COSSOR
TELE-CHECK

TELEVISION ALIGNMENT

AND

PATTERN GENERATOR

MODEL 1320

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INTRODUCTION

The Cossor Television Alignment Oscillator and Pattern Generator is a light-weight electronic instrument designed to enable service engineers to align the R.F. and I.F. circuits and to check the time-bases of commercial television receivers.

The tests and adjustments which can be carried out using this instrument are as follows :

1. *Alignment of R.F. and I.F. Circuits*

A frequency modulated carrier output from the instrument enables the response curves of the R.F. and I.F. circuits to be displayed upon the screen of a cathode-ray oscillograph.

2. *Checking the Centre Frequency of the R.F. and I.F. Circuits*

A signal injected into the instrument from an external signal generator produces a marker " pip " on the oscillograph trace, obtained in (1) above, at a point corresponding to the signal frequency.

3. *Comparison of Sound and Vision Channels*

If a double beam oscillograph is used in conjunction with the instrument the response curves of the sound and vision channels can be displayed simultaneously, and any interaction detected.

4. *Checking the Linearity of the Frame and Line Time-bases*

Two amplitude modulated carrier outputs from the instrument will produce black and white band patterns on the screen of the television tube. Any non-linearity of the time-bases is thus made immediately apparent. No ancillary equipment is required for this test.

FIG. 1. ***Front view of the Cossor Television Alignment Oscillator and Pattern Generator.***

SPECIFICATION

CARRIER FREQUENCY:

7 to 70 Mc/s. continuously variable.

Calibration accuracy, 2 Mc/s.

FREQUENCY:

Frequency Modulation up to 7 Mc/s. bandwidth.

MODULATION:

Amplitude Modulation on F.M. less than 10%.

Preset adjustment of bandwidth to suit oscillograph scanning voltages between 100 to 300. A larger sweep voltage can be used but must be attenuated externally.

EXTERNAL CALIBRATION:

Provision for injection of frequency marker pip from external signal generator.

Input impedance for external signal generator 80 ohms.

AMPLITUDE MODULATION:

Square wave modulation for time-base linearity check.

Modulation frequencies:

80 Kc/s. (vertical bars)

400 c/s. (horizontal bars).

Amplitude Modulation Depth 20 to 40%.

ATTENUATOR:

Normal output impedance, 80 ohms.

Impedance on maximum output range, 0–1,000 ohms.

Maximum output, 50 mV.

Minimum output, 25 μV.

Arbitrary calibration.

POWER SUPPLY:

207, 225, 244 volts. 50 to 100 cycles.

Consumption, approx. 40 watts.

FRONT PANEL CONTROLS, ETC.:

Carrier Tuning (slow motion);

Modulation switch

(*a*) F.M. + 3·5 Mc/s. (7 Mc/s. bandwidth);

(*b*) Line 80 Kc/s. (vertical bars);

(*c*) Frame 400 c/s. (horizontal bars).

Attenuator Coarse—4 position switch.

Attenuator Fine—Potentiometer.

On/Off Switch.

Red Indicator Light.

PRE-SET CONTROLS:

P 2 Frequency modulator bias potentiometer.

P 4 80 Kc/s. multivibrator frequency control.

P 5 400 c/s. multivibrator frequency control.

L 1 Iron dust core tuning for F.M. Oscillator.

L 2 Iron dust core tuning of the Amplitude Modulation Compensating Coil.

Mains tapping, 207, 225, 244 volts.

TERMINALS:

X (Oscillograph X Scanning Voltage).

Earth Chassis.

Signal Generator (for frequency calibration marker).

R.F. Output (Co-Axial plug and socket).

Three feet of Uniradio 30 co-axial cable with crocodile clips at one end and co-axial silver-plated plug at the other are provided.

SIZE:

$10'' \times 7\frac{11}{16}'' \times 6''$ (excluding handles and feet).

WEIGHT:

13 lbs. 15 ozs.

FINISH:

Grey front panel with black escutcheon and chromium-plated handles, black crackle case.

TECHNICAL DESCRIPTION

INTRODUCTION

A block schematic diagram of the instrument is shown in Fig. 2.

The circuit consists of :

(1) A reactance valve stage which is controlled by the X-sweep voltage derived from an oscillograph. This stage behaves as a variable capacitance and forms part of the resonant circuit of the F.M. oscillator (Stage (2)).

(2) A frequency modulated oscillator working on a frequency of 115 Mc/s. ± 3·5 Mc/s. and a buffer stage.

(3) A variable frequency oscillator with a frequency range from 122 Mc/s. to 185 Mc/s., and a mixer stage to provide the R.F. output in the frequency band 7–70 Mc/s.

(4) A multivibrator which can be switched in to anode-modulate the variable frequency oscillator. The depth of modulation obtainable is 20 to 40%, and the modulation frequencies are 400 c/s. and 80 Kc/s.

(5) A potentiometer giving fine control of the R.F. signal level, feeding into a 4-range switch type attenuator network. The signal range is from 25 microvolts to 50 millivolts. The controls are not calibrated.

(6) A power pack delivering A.C. heater volts and 150 volts smoothed D.C. for H.T. supply.

(7) Input for the marker signal from an external signal generator, so that the frequency of the R.F. signal can be determined more accurately than is possible with the calibrated scale of the oscillator tuned circuit.

CIRCUIT ANALYSIS

The circuit is shown in Fig. 3.

POWER SUPPLY

Both mains input lines are fitted with fuses, and decoupled by C 1 and C 2 to avoid mains lead radiation.

The power pack is of conventional design and provides 150 volts D.C. for the H.T. rail and 6·35 volts A.C. for the heaters. The transformer has primary tappings at 207, 225 and 244 volts.

REACTANCE VALVE STAGE. V 3

This is a standard circuit in which a voltage applied to the grid is phase-shifted 90° with respect to the anode voltage. Assuming that the anode current is in phase with the grid voltage, the anode voltage and current will be in phase quadrature and the anode-ground impedance will be purely reactive. The magnitude of the reactance will depend upon the magnitude of the anode current.

By varying the anode current, therefore, the reactance of V 3 and hence the resonant frequency of the oscillatory circuit associated with V 4 can be varied. The variation is achieved by injecting the time-base scanning voltage of an oscillograph at the terminal X. A fraction of this voltage derived from the network P 1, R 2, R 5, P 2 is applied to the grid of V 3. The amplitude of this voltage is adjusted by varying P 1, the setting

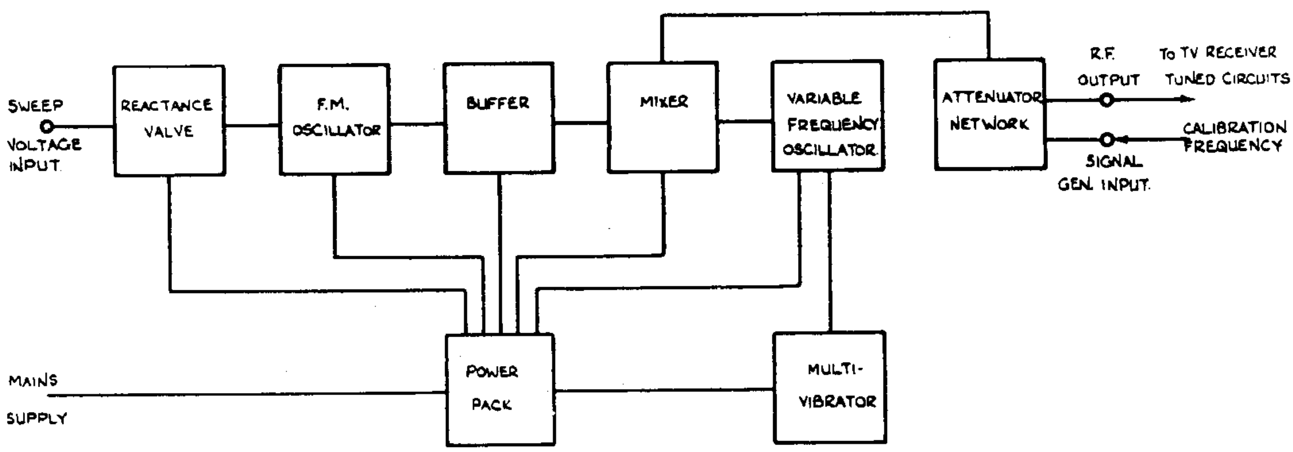


FIG. 2 *Block diagram, broken down to component sections.*

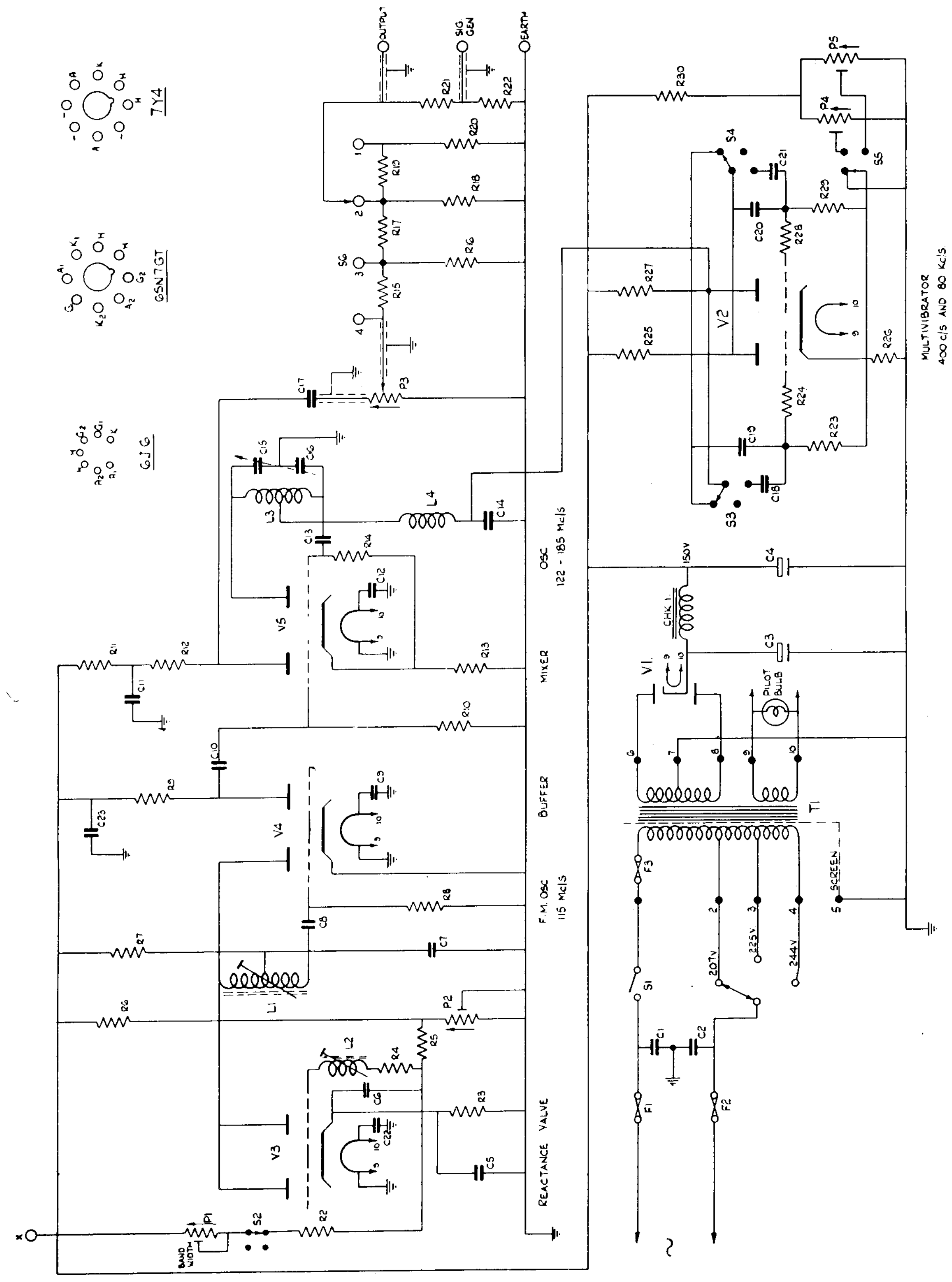


FIG. 3. *Circuit Diagram. For Parts List see Page* 19

of which will depend upon the oscillograph employed. P 2 is adjusted to provide a bias voltage to suit the characteristics of V 3, and need only be adjusted when this valve is changed.

If the anode voltage and current of V 3 are not exactly in phase quadrature the anode-ground impedance will have a resistive component which will also vary with the anode current. This would result in amplitude modulation as well as frequency modulation of the oscillator output and to avoid this the pre-set inductance L 2 is incorporated in the anode-grid phase-shifting network. In the alignment of this stage L 2 is adjusted to eliminate amplitude modulation of the oscillator output.

115 Mc/s. OSCILLATOR AND BUFFER STAGE. V 4

The first half of V 4 is the 115 Mc/s. oscillator, L 1 and the reactance valve stage forming the resonant circuit. The oscillatory voltage appearing on the grid of the oscillator half is fed directly to the grid of the other half of the valve, which is the buffer stage.

The purpose of this latter stage is to prevent " pulling " with the heterodyne oscillator V 5.

THE VARIABLE-FREQUENCY OSCILLATOR AND MIXER STAGE. V 5

The output from the anode of V 4 is taken to the grid of the first half of V 5 via C 10. The other half of V 5 with its associated components constitutes a Colpitts Oscillator, which can be tuned from 122 Mc/s. to 185 Mc/s. by means of the split-stator tuning condenser C 15, C 16. Frequency adjustment of the oscillatory circuit for tracking is achieved by varying the spacing of the turns of L 3.

As the two sections of V 5 have a common cathode the outputs of V 4 and of the variable-frequency oscillator are mixed in the first half of V5, the heterodyned output being taken from the anode of this section to the attenuator network via C 17.

THE ATTENUATOR

P 3 is a non-inductive potentiometer which provides a fine control of output attenuation. Coarse control is effected by the step attenuator comprising S 6 and R 15–20.

This switch control provides nominal attenuation steps as follows :

Position	1 ...	1,000 : 1
,,	2 ...	100 : 1
,,	3 ...	10 : 1
,,	4 ...	1 : 1

In practice, however, the attenuation in position 1 is 300 : 1 owing to the shunting of the attenuator by stray capacity.

OUTPUT AND SIGNAL GENERATOR TERMINALS

The output is taken from the rotor of S 6 across R 21 and R 22. Provision is made for the injection of a frequency calibration signal from an external signal generator at the junction of these resistors. This signal, in conjunction with the F.M. output of the alignment oscillator produces a marker pip on the response curve displayed on the oscillograph screen. The input signal amplitude from the signal generator required to produce this marker pip varies with the amplitude of the alignment oscillator output but is never more than 50 mV.

MULTIVIBRATOR STAGE. V 2 (Pattern Generator)

This is a conventional symmetrical multivibrator designed to operate at either 400 c/s. or 80 Kc/s. The square wave output from this stage is used to modulate the variable-frequency oscillator section of V 5 and hence to produce an amplitude-modulated carrier output from the instrument. The change of multivibrator frequency is effected by switching the condensers C 18 and C 21 in and out of circuit by means of the switches S 3, S 4. The third position of the switches connects the two anodes of V 2 together and thus stops the multivibrator.

The potentiometers P 4 and P 5 provide control of the D.C. bias on the valve grids at the two frequencies and hence give a fine control of multivibrator frequency.

The patterns required in order to check the linearity of the receiver time-bases consist of sets of eight black and eight white horizontal or vertical bars on the screen of a standard television receiver. In the alignment of the pattern generator P 4 and P 5 are adjusted to produce these patterns.

The resistors R 24 and R 18 are to prevent parasitic oscillations. Should such oscillations occur the effective time constants of the grid circuits will be reduced and difficulty may be experienced in obtaining the desired frequencies.

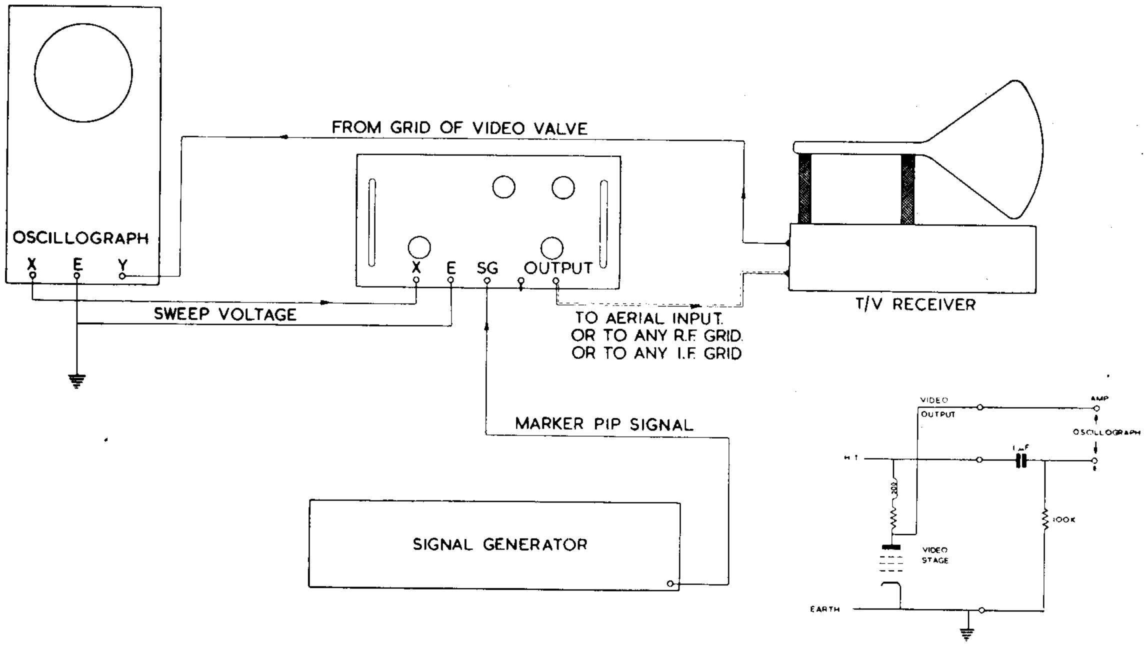
OPERATION

ALIGNMENT OF R.F. AND I.F. CIRCUITS

NOTE.—It is important that the correct mains transformer tapping is used since an appreciable drop in the internal supply voltages will cause amplitude modulation of the output signal.

may be avoided by connecting the amplifier as shown in Fig. 4, when the return circuit of the amplifier input is connected via a 1 μF. or 2 μF. condenser to the H.T. rail. A leak is provided to avoid the possibility of a shock.

Care should be taken in carrying out the alignment that a normal signal level input is used.



The connections to the oscillograph and signal generator are shown in Fig. 4 and require little explanation. The screened output lead from the instrument has two short leads fitted with crocodile clips to provide easy connection to the test points selected. When connection is made to a bias or H.T. point it will be necessary to insert a 0·01 μF. blocking condenser in series with the RED lead.

In modern receivers the video signal is available at either the grid or the cathode of the C.R.T., and since its magnitude is only of the order of 20 volts an oscillograph amplifier must be used. If this amplifier is connected between the anode of the video output valve and ground, however, the oscillograph trace may be upset by hum from the H.T. rail of the receiver. This difficulty

Too large an input will cause overloading and the resultant response curve displayed will be misleading. It is therefore advisable to reduce the input while looking at any response curve and see

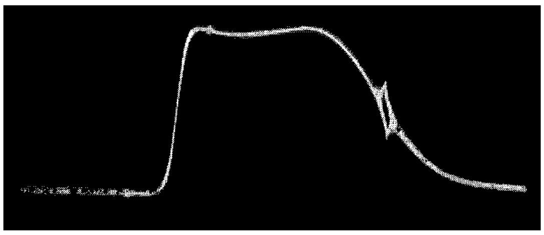


FIG. 5

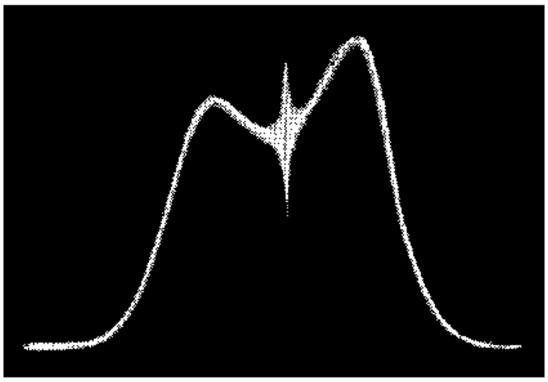


FIG. 6

if the curve changes in shape. If it does, overloading is probably occurring. This may be because the original input was too great, in which case the signal should be reduced to the minimum level at which the curve can be seen clearly. Alternatively there may be a fault in the receiver which must be located before proceeding further. Reference to the receiver specification should make it clear whether the overloading effect is due to too large an input signal or to a fault.

It will be found that in some receivers there is a variation of the response curve with changes of contrast setting. If so, the contrast control should be set to the point at which there is a reasonable range of black and white on the picture

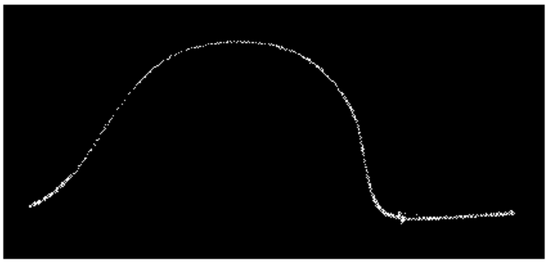


FIG. 7

before attempting to realign the receiver. After alignment the contrast setting may have to be changed again and it may be necessary to repeat the procedure to obtain the best adjustment of the set.

TYPICAL RESPONSE CURVES

The response curves illustrated were obtained using the alignment oscillator, a Cossor Double Beam Oscillograph and two types of standard television receiver.

These curves are only intended as examples, and must not be taken as correct for all television receivers. Manufacturers' requirements differ considerably, and the service handbook should be consulted for each type of set.

In all but one of the cases shown the input was connected to the aerial socket and the output taken from the diode load, the video valve having been removed. The remaining illustration Fig. 10 shows only the response of the I.F. stages.

The curve shown in Fig. 5 was obtained from a correctly aligned receiver employing single sideband tuning. It will be seen that the curve, though correct, is not symmetrical.

The station frequency to which the receiver is to be tuned is indicated by the marker " pip," the

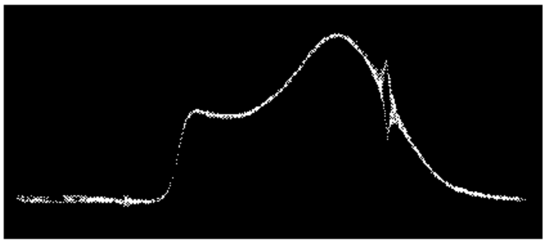


FIG. 8

alignment being made with the marker 6 dB below the substantially flat top of the response curve.

Fig. 6 shows the response curve of a correctly aligned double sideband receiver, the marker in this case being in the centre of the 7 Mc/s. sweep. The curve is not symmetrical but is within the tolerances allowed by the manufacturer.

Fig. 7 shows one effect of overloading, on a single sideband receiver, the conditions being identical except for an increase in input signal amplitude.

Incorrect tuning of a single sideband receiver is the subject of the next two illustrations. In Fig. 8 the low video frequency of the curve (nearest the marker) has been peaked. This will result in a loss of fine detail in the television picture. In Fig. 9 the high video frequency response

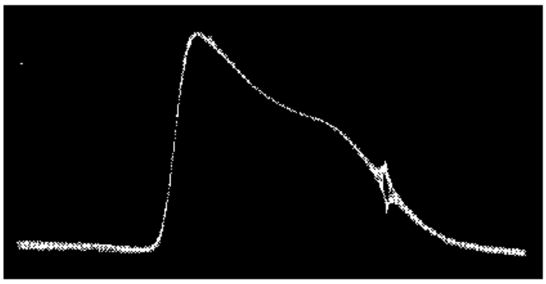


FIG. 9

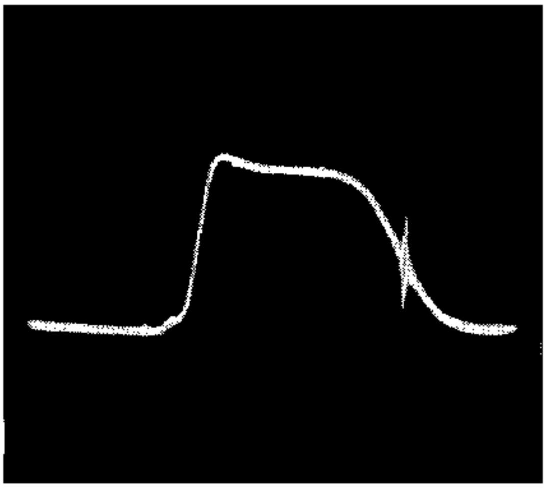


FIG. 10

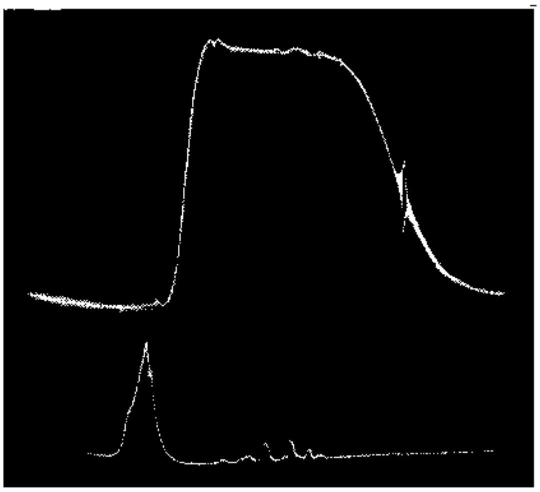


FIG. 11

is too great. This results in a blurred picture, because although the fine detail is present it is obscured by the indeterminacy of the black and white masses. Synchronism also is unreliable and weak.

To correct these curves the normal alignment process must be carried out starting at the detector end and working back, tuning stage by stage, to the aerial input. In the case of superheterodyne receivers the alignment oscillator frequency will, of course, have to be changed for the I.F. alignment to the intermediate frequency.

Fig. 10 shows a typical curve for a correctly aligned I.F. strip.

If Fig. 11 is shown the simultaneous presentation of the sound and vision response curves using a Cossor Model 1035 Double Beam Oscillograph. The vision output was connected to the A 1 terminal and the sound output to the A 2

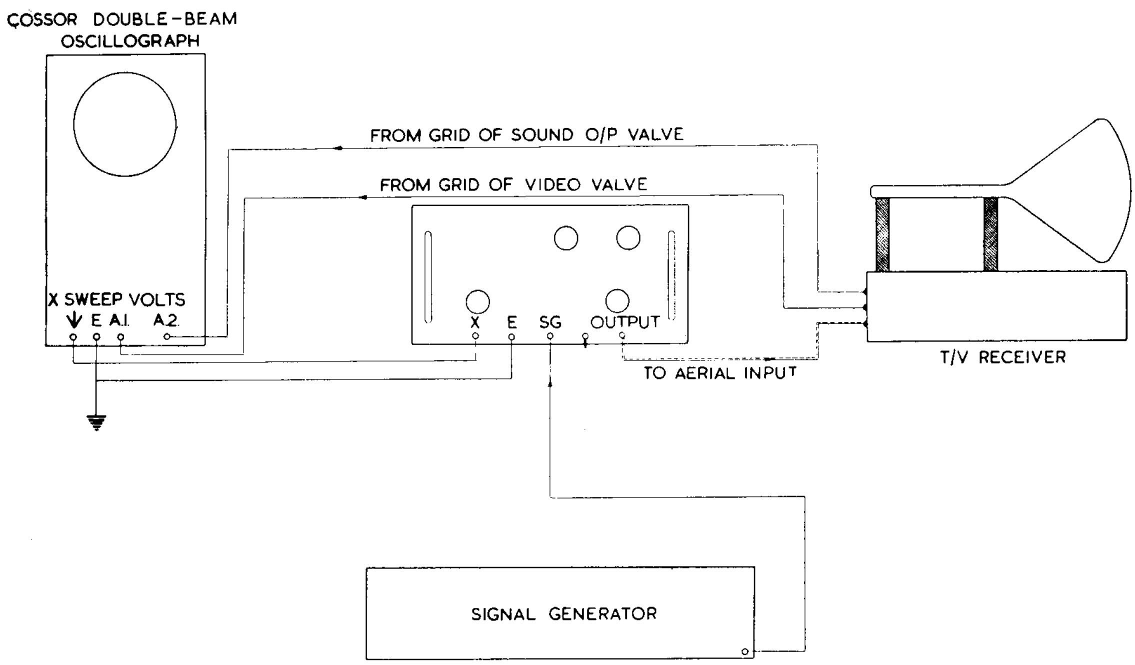


FIG. 12. *Connections for simultaneous viewing of sound and vision response curves.*

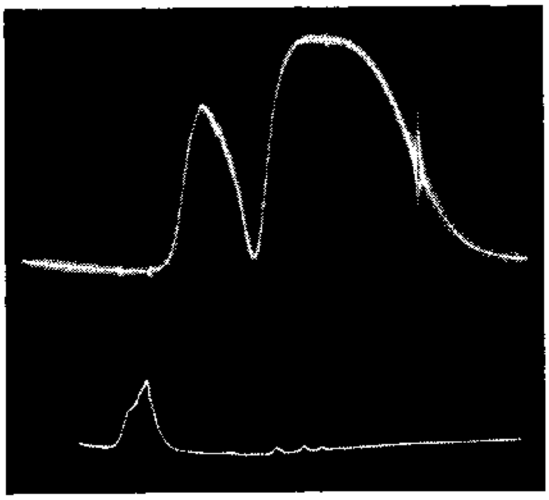


FIG. 13

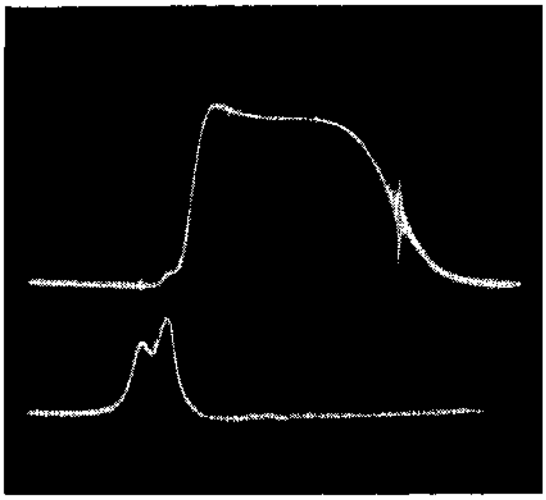


FIG. 14

terminal, Fig. 12. As will be seen there is slight interaction between the two channels.

This form of presentation is particularly valuable as such interaction will not always be apparent when the two channels are tuned independently, and the fault may only appear when the receiver is tested on a television programme.

Fig. 13 shows the effect when the sound rejector circuit in the vision strip is mistuned. A group of the vision modulating frequencies is completely cut off.

In Fig. 14 the sound rejector is correctly aligned, as is the whole vision strip, but the sound tuning is incorrect, a double hump being visible.

PATTERN GENERATOR

Fig. 15 shows the connections necessary to carry out the time-base linearity test. By switching the instrument either to " FRAME 400 c/s." or " LINE 80 Kc/s." a pattern of evenly spaced horizontal or vertical bars is displayed upon the television screen, as shown in Figs. 16 and 17. From these patterns any non-linearity of the receiver time-bases can readily be detected.

No ancillary equipment is required for this test.

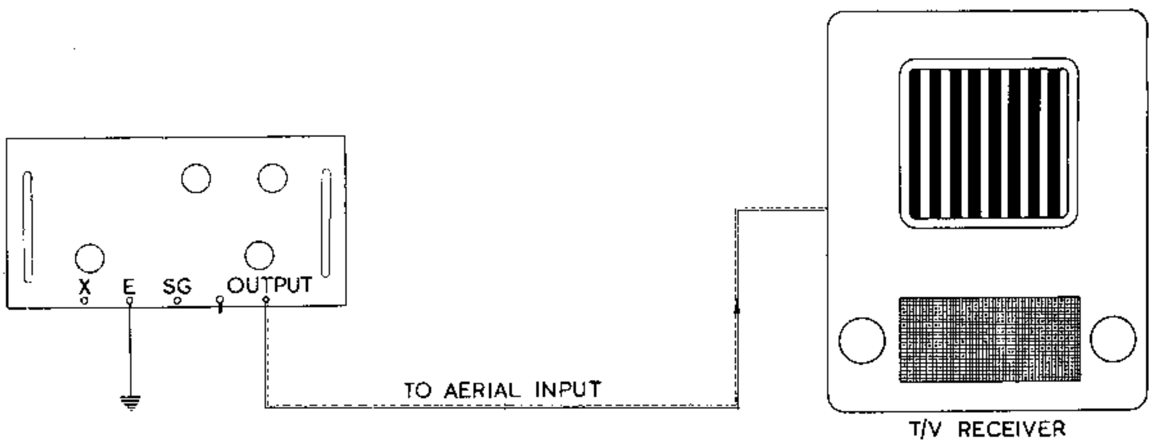


FIG. 15. *Use of the instrument for displaying time-base linearity patterns.*

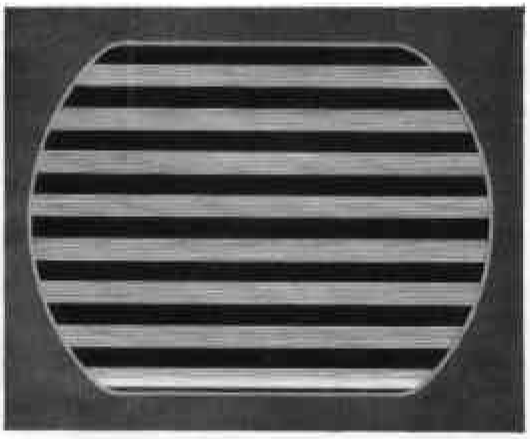


FIG. 16 *The 400 c/s. pattern.*

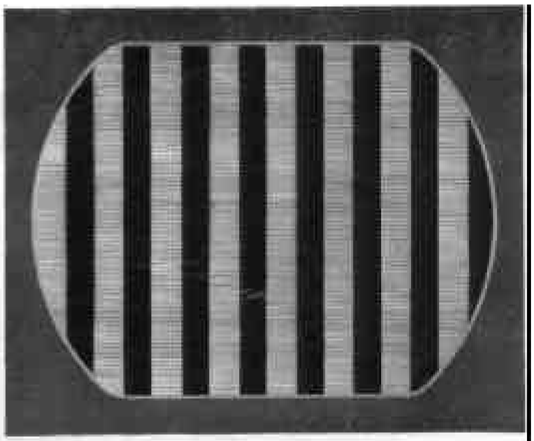


FIG. 17 *The 80 Kc/s. pattern.*

SERVICE AND MAINTENANCE

ALIGNMENT OF THE INSTRUMENT

A satisfactory method of aligning the various sections of the instrument is given below:

1. *Tracking of Variable Oscillator* (122–185 *Mc/s.*)

Set Modulation switch to " FRAME 400 c/s. " and check that a square wave of approx. 30 volts peak to peak appears between any point on L 3 and ground. This is to ensure that any oscillation generated by V 5 will be modulated by this waveform.

Remove V 3 and V 4 and inject a signal of approx. 100 mV at 115 Mc/s. into the junction of R 9, C 10. Connect the output to the sound channel of a normal television receiver (or similar detector) operating at 60 Mc/s. and verify that the fundamental is picked up when the carrier tuning scale is set to 60 Mc/s. and that at scale readings of 30 and 20 Mc/s, the second and third harmonics are detected. It is also advantageous to employ a similar method to detect the accuracy at approximately 10 Mc/s.

The accuracy of calibration of this scale can be adjusted to within ± 2 Mc/s. by variation of the spacing of the turns of L 3.

2. *Alignment of the* 115 *Mc/s. Oscillator and Frequency Modulator*

Adjust the tuning of the heterodyne oscillator V 5 to detect a convenient output signal, say 60 Mc/s., on the television receiver. Remove the 115 Mc/s. Signal Generator and replace V 3 and V 4. Adjust the core of L 2 to minimum inductance and the core of L 1 until the output frequency is 60 Mc/s. Connect the time-base voltage from a standard oscillograph to the X terminal and the video output of the television receiver to the Y deflection amplifiers. Short circuit P 1 and switch to F.M.

A response curve of the vision channel of the receiver will be traced on the screen and the curve may be positioned at any point along the trace by variation of the carrier tuning control C 15/C 16. A continual slow rotation of this control will provide the following information on the modulation characteristics of the oscillator:

(*a*) NON-LINEARITY OF FREQUENCY MODULATION will be indicated by a change in width of the curve as it progresses along the trace.

(*b*) SWEEP BANDWIDTH will be indicated by a difference in the frequency readings on the Carrier Tuning Control when the curve is positioned at the end of the range of linear modulation obtained from (*a*) above.

(*c*) AMPLITUDE MODULATION will be indicated by the locus of any point on the peak of the response curve.

Increase the inductance of L 2 until the frequency modulation is linear over a bandwidth of not less than 7 Mc/s. and see that the amplitude modulation accompanying 7 Mc/s. of the linear sweep does not exceed ± 10%. During the adjustment of L 2 it will be necessary to switch back to the 400 c/s. modulation and readjust the carrier frequency calibration to 60 Mc/s. by variation of L 1.

Increase the value of P 1 until the 7 Mc/s. bandwidth occupies the whole scan of the oscillograph tube. It may be observed that one end of the trace so produced shows signs of non-linearity, in which case adjustment of P 2 will move this portion of the modulation cycle off the end of the trace and the linear 7 Mc/s. band may be placed symmetrically about the centre of the screen.

3. *Pattern Generator*

Switch to "FRAME 400 c/s." and adjust P 5 to set the repetition frequency of the square wave to 400 c/s. Tune the vision response curve to the centre of the trace and adjust the output to produce a 4 cm. (approx.) picture on the tube. Return to 400 c/s. modulation and check that the peak to peak amplitude of the wave (excluding overshoot) is not less than 20% of the amplitude of the vision response curve. Repeat this test at 80 Kc/s.

4. *Attenuator*

Although the attenuator carries only an arbitrary calibration the operation of P 3 should be checked to ensure that it is continuous, and the attenuation ratios checked against those given in the circuit analysis above.

MAINTENANCE

A list of voltage and current readings taken on a prototype instrument, running with a mains input of 234 volts on the 215/234 mains tapping, is given below.

These will serve as a guide to the correct voltages and circuits for individual instruments. A list of these should be prepared and their values checked at regular intervals.

Primary Current	160 mA.
V 1 anodes to ground (R.M.S.) ...	175 volts
Heater volts	6·6 volts.
D.C. Potential across C 3 ...	190 volts.
D.C. Potential across C 4 ...	180 volts.
Ripple across C 4, less than ...	500 mV peak to peak.
H.T. Current to V 3, V 4 and mixer section of V 5	33 mA.
H.T. Current to V 5 Oscillator:	
(*a*) F.M.	6·5 mA.
(*b*) 400 c/s.	4·4 mA.
(*c*) 80 K/cs.	4·1 mA.
Total H.T. Current:	
(*a*) F.M.	49·5 mA.
(*b*) 400 c/s.	53 mA.
(*c*) 80 Kc/s.	53 mA.
Potential across R 3, C 5	10–20 volts, depending on V 3.
Potential across R 13 ...	1·8 volts.
V 2 anodes to ground (F.M.)	148 volts (AVO 1,000 v. range)
Amplitude of 400 c/s. square wave (neglecting overshoot)	40 volts peak to peak.
Amplitude of 80 Kc/s. ...	30 volts peak to peak.
D.C. level at V 2 Multi anode (400 c/s.) ...	150 volts. (Oscillograph measurement)

It will probably be found that a change of valve or other component will affect the frequency settings of the Alignment Oscillator. If so, the setting up procedure described above should be followed.

FAULTS ON THE INSTRUMENT

As all components are conservatively rated a breakdown is unlikely. Should a fault occur, however, by applying normal principles of radio servicing it should be easily located.

It must however, be remembered that the wiring layout is very important at the high frequencies present in this instrument. Replacements of components or wiring must be identical with the items removed.

Careful note should be taken of the exact run of the wiring involved before removing any item. The detailed chassis photographs Figs. 18, 19 and 20 will simplify this task.

The following rules should be observed:

(i) All wiring in the R.F. Section of the unit is routed by the shortest path.

For example, R 4, C 6 and C 8 must, if replaced, be fitted exactly as in the original layout.

(ii) Soldering.

Only one wire should be connected to each valve pin and a valve must be inserted in the holder whilst wiring is being replaced.

The reasons are that the low capacity holders necessary in the R.F. Section of this unit have pins which fit loosely into the base. If a strain is exerted when no valve is inserted, the pins may be pulled out of line. Also, flux must not run down to the point where contact is made with the valve pins. If this precaution is not observed bad contacts will result.

It will be noted that adjustment of L 3 is obtained by closing or opening the spaces between turns. In no circumstances must the overall length vary by more than ½" from maximum to minimum.

Other points to be noted in the performance of the equipment are :

If V 4 emission goes down the oscillator will have a large percentage of amplitude modulation each time the grid of V 3 has a positive voltage applied to it.

If the emission of V 3 goes down amplitude modulation will also be present to a degree outside the specification limits.

In either of the above cases oscillation may stop altogether but it is more probable in the case of V 4.

Injection of the marker pip signal from an external signal generator may cause trouble if its input voltage is too high. The signal should be fed at such a level that the marker pip can be clearly seen, but signal strength in excess of this should be avoided.

If the transformer T 1 has to be moved this can be done without disconnecting its input and output leads. Similarly, the main smoothing condenser has been mounted so that it can easily be removed to obtain access to components beneath.

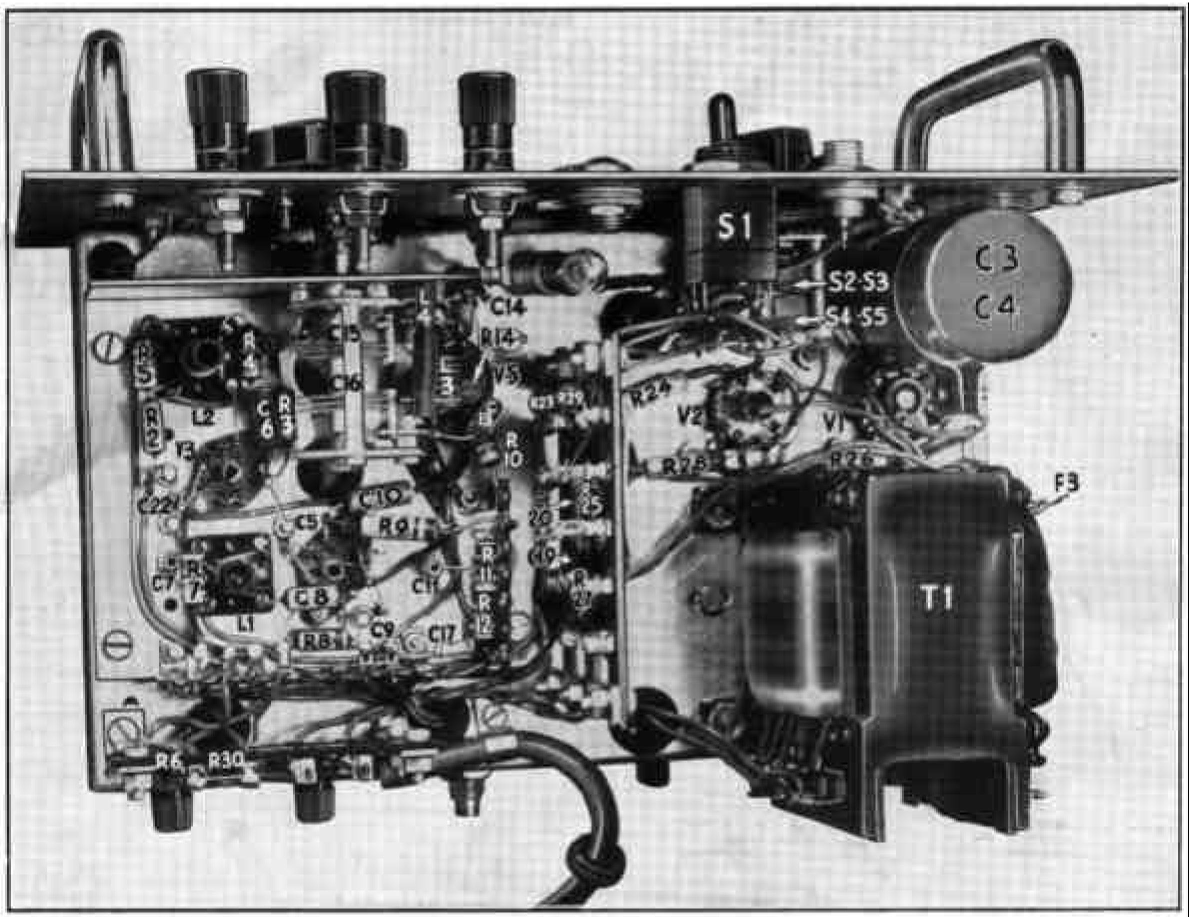


FIG. 18. *View of chassis, lower deck.*

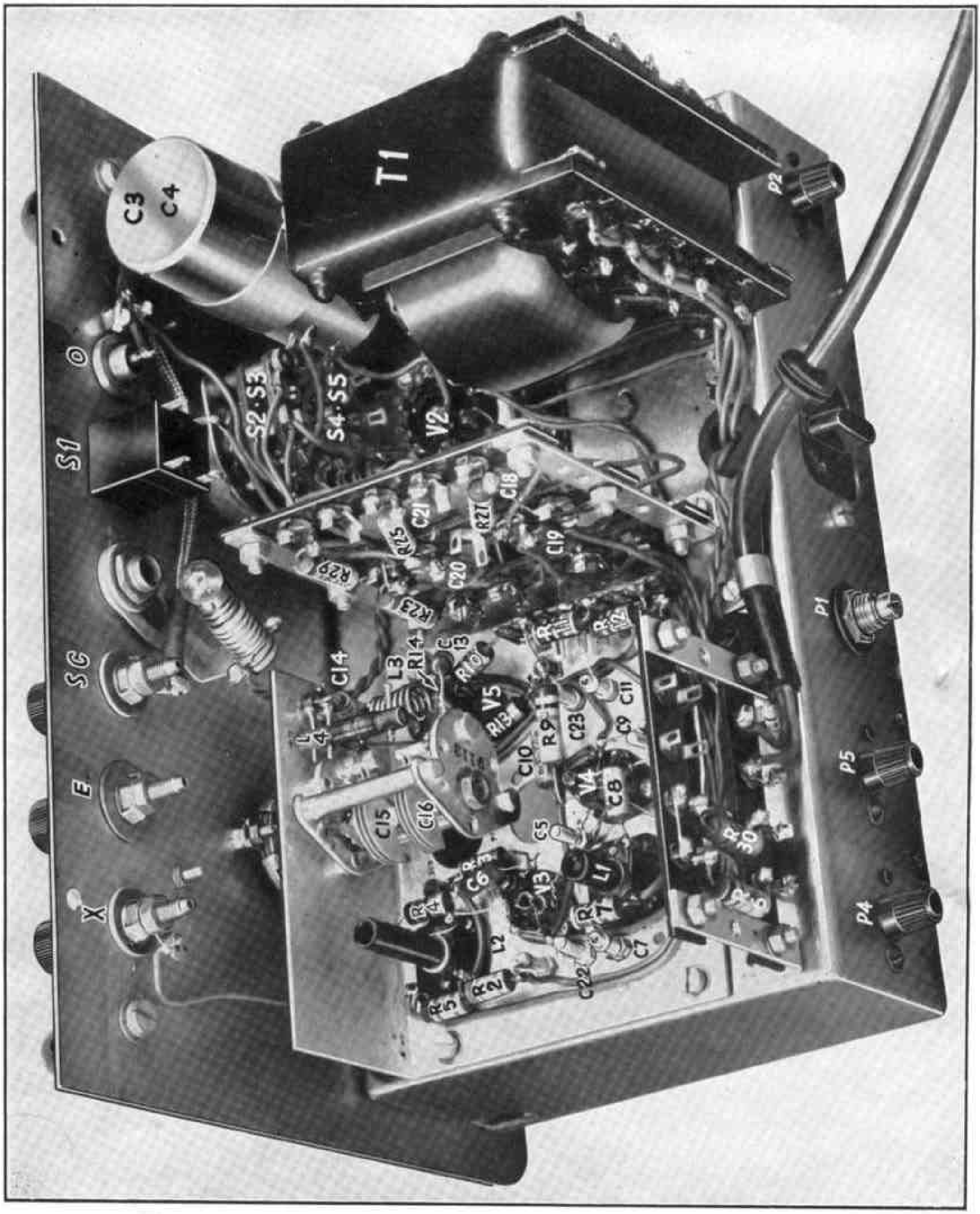


FIG. 19. *View of chassis, lower deck*

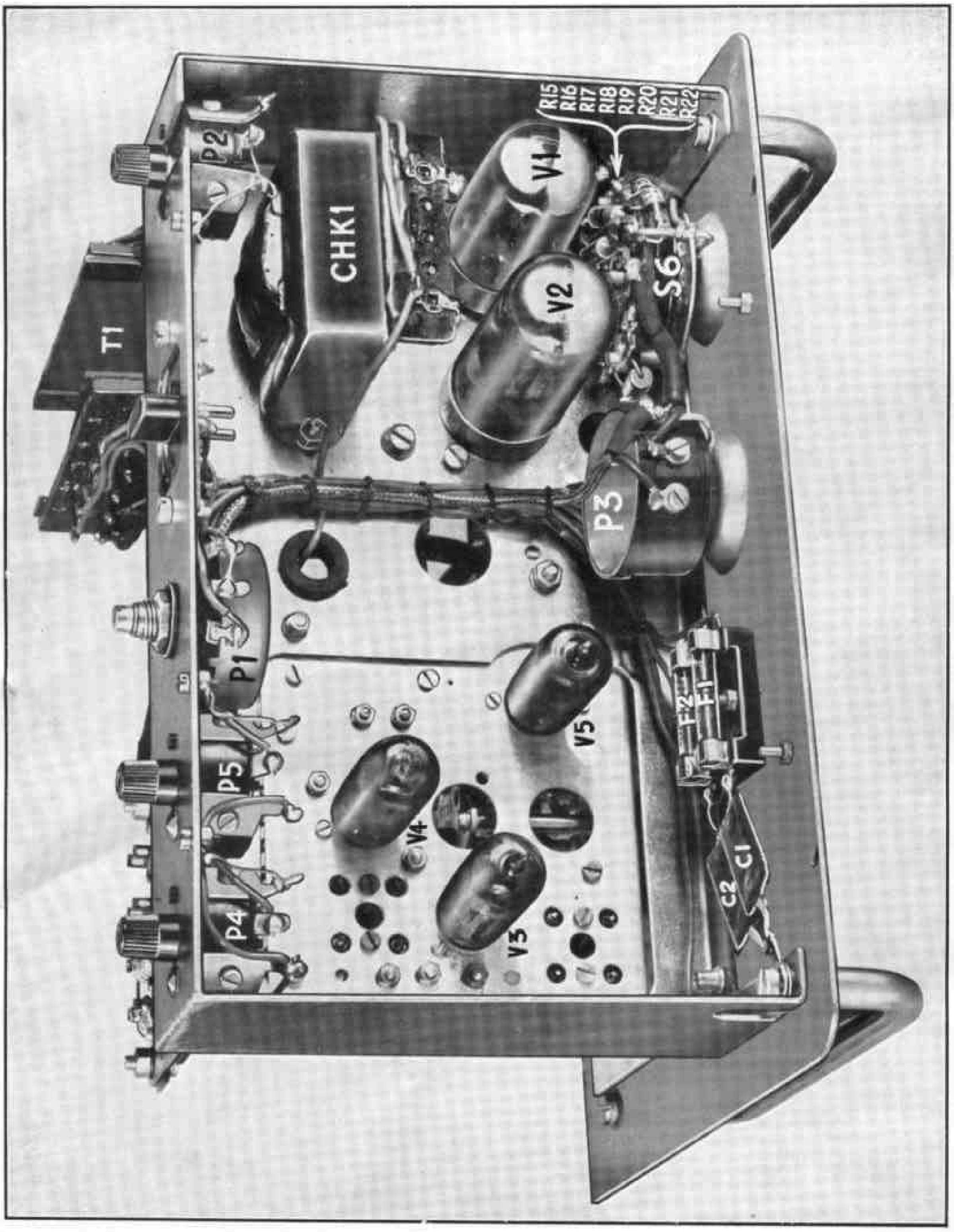


FIG. 20. *View of chassis, Upper deck.*

PARTS LIST

Ref.	Value	Rating	Part No.
V 1	7Y4		
V 2	6SN7GT		
V 3	6J6		
V 4	6J6		
V 5	6J6		
R 1	—	—	—
R 2	330K ± 10%	¼-W	DRO9/33410
R 3	2.2K ± 10%	¼-W	DRO9/22210
R 4	56 ± 10%	¼-W	DRO9/56010
R 5	270K ± 10%	¼-W	DRO9/27410
R 6	150K ± 10%	½-W	DRO8/15410
R 7	820 ± 20%	¼-W	DRO9/82120
R 8	22K ± 10%	¼-W	DRO9/22310
R 9	10K ± 10%	½-W	DRO8/10320
R 10	10K ± 20%	¼-W	DRO9/10320
R 11	1K ± 20%	¼-W	DRO9/10220
R 12	2.2K ± 10%	¼-W	DRO9/22210
R 13	100 ± 10%	¼-W	DRO9/10110
R 14	18K ± 10%	¼-W	DRO9/18310
R 15	680 ± 10%	¼-W	DRO9/68110
R 16	82 ± 10%	¼-W	DRO9/82010
R 17	680 ± 10%	¼-W	DRO9/68110
R 18	82 ± 10%	¼-W	DRO9/82010
R 19	680 ± 10%	¼-W	DRO9/68110
R 20	82 ± 10%	¼-W	DRO9/82010
R 21	150 ± 10%	¼-W	DRO9/15110
R 22	82 ± 10%	¼-W	DRO9/82010
R 23	220K ± 10%	½-W	DRO8/22410
R 24	470 ± 20%	½-W	DRO8/47120
R 25	4.7K ± 10%	½-W	DRO8/47210
R 26	470 ± 10%	½-W	DRO8/47110
R 27	10K ± 10%	½-W	DRO8/10310
R 28	470 ± 20%	½-W	DRO8/47120
R 29	220K ± 10%	½-W	DRO8/22410
R 30	47K ± 10%	½-W	DRO8/47310
S 1	S.P. On-Off	—	M.153525
S 2, S 3, S 4, S 5	4 Pole 3 Position 2 Wafer		RT-48/21
S 6	1 Pole, 4 Position, 1 Wafer	—	RT-48/22

Ref.	Value	Rating	Part No.
C 1	220pF ± 20%	500 v. or 750 v.	
C 2	220pF ± 20%	500 v. or 750 v.	
C 3, C 4	32 + 32µ F	250 v.	
C 5	1000pF ± 20%	—	M.129545
C 6	3000pF ± 20%	350 v.	M.129547/2
C 7	1000pF ± 20%	—	M.129545
C 8	33pF ± 10%	—	
C 9	1000pF ± 20%	—	M.129545
C 10	33pF ± 10%	—	—
C 11	1000pF ± 20%	—	M.129545
C 12	1000pF ± 20%	—	M.129545
C 13	10pF ± 10%	—	M.129579/3
C 14	47pF ± 20%	—	—
C 15	2 × 18.1pF Max.		RT-48/15
C 16	Split Stator		
C 17	1000pF ± 20%	—	M.129544
C 18	4700pF ± 10%	350 v.	—
C 19	22pF ± 10%	350 v.	—
C 20	22pF ± 10%	350 v.	
C 21	4700pF ± 10%	350 v.	
C 22	1000pF ± 20%	—	M.129545
C 23	1000pF ± 20%	—	M.129545
P 1	2 M.	1½-W	—
P 2	30 K	—	—
P 3	90 Non-Inductive	3-W	—
P 4	30 K	—	—
P 5	30 K	—	—
L 1	F.M. Osc. Coil	—	RT-48/26
L 2	Reactance Coil	—	RT-48/27
L 3	Variable Osc. Coil	—	RT-48/28
L 4	R.F. Choke	—	RT-48/25
F 1	—	1 Amp.	M.157503/5
F 2	—	1 Amp.	M.157503/5
F 3	Thermal Cut-out on Transformer		
T 1	Transformer	—	KA.29138
CHK1	L.F. Choke	—	KA.29139
Pilot Light	6.5v. .3 Amp.	—	M.201505