EDDYSTONE MODEL 'S950'

CRYSTAL CONTROLLED VHF RECEIVER

INTRODUCTION

The EDDYSTONE Model 'S950' is a crystal controlled single conversion superhet receiver for the reception of amplitude modulated signals in the VHF band 110-130 Mc/s.

The receiver is designed for rack mounting and is mainly intended for installation at remote receiving stations. Provision is made for connection to 600 ohm lines for feeding received signals to the distant listening point.

High quality components are employed throughout and the receiver is suitable for continuous unattended operation over the ambient temperature range 0°C to +55°C.

TECHNICAL DATA

GENERAL

Frequency Coverage.

The receiver may be adjusted to any frequency in the range 110-130 Mc/s by inserting the appropriate crystal. Details of crystals etc. will be found in the Section dealing with "Operation".

Intermediate Frequency.

10.7 Mc/s. A crystal filter is fitted to provide adequate selectivity.

Input and Output Impedances.

Aerial Input	50 ohms (unbalanced).
Audio Output	Monitor Speaker : 2.5 ohms.
	Lines : 600 ohms. (balanced or unbalanced)
	Telephones : nominally 2000-4000 ohms but lower impedances may be used satisfactorily.

Stage Sequence. (See Table on following page)

PERFORMANCE

Sensitivity.

5uV for 50mW output. Signal-to-noise ratio 15dB (Carrier modulated 30% at 400 c/s)

Image Rejection.

Varies from -45dB to -55dB throughout the range.

STAGE SEQUENCE

The following Table lists the valves and germanium diodes used in the Model 'S950' together with their functions.

Circuit Ref	Type	Circuit Function
V1	ECC189	Cascode RF Amplifier.
V2	6AK5	Mixer.
V3	6U8	Local Oscillator (crystal controlled).
V4	EF183	1st IF Amplifier.
V5	EF183	2nd IF Amplifier.
V6	EF183	3rd IF Amplifier.
D1	GEX34	AGC Rectifier.
D2	GEX34	Signal Detector.
V7A	6U8	1st AGC Amplifier. (pentode)
V7B		2nd AGC Amplifier. (triode)
V8A	6U8	Relay Control Valve. (triode)
V8B		AF Amplifier. (pentode)
V9A	6U8	Line Output Amplifier. (triode)
V9B		Monitor Amplifier. (pentode)

Spurious Response.

Greater than 65dB down at all frequencies.

Selectivity.

The following figures are indicative of the overall selectivity:-

Response at 10.7 Mc/s ± 10 kc/s . . . . . less than -3dB.
Response at 10.7 Mc/s ± 25 kc/s . . . . greater than -40dB.
Response at 10.7 Mc/s ± 45 kc/s . . . . greater than -80dB.

Stability.

After a 10 minute warm-up period, the total drift will not exceed 50 c/s.

Muting Level.

The potentiometer RV1 can be adjusted so that the muting falls out at signal levels down to 6uV.

AGC Characteristic.

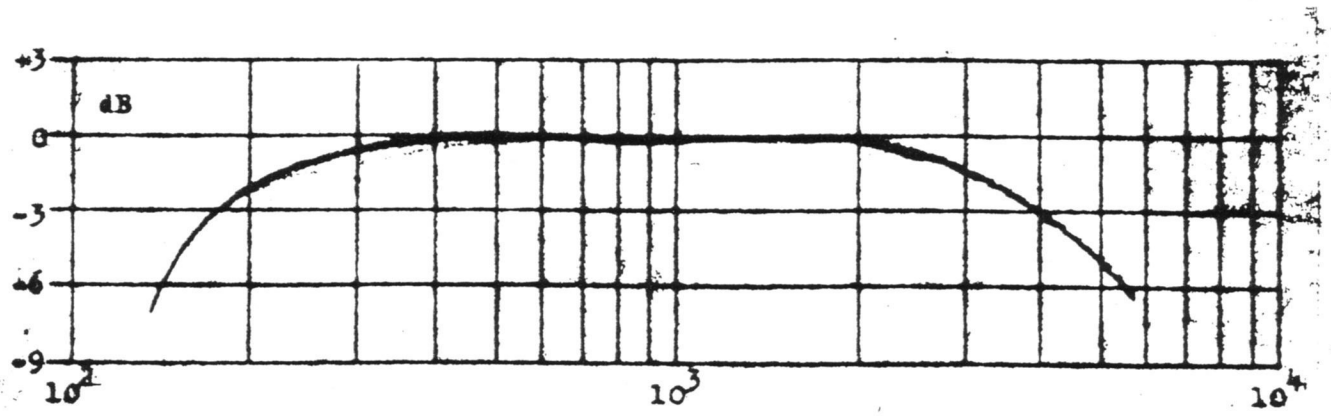
The output changes by no more than 6dB with a carrier variation of 60dB above 6uV. The AGC is permanently in operation and also serves to operate the muting and channel indication circuits.

Audio Output.

A maximum output of 200mW is available from either the Line or Monitor Amplifiers. Gain adjustments on either output are independent. The telephone output is attenuated to a comfortable level.

Audio Response.

The audio response has been centred in the band 300-3000 c/s as can be seen from the graph below. Output 50mW at 1000 c/s.



Frequency in cycles

CIRCUIT DESCRIPTION

THE RF SECTION

This portion of the receiver employs a high-gain low-noise cascode amplifier (V1) feeding a low-noise Mixer Stage V2. The Local Oscillator Stage is crystal controlled and uses a ~~variant of the well known Butler~~ capacity tuned series mode overtone circuit.

The aerial input impedance is fixed at 50 ohms by tapping the aerial feeder down on the input coil L1. This inductor, together with L2 and the associated tuning capacitor, forms a bandpass tuning circuit with top capacity coupling (C2, 1pF). Use of this type of input circuit gives vastly improved image rejection and added protection against spurious responses.

The cascode circuit comprises a neutralised* triode amplifier (V1A) followed by a grounded grid amplifier V1B. AGC is applied to the first triode via the feed resistor R1, while the bias on V1B is fixed at approximately one volt negative by the potential divider R5 and R7. The grid of the second triode is maintained at earth potential to RF by the capacitor C10.

The Mixer Stage V2 operates as a single electrode (additive) mixer, both signal and oscillator voltages appearing at the control grid. Injection from the local oscillator is by means of C43 (1.5pF). The 6AK5 high slope pentode used in the V2 position develops its own bias due to grid current through R8; no AGC is applied.

Overtone crystals are used in the Local Oscillator Stage which employs a 6U8 triode-pentode, the triode portion functioning as a grounded grid oscillator when the plate circuit (L6,C47) is tuned to the ~~fundamental~~ overtone frequency of the crystal. V3A, in addition to selecting the desired harmonic ~~overtone~~ (L5,C45) also serves as a cathode follower to maintain feedback to the triode portion V3B. Full instructions for adjustment of the two tuning controls are given later. (See Section dealing with "Operation")

Extensive decoupling is applied to the supply feeds to V1, V2 and V3 in the interest of consistent stable operation, while extra precautions are taken in the form of parasitic stoppers in the ~~Butler~~ V3A/B circuit (R53, R56 and R58).

* The stage is neutralised for lowest noise figure, L3, the neutralising inductor taking the form of a short length of wire in the shape of an arc between pins 3 and 6 of the ECC189.

THE IF/AF SECTION

The signal output from the Mixer Stage is fed via the selective crystal filter circuit (FL1) to the three high slope RF pentodes that make up the 10.7 Mc/s IF Amplifier. AGC is applied to the first two stages (V4 and V5).

The crystal filter unit provides excellent selectivity (greater than 80dB rejection outside the passband) and avoids the need for double conversion. This is an advantage in that less stages are required and

the consumption of the unit is correspondingly reduced. In addition, the possibility of spurious responses occurring is considerably less when single conversion is employed.

By virtue of the concentrated selectivity at the head of the IF chain, the coupling between the IF stages need not take the form of a transformer and this allows some reduction in the size of the unit as a whole. In point of fact, V4 is choke capacity coupled to V5 which employs tuned choke coupling to V6.

A normal IF transformer is used between V6 and the Signal Detector D2, while D1 (the AGC Rectifier) is fed direct from the anode of V6 via the coupling capacitor C31. AGC is applied to V1, V4 and V5 and also via the potentiometer RV1 to the grid of V7A.

Audio signals from the Signal Detector pass via C33 to the grid of V8B which is the pentode portion of a 6U8. Output from this stage is taken to the two potentiometers RV2 and RV3 which function as independent gain controls for V9A and V9B respectively. V9A (triode portion of 6U8) feeds T2 which gives a 600 ohm output for connection to low impedance lines feeding a remote listening position. The other transformer (T3) has a 2.5 ohm secondary winding for connection to a small monitor speaker. As an alternative to loudspeaker monitoring, telephones may be connected at JK1. Insertion of the telephone plug disables the speaker (if connected).

The audio amplifiers are designed to operate with a response centred in the range 300-3000 c/s in the interest of increased intelligibility.

Adjustment of RV3 has no effect on the 600 ohm output level, so that local monitoring can be carried out at the desired volume without need for re-adjustment of the line output gain control.

MUTING AND CHANNEL INDICATION

The function of the stages V7A, V7B and V8A is to provide a visual indication(in the form of an illuminated lamp) that a signal is being received and also to mute the receiver during 'no-signal' periods. This latter facility is of immense value in reducing operator fatigue due to background noise, while the visual indication is a necessity when a number of receivers are in use on different channels. In this case the bulb would be labelled with the appropriate channel number to facilitate selection of the corresponding transmitter.

AGC is applied to the grid of V7A, the voltage being variable by means of RV1. This is the Muting Level Adjustment and is only operative when the Muting Switch S1 is in the 'ON' position (S1 and RV1 are ganged). In the 'OFF' position of S1, maximum AGC is applied to V7A to ensure operation of the channel light at all signal levels when the muting arrangement is not in use.

In the absence of a signal, V8A causes the relay A/2 to become energised and this closes contact A1 and opens A2. If S1 is in the closed position (ON), the output of the audio amplifier V8B is shorted to earth via A1 and the background noise is quieted.

On receipt of a signal, an amplified AGC voltage appears at the grid

of V8A causing the relay to de-energise. A1 opens, allowing the audio stages to function normally while A2 closes to apply 6.3V AC to SKT2/8 for operation of the channel indicator lamp.

Instructions for adjusting the potentiometer RV1 will be found in the Section dealing with "Operation".

MECHANICAL FEATURES

The receiver is designed for rack mounting in a standard rack, has a panel height of only 3½" and a width of 19". The depth of the unit is 4⅜" (over projections) and the total weight 5½ lbs.

Adequate ventilation is provided in the case which is fitted with a hinged front cover to allow manipulation of the controls and also to facilitate valve replacement without the need for removing the unit from the rack.

All permanent connections are made at the rear of the unit. Temporary connections (meter for tuning and telephones for monitoring) are made from the front.

The outer case of the unit is finished in oyster grey hammer and the control functions are printed in white on a black background for ease in reading.

NOTE: Future versions will most likely employ a slightly deeper cabinet but the panel height will remain 3½".

INSTALLATION

After unpacking the unit, first check that all valves are correctly seated and that no damage has occurred in transit.

Supply voltages necessary to operate the receiver are as follows:-

HT	. . . .	170-200V at approximately 90mA.
LT	. . . .	6.3V at approximately 3.25A. (excluding channel lamp)

All connections to the unit (except the aerial input) are made by means of a 12 way female connector (Elcom Type S12 fitted with Cover Type C12E and locking device) and this mates with the male socket (SKT2) at the rear of the case. The connections are shown on the circuit diagram but are repeated here for convenience.

1, 2, 3	600 ohm output. (strap '2' to '10' for balanced output)	7	Not used.
4	Not used.	8, 9	LT supply to channel lamp ('8' earthy)
5, 6	2.5 ohm output ('6' earthy)	10	Earth and common HT and LT.
		11	LT
		12	HT

When connecting up the audio outputs it is advisable that screened lead should be used but other connections can be unscreened. Adequately rated cable should be used for the LT and earth connections to prevent excessive voltage drop resulting in a low heater supply.

The aerial feeder should be terminated with a coaxial plug (Type UG260/U) to mate with the coaxial socket (SKT1) at the rear of the unit. The aerial system used will of course depend on the coverage required and any system having a feed impedance of 50 ohms may be used.

Once installed, the receiver should be checked by carrying out the normal tuning procedure described in the following Section.

OPERATION

CONTROL FUNCTIONS

RF Tuning Controls.

These two controls permit alignment of the input ('A') and inter-stage ('B') circuits.

Oscillator Tuning Controls.

Control 'B' selects the overtone frequency of the crystal in use, i.e. the frequency marked on the crystal, while control 'A' selects the desired harmonic of this frequency.

With the circuit employed, multiplication factors of 2 or 3 times may be used and since the oscillator may operate either above or below the signal frequency, a choice of four crystal frequencies is possible for any one signal frequency. (See Appendix 'A')

Muting.

Potentiometer with switch. The control is arranged so that in the 'OFF' position of the switch the muting is rendered inoperative but the slider of the potentiometer takes up a position to provide maximum AGC to V7A. This ensures that the channel lamp functions at all signal levels when the muting is switched out.

Gain Controls.

Provide independent adjustment of the Monitor and Line outputs.

TUNING INSTRUCTIONS

Check that the twelve-way plug is connected at the rear and that its connections are correctly terminated (power supply, audio outputs and channel lamp). Ascertain that a suitable aerial is available for connection at SKT1 but do not connect at this stage.

Calculate the required crystal frequency (see Appendix 'A') and insert appropriate crystal in the socket on the front of the unit.

NOTE: The hinged cover can be lowered by turning the three fasteners so that their 'slots' lie in a vertical position.

Apply HT and LT from the supply source and, while the unit is warming up, set the four tuning controls approximately to the correct settings for the frequency in use (see Appendix 'B'). Switch 'OFF' the muting and turn the two gain controls fully anti-clockwise.

A 1 milliamp meter provided with a lead terminated in a standard jack plug should now be connected to the socket labelled 'CRYSTAL CURRENT'. The sleeve of the plug is the negative meter connection.

Adjustment of the Oscillator 'B' control will now give a rise of current in the meter and this will reach a peak when I6,C47 tune to the overtone frequency of the crystal.

NOTE: The peak has a very sharp characteristic when control 'B' is very nearly correctly set to the overtone frequency. Away from this point, the slope of the characteristic is much more gradual and care should be exercised to ensure that the peak is correctly selected.

Having found the peak, de-tune control 'B' slightly so that the measured current falls by 5%. This will ensure consistent oscillation of the crystal.

Control 'A' should now be adjusted for a slight 'dip' in the meter reading after which the meter may be disconnected. The oscillator is now correctly tuned.

Next connect a modulated signal generator covering the range 110-130 Mc/s at SKT1. Adjust the monitor AF gain for background noise in the speaker or telephones and then tune the generator to the desired signal frequency. Once the signal has been located, peak the two RF controls for maximum audio output. The tuning adjustments may now be considered complete except for a possible slight re-adjustment of the RF 'A' control when the aerial is connected.

Now switch 'ON' the muting and, with an input signal of 6uV, adjust the muting control (clockwise rotation) until the channel lamp is extinguished. Move the control back again until the lamp lights and then half a division further anti-clockwise. Once set, the control should not be touched again.

Finally, set up the line output level by using any method which meets the local requirements (adequate power is available for connection to any normal line link). Connect the aerial in place of the generator and check the adjustment of the RF 'A' control using a normal signal on the tuned frequency.

The lid may be closed by applying pressure to the three fasteners after their slots have been set in a horizontal position.

APPENDIX 'A'

CALCULATION OF CRYSTAL FREQUENCY

The following formula should be used in calculating the frequency of the crystal for reception on any desired signal frequency f_s.

$$\text{CRYSTAL FREQUENCY} = \frac{f_s \pm 10.7}{2} \quad \text{OR} \quad \frac{f_s \pm 10.7}{3} \quad \text{MCS.}$$

The figure obtained will be the overtone frequency of the crystal.

The holder provided is suitable for Inter Services Type D or American Style HC-6/U crystals and these are available in overtone types for frequencies up to 100 Mc/s.

The following Table gives the crystal frequencies for signal frequencies of 110, 120 and 130 Mc/s. It will be noted that four frequencies of crystal are suitable for any signal frequency.

Signal Freq. f_s	Injection Frequency	Crystal Overtone Frequency	Harmonic of Overtone
110 Mc/s	f_s + 10.7	60.350 Mc/s	2nd.
110 Mc/s	f_s + 10.7	40.233 Mc/s	3rd.
110 Mc/s	f_s - 10.7	49.650 Mc/s	2nd.
110 Mc/s	f_s - 10.7	33.100 Mc/s	3rd.
120 Mc/s	f_s + 10.7	65.350 Mc/s	2nd.
120 Mc/s	f_s + 10.7	43.566 Mc/s	3rd.
120 Mc/s	f_s - 10.7	54.650 Mc/s	2nd.
120 Mc/s	f_s - 10.7	36.433 Mc/s	3rd.
130 Mc/s	f_s + 10.7	70.350 Mc/s	2nd.
130 Mc/s	f_s + 10.7	46.900 Mc/s	3rd.
130 Mc/s	f_s - 10.7	59.650 Mc/s	2nd.
130 Mc/s	f_s - 10.7	39.766 Mc/s	3rd.

NOTE: In this, the first development prototype, coverage of the Oscillator 'B' control is insufficient to cover the extremities of the total coverage above (33.1-70.35 Mc/s). Further Models will have a modified L/C circuit to cover the whole range.

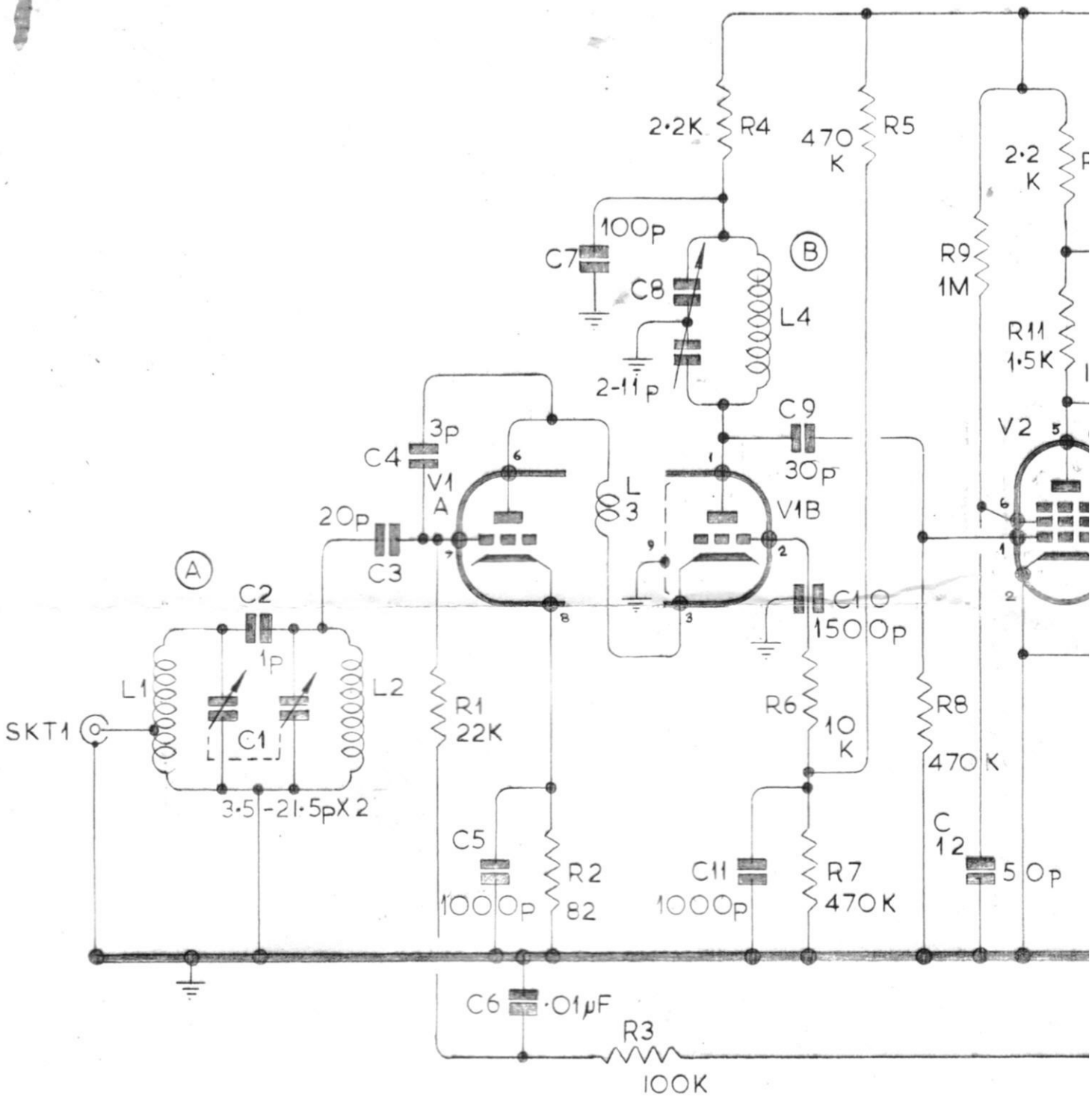
APPENDIX 'B'

RF AND OSCILLATOR CONTROL SETTINGS

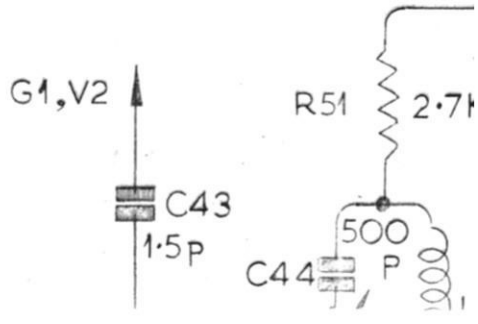
(Ser. No. PP0001 only)

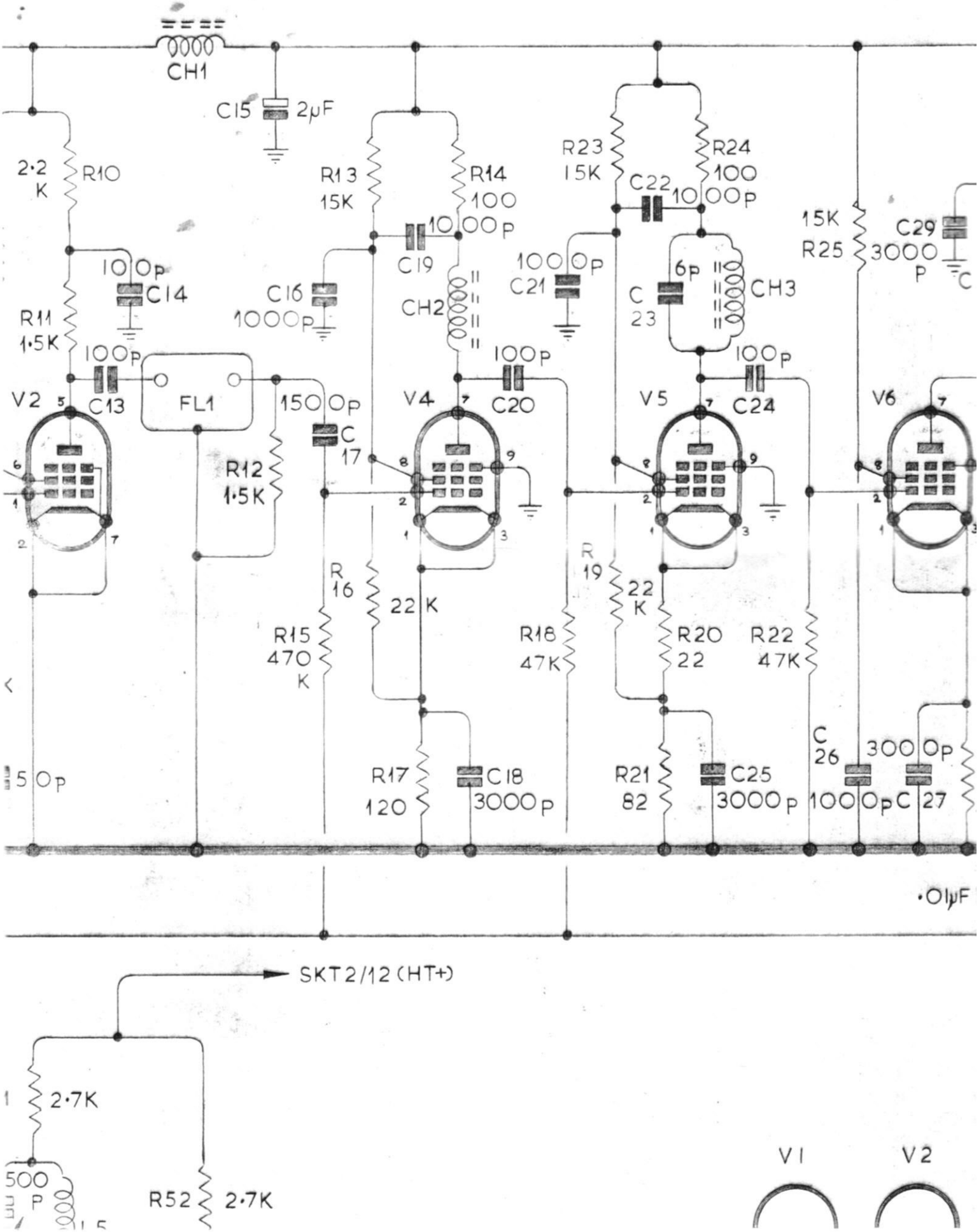
Frequency	RF Settings		Oscillator Settings	
	A	B	A	B
115 Mc/s	8	6	8	8
125 Mc/s	5	5	1	6
127 Mc/s	4	3.5	1	6

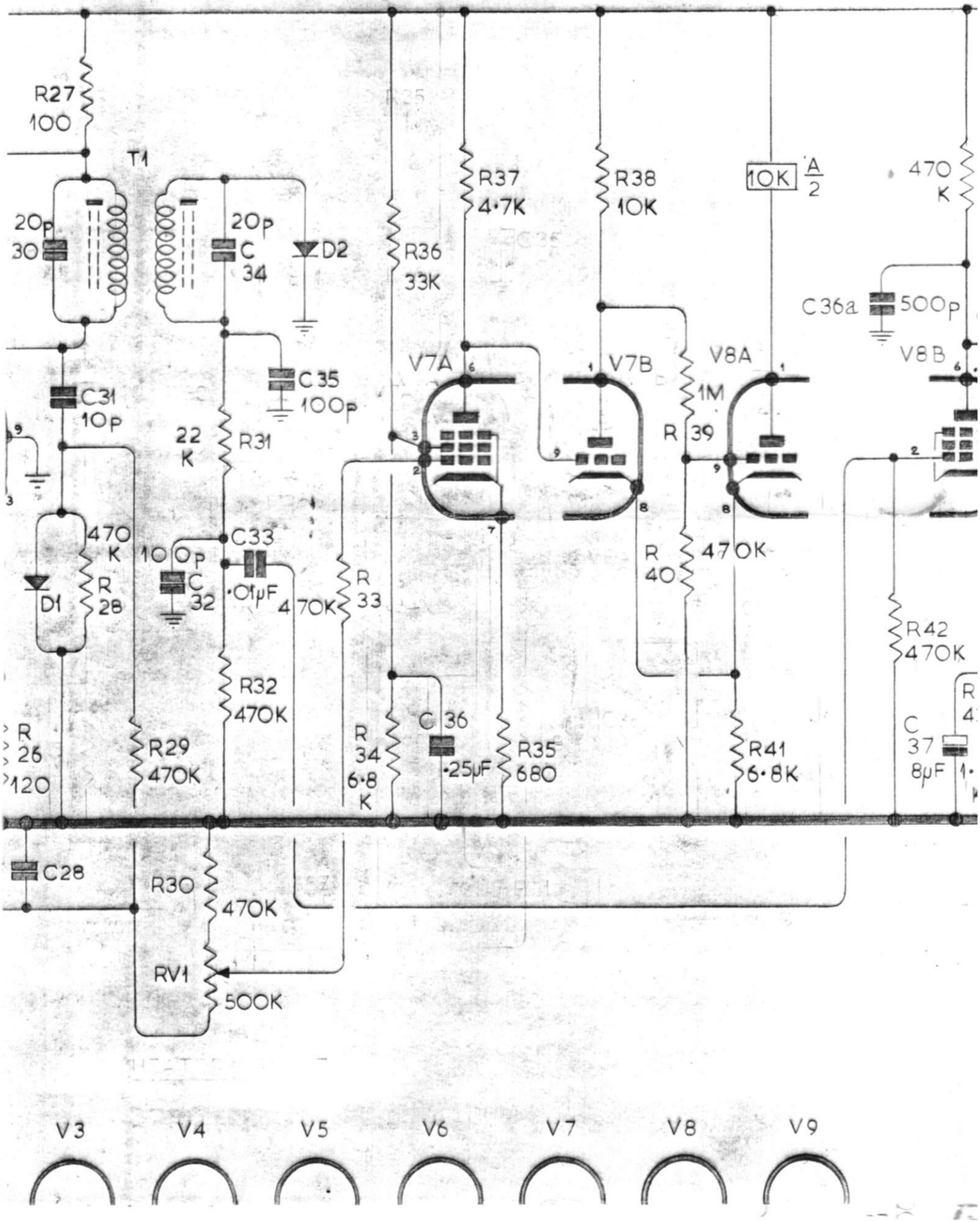
The settings given above are approximate only.



STAGE	TYPE	FUNCTION
V1	ECC189	CASCODE RF AMP
V2	6AK5	MIXER
V3	6U8	LOCAL OSCILLATOR
V4	EF183	1 ST IF AMP
V5	EF183	2ND IF AMP
V6	EF183	3RD IF AMP
V7	6U8	1 ST & 2ND AGC AMPS




CH1
C15 2μF
2·2 K R10
R13 15K
R14 100
10 00P
C19
R23 15K
R24 100
C22 10 00P
15K R25
C29 3000 P
10 0P C14
C16 1000P
CH2
100P C21
6P C 23
CH3
R11 1·5K
100P C13
FL1
150 0P
C 17
100P C20
100P C24
V2
V4
V5
V6
R12 1·5K
R 16
22 K
R15 470 K
R 19
22 K
R18 47K
R20 22
R22 47K
5 0P
R17 120
C18 3000P
R21 82
C25 3000P
C 26
300 0P
100 0P
C 27
·01μF
SKT 2/12 (HT+)
2·7K
500 P
R52 2·7K
V1
V2


R27
100
T1
20p
30
20p
C
34
D2
R36
33K
R37
4·7K
R38
10K
10K A/2
470
K
C36a
500p
V7A
V7B
V8A
V8B
C35
100p
C31
10p
22
K
R31
1M
R
39
470
K
D1
R
28
C33
10Op
C
32
·01μF
470K
R
33
R
40
47OK
R42
470K
R32
470K
R
26
120
R29
470K
R
34
6·8
K
C 36
·25μF
R35
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R41
6·8K
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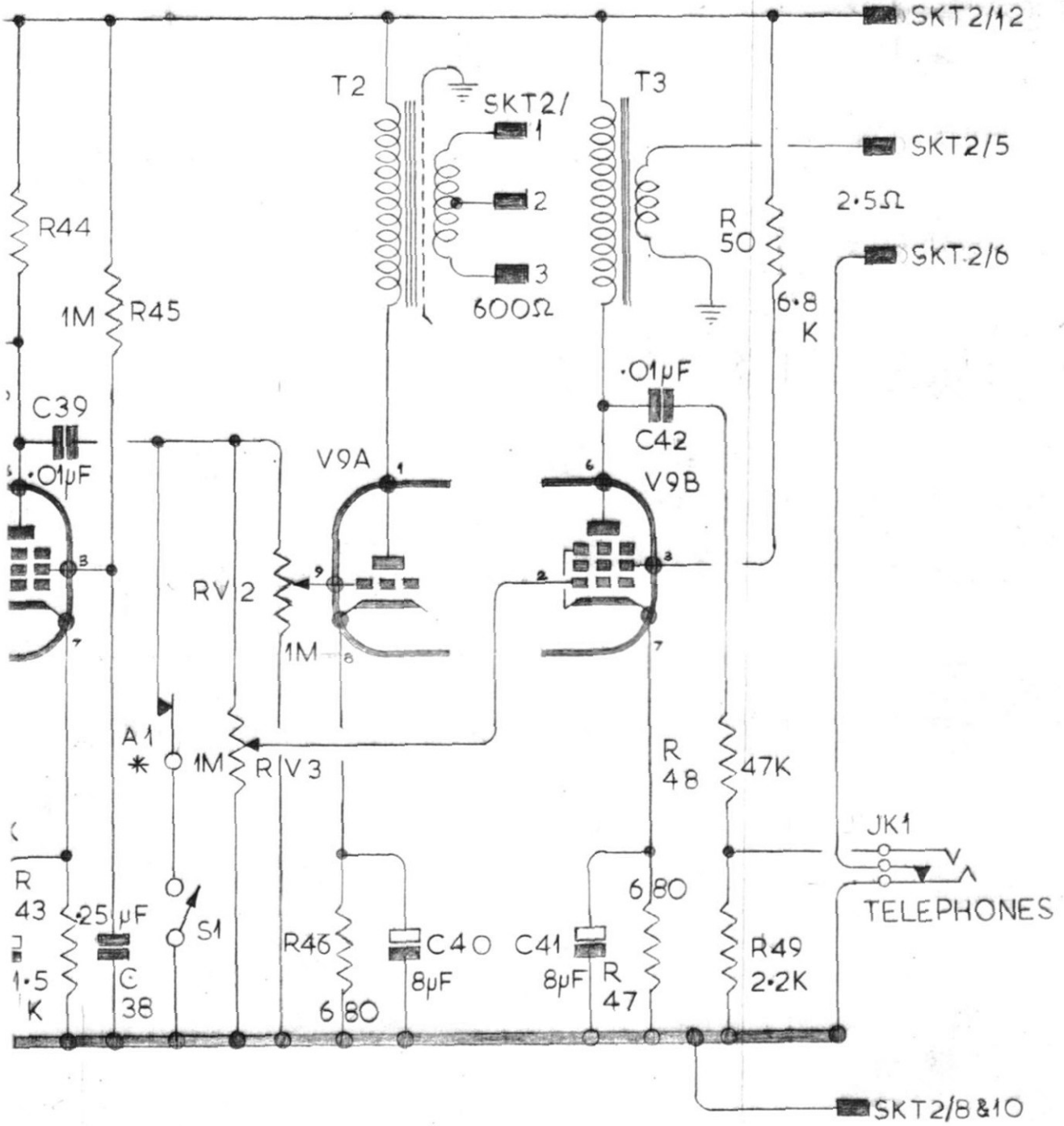
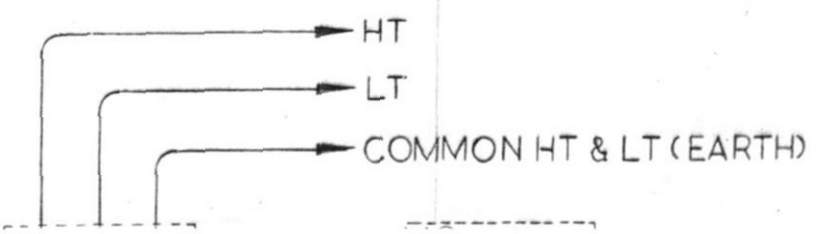
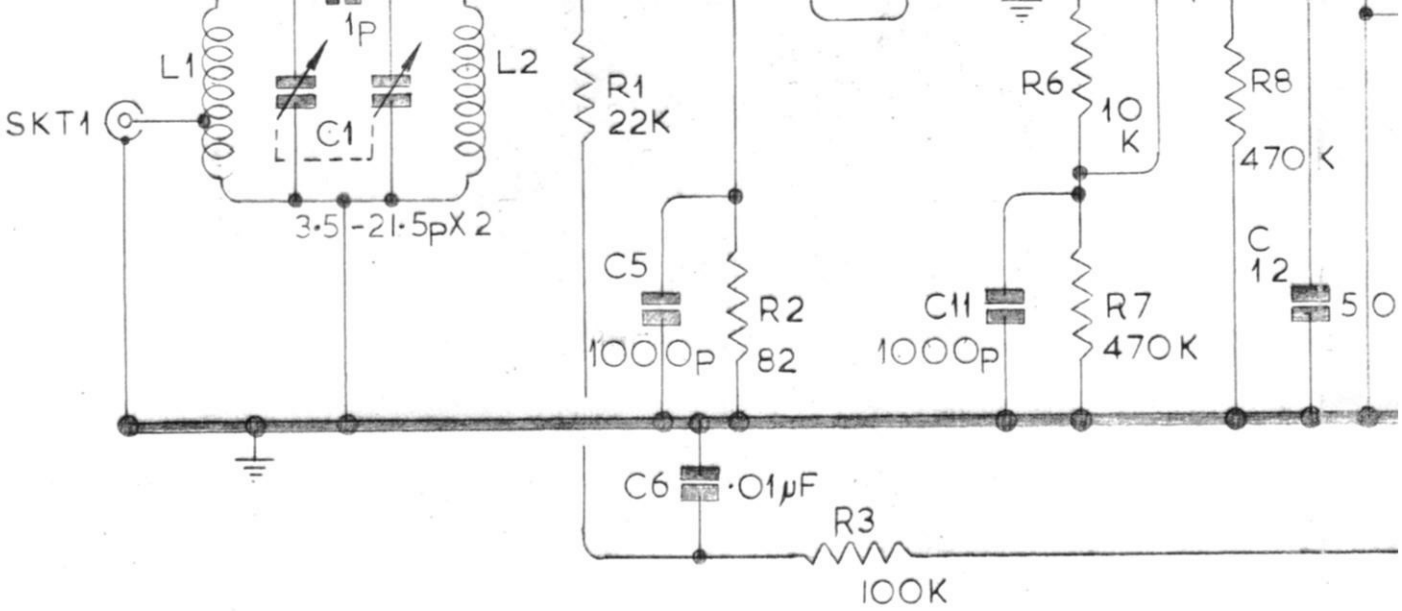
V3
V4
V5
V6
V7
V8
V9



VIEW LOOKING ON
CONNECTIONS TO
12 WAY FEMALE PLUG
MATING WITH SKT2





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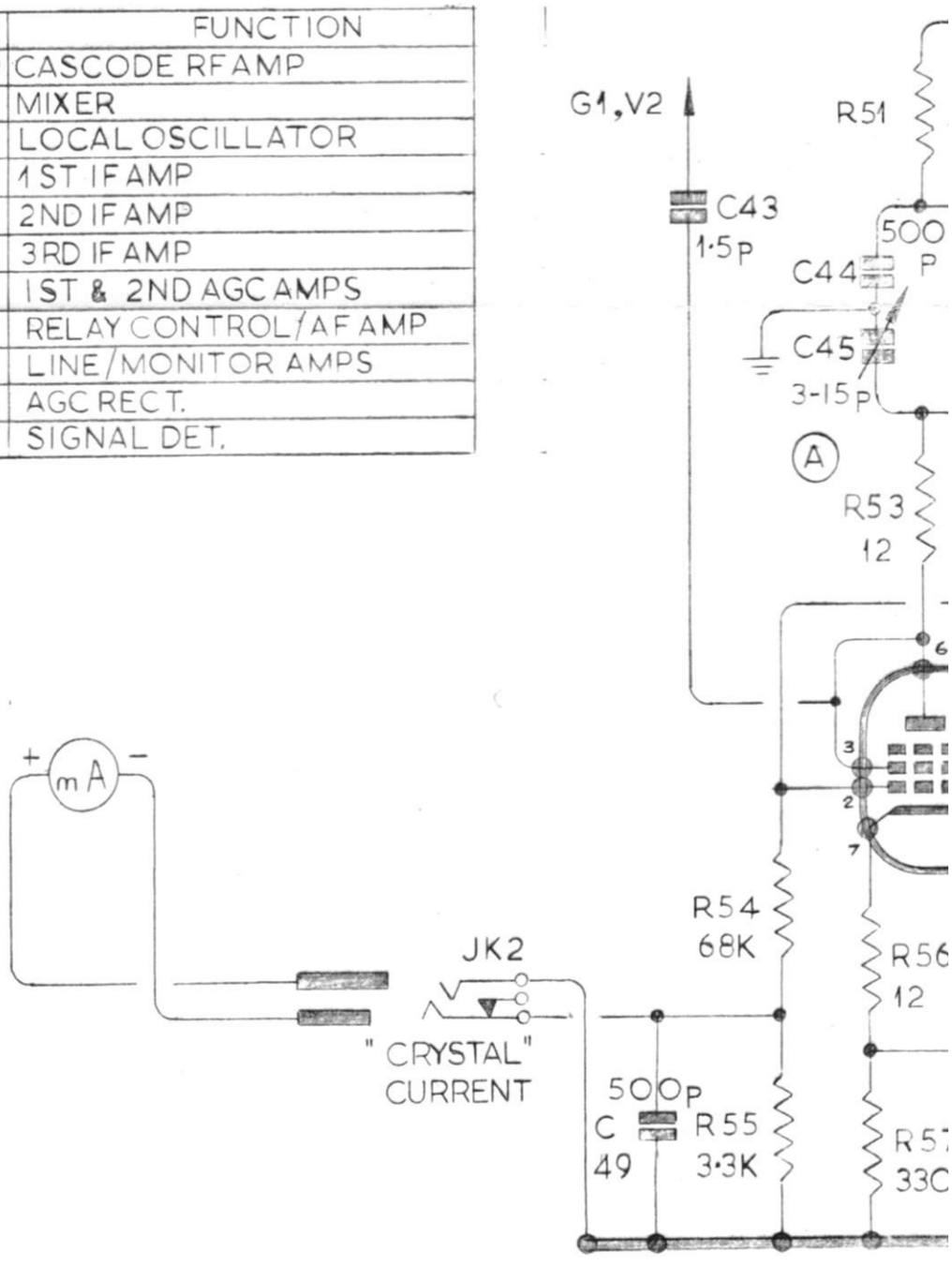
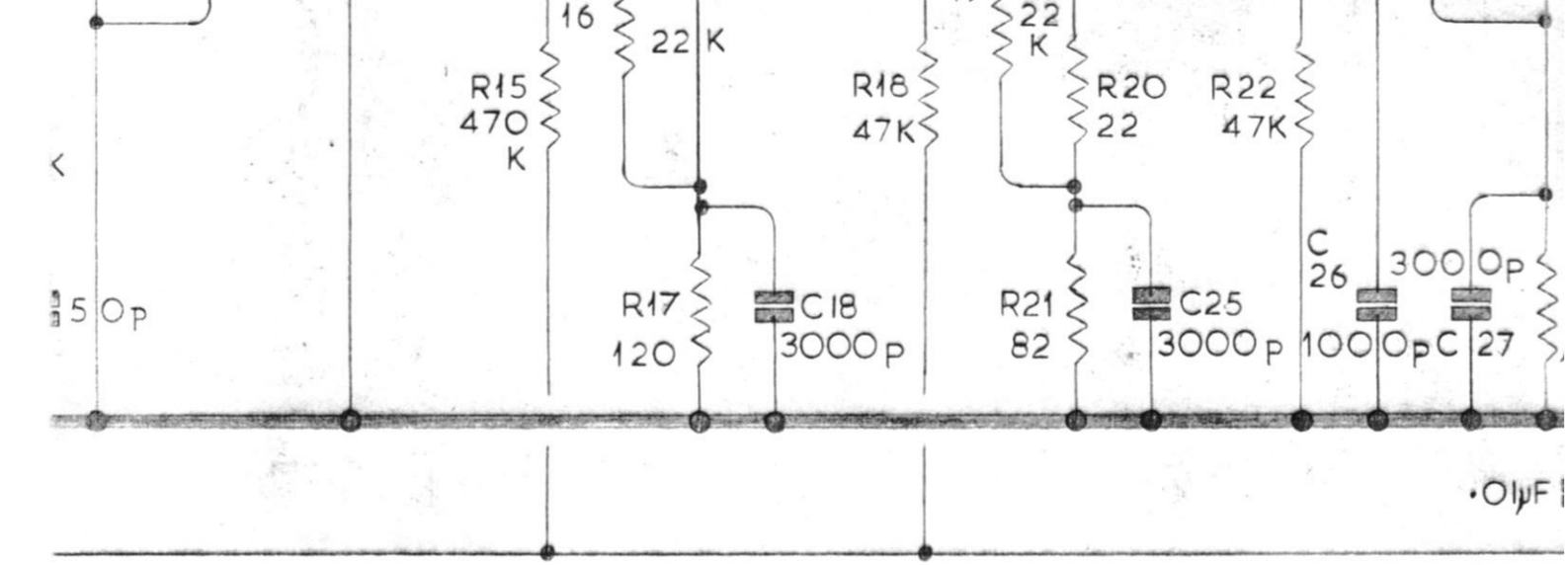
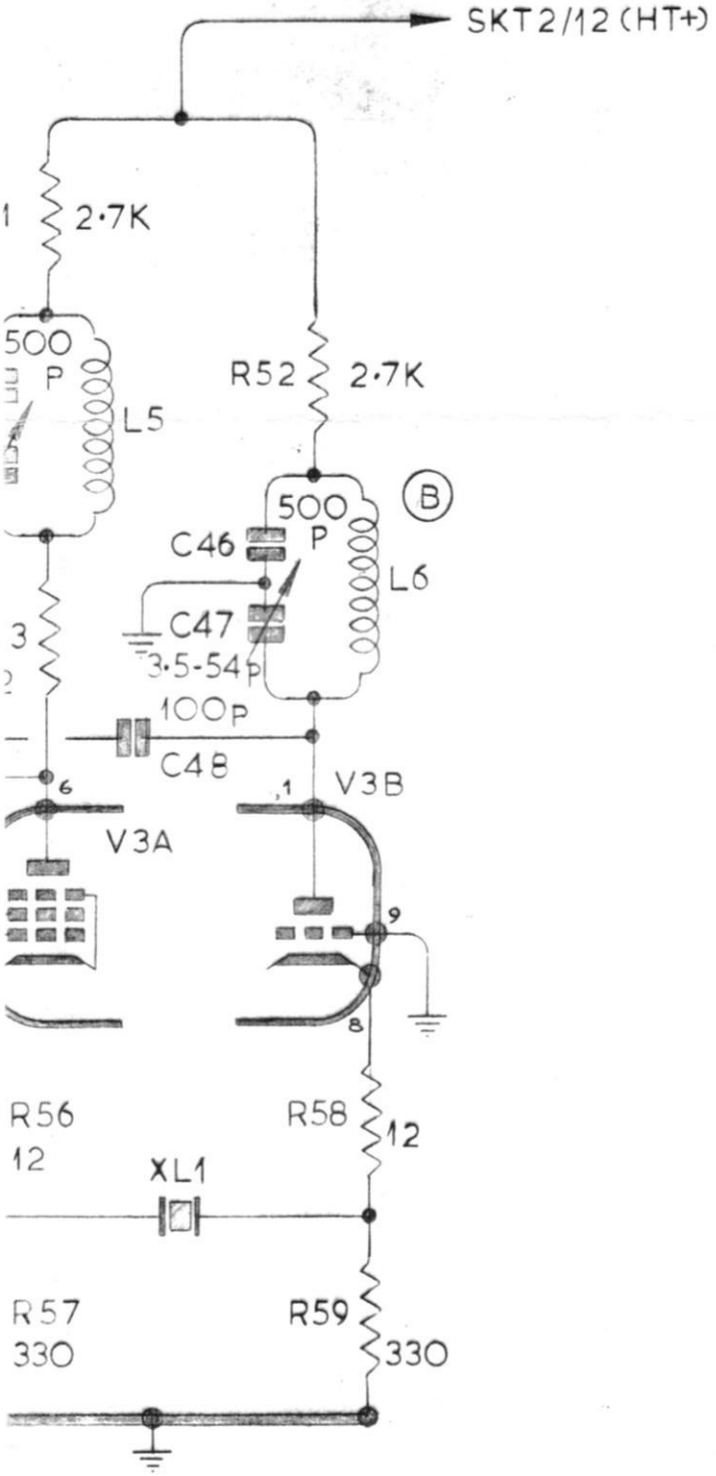
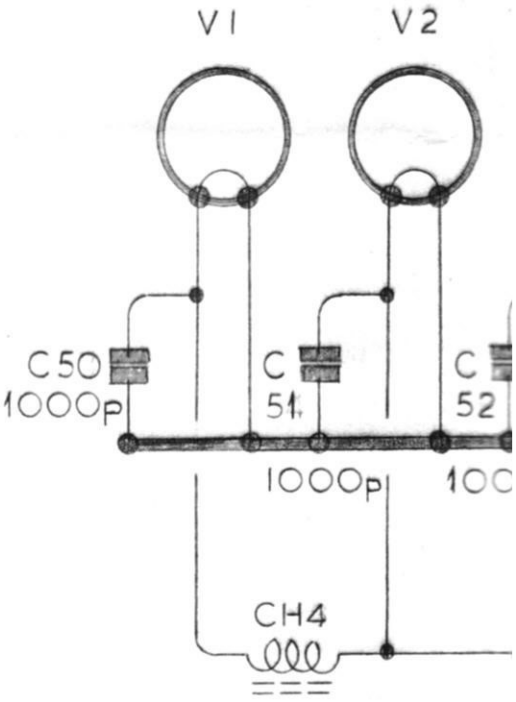
V7	6U8	1ST & 2ND AGC AMPS
V8	6U8	RELAY CONTROL/AF AMP
V9	6U8	LINE/MONITOR AMPS
D1	GEX34	AGC RECT.
D2	GEX34	SIGNAL DET.

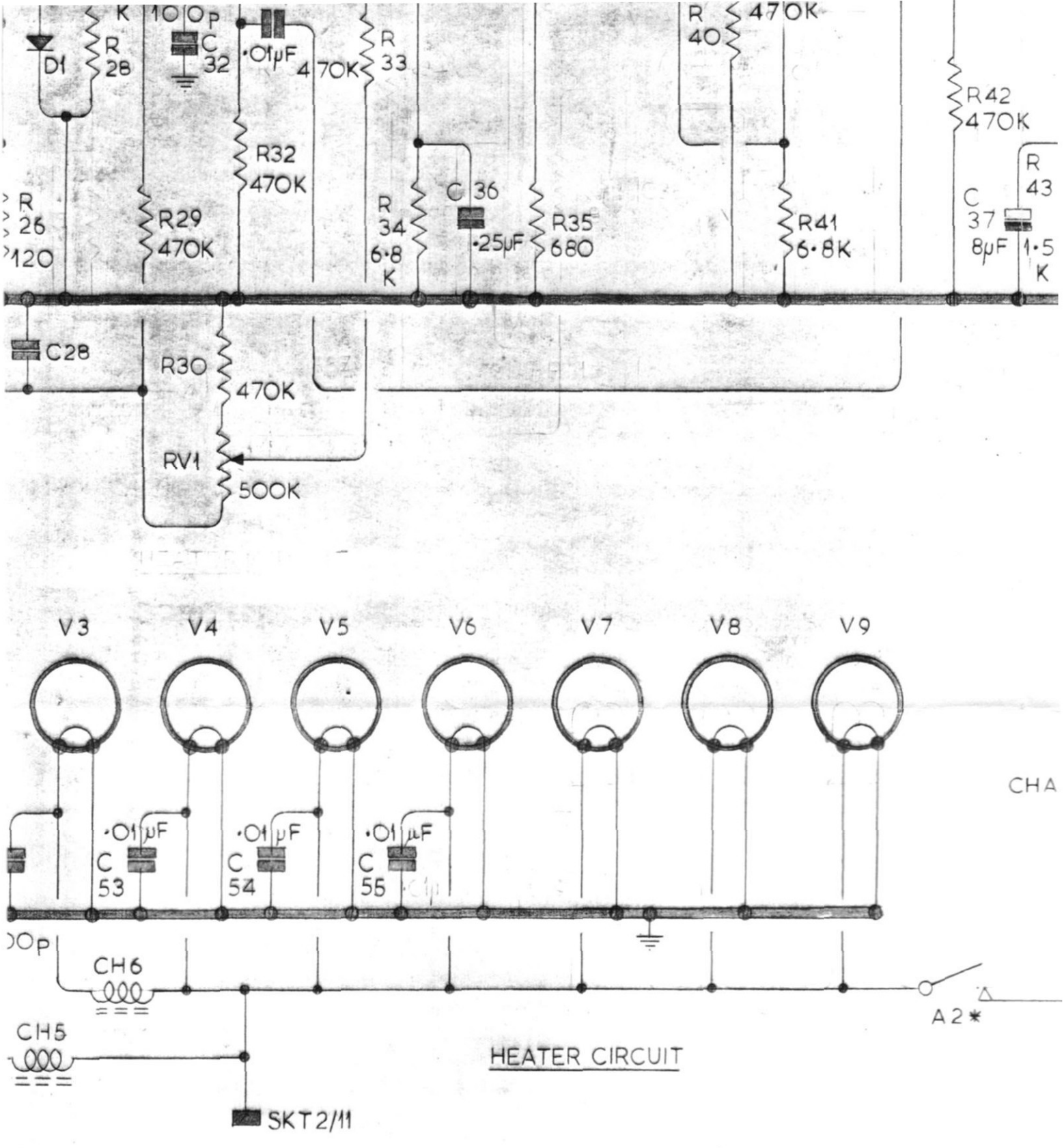




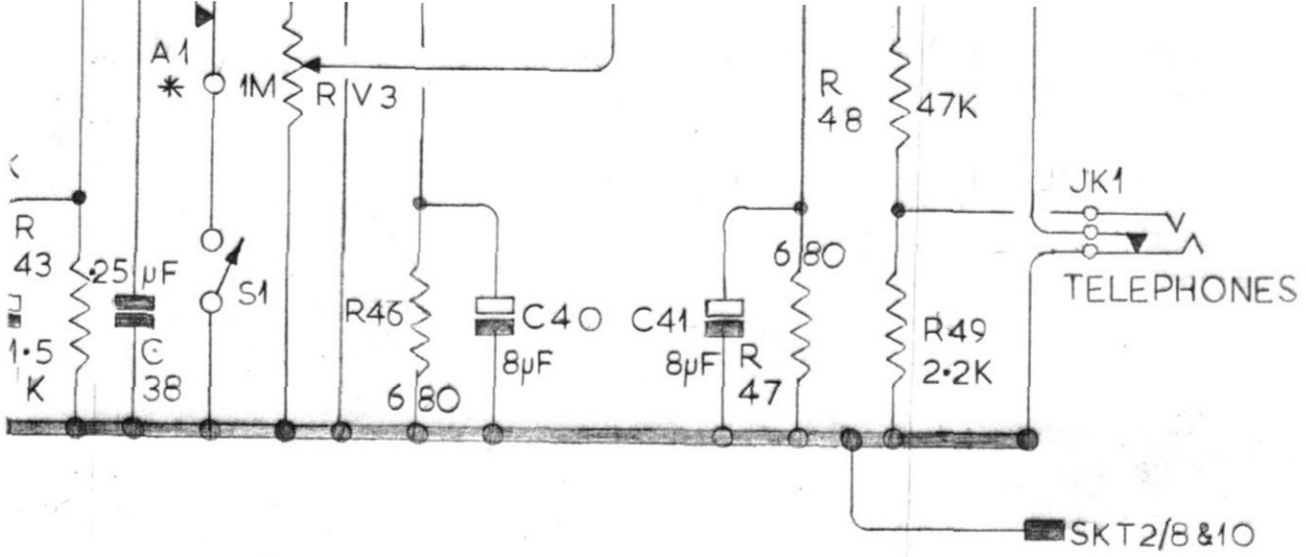


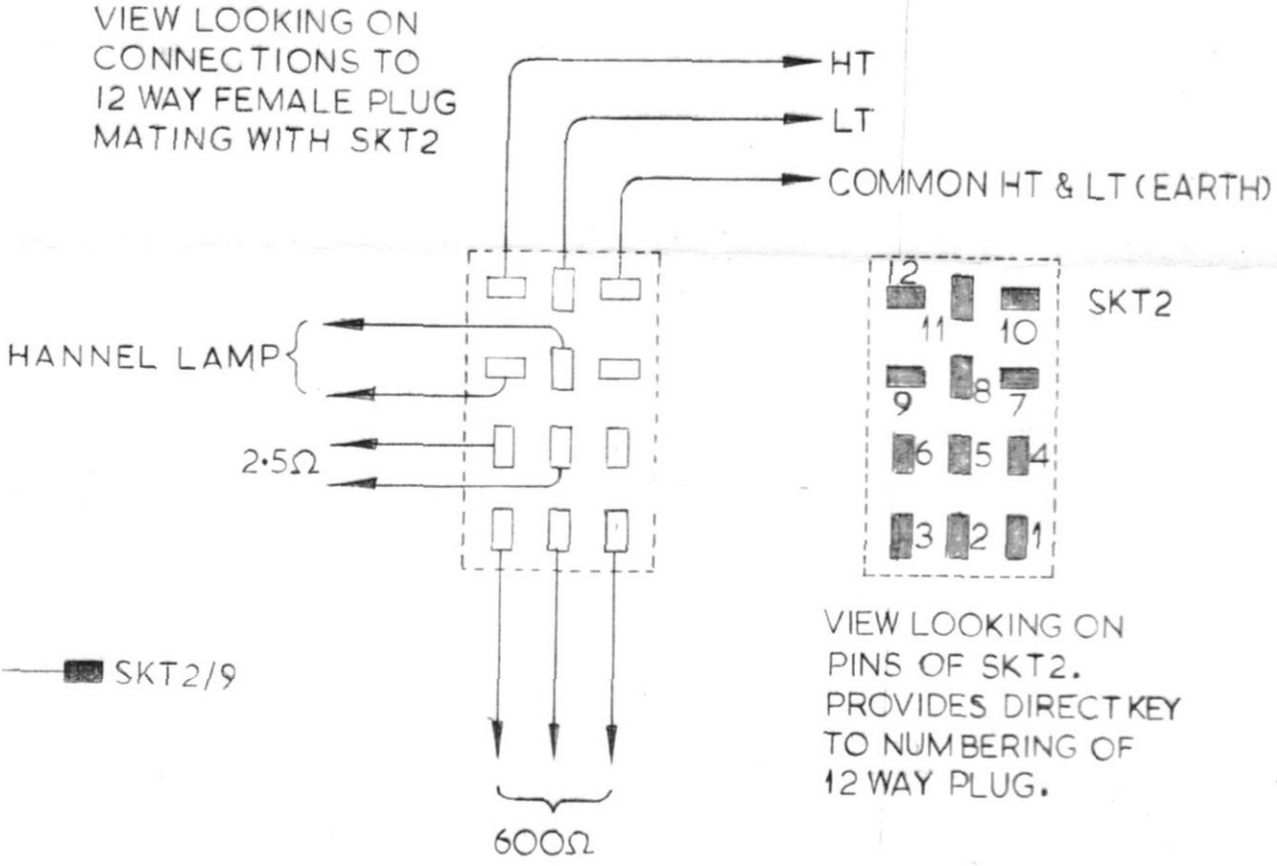


Provisional



Circuit Diagram - Model "S950" BP1338





* NOTE RELAY CONTACTS SHOWN IN 'ENERGISED' POSITION.
A1 OPENS, A2 CLOSES ON RECEIPT OF SIGNAL.