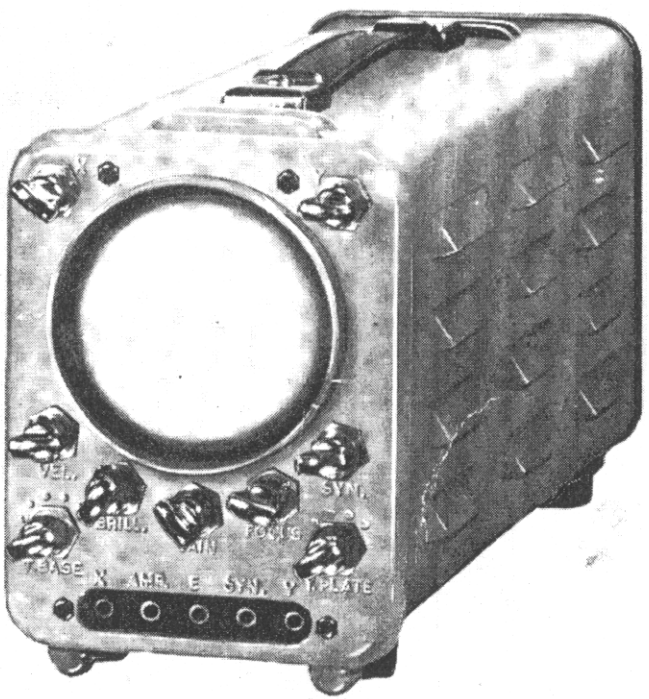
# COSSOR

## *oscillograph*




## *model 1039M Mk II*

## *instruction book*

# COSSOR
# *oscillograph*

## *model 1039M Mk II*

Please note our new address:-

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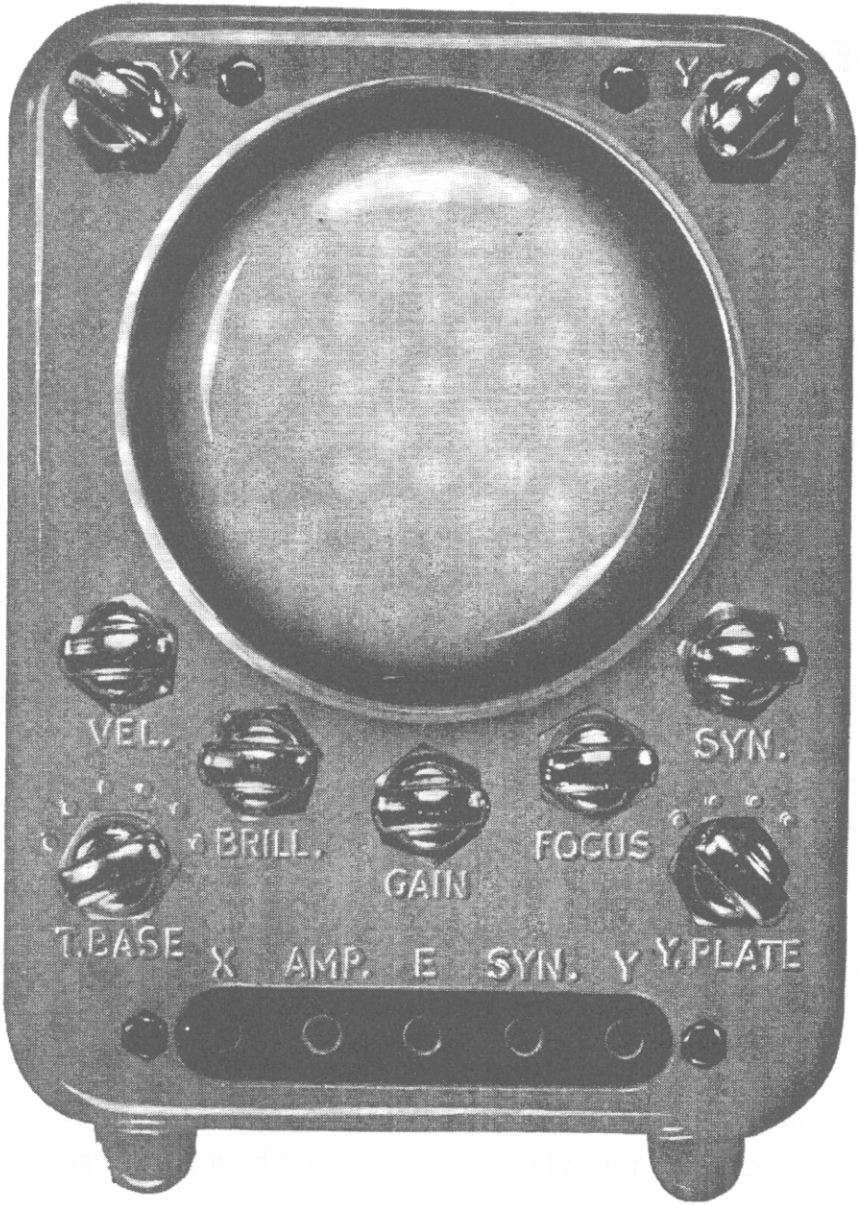
# illustrations




FRONT PANEL

# introduction

The Cossor model 1039M Mk II oscillograph is intended for use by Service engineers in either the field or workshop. It enables sources of distortion in a.f. amplifiers to be traced, ripple on h.t. supplies to be checked and many other electrical characteristics to be displayed. The instrument is a suitable companion to the Cossor "Telecheck"; with this combination, the alignment of television receivers can be carried out in a customer's home. The response of television r.f. and i.f. circuits can be displayed on the cathode-ray tube screen and all adjustments made while observing their effect.

Miniature components and a compact mechanical design have enabled the size and weight of the instrument to be kept small, while retaining many of the facilities offered by larger instruments. A cathode-ray tube having a screen diameter of $2\frac{3}{4}$ inches is used, this being large enough to provide a clear display of a waveform or response curve.

The instrument is finished in a high-grade, sage-grey stove enamel. When not in use the tube face is protected by a metal cap and the leather carrying handle fitted to the top of the oscillograph folds flat.

# *specification*

## Dimensions

Height: 5½ in. 14 cm.

Width: 4½ in. 11·5 cm.

Length: 13½ in. 34·3 cm.

Weight: 10¼ lb 4·6 kg (approximately).

## Power Rating

Mains supply: 220 to 240V.

Frequency: 50 to 100 c/s.

Power consumption: 30W.

Amplifier and time base: 260V d.c.

Cathode-ray tube e.h.t.: 860V d.c.

## Cathode-ray Tube

Type 24D single-beam 2¾ in. (70 mm) diameter, flat screen, green fluorescent trace.

Mean Y sensitivity direct to tube: 900/Va3 mm/V (1 V/mm).

Mean X sensitivity direct to tube: 520/Va3 mm/V (1·6 V/mm).

Input impedance to Y plate from front panel: 2MΩ in parallel with 30pF.

Input impedance to X plate from front panel: 200kΩ in parallel with 30pF.

**Time Base**

Free-running sawtooth generator.

Frequency range 10 c/s to 50 kc/s.

Switched range control, with time base off in position 1, and external time base in.

Continuously variable velocity control.

Output available at X socket at high impedance.

Flyback suppressed.

Minimum amplitude of scan 5 cm.

External synchronisation with positive signal.

High impedance at SYN input socket.

**Amplifier**

Single-stage amplifier.

Switch control selects, with GAIN control at maximum setting, either,

(a) Gain of 75 from 25 c/s to 120 kc/s (30 per cent down).

Sensitivity giving at least 1 cm deflection for 0·15V peak-to-peak.

Full-screen deflection.

(b) Gain of 20 from 25 c/s to 1·5 Mc/s (30 per cent down).

Sensitivity giving at least 1 cm deflection for 0·56V peak-to-peak.

Full-screen deflection.

Continuously-variable gain control.

# operating procedure

## POWER SUPPLIES

Connect the instrument to an a.c. mains supply of between 220 and 240 volts, 50 to 100 cycles per second.

The oscillograph may, however, be operated from supplies of between 200 and 250 volts, 50 to 100 cycles per second, if a slight reduction in valve life is accepted. Since the power consumption is very low (30 watts) standard 2-ampere flex is adequate. A mains on/off switch is not provided.

## INITIAL SETTING-UP PROCEDURE

Set the T. BASE range switch to position 2 and BRILL control fully clockwise. After a few minutes a trace will appear on the screen of the c.r.t. Centre this by means of X and Y shift controls. Use the FOCUS control to give a sharply-defined trace, reducing the brilliance to give the least intensity tolerable and refocusing as necessary.

**NOTE:** It is important to keep the brilliance level as low as possible as not only does this prolong the life of the c.r.t. but in addition permits the maximum sharpness of delineation to be obtained.

## OBSERVING WAVEFORMS OF AMPLITUDE GREATER THAN 10 VOLTS

Apply the waveform to be observed between the Y and E sockets. Set the Y PLATE switch in position 1, so that a direct connection is made from the Y socket to the c.r.t. Y plate. If there is a d.c. component present in the waveform under examination as, for instance, in the examination of ripple on the output of a power pack, set the switch to position 2, thereby inserting the blocking capacitor C4.

**NOTE:** As C4 is rated at 350 volts d.c. a separate external capacitor of suitable voltage rating must be used, with the Y PLATE switch in position 1, if the d.c. voltage is likely to exceed this value.

Adjust the T. BASE and VEL controls to give a suitable presentation on the screen. Obtain synchronisation of the time base with the waveform displayed at a fundamental frequency or a submultiple of it, by connecting the SYN and Y sockets together.

The time base can be locked also to another waveform arising elsewhere in the circuit under test, sharp positive-going pulses being the most effective for this purpose.

Rotate the SYN control as far in an anticlockwise direction as is consistent with effective locking, thus ensuring that there is no shortening or distortion of the trace due to an excessive synchronising signal.

## OBSERVING WAVEFORMS OF AMPLITUDE LESS THAN 10 VOLTS

Connect the waveform to be observed, between the AMP and E sockets and set the Y PLATE switch to position 3 or 4. Adjust the GAIN control to provide a trace of the desired size.

**NOTE:** The remarks regarding the time base and synchronisation in the preceding paragraph apply also in this case. The input capacitor C1 is rated at 350 volts d.c. and an additional capacitor must be connected in series when the d.c. component of the waveform to be examined is in excess of this value.

To observe sinusoidal waveforms at frequencies up to approximately 200 kc/s, set the Y PLATE switch to position 3.

To observe any waveform that departs from the sinewave shape and has a fundamental frequency greater than approximately 20 kc/s, set the Y PLATE switch to position 4.

## MEASURING D.C. POTENTIALS

Apply the potential to be measured between the Y and E sockets with the Y PLATE switch in position 1, so that a direct connection is made from the Y socket to the c.r.t. Y plate. Set the T. BASE switch to position 3 or 4.

The deflection of the trace from the reference position (i.e. when Y and E are connected) is directly proportional to the applied signal and will produce a deflection of approximately 1 cm for 10 volts. Because the tube sensitivity will vary with the mains voltage, calibration—with a known potential—is required for accuracy.

The input impedance to the Y plate of the c.r.t. is 2MΩ, therefore the oscillograph can be used as a high-impedance voltmeter.

A positive voltage on the Y socket causes an upward deflection, a negative voltage a downward deflection.

**N.B.:** The E socket is connected directly to the instrument case and if it is not at earth potential, as for example, in measuring the potential across an anode load, care must be taken to avoid personal injury or damage to associated equipment through accidental short circuits. Under no circumstances must the potential difference between the instrument case and earth exceed 1,000 volts. If this is exceeded, the insulation of the mains transformer primary winding may break down.

## MEASURING A.C. POTENTIALS

Display the a.c. waveform on the c.r.t. screen in accordance with the instructions given in the paragraphs dealing with this and measure its peak-to-peak amplitude.

If the amplitude is greater than approximately 10 volts, set the Y PLATE switch to position 1 and apply the signal directly to the tube deflection plate via sockets Y and E. Calibrate the instrument with a known d.c. potential to ascertain the deflection sensitivity.

If difficulty is experienced in keeping the trace on the screen, due to a large d.c. component being present with the displayed waveform, set the Y PLATE switch to position 2, to block the d.c.

**NOTE:** The previous remarks apply should the amplitude of the d.c. component exceed the 350 volts which the capacitor is rated to withstand.

In measuring high-frequency inputs, the input capacitance, which is approximately 30pF, provides a by-pass path to earth and this

must be considered when dealing with frequencies above approximately 10 kc/s. At 1 Mc/s the input impedance will be of the order of 5kΩ.

If the amplitude to be measured is less than approximately 10 volts, the amplifier can be used, the signal being applied between the AMP and 'E' sockets. The instrument can be calibrated as follows:—

1 Measure the amplitude of the trace produced by the unknown signal.

2 Without adjusting the GAIN control, apply a signal of known voltage to produce a trace of the same amplitude.

## MEASURING CURRENT

The instrument will not measure current directly, but this can be achieved by measuring the potential difference across the ends of a standard resistance inserted in the circuit. For a.c., a non-inductive resistance must be used.

## MEASURING FREQUENCY AND PHASE DIFFERENCE

To estimate the frequency of a signal, adjust the T. BASE switch and VEL control to show, say, one cycle of the waveform. Without altering the setting of the VEL control or the position of the T. BASE switch, substitute a signal from a variable source until the same display is obtained. The frequency of the unknown signal can then be read off the dial of the external oscillator.

With the external calibrated oscillator, an accurate comparison of the unknown frequency can be made with one that is known, as follows:—

Set the T. BASE switch to position 1, and inject the oscillator output at the X socket. Apply the unknown signal to the Y plate and adjust the oscillator frequency until a circle, straight line or ellipse is displayed, indicating that the two frequencies are equal, the shape of the figure depending on the phase difference between

the two signals. If the frequencies are not exactly equal, the shape will be seen to change.

The phase difference between two sinusoidal voltage waveforms of the same frequency can be assessed from the shape of the display. If they are of equal amplitudes, a circle is seen when the phase difference is 90 degrees, and a straight line inclined at 45 degrees to right or left if the phase difference is zero or 180 degrees respectively. Any other phase difference or amplitude difference will cause an ellipse to be traced. Reference to the sections in acoustics or general physics books dealing with simple harmonic vibrations at right angles to each other will provide the information necessary to interpret the observed result.

## OBSERVING RESPONSE CURVES

The response curves of complete equipments or portions of them, can be displayed on the oscillograph if an oscillator is available whose frequency can be modulated by a control voltage. A suitable oscillator is the Cossor "Telecheck". The oscillograph, in conjunction with this oscillator, can be used as follows for the alignment of television receivers.

Apply the scanning voltage, appearing at the X socket on the oscillograph, to the X socket on the oscillator, where it is used to modulate the frequency of the output signal. Apply this modulated output to either, the grid of one of the r.f. or i.f. valves or the aerial terminal of the receiver. Connect the video signal from the grid of the video amplifier valve, or from the grid or cathode of the c.r.t. to the Y socket of the oscillograph. Set the time base control to a frequency between 25 c/s and 50 c/s (higher repetition frequencies may cause spurious results). As the distance along the trace in the X direction is proportional to frequency difference, and in the Y direction it is proportional to output amplitude, the response curve of the receiver circuits, over the frequencies through which the oscillator is swept, is presented on the oscillograph screen.

Further details of this test procedure are provided in the instruction manuals for the "Telecheck". Using the Cossor model 1324 a similar procedure can be adopted when aligning f.m. broadcast receivers.

# circuit description

This instrument incorporates a 2¾-inch, type 24D cathode-ray tube which has a higher plate sensitivity than the 23D used previously in a similar instrument. The plates may be driven asymmetrically and this has been used to advantage in the design of the instrument.

## CATHODE-RAY TUBE

E.H.T. of approximately 860 volts, derived from a voltage-doubler circuit MR3, MR4 and capacitor C22 is applied to the cathode-ray tube.

Smoothing is effected by C23, C24 and R34. The voltage-doubler circuit provides a negative output to the cathode of the c.r.t. and enables the anodes to be earthed.

A separate heater winding is provided for the c.r.t. which avoids possible breakdown between heater and cathode.

Sawtooth scanning voltages are applied to one X plate of the c.r.t. while the other X plate is a.c.-coupled to earth and provides X shift.

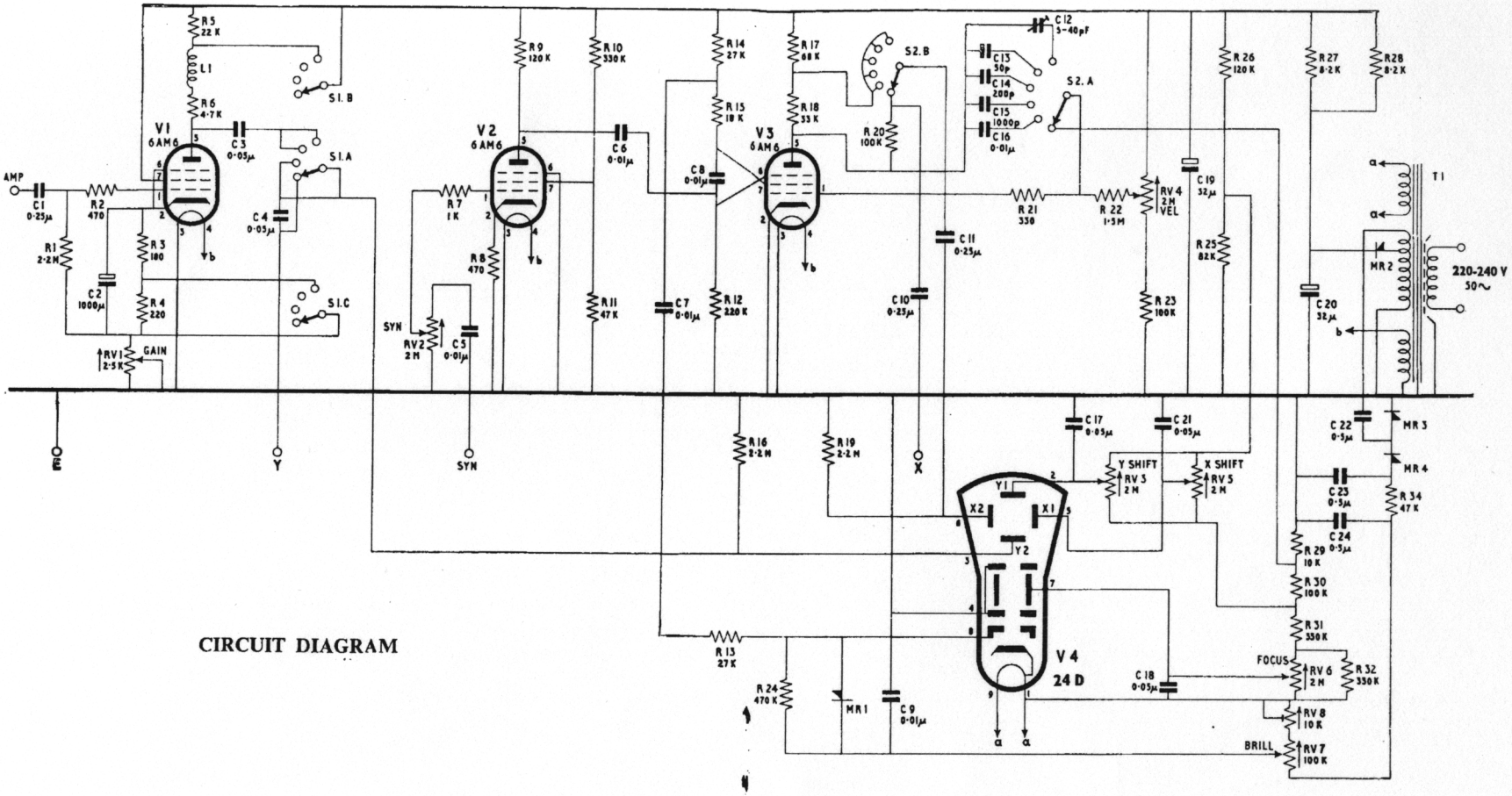
The work voltage is applied to one Y plate of the c.r.t. and Y shift applied to the other, which is a.c.-coupled to earth.

The input to the Y plate is selected by switch S1.A from the output of the Y amplifier or the Y socket on the front panel, to which it may be a.c.- or d.c.-connected.

The brightness control RV7 sets the d.c. level of the grid via MR1. RV8 is a preset brightness control which should be adjusted so that, with the panel-operated control at maximum, optimum brightness is obtained without defocusing. This should be re-adjusted if the c.r.t. is changed.

## TIME BASE

The h.t. supply to the time base and amplifiers is provided via metal rectifier MR2. Filter components C20, C19, R27 and R28 provide smoothing.




**CIRCUIT DIAGRAM**

The time base sawtooth voltage is derived from a single valve (V3) operating as a Miller-transitron oscillator. The time base repetition frequency is determined by R22 and RV4 in conjunction with the switch-selected capacitors C12-C16. Capacitor C8 in conjunction with the earth return of R12 maintains V3 in a free-running condition.

The sawtooth output to the X plate is taken from a tap in the anode circuit of V3, at the junction of R17-R18, to supply the required X scanning voltage. The trace is blacked out during the flyback by virtue of a negative voltage developed between grid and cathode of V4, due to d.c.-restoration of the a.c.-coupled screen waveform applied via R13 to MR1.

The sawtooth voltage is made available, at suitable amplitude, to drive wobbulators via the X output socket, which is connected to V3 via C10 and R20. When the time base is off, the X socket is a.c.-coupled to the X plate via C10 and C11. The input impedance is approx. 200kΩ.

A synchronising signal may be injected at the SYN socket and its amplitude controlled by RV2. This is applied to the grid of sync. amplifier V2. The sync. signal, developed across R9 in the anode circuit, is a.c.-coupled via C6 to the suppressor of V3, where the negative-going part of the signal controls the start of the time base sweep.

It is essential that minimum sync. levels for satisfactory signal synchronisation be used. Excessive sync. level may distort the displayed waveform.

## Y AMPLIFIER

The single-valve Y amplifier (V1) can provide a maximum voltage gain of at least 75 over the range 25 c/s–120 kc/s and a gain of 20 from 25 c/s–1·5 Mc/s (—3dB). Switches S1.B and S1.C select the above conditions. In the wide-band positions, S1.B short-circuits part of the anode load to improve the high-frequency response. Partial compensation is made for the resulting loss in gain by reduction in valve bias, part of which (R4) is shorted out by switch S1.C. The inductor L1 is included to improve high-frequency response.

Gain is controlled by variation of negative feedback. By increasing the value of the cathode resistance (RV1) up to its maximum of 2·5kΩ, the gain is reduced by approximately 10 : 1. This means that although the output from the amplifier cannot be reduced to zero, the two amplifier ranges overlap to provide continuous variation of the gain up to a maximum of approximately 75. An advantage of this type of gain control is that it provides continuous operation over its whole range, with little variation in the frequency response of the amplifier. R3 and R4, decoupled by C2, provide the bias voltage for V1. The grid resistor R1 is joined to the junction of R4 and RV1 so that variation in RV1 does not alter the bias applied to the valve.

The switch S1.A connects the amplifier output or the front panel Y socket to one Y plate of the c.r.t. The Y socket may be connected directly or through blocking capacitor C4 to the c.r.t. In switch positions 3 and 4 the amplifier is connected to the tube and its output appears at the Y socket. The amplifier can, thus, be used independently of the oscillograph, its output impedance being approximately 25kΩ on the 120 kc/s range and 4·7kΩ on the 1·5 Mc/s range.

# maintenance and service

Each oscillograph is fully tested before it leaves the factory to ensure that its performance meets the specification and a long period of trouble-free operation should be obtained from every instrument.

Should the oscillograph fail to operate correctly, location of the cause will be simplified by reference to the following paragraphs which list a number of faults that may develop, with suggestions as to the components responsible. Before attempting to investigate a fault, the controls and mains supply should be checked carefully to ensure that, for example, disappearance of the trace has not been caused by accidental rotation of the brilliance or shift controls or the mains input plug becoming detached.

The instrument can be withdrawn from the case, once the four chromium plated screws in the back cover have been removed. The components can then be identified with the aid of the circuit diagram and the annotated photographs.

## VOLTAGE READING

The following table of voltages is given as a guide to average operating conditions and some variations can be expected. Unless stated otherwise the values quoted are those obtained using an Avometer model 7 (500 ohms per volt) on the highest possible range, consistent with a reasonable deflection. The figures are based on a nominal mains voltage of 230 volts at 50 cycles per second. All measurements are made with respect to chassis with the exception of the c.r.t. heater voltage.

Control positions for voltage measurements are:

| | |
|---|---|
| BRILLiance | optimum brightness |
| Y PLATE | fourth position |
| GAIN | maximum |
| Time BASE | second position |
| VELocity | maximum |
| FOCUS | minimum spot size |

| | | | | | |
|---|---|---|---|---|---|
| E.H.T. Secondary (Marked 385V) | | 390V r.m.s. | | | |
| H.T. Secondary (Marked 260V) | | 260V r.m.s. | | | |
| C.R.T. heaters (Check across pins 1 and 9) | | *6·4V r.m.s. | | | |
| Valve Heaters | | *6·35V r.m.s. | | | |
| Unsmoothed e.h.t. | | 930V d.c. | | | |
| Smoothed e.h.t. | | 870V d.c. | | | |
| Unsmoothed h.t. | | 290V d.c. | | | |
| Smoothed h.t. | | 225V d.c. | | | |
| V1 Anode | Pin 5 | 185V d.c. | | | |
| V1 Screen | Pin 7 | 225V d.c. | | | |
| V1 Cathode | Pin 2 | †2·0V d.c. | | | |
| V2 Anode | Pin 5 | 183V d.c. | | | |
| V2 Screen | Pin 7 | 28V d.c. | | | |
| V2 Cathode | Pin 2 | †0·15V d.c. | | | |
| V3 Anode | Pin 5 | 134V d.c. | | | |
| V3 Screen | Pin 7 | 180V d.c. | | | |

**NOTE:** **10V a.c. range on Avometer model 7.*
*†10V d.c. range on Avometer model 7.*

All other readings taken on 1,000V (a.c. or d.c. as applicable) range of Avometer model 7.

## TIME BASE

### Shortening of Sweep

Check V3 and change if necessary.

**NOTE:** If V3 is changed, the trimmer C12 must be adjusted to give a maximum time base repetition frequency of not less than 50 kc/s.

Check h.t. rail (see voltage table).

Check C8 for open- or short-circuit.

Check C11 for open-circuit.

### Ineffective Flyback Black-out

Check metal rectifier MR1.

Check C7 for open- or short-circuit.

### Erratic Operation of Time Base

Check RV4 for bad contact on slider.

Check S2 for bad contact.

Check V3 and change if necessary.

### No Sweep on one or more Ranges

Check C12, C13, C14, C15 and C16 for open- or short-circuit.

Check h.t. voltages (see voltage table).

## Y AMPLIFIER

### 50 c/s Ripple on Trace, Greater than 0·2 cm peak-to-peak:

Check C19, C20, for low-capacity or open-circuit.

Check power supply (see voltage table).

Check C2 for short-circuit.

Check V1 for heater/cathode short and change if necessary.

### Reduced Y Deflection and Distortion of Trace:

Check V1 and change if necessary.

Check supply voltages (see voltage table).

Check C3 for open-circuit.

**Distortion of Trace at all Amplifier levels:**

Check setting of RV2, this should be set to the minimum always for effective synchronisation.

**Erratic Y Gain Control:**

Check RV1 and S1 contacts.

**Low Y Amplifier Gain**

Check V1 and change if necessary.
Check supply voltages (see voltage table).
Check C3 for open-circuit.

**No Y Amplifier Gain**

Check V1 and change if necessary.
Check L1, C3 and S1 for open-circuits.
Check supply voltages (see voltage table).

**No or little Sync**

Check V2 and change if necessary.
Check C6 for open-circuit.
Check C5 for open-circuit.
Check supply voltage to V2 (see voltage table).

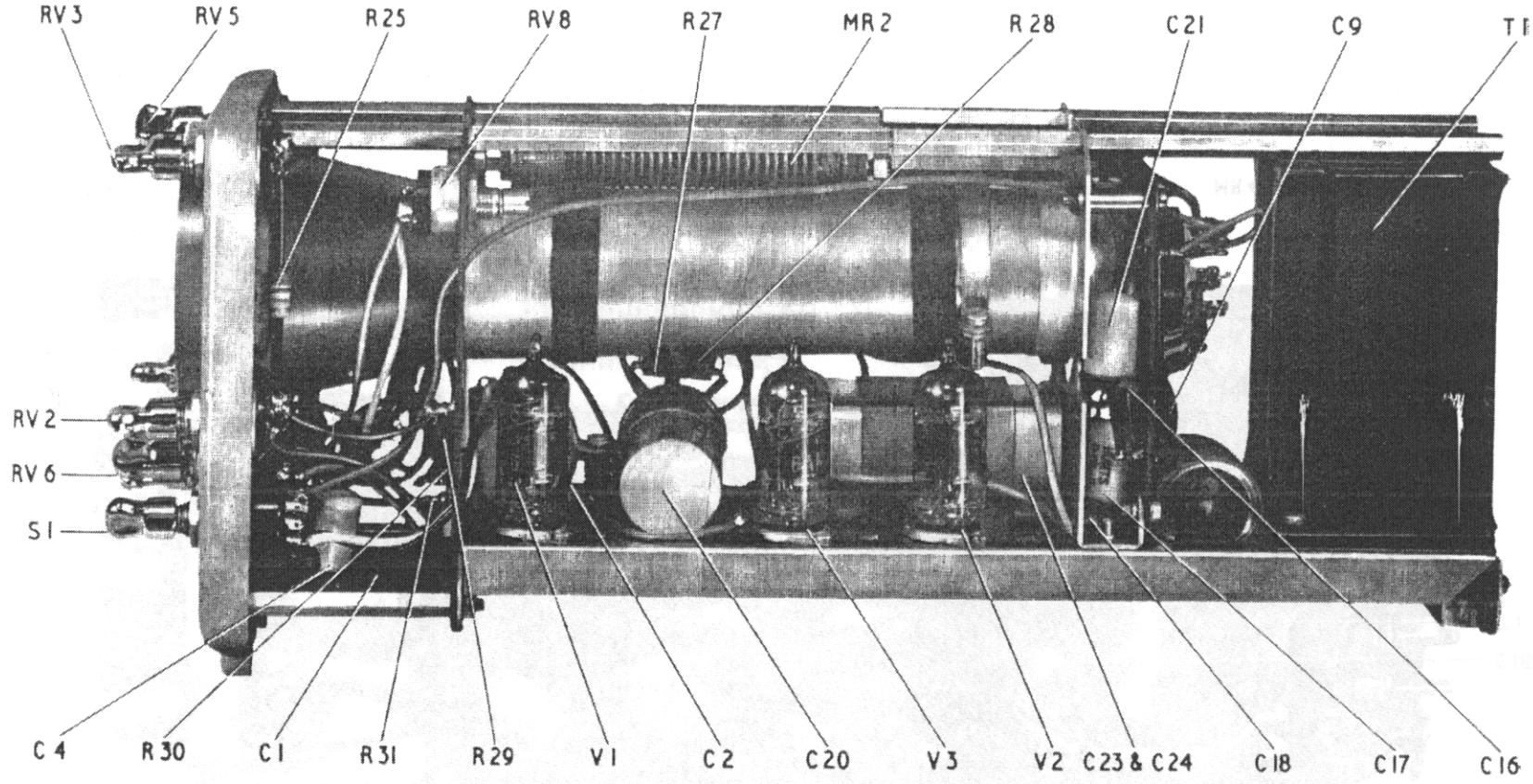
## CATHODE-RAY TUBE

**No Trace or Spot Visible**

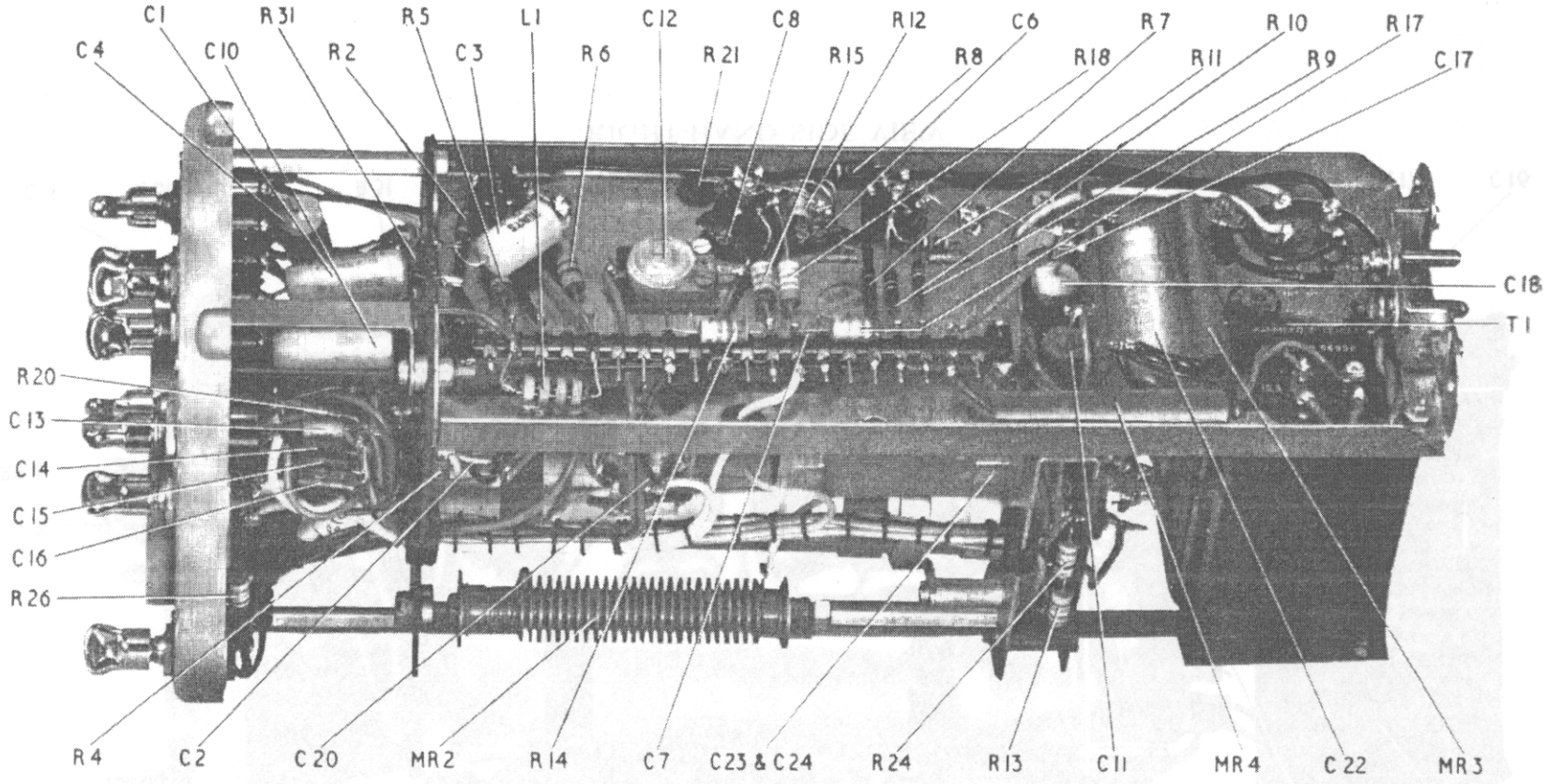
Check RV7 for open-circuit.
Check c.r.t. supply voltages (see voltage table).
Check c.r.t. heater continuity.

**Low e.h.t. volts**

Check for e.h.t. leakage to chassis via C23, C24 and C9.
Check metal rectifiers MR3 and MR4.
Check secondary voltages from mains transformer.




RIGHT-HAND SIDE VIEW




THREE-QUARTER UNDERSIDE VIEW

# parts list

| Ref. | Value | Tolerance | Rating | Part Number |
|---|---|---|---|---|
| R1 | 2·2MΩ | ±20% | ¼W | DR93/22520 |
| R2 | 470Ω | ±20% | ¼W | DR93/47120 |
| R3 | 180Ω | ±10% | ¼W | DR09/18110 |
| R4 | 220Ω | ±10% | ¼W | DR09/22110 |
| R5 | 22kΩ | ±10% | ½W | DR08/22310 |
| R6 | 4·7kΩ | ±10% | ½W | DR08/47210 |
| R7 | 1kΩ | ±20% | ¼W | DR93/10220 |
| R8 | 470Ω | ±20% | ¼W | DR93/47120 |
| R9 | 120kΩ | ±20% | ¼W | DR93/12420 |
| R10 | 330kΩ | ±20% | ¼W | DR93/33420 |
| R11 | 47kΩ | ±20% | ¼W | DR93/47320 |
| R12 | 220kΩ | ±20% | ¼W | DR09/22420 |
| R13 | 27kΩ | ±20% | ¼W | DR09/27320 |
| R14 | 27kΩ | ±10% | ¼W | DR09/27310 |
| R15 | 18kΩ | ±10% | ¼W | DR09/18310 |
| R16 | 2·2MΩ | ±20% | ¼W | DR09/22520 |
| R17 | 68kΩ | ±10% | ¼W | DR09/68310 |
| R18 | 33kΩ | ±10% | ¼W | DR09/33310 |
| R19 | 2·2MΩ | ±20% | ¼W | DR09/22520 |
| R20 | 100kΩ | ±20% | ½W | DR93/10420 |
| R21 | 330Ω | ±20% | ½W | DR93/33120 |
| R22 | 1·5MΩ | ±10% | ¼W | DR09/15510 |
| R23 | 100kΩ | ±20% | ¼W | DR09/10420 |
| R24 | 470kΩ | ±20% | ¼W | DR09/47420 |
| R25 | 82kΩ | ±10% | ¼W | DR09/82310 |
| R26 | 120kΩ | ±10% | ¼W | DR09/12410 |
| R27 | 8·2kΩ | ±20% | ½W | DR08/82220 |
| R28 | 8·2kΩ | ±20% | ½W | DR08/82220 |
| R29 | 10kΩ | ±10% | ¼W | DR09/10310 |
| R30 | 100kΩ | ±10% | ¼W | DR09/10410 |
| R31 | 330kΩ | ±10% | ¼W | DR09/33410 |
| R32 | 330kΩ | ±10% | ¼W | DR09/33410 |
| R33 | | | | |
| R34 | 47kΩ | ±10% | ¼W | DR09/47310 |
| C1 | 0·25μF | ±25% | 350V | M129603 |
| C2 | 1000μF | 50% −20% | 6V | M131618 |
| C3 | 0·05μF | ±20% | 350V | M129662 |
| C4 | 0·05μF | ±20% | 350V | M129662 |
| C5 | 0·01μF | ±20% | 350V | M129666/2 |

| Ref. | Value | Tolerance | Rating | Part Number |
|---|---|---|---|---|
| C6 | 0·01μF | ±20% | 350V | M129666/2 |
| C7 | 0·01μF | +100% −0% | 2kV | M129661 |
| C8 | 0·01μF | ±20% | 350V | M129666/2 |
| C9 | 0·01μF | +100% −0% | 2kV | M129661 |
| C10 | 0·25μF | ±25% | 350V | M129603 |
| C11 | 0·25μF | ±25% | 350V | M129603 |
| C12 | 5–40pF | — | 350V | M127520 |
| C13 | 50pF | ±20% | 600V | M129664 |
| C14 | 200pF | ±20% | 600V | M129665 |
| C15 | 1000pF | ±20% | 350V | M129666 |
| C16 | 0·01μF | ±20% | 350V | M129666/2 |
| C17 | 0·05μF | ±20% | 350V | M129662 |
| C18 | 0·05μF | ±20% | 350V | M129662 |
| C19 | 32μF | +50% −20% | 350V | M131622 |
| C20 | 32μF | +50% −20% | 350V | |
| C21 | 0·05μF | ±20% | 350V | M129662 |
| C22 | 0·5μF | ±20% | 500V | M129604 |
| C23 | 0·5μF | — | 1000V | M129673 |
| C24 | 0·5μF | — | 1000V | |

| Ref. | Description | Part Number |
|---|---|---|
| RV1 | 2·5kΩ potentiometer | M158526/3 |
| RV2 | 2MΩ potentiometer | M158553 |
| RV3 | 2MΩ potentiometer | M158553 |
| RV4 | 2MΩ potentiometer | M158553 |
| RV5 | 2MΩ potentiometer | M158553 |
| RV6 | 2MΩ potentiometer | M158553 |
| RV7 | 100kΩ potentiometer | M158553/3 |
| RV8 | 10kΩ potentiometer | M158553/4 |
| MR1 | Germanium diode | M183526 |
| MR2 | Rectifier | M183514/2 |
| MR3 | Rectifier | M183513 |
| MR4 | Rectifier | M183513 |
| T1 | Transformer | M159513 |
| L1 | Choke | KA88089/2 |
| S1 | 4-way, 3-pole switch | M153587 |
| S2 | 6-way, 2-pole switch | M153588 |

| Ref. | Valve | Base | Ref. | Valve | Base |
|---|---|---|---|---|---|
| V1 | 6AM6 | B7G | V3 | 6AM6 | B7G |
| V2 | 6AM6 | B7G | V4 | 24D | B9G |