3-1	175V. to sender valves.
		3-2	Disconnects battery homing line from front panel SK 2F.
		3-3	Earth SK1e turning relays RL1-1 and RL4-1 in PSU.
		3-4	Disconnects Rebro line.

Noise on/off to off
SWC

RL4/2	Squelch	4-1	Earth anode of 1st A.F.A.
		4-2	Light signal lamp.

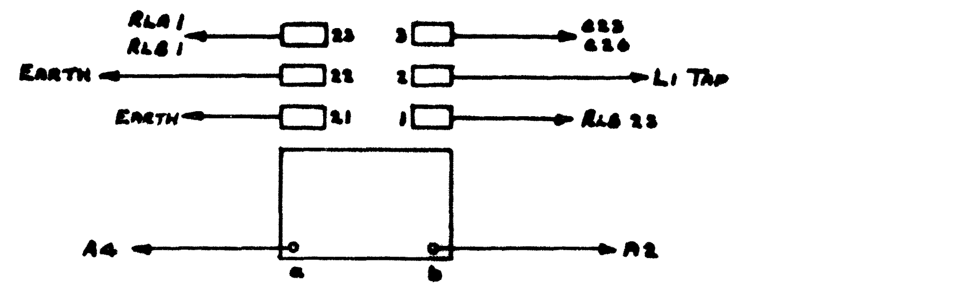
DN 4153/II(65)

RELAY DATA



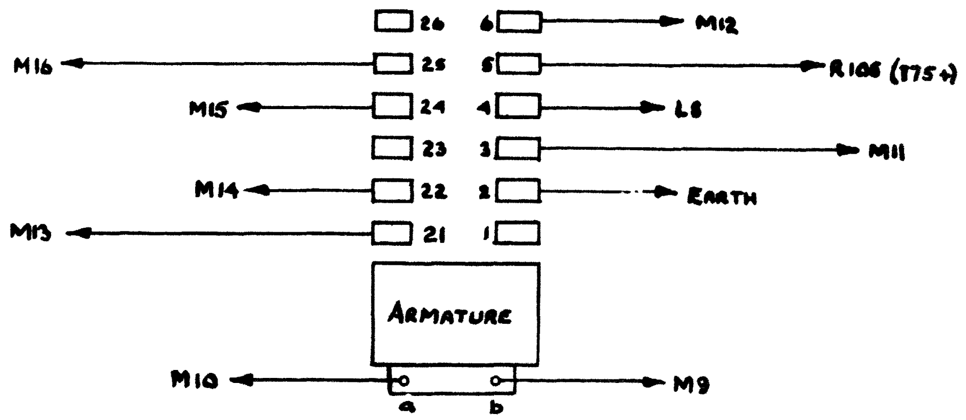
RELAY RLA. VIEWED FROM REAR OR TAG END.

AERIAL SWITCHING: TEST CURRENT: OPERATE 17MA, RESISTANCE 700Ω



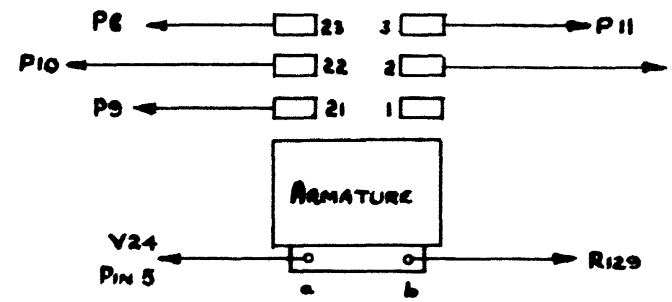
RELAY RLB. VIEWED FROM REAR OR TAG END.

CALIBRATOR SWITCHING. TEST CURRENT: OPERATE 17MA RESISTANCE 700Ω



RELAY VIEWED FROM TAG END. RELAY RLC.

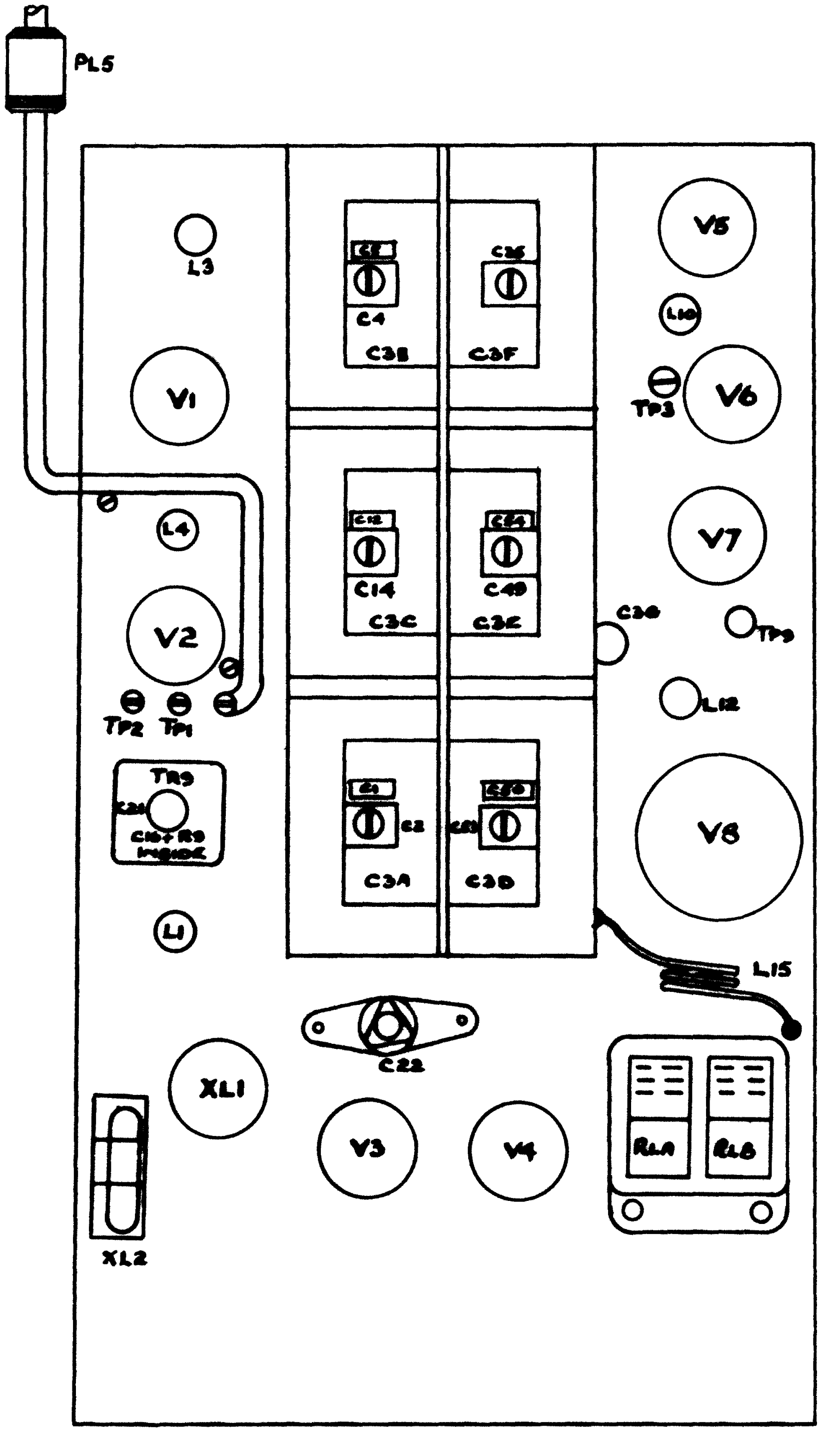
SEND-RECEIVE. TEST CURRENT: OPERATE 24 MA, RESISTANCE 670Ω



RELAY VIEWED FROM TAG END. RELAY RLD.

SQUELCH. TEST CURRENT: OPERATE 6·5 MA RESISTANCE 7600Ω.

Figure 54



R.F. CHASSIS – TOP

Figure 56

R.F. CHASSIS – BOTTOM.

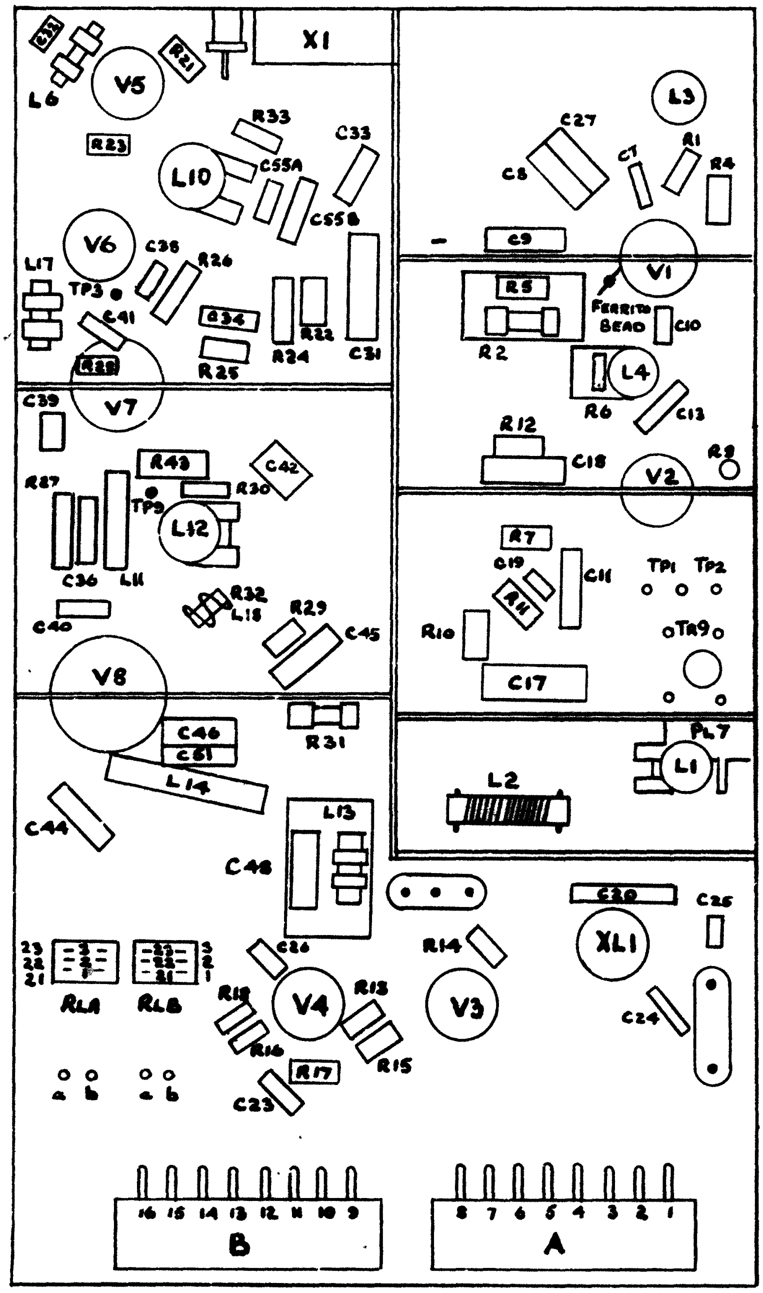
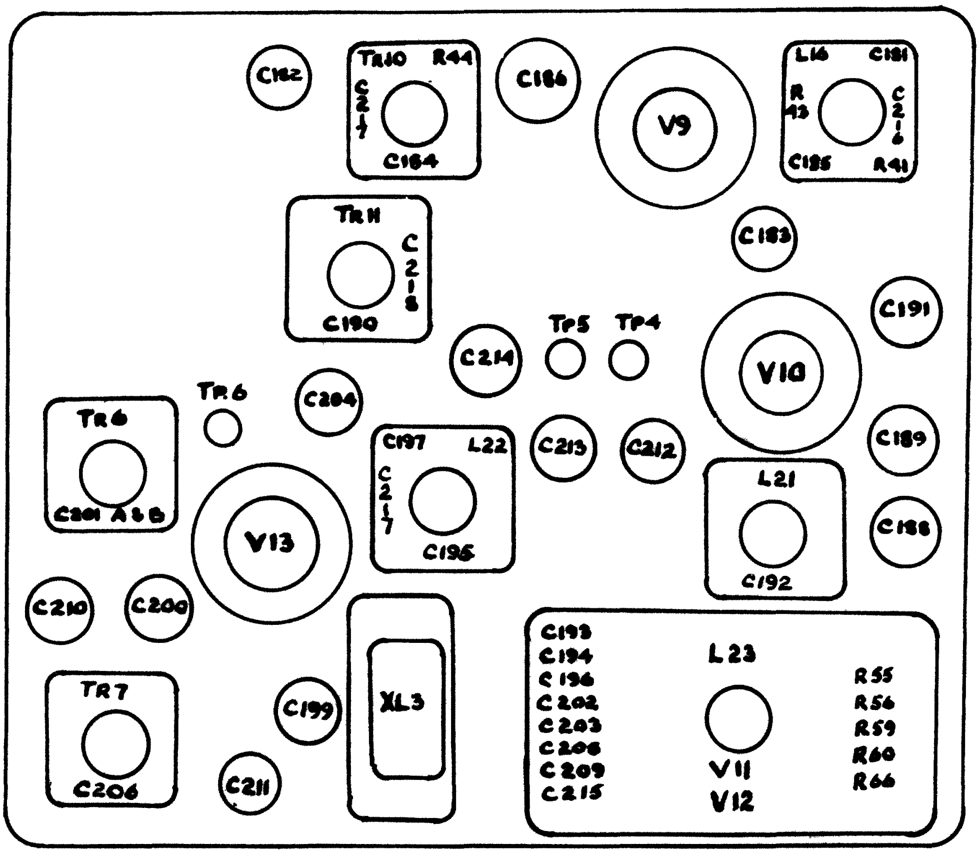


Figure 56

Component Layout 1st I.F. Unit



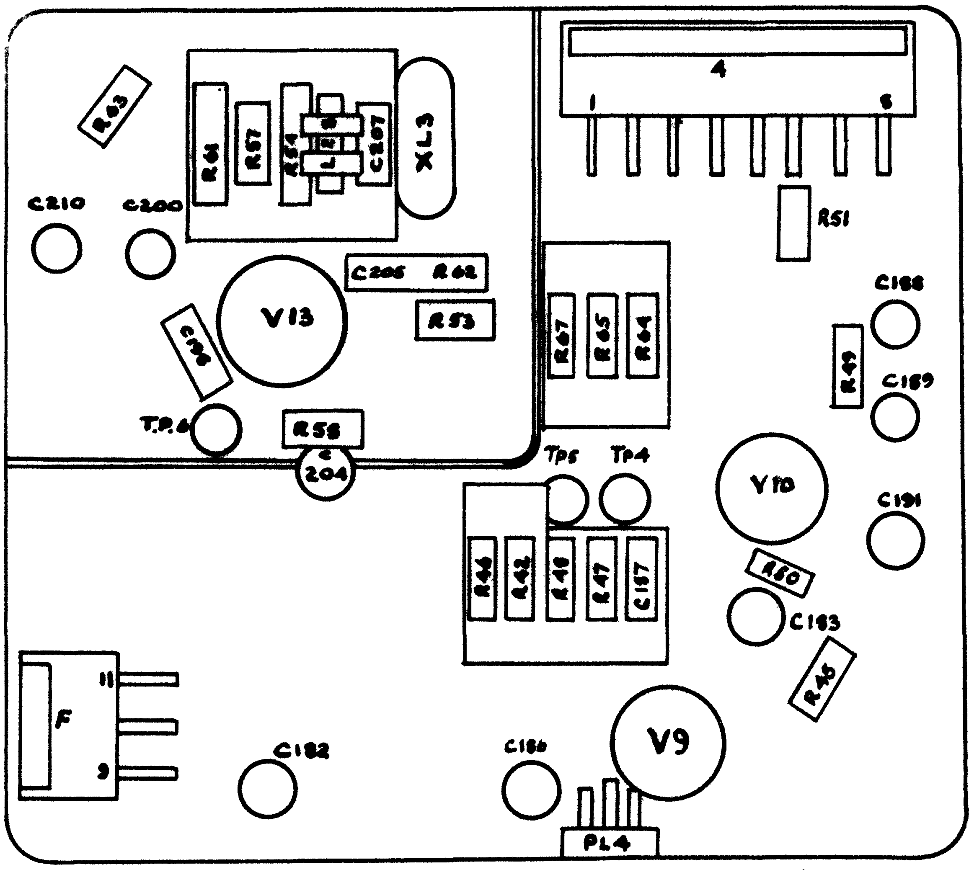


Figure 57

Component Layout.

2nd I.F. Unit

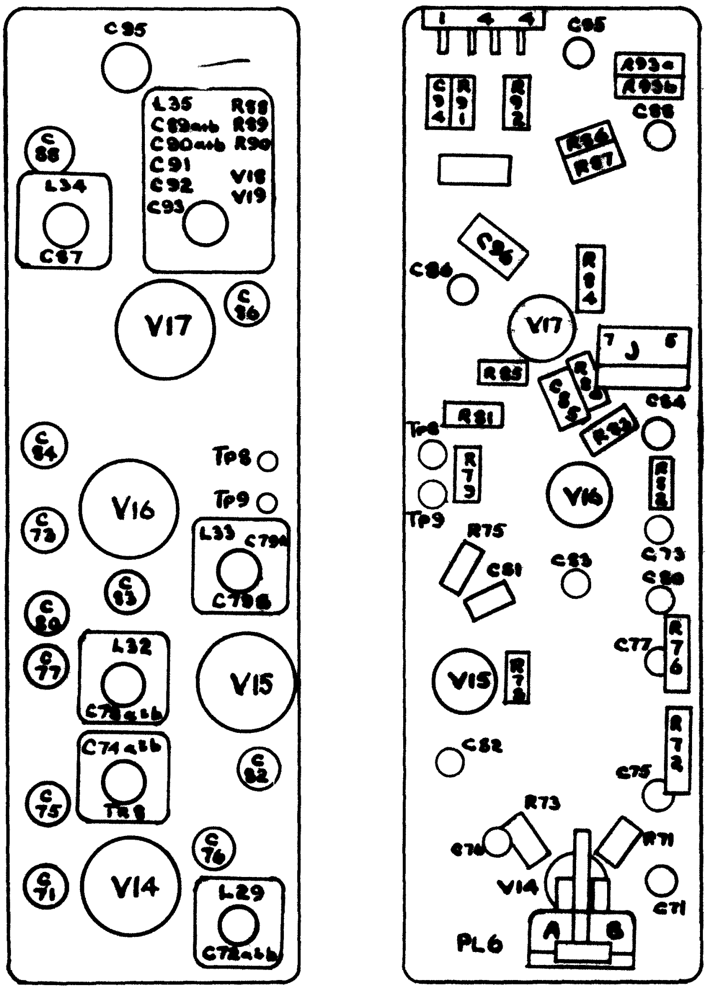


Figure 58

COMPONENT LAYOUT

1ST. Rx L.O. UNIT

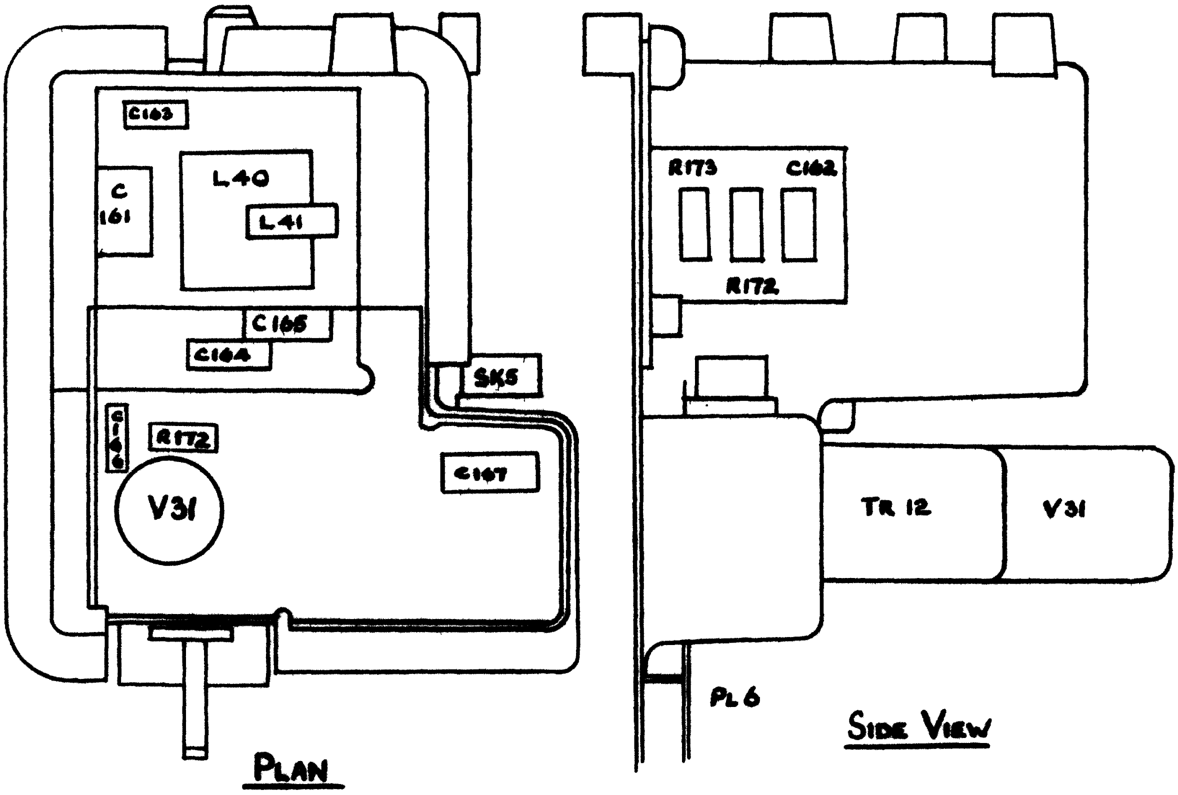


Figure 59

Component Layout.

Squelch Unit

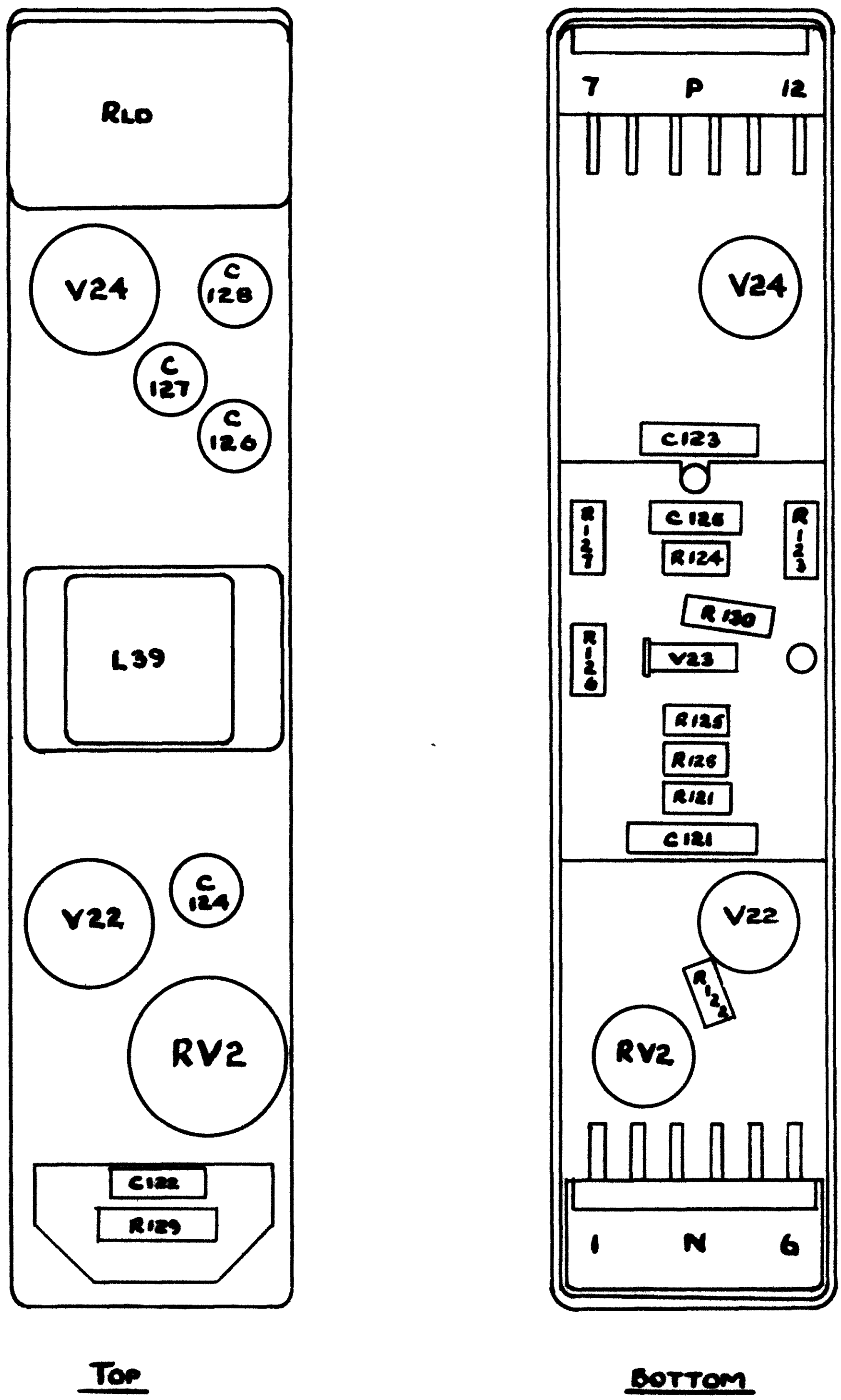


Figure 60

COMPONENT LAYOUT

A.F UNIT

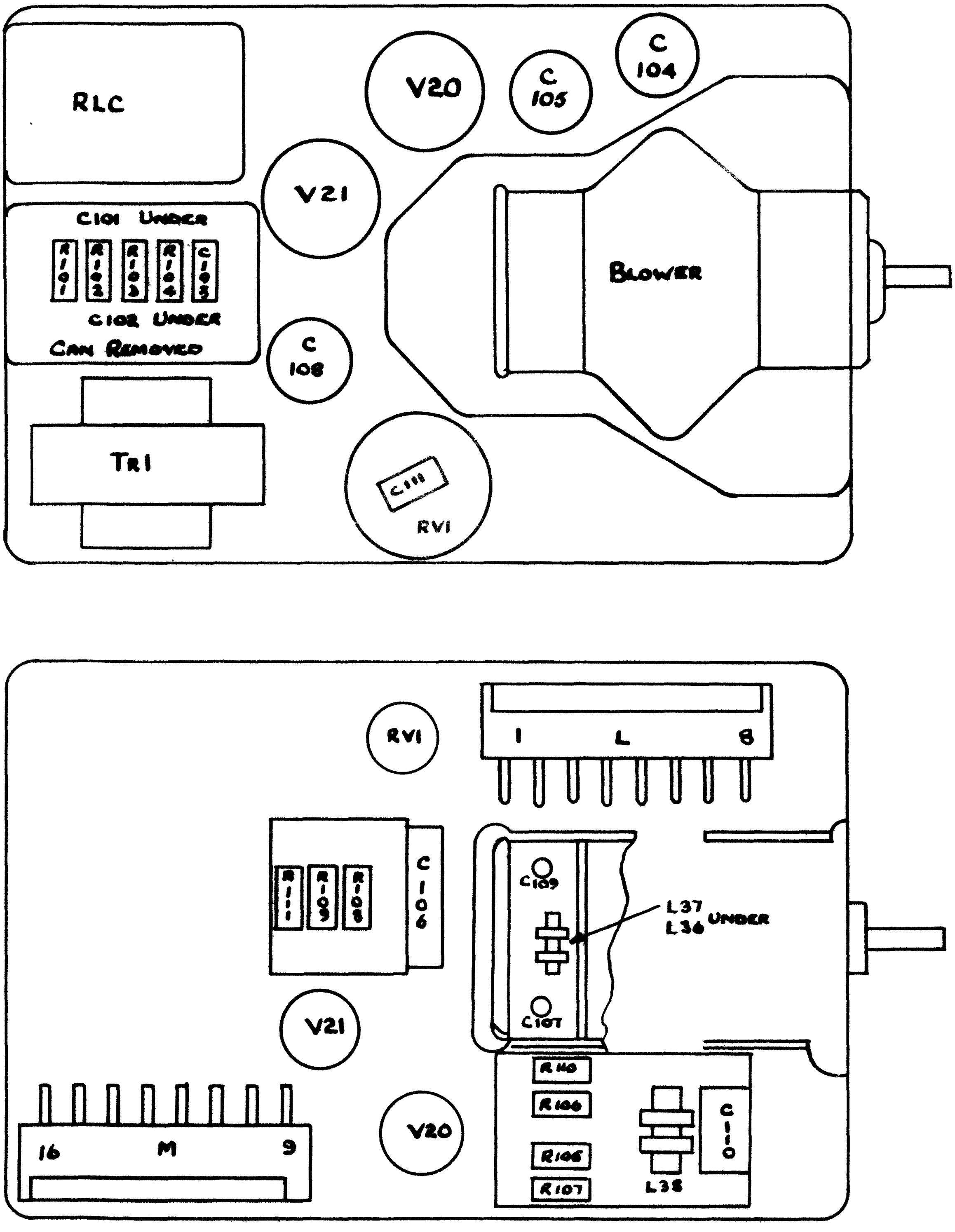


Figure 61

COMPONENT LAYOUT

A.M.C. UNIT

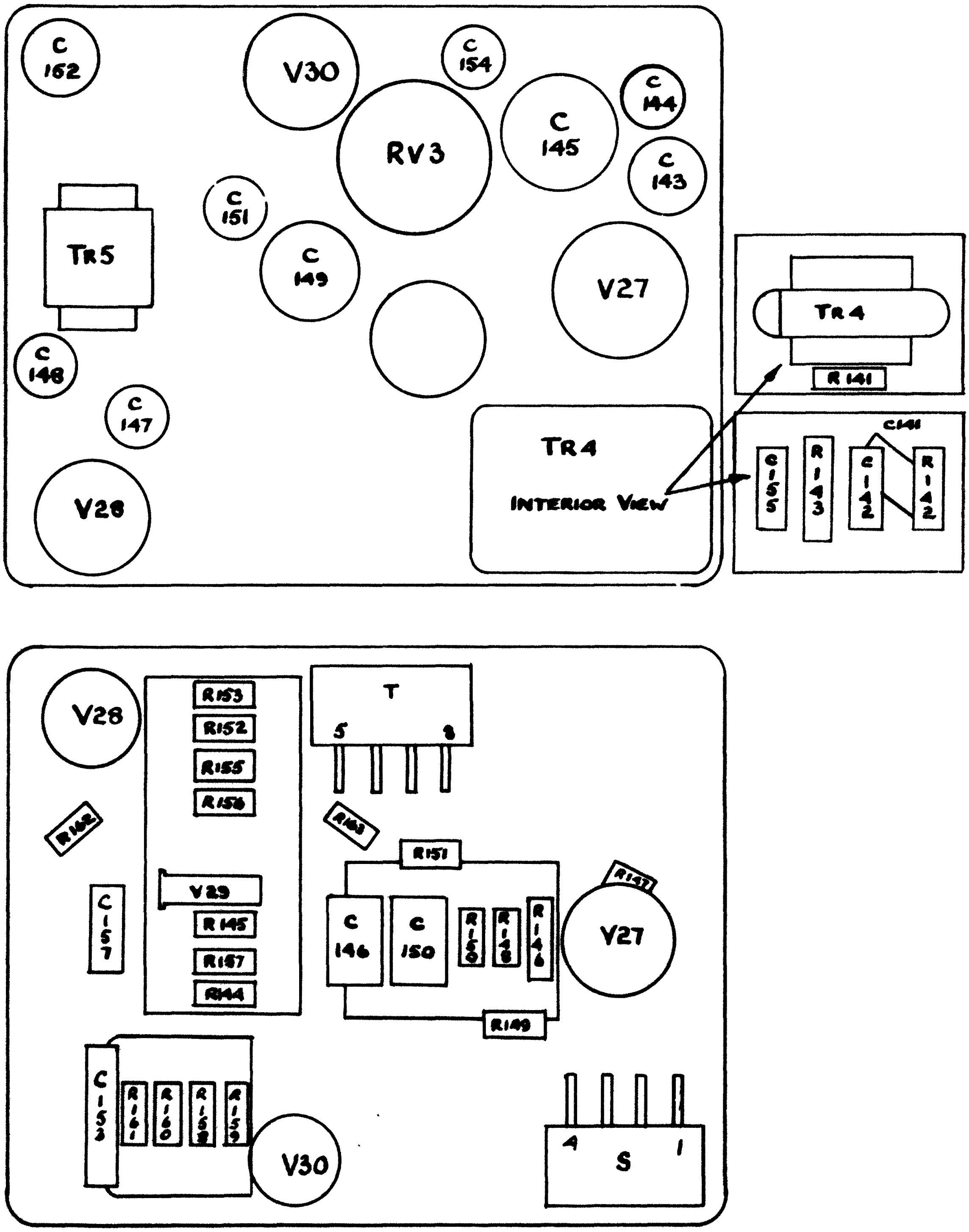
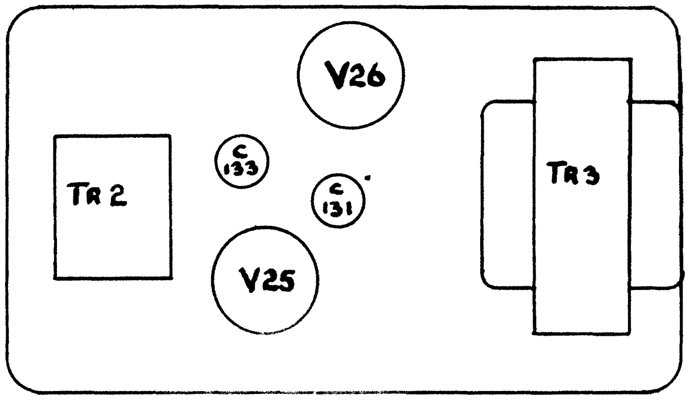


Figure 62

Component Layout

I.C. Amp Unit



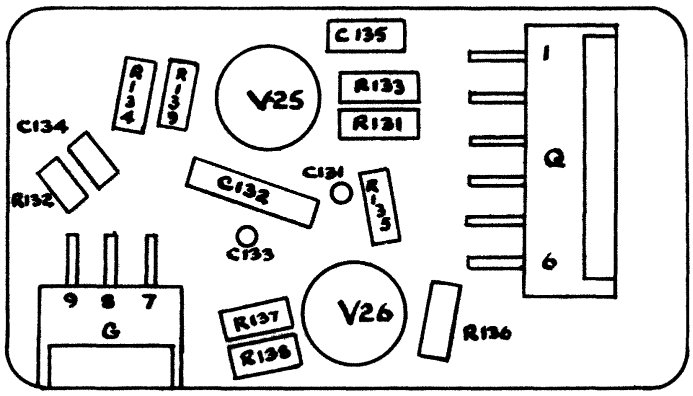


Figure 63

Component Layout Junction Distribution No 9

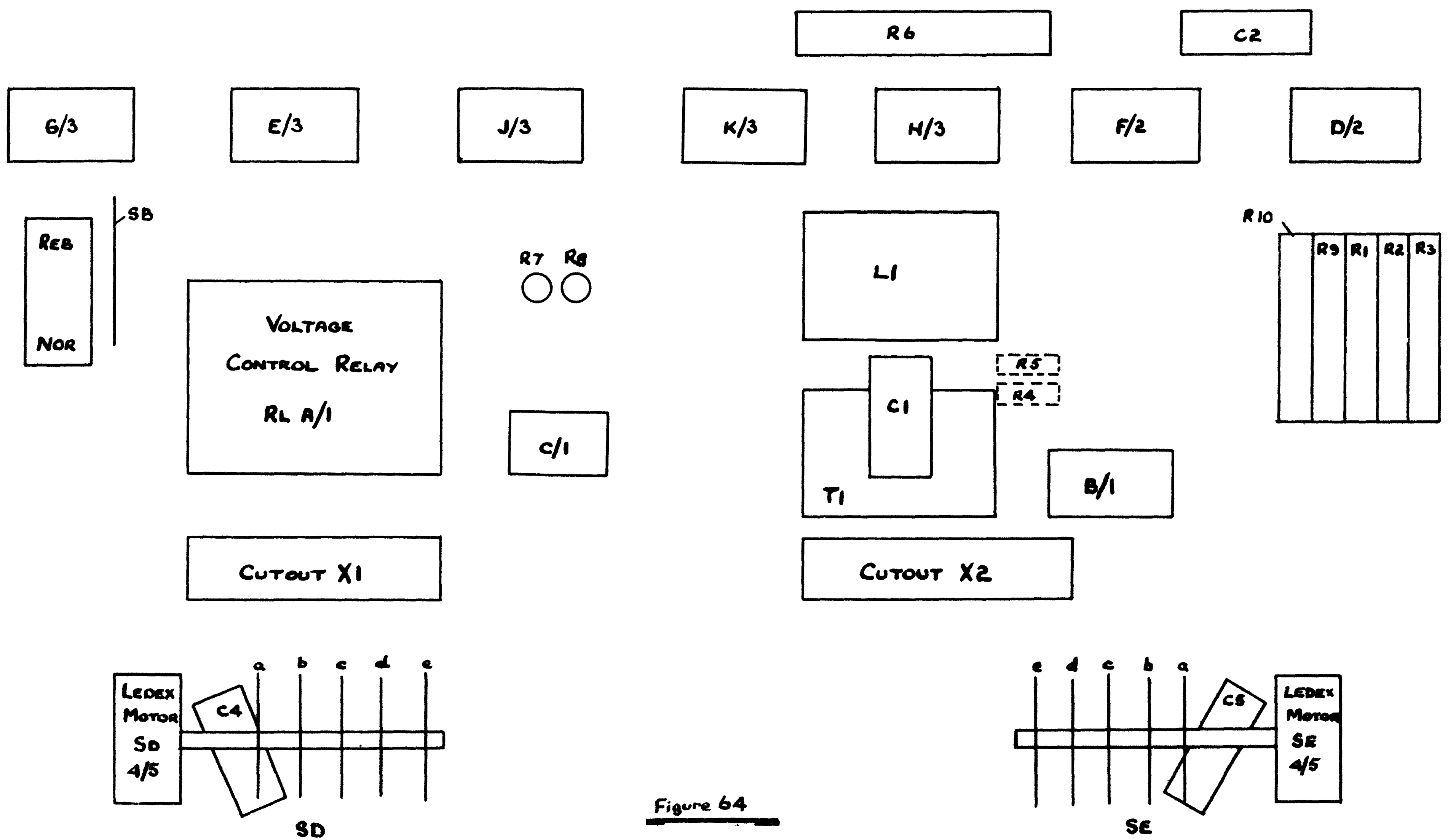


Figure 64

POWER SUPPLY UNIT – TOP VIEW.

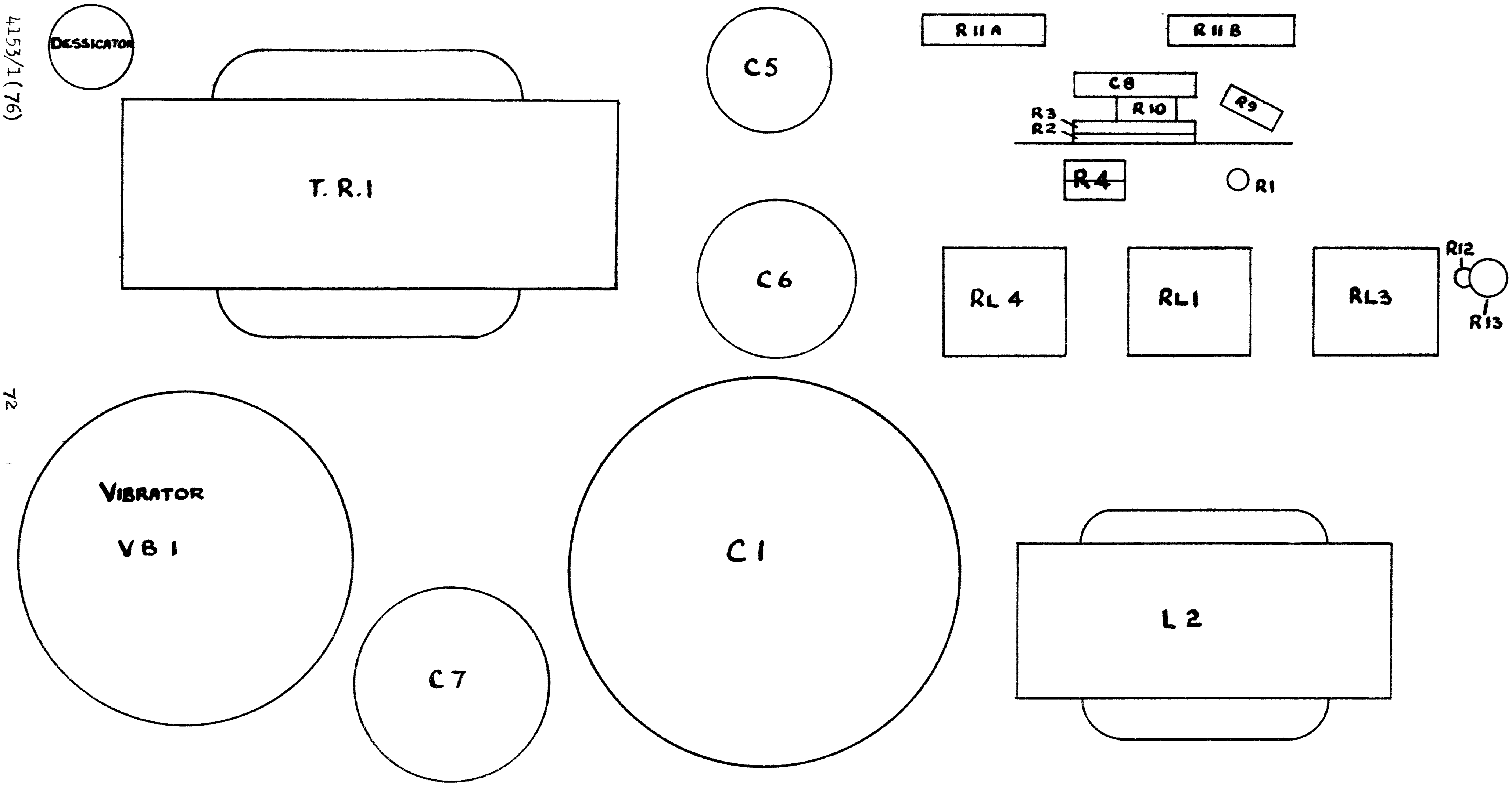


Figure 65

POWER SUPPLY UNIT – UNDERNEATH VIEW

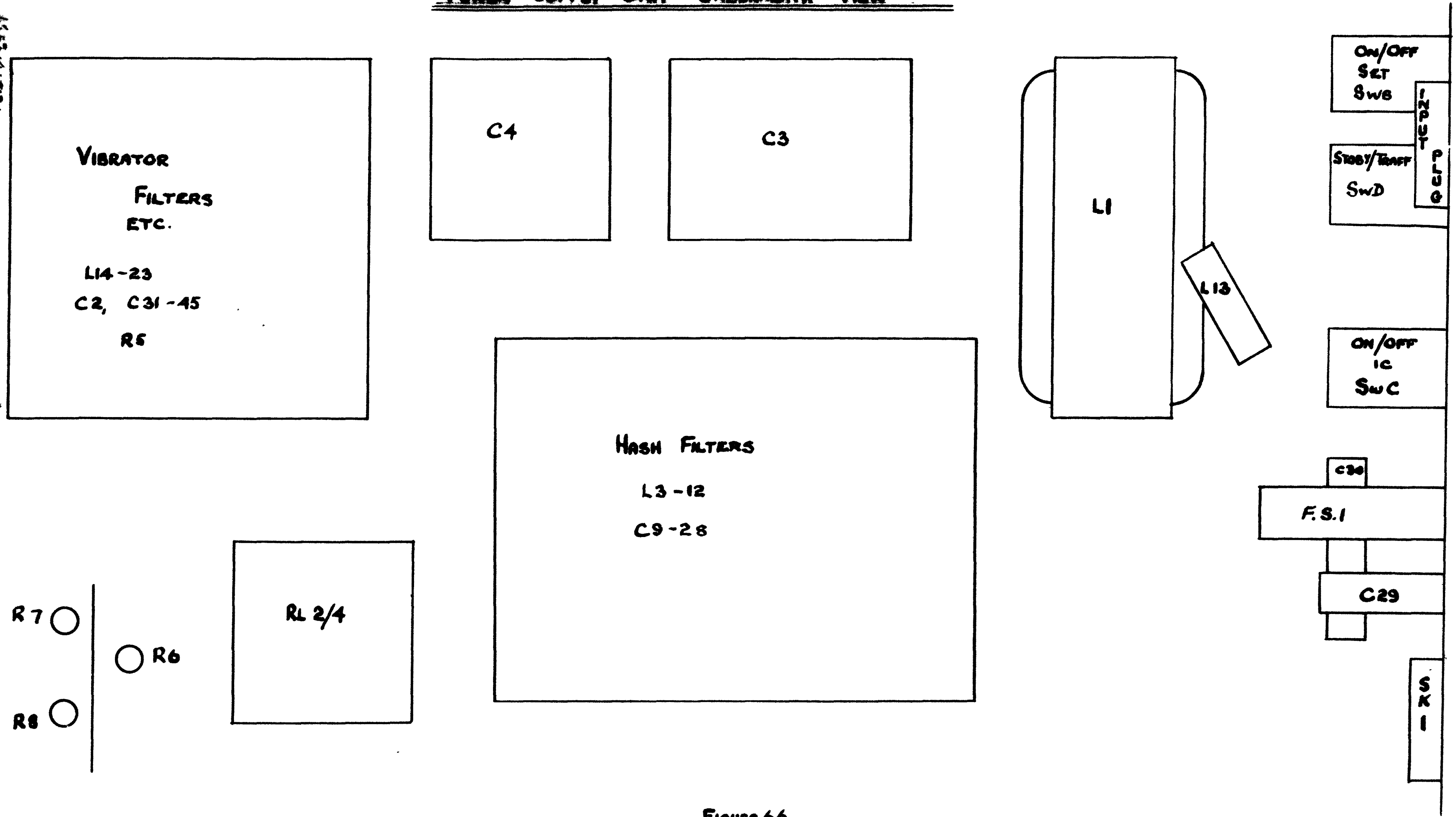


Figure 66

POINT TO POINT WIRING. Front panel and 'A' bracket terminals.

CONNECTION		COLOUR		
FROM	TO	MAIN	MARKER	WIRE
PL1-A	SwBb6	S	-	Z
B	SwAd5	R	W	Z
C	SK2-K	G	-	Z
D	35	BN	G	Z
E	SwBa0	BN	B	Z
F	42	BN	W	Z
F	PL1-L	BN		Z
G	44	BN	R	Z
H	50	-	-	V
J	No connection			
K	No connection			
L	40	BN	W	Z
L	PL1-Q	BN		Z
M	38	BN	V	Z
N	PL1-H	-	-	V
O	No connection			
P	No connection			
Q	39	BN	W	Z
Q	PL1-V	BN		Z
R	SWA-11	S	BN	Z
S	PL1-N	-	-	V
T	No connection			
U	No connection			
V	13	BN	W	Z
W	37	BN	S	Z
X	14	BN	-	Z
Y	15	BN	-	Z
Z	41	BN	Bk	Z
SK2-A	1	BK	G	Y
B	2	Braiding of SK2-A		
C	4	BK	B	Y
D	SwAh4	G	W	Z
E	3	S	G	Z
F	43	B	BN	Z
G	10	Braiding of SK2-M		X
H	8	S	W	Z
J	6	BK	W	Y
K	PL1-C	G	-	Z
L	22	R	-	Z
M	9	BK	S	Y
SK6-A	13	BN	W	Z
B	16	R	W	Z
clip	51	BK	-	Z
LP1-A	SwAa9	B	-	Z
B	M1-B			U
LP2-A	52	BK		Z
B	R181			
R181	53	Direct		
M1-A	SwAf5			
B	52			U
RV4-A	SwC-6	BK		Z
A	SwAg-9	BK		Z
B	SwAc-8			U
R182	SwBb-2			
R182	SwBb-5			

Colour Key

R - RED

W - WHITE

G - GREEN

O - ORANGE

B - BLUE

Bn - BROWN

Bk - BLACK

V - VIOLET

S - SLATE

P - PINK

POINT TO POINT WIRING (Contd.)

CONNECTION		COLOUR		
FROM	TO	MAIN	MARKER	WIRE
1	SK2-A	BK	G	Y
2	SK2-B	Braiding of 1		X
3	SK2-E	S	G	Z
4	SK2-C	Bk	B	Y
5	Braiding	of 4		X
6	SK2-J	BK	W	Y
7	Braiding	of 6		X
8	SK2-H	S	W	Z
9	SK2-M	B	S	Y
10	SK2-G	Braiding of 9		X
11	SwAf1	BK	-	Y
12.		Braiding of 11		X
13	SK6a	BN	W	Z
13	PL1-V	BN	W	Z
14	PL1-X	BN	-	Z
15	PL1-Y	BN	-	Z
16	SK6B	R	W	Z
16	SwAa-5	R	W	Z
17	SWC6	BK	-	Z
18		Braiding of 19		X
19	SWAc9	BK	R	Y
20		Braiding of 21		X
21	SwAf3	BK	O	Y
22	SK2-L	R		Z
23	No connection			
24	53	BN	-	Z
25	SwAb3	BN	O	Z
26	No connection			
27	SwAc7	P	-	Z
28	SwAd2	R	G	Z
29	SwAd1	R	V	Z
30	SwAe11	R	O	Z
31	SwBb2	R	BK	Z
32	SwAg11	G	B	Z
33	SwAh5	G	-	Z
34	SwC7	O	BK	Z
35	PL1-D	BN	G	Z
36	SwBa12	BN	B	Z
37	PL1-W	BN	S	Z
38	PL1-M	BN	V	Z
39	PL1-Q	BN	W	Z
40	PL1-L	BN	W	Z
41	PL1-Z	BN	BN	Z
42	PL1-F	BN	W	Z
43	SK2-F	B	B	Z
44	PL1-G	BN	R	Z
45	SwAa11			
46	No connection			
50	PL1-H			V
51	SK6-clip	BK		Z
52	SwAb5			U
52	M1-B			U
52	LP1-A	BK		Z
52	24	BN		Z
53	R181	Direct		

POINT TO POINT WIRING (Contd.)

CONNECTION		COLOUR		
FROM	TO	MAIN	MARKER	WIRE
SwAa7	SwAa8	-	-	U
SwAa8	SwA9	-	-	U
SwAa9	LP1-A	B		Z
SwAa11	45	S	BN	Z
SwA11	PL1-R			
SwAb1	SwAb2	-	-	U
SwAb2	SwAb3	-	-	U
SwAb3	25	BN	O	Z
SwAb5	SwAc11	BK	-	Z
SwAb5	52	-	-	U
SwAc7	SwAc8	-	-	U
SwAc7	27	P	-	Z
SwAc8	RV4-B	P	-	Z
SwAc9	19	BK	R	Y
SwAc11	SwAb5	BK	-	Z
SwAc11	SwAg9	BK	-	Z
SwAd1	29	R	V	Z
SwAd2	28	R	G	Z
SwAd5	16	R	W	Z
SwAd5	PL1-8	R	W	Z
SwAe10	SwBb4	O	-	Z
SwAe11	30	R	O	Z
SwAf1	SwAf2	-	-	U
SwAf1	11	BK	-	Y
SwAf2	SwAf1	-	-	U
SwAf3	21	BK	O	Y
SwAf5	M1-A	O	-	Z
SwAg9	RV4A	BK	-	Z
SwAg10	SwAh4	G	-	Z
SwAg11	32	G	BN	Z
SwAh4	SwAg10	G	-	Z
SwAh4	SK2-D	G	W	Z
SwAh5	33	G	-	Z
SwBa10	PL1-E	BN	B	Z
SwBa12	36	BN	B	Z
SwBb2	R182	Direct	-	-
SwBb2	31	R	BK	Z
SwBb5	R182	Direct		
SwBb6	PL1-A	S	-	Z
SwC6	RV4-A	BK	-	Z
SwC6	17	BK	-	Z
SwC7	34	O	BK	Z
PL8-A	B16			W
PL8-B	50			V
PL8-B		Braiding of PL8-A		

Terminal No.	Receive		L.P. Send		H.P. Send		Remarks
	Volts	Current	Volts	Current	Volts	Current	
A1	180V	.01A	175V	.009A	175V	.009A	D.C.
A2	22V	-	22V	.029A	22V	.029A	D.C.
A3	22V	-	-	.029A	-	.029A	D.C.
A4	22V	-	22V	-	22V	-	D.C.
A5	6.7V	0.8A	6.7V	0.8A	6.7V	0.8A	A.C.
A6	6.7V	0.76A	6.7V	0.76A	6.7V	0.76A	A.C.
A7	12.5V	0.53A	12.5V	0.53A	12.5V	0.53A	A.C.
B11	-	-	55V	.015A	350V	0.12A	D.C.
B12	-	-	175V	.04A	175V	.04A	D.C.
E5	6.8V	0.54A	6.8V	0.54A	6.8V	0.54A	A.C.
E6	-	-	175V	.0063A	175V	.0063A	D.C.
E7	180V	.015A	175V	.012A	175V	.012A	D.C.
E8	18.5V	.15A	12.5V	.15A	12.5V	.15A	D.C.
H1	-	-	-4V	-	-4V	-	D.C. (120 Range)
J6	6.6V	1.05A	6.6V	1.05A	6.6V	1.05A	A.C.
J7	180V	.018A	175V	.02A	175V	.02A	D.C.
L5	8V	-	8V	-	8V	-	D.C. (120 Range)
L6	180V	.0095A	175V	.08A	175V	.065A	D.C.
L7	6.7A	0.4A	6.7V	0.4A	6.7V	0.4A	A.C.
L8	180V	-	-	-	-	-	
M9	22V	.22A	22V	.24A	22V	.24A	D.C.
M10	22V	-	-	.03A	-	.03A	D.C.
M11	22V(on HP)	-	-	-	-	.06A	D.C. With switch on HP only.
M12	-	-	175V	.07A	175V	.058A	D.C.
M15	24V	-	24V	-	24V	-	D.C.
M16	24V	-	-	-	-	-	D.C.
N2	6.6V	0.6A	6.6V	0.6A	6.6V	0.6A	A.C.
N3	180V	.005A	175V	.0106A	175V	.0107A	D.C.
P7	13V	.0006A	13V	.0006A	13V	.0006A	D.C. (12V Range) (4V on 1060)
P9	8V	-	8V	-	8V	-	D.C. (120V Range)
P10	8V	-	-	-	-	-	
Q4	180V	.009A	175V	.009A	175V	.009A	
S1) S2)	6.8V	.78A	6.8V	.78A	6.8V	.78A	) A.C. Volts across) S1 to S2.) Current in S1.
T5	-	-	175V	.0065A	175V	.0065A	D.C.
T6	12.5V	.35A	12.5V	.35A	12.5V	.35A	D.C.

All measurements made with Instrument testing, Avometer, universal 40 range.

Terminal No.	Volts			Remarks
	Receive	Send L.F.	Send H.P.	
8		-4	-4	D.C. Measured on 120V Range
13	6.8	6.8	6.8	A.C.
14) 15)	7	7	7))	A.C. across 14 and 15
16	180	175	175	D.C.
22	180	-	-	
25	22	22	22	D.C.
27	13	13	13	
30	-	55	350	D.C.
31	-	175	175	D.C.
32	22	-	-	D.C.
33	22	-	-	D.C.
34	8	-	-	D.C. 120V Range
35	22	22	22	D.C.
36	23	-	-	D.C. Only when set switched to High Power (Receive)
37	7	7	7	A.C.
38	13	13	13	A.C.
39	7	7	7	A.C.
40	7	7	7	A.C.
41	7	7	7	A.C.
42	7	7	7	A.C.
43	24	-	-	D.C.
44	24	24	24	D.C.
46	12.5	12.5	12.5	D.C.

All measurements made with Instrument testing Avometer, universal 40 range.

TEST POINTS

Throughout the set certain points in the circuit are brought up as terminals onto the top of the respective chassis. To these can be connected meters which will give an indication of the performance of the set (bandwidth, selectivity, etc.). Some are R.F. points at which measurements are made with a valve-voltmeter, whereas an Avometer can be used on others. They are also very important for initial alignment.

Tp 1 & 2

In the cathode circuit of the 1st mixer these are usually connected together but can be opened and a Valve-Voltmeter put between them. This will give a reading of R.F. on the mixer anode. Thus the sensitivity and bandwidth can be measured with a suitable input (VFO). For this the anode dropper R10 is used as a load.

The larger signal on Transmit causes excess grid current bias (C13, R8) which will reduce the mixer cathode current. This can be detected by using an AVO between Tp 1 and 2 (connected) and earth thus testing the set up to the mixer grid.

Tp 4

This is effectively on the anode of the 1st I.F. and a meter between here and earth gives readings of R.F. at this point. It is again used for measurement of selectivity etc.

Tp 6

This is a similar point on the anode of the 2nd Mixer. It is used in the same way but also serves as a point for injection of a 2.4 Mc/s signal to align the 2nd I.F. strip.

Tp 7

This is on the anode of the second stage of the 2nd I.F.A. It is again used in the same way for R.F. measurements.

Tp 8

This is in the grid circuit of the 1st receiver limiter. An Avo between here and earth measures grid current. The limiters start with zero bias. Any incoming signal causes grid current to flow, the size of which is proportional to the amplitude of the incoming signal. Thus the reading at Tp 8 is a measure of signal strength and shows how the set is working up to that point. It is considered a very important point and is brought out onto the front panel at Sk2h.

Tp 5

This is in the grid circuit of the s/c limiter and gives a similar reading to Tp 8 for signal on the anode of the 1st IFA.

Tp 3

This is in the driver cathode circuit so that an Avo between here and earth measures cathode current. Thus the transmitter can be seen to be operating up to the driver grid. When the grid is earthed the reading on Tp 3 should go up.

Tp 9

This is in the grid circuit of the P.A. and measures grid current of the final stage, thus giving a drive reading.

By means of these test points both transmitter and receiver are split up and faults can be located to any one section between points.

LOGICAL FAULT FINDING C42

Attempt to set up on a frequency. Possible faults under certain conditions are indicated in enclosed squares.

A. Cursor Adj.
B. Channel Adj.

- O.K.
- No result A & B → Tune R.F.
  - O.K. → Avo on Tp 8
    - Reading → [Limiters]
    - No reading → [Avo on L1, L2(o/p Trxfmr), note reading. Take out XL3.]
      - No reduction → [2nd L.O.]
      - Reduction → [2nd Mixer, 2nd I.F.A.]
  - No result → [Meter, 1st Mixer, C.F.O., 1st I.F.A.]
- No result A. → [System switch 2Mc/s Osc.]
- No result B. → [System switch 100Kc/s]

C. Tune R.F.

- O.K.
- No reading → [s/c Limiter or Discriminator, M.O.]

D. Operate, Noise "On"

- Noise → Noise "Off". Squelch control anticlockwise
  - Silence no lamp → Squelch control clockwise
    - Noise, lamp on → Check for A.F.C. Detune C.F.O. till noise is audible in phones
      - ½Mc/s detuning each way → L.P. press pressel →
      - Less than ½Mc/s → [Modulator (This may also cause low power o/p)]
    - Noise no lamp → [Lamp cct.]
    - Silence no lamp → [D.C. Amp. RV 2]
  - Noise lamp on → [RV 2, Noise Amp. Noise Rect.]
  - Noise no lamp → [Muting tone]
- Silence → [De-emphasis, RV 1, A.F.A.]

Low power, press pressel

- Deflection on A.T.U. meter (Tune for Max.)
  - Switch to H.P.
    - A.T.U. reading
      - Speak into Mic.
        - Sidetone
          - Check external leads
            - O.K.
        - No sidetone
          - **[Mod Amps.]**
        - Strong sidetone with extinction of signal lamp when blowing hard into Mic.
          - **[A.M.C. loop]**
    - No reading
      - **[H.P. relay]**
- No A.T.U. deflection
  - Switch to H.P.
    - No A.T.U. deflection
      Check for Avo reading at Tp 9
      - -ve reading Tp 9
        - **[P.A.]**
      - No Tp 9 reading
        - **[Driver]**
    - A.T.U. deflection
      - **[P.A. H.T. supply on L.P. R. 182]**

Inter Service Type	Commercial equiv.	Selector switch setting	Tester	V H	V g-	V A	V SG	Anode selr	Ma/V	Ia mA
CV850	6AK5	4 1 2 3 6 5 1 0 0	a	6		100	100		4	
		4 1 2 3 6 5 1 0 0	b	6	2.3	150	150		4.3	7
			c							
CV133	604	6 0 2 3 6 4 1 0 0	a	6		100	-		3	
		6 0 2 3 6 4 1 0 0	b	6	8.5	250	-		2.2	1055
			c							
CV2243	PSG8	0 4 1 2 3 0 6 5 1	a	6		200	125		8	
		0 4 1 2 3 0 6 5 1	b	6	2	200	125		8.4	14
			c							
CV2220		2 1 5 1 4 4 1 3 0	a	12		100	100		5	
		2 1 5 1 4 4 1 3 0	b	12	20	300	250		5.5	50
			c							
CV2209		4 1 2 3 6 1 5 0 0	a	6		200	200		3	
		4 1 2 3 6 1 5 0 0	b	6	4	200	200		3.5	5.75
			c							
CV2128 Hexode	ECH81	5 4 1 2 3 7 1 6 4	a	6		100		A2	2.3	
		5 4 1 2 3 7 1 6 4	b	6	2	250	100	A2	2.4	6.5
			c							
CV2128 Triode	ECH81	5 4 1 2 3 7 1 6 4	a	6		150	100	A	2.4	
		5 4 1 2 3 7 1 6 4	b	6	3	100	-	A	2.3	5
			c							-
CV469	EA76	2 8 1 3 8 0 0 0 0	a	6	-	-	-	-	-	-
		2 8 1 3 8 0 0 0 0	b	6	-	-	-	-	-	5
			c							
CV4015	9D6	4 1 2 3 6 1 5 0 0	a	6	-	100	100	-	2.5	-
		4 1 2 3 6 1 5 0 0	b	6	2.5	250	200	-	2.5	8
			c							

Notes:- 'a' refer to Tester, valve, Avo No. 1, Mk. 1 or 2

'b' refer to Tester, valve, Avo, No. 3

'c' refer to Tester, valve, XT160 (to be published later).