INTRODUCTION

1. The oscilloscope Type 13A Stores Reference 10S/831 is a general-purpose twin-beam portable cathode-ray oscilloscope and monitor. Fig. 1 shows a general view of the instrument. It is fully tropicalized and resembles in general design the oscilloscope Type 13, but incorporates a number of improved features. The cathode-ray tube employed is electrostatically focused and deflected. Its screen is of the green-trace short-afterglow type and has an effective diameter of 4½ in. On it, either beam will display a graphical representation on a time axis of the variations of a voltage or of any other physical quantity which can be reproduced as a voltage. The twin-beam facility enables two independent voltages to be displayed simultaneously on the same time scale.

2. The time-base is linear. When free-running, it can operate at recurrence frequencies from 2 c/s to 750 kc/s; the sweep velocity is high enough at the top of the range for waveforms having recurrence frequencies up to 10 Mc/s to be readily investigated. The timebase may be synchronized to the input waveforms. In addition, calibration markers at intervals of 1 μS or of 10 μS may be applied to both traces independently of the work voltages; and the vertical deflection may be calibrated in terms of voltage (*see Chap. 2*), so that with the aid of the millimeter graticule provided with the instrument accurate quantitative measurements can be made. The timebase sawtooth waveform is available externally for sweeping a visual-alignment signal generator or frequency modulated oscillator, or for other special purposes. If required, external deflection may be applied to the X1-plate, either direct or through a times-30 amplifier; the internal timebase is then suppressed. This facilitates the production of circular traces or Lissajou's figures.

3. Alternatively, the timebase may be triggered from either a positive or a negative wavefront; it is then suitable for monitoring pulse waveforms from 1 μS to several milliseconds in duration. This arrangement is also suitable for single-stroke operation for observation of transient or non-repetitive waveforms.

4. The input to the Y-plates of the cathode-ray tube may be direct (DC or AC connection) or amplified by the separate Y1 and Y2 amplifiers. They have gains up to 27 times, subject to the falling-off at the ends of the video-frequency spectrum which may be observed in Fig. 8.

5. Alternatively the amplifiers may be connected in cascade to the Y1 plate, giving a gain of up to 750 times. For improved HF response the cascaded amplifiers may be HF compensated; the gain is then up to 60 times, the amplifier having the much improved response shown in fig. 8. In practice waveforms containing frequency components up to 10 Mc/s may be displayed with fair accuracy. For investigation of waveforms of very large amplitude, on the other hand, a switched attenuator is available on Y2 input only.

6. For investigating circuits of very high impedance, and radio-frequency circuits, a cathode-follower probe of good frequency response is provided whose output may be switched to either Y-plate or either amplifier.

7. The instrument is designed to operate from 115V or 230V 50 c/s AC supply, and its power consumption is 160 watts. The overall dimensions are 24 in. by 15 in. by 10 in., and the weight is approximately 75 lb. These figures include the detachable front cover, which carries the cathode-follower probe and connector, together with the

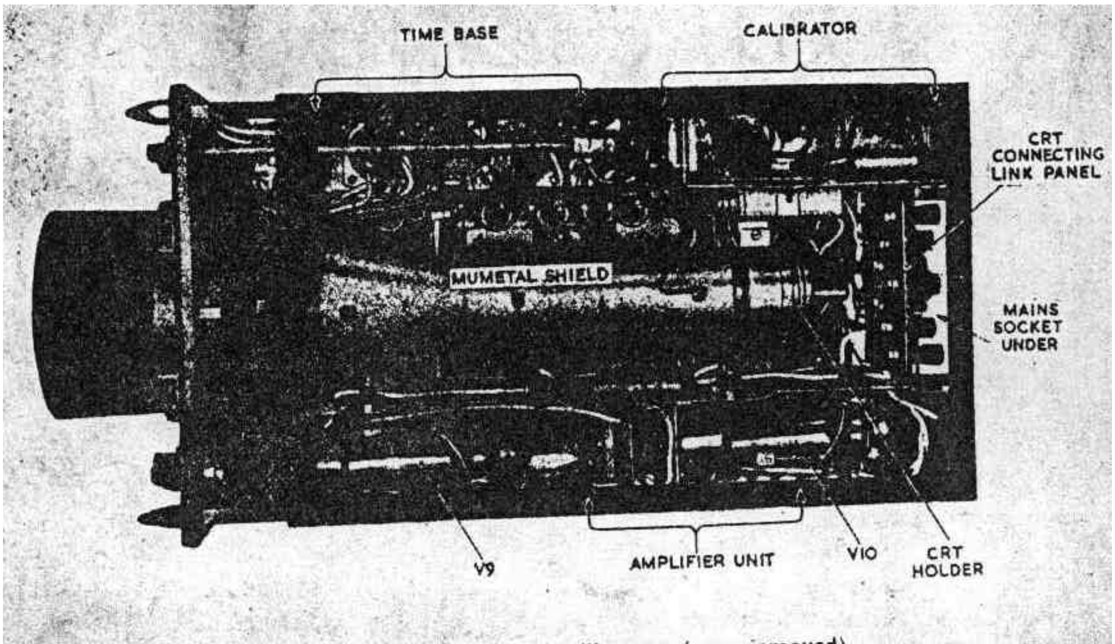


Fig. 2. Plan view of oscilloscope (case removed)

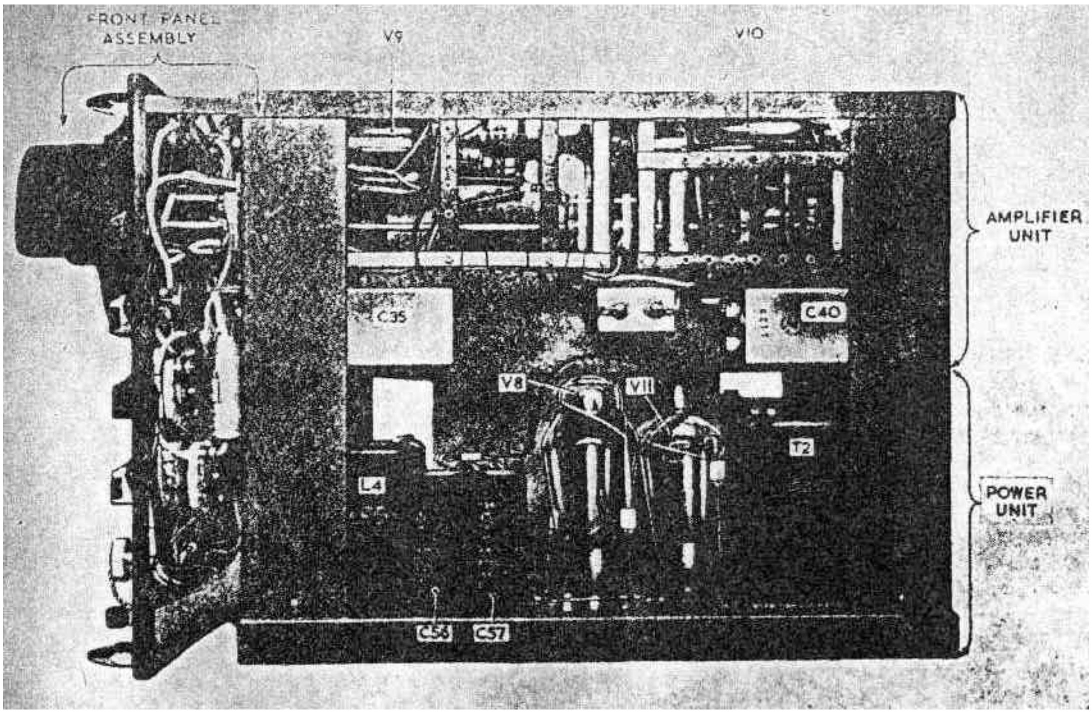


Fig. 3. Right side of oscilloscope (case removed)

connector leads and the mains connector when they are not in use. On the hinged lid which covers the probe unit are etched brief operating instructions and the oscilloscope circuit diagram.

Note...

The circuit diagram etched inside the hinged lid may not incorporate the latest modifications and amendments. Always check by referring to this publication.

CIRCUIT DESCRIPTION

General

8. The complete circuit diagram of the oscilloscope Type 13A is shown in fig. 9. It will be seen that the circuit comprises four distinct units interconnected by suitable switching arrangements. The units are the power unit, the cathode-ray tube and its associated network on the front panel, the timebase and calibrator, and the amplifier unit. These units form separate assemblies within the oscilloscope, as can be seen from the photographs in fig. 2 to 4. All the controls and most of the cathode-ray tube network are mounted on the front panel; the power unit forms the base of the instrument, and the amplifier and timebase/calibrator assemblies are on either side of the cathode-ray tube itself.

Power unit

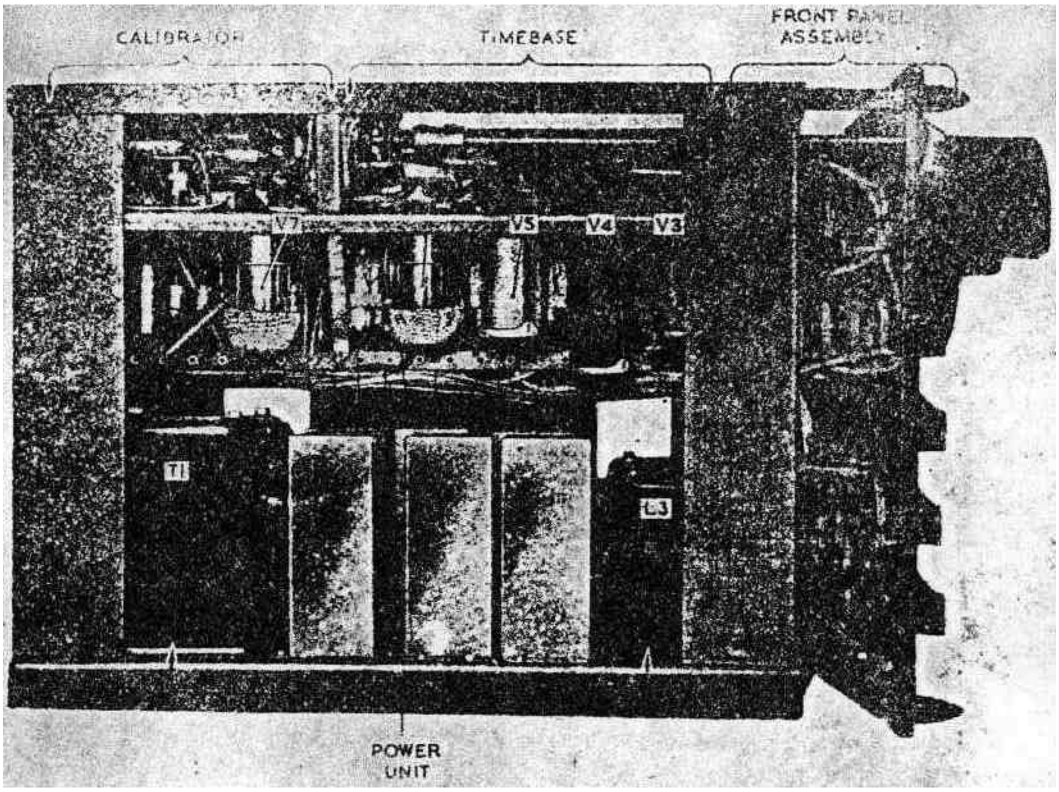
9. The mains input is to the 3-pole Mk. 4 plug at the rear of the oscilloscope. Separate transformers T1 and T2 are used for the HT and LT supplies. The LT transformer may be switched on independently of the HT; this enables the heaters to be switched on for a warming-up period before the oscilloscope is used, a feature especially valuable when there is a possibility of moisture being present in the neighbourhood of the EHT circuits. T2 also supplies a 50V peak-to-peak 50 c/s sine-wave for Y-calibration. Each transformer is separately protected by cartridge fuses situated on the front panel. Details of the connections to be changed when the mains voltage is altered from 230V to 115V are given later in the operating instructions. A red pilot lamp on the front panel indicates whether power is being applied to T2.

HT and EHT supplies

10. The HT rectifier circuit is of a conventional type using the double-diode V8 (CV 378) and a two-section LC ripple filter. The HT voltage during normal operation is approximately +430V to the amplifier unit; this is dropped to +380V for the timebase stages by R26. The EHT rectifier supplies −1,200V to the cathode-ray tube network from a half-wave rectifier V11 (CV 1120) and an RC ripple filter comprising R79, C56 and C57.

Cathode-ray tube circuit

11. The cathode-ray tube (CV 1596) is operated with its final anode and deflector plates at about earth potential, and with a large negative voltage on the cathode and grid. Advantages of this arrangement are that direct connections may easily be made from external circuits to the deflector plate (which must necessarily be at about final anode potential), and that hand-capacity effects on the trace are much reduced.



Cathode-ray tube

12. The cathode-ray tube itself is of a conventional type except that there is a splitter plate across the opening in the third anode (*see fig. 5*). This splitter plate, which is at about earth potential, splits the stream of electrons into two separate beams, each of which is controlled independently by the nearer Y-plate so that two independent traces are produced on the screen. The same voltage on Y1 and Y2 plates will deflect the respective beams in opposite directions so that while the Y1 trace is conventional (positive voltage deflects upwards), the Y2 trace is "upside-down." This fact must be borne in mind when comparing two waveforms on the two traces. The splitter plate is also used to modulate both traces with calibration pips or the output from the probe unit as explained in the operating instructions. The X-plates deflect both beams simultaneously, and with normal connections the spots move conventionally from left to right of the screen. X1 plate is used for timebase deflections and X2 for X-shift.

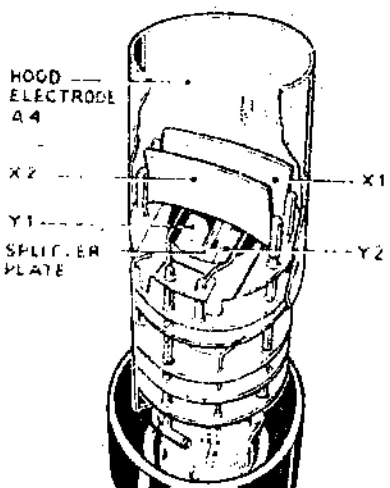


Fig. 5.
Electrode assembly of twin-beam CRT

13. The appropriate potentials for the tube electrodes are obtained from the chain of resistors R56 to R62, R71 and R77 which extends from the +430V line down to the -1,200V line. The most negative electrode is the grid, whose potential is controlled by the BRILLIANCE potentiometer R77. The FOCUS control R62 affects the potential of the second or focusing anode. Shift voltages, both positive and negative, are taken from R73, R69 and R63 for X-shift, Y1-shift and Y2 shift respectively.

Timebase circuit

14. The timebase circuit used in the oscilloscope Type 13A gives a linear negative-going sawtooth waveform with rapid flyback for application to the

X1-plate of the cathode-ray tube and to any external circuit requiring it, for example a frequency modulated oscillator. Its velocity, and hence its recurrence frequency when free-running, can be adjusted over a wide range by coarse and fine controls. Controls are also provided for amplitude and flyback velocity. Square-wave outputs are also provided to the cathode-ray tube grid (for flyback blackout) and to the calibrator circuits. The timebase can operate either free-running or triggered; when it is not in use the valve V5 can be employed as a times–30 amplifier for the external waveform being applied to the X1-plate.

Normal Miller timebase action

15. The timebase valve V5 (pentode CV1091) itself works as a Miller integrator stage, operated by a multivibrator consisting of two pentodes, V3 (CV1091) and V4 (CV173). In the ordinary Miller circuit a high-gain pentode is arranged with capacitive feedback from anode to grid (*fig.* 6). The action is as follows:—

(1) Before the trace starts, the anode current is cut off by a large negative voltage on the suppressor-grid, so the anode is at HT potential. The grid resistor is returned to a positive potential, so that grid current tends to flow and the grid remains near earth potential.

(2) To start the trace the suppressor-grid is raised to earth potential so that, instantaneously, the space current which was previously flowing to the screen is diverted to the anode, whose potential starts to fall. The fall is transferred to the grid since the grid-anode condenser C cannot change its charge instantaneously.

(3) The grid potential is thus driven down nearly to cut-off, so tending to reduce the anode current once more and halt the fall in anode potential. The resulting "Miller step" may be seen at the beginning of the trace period in waveform (a) of fig. 7.

(4) Condenser C now starts discharging through the grid resistor to a positive potential, raising the grid potential and tending to increase the anode current and lower the anode voltage once more; but the drop at the anode is transferred back to the grid by C, and an equilibrium is set up with the anode voltage falling linearly until it "bottoms." This linear fall is suitable for timebase deflection.

(5) When the suppressor-grid is taken negative once again, the anode current is cut off and the anode rises to HT level with a comparatively short time-constant depending on C and the effective anode load. This rise forms the flyback.

Timebase action in oscilloscope Type 13A

16. Here the normal arrangement of multivibrator has been somewhat modified in order to make the circuit more versatile. As fig. 6 shows, one multivibrator valve V4 has its cathode directly connected to the anode of the Miller valve V5. This means that the timing of the multivibrator is controlled by the Miller valve itself.

Free-running timebase operation

17. When the TRIG.-SYNC. switch is in positions 3, 4, 5 or 6 (*fig.* 9) the timebase is self-operating. During the flyback period V3 is cut off and V4 is fully conducting. When V5 anode voltage, which is also cathode bias for V4, reaches a certain level the anode current of V4 will fall sharply; and the consequent rise in its anode voltage will raise the grid of V3 via C7 and so bring V3 into conduction. This positive-going edge from V4 anode is also applied to V5 suppressor to initiate the Miller timebase action. The fall in V3 anode potential is applied direct to V4 grid, so that V4 is fully cut off (*waveform* (c), *fig.* 7).

18. This state of affairs continues until V5 anode (and so V4 cathode) reaches a voltage low enough for V4 to start conducting again, so reversing the

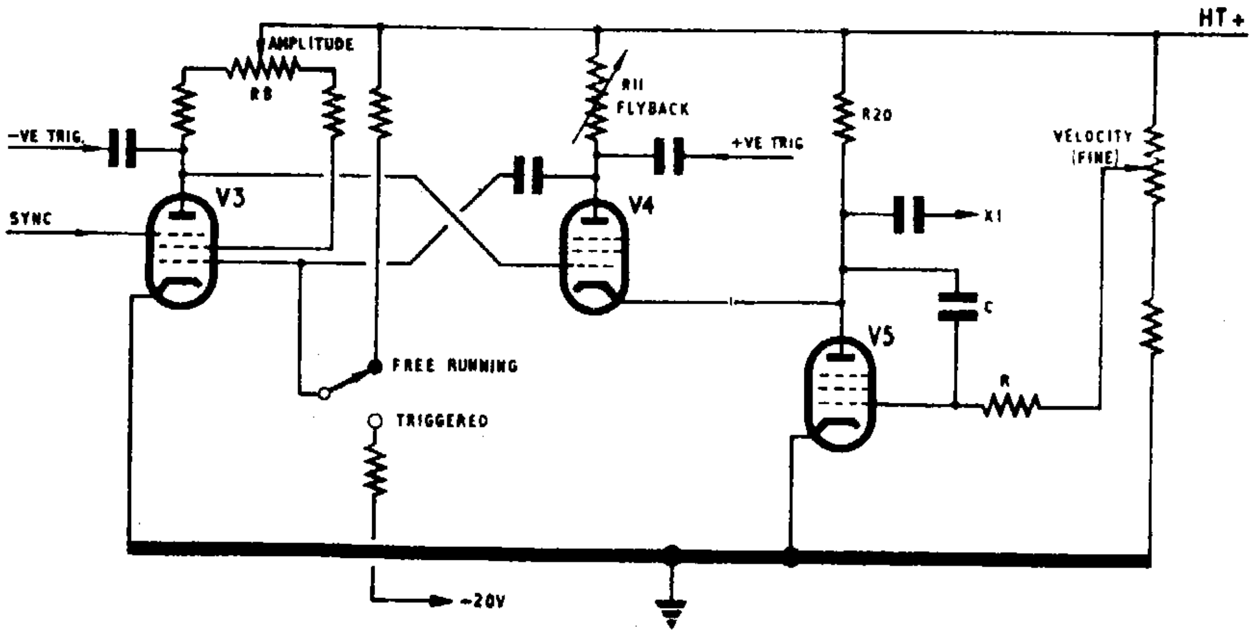
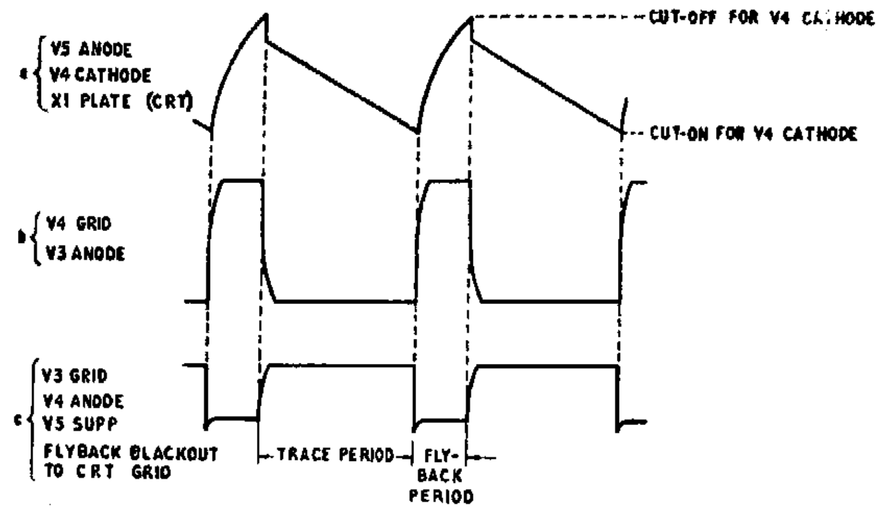


Fig. 6. Timebase circuit (simplified)



NOTE - SHAPE AND AMPLITUDE OF THESE WAVEFORMS WILL DEPEND ON THE SETTING OF VELOCITY, AMPLITUDE AND FLYBACK CONTROLS

Fig. 7. Timebase waveforms (simplified)

multivibrator. The latter now applies a negative edge to V5 suppressor, and thus terminates the timebase period. The exact voltage at which V4 cathode becomes sufficiently positive for V4 to conduct (i.e. the sawtooth amplitude) clearly depends on V4 grid voltage. This in turn is controlled by the potentiometer R8, which thus forms the AMPLITUDE control.

19. Control of VELOCITY RANGE is obtained by switching in different values of C and R. The FINE VELOCITY control R13 alters the "aiming potential" of V5 grid. During flyback the charging path for C is the valve V4 in series with the variable resistor R11; the latter therefore provides control of flyback velocity (labelled FLYBACK). It can be used as a fine frequency control at the higher velocity ranges.

20. When the circuit is in this free-running condition it may be synchronized to run at some given frequency (or a sub-multiple thereof) by injecting a proportion of the signal concerned into the suppressor-grid of V3; this will cause the multivibrator to reverse prematurely in synchronism with the incoming signal. Excessive amplitude of the synchronizing waveform may be avoided by turning down the SYNC. AMP. control to the minimum setting for which good locking is obtained.

21. The square-wave from the grid of V3, which is applied to the suppressor-grid of the Miller valve V5 is also used to operate the calibrator circuits. The similar square-wave from V4 anode is applied through the high-voltage condenser C18 to the cathode-ray tube circuit in order to black out the flyback.

Triggered timebase operation

22. When the TRIG.-SYNC. switch is in position 1 (−VE) or 2 (+VE) it will be seen from fig. 9 that the circuit is modified for triggered operation. The grid resistor R5 of the valve V3 is now returned to a negative potential of about 20V, so that V3 is normally cut off, while V4 is conducting and C is charged up nearly to full HT. The Miller valve V5 will conduct moderately, but the Miller action cannot start while V4 is conducting, so conditions resemble those during the flyback of the free-running system described previously.

23. When a positive trigger pulse of 30V or more in amplitude is applied to V3 grid, V3 and V4 operate as a kind of flip-flop, since V3 begins to conduct. By the usual cumulative action V4 is cut off, thus allowing V5 to starts its Miller time-base action. When V5 anode, and so V4 cathode, has fallen far enough to bring V4 into conduction again, the flip-flop reverses; C is rapidly re-charged to HT, and the original situation is restored until a new trigger pulse arrives.

24. A negative trigger pulse applied to V4 grid will clearly be equally effective in starting the flip-flop action, since V4 anode will rise and bring V3 into conduction as before.

25. Square-waves from the flip-flop are again supplied for flyback black-out, and to operate the calibrator circuits.

26. Normally a positive trigger pulse will be differentiated by the short time constant C1, R3, giving a short positive pulse at the front edge and a short negative pulse at the back edge. To prevent the negative pulse from reversing the flip-flop and so terminating the trace prematurely, the diode V1 (CV 1092) is included to pass only the positive pulse. This also ensures that no timebase waveforms are fed back to the triggering source. Similarly, the diode V2 (CV 1092) is included when negative-going trigger pulses are in use.

27. It will be observed from fig. 9 that during triggered operation the large condenser C18 is virtually connected in parallel with C7, so that the flip-flop pulse duration of V3 and V4 acting as an ordinary flip-flop would be much longer than any trace duration actually available. In fact, therefore, the operation is always terminated by the Miller run-down bringing V4 into conduction, and not by ordinary flip-flop action.

28. The timebase will start operating after a delay of 0·25 μS for negative trigger pulses and 1 μS for positive, provided that the trigger pulse edge has a reasonably short rise time. The timebase can be triggered on any velocity range by pulses of about 30V amplitude or more, and timebase durations from 1 μS to 400 mS are available. It should be noted, however, that at the highest velocities the trace brilliance will be too low for satisfactory observation unless the trigger recurrence frequency is at least 300 pulses per second, and even then the viewing hood must be used.

29. The controls of AMPLITUDE, VELOCITY RANGE, FINE VELOCITY and FLYBACK operate just as they do during free-running operation. It will be seen from fig. 9 that in all positions of the VELOCITY RANGE switch except 1 and 2 the internal timebase waveform is supplied to the X1 socket on the front panel for external use.

External timebase operation

30. On position 2 of the VELOCITY RANGE switch, marked X × 1, the X1 socket on the front panel is AC connected by a 0·25μF condenser C8 to V5 anode and so to the X1-plate of the cathode-ray tube, V5 being now permanently cut off. Thus external timebase waveforms may be applied to the oscilloscope.

31. When only a small external timebase waveform is available, the VELOCITY RANGE switch S2 may be turned to position 1, marked X × 30. Here the timebase condenser is disconnected by wafer S2a, and the V5 anode load reduced below 22,000 ohms. Also, S2c brings the cathode bias system R21, C14 into circuit. V5 now becomes a video amplifier with a fixed gain of about 30 times, so that external timebase waveforms applied to X1 socket are amplified 30 times before connection to the X1 plate itself.

Internal synchronization

32. During free-running operation the most commonly used sources of synchronization are the work voltages and the 50 c/s mains, so facilities are provided to synchronize the timebase from them without external connections by setting the TRIG.-SYNC. switch S1 to 50 C/S, Y1 or Y2 as required. The appropriate connections are then made by wafer S1a.

Calibrator

33. To enable time calibration marks to be displayed on the timebase, a calibrator circuit is included in the oscilloscope. It employs two double triodes V6 and V7 (both CV 1988). Here V7A is arranged as a Hartley oscillator. The oscillatory inductance, as selected by switch S5, is L1 for 100 kc/s operation and L2 for 1 Mc/s operation. These correspond to marker intervals of 10 microseconds and 1 microsecond respectively. C19 is the oscillatory condenser in either case.

34. During the flyback period V6B is cut off at the grid by a negative voltage from V3 grid, so that V6B anode is at HT voltage, and V6A is conducting heavily because its grid is DC connected to V6B anode. Thus during flyback the oscillatory circuit is virtually short-circuited by the valve V6A, and no calibration marks are produced.

35. When the trace starts, a positive square wave is applied to V6B grid from V3 grid, so V6B anode falls and V6A is cut off. This removes the heavy damping from the LC oscillatory circuit, which therefore begins to oscillate. The resulting sinewave is applied to the grid of the pulse-forming amplifier V7B through C23. This grid biases itself back until only the positive peaks of the sinewave cause V7B to conduct, and so a train of short negative-going pulses is produced at V7B anode. These pulses are applied via C25 to the splitter plate of the cathode-ray tube, and so cause markers to appear in opposite directions on the two traces.

Y-plate input circuits

36. The type of input to the Y-plates is chosen by the switch S3, marked Y PLATE SELECTOR. The five positions of the switch give, in succession, DC connection (direct to Y-plates); AC connection (through 0·25 microfarad condensers); A1 A2 (one stage of amplification on each Y-plate independently); 2A1 (two stages of amplification in cascade to Y1-plate, Y2-plate restored to AC connection); and 2A1HF (two cascaded stages of amplification to Y1-plate with extra HF compensation, Y2 again restored to AC connection).

37. When the DC and AC positions are used, the work voltages must be applied to Y1 and Y2 sockets on the front panel. In the A1 A2 position the A1 and A2 sockets are used, but in the 2A1 and 2A1HF positions the A1 socket is used for one work voltage and the other is applied to Y2 socket.

Position 1 (DC)

38. In position 1, DC, direct connections are made from the Y1 and Y2 sockets on the front panel to the Y1 and Y2 plates, by wafers S3j and S3d respectively.

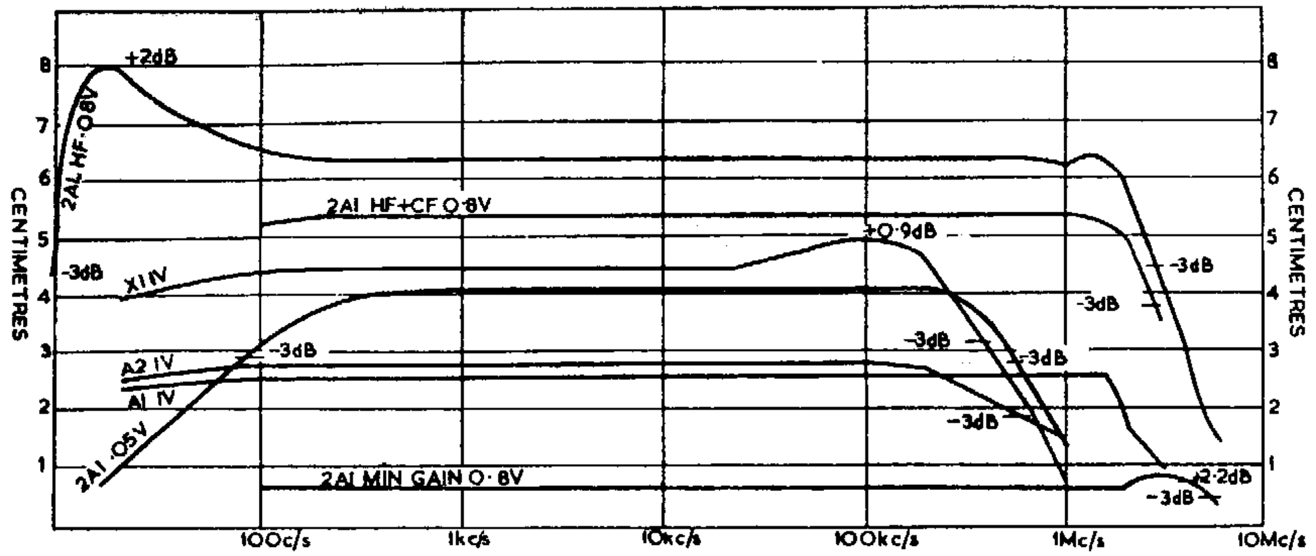
39. The shift networks are connected in this, as in all, positions, but the sources of DC shift voltage have a very high impedance. When, therefore, the Y PLATE SELECTOR switch is at position 1 the Y shift controls will be inoperative unless the external sources of work voltage also have a very high impedance. In such cases the Y shift controls should be set at approximately mid-position to prevent the shift voltages affecting the external circuit.

Position 2 (AC)

40. In position 2, AC, the Y1 and Y2 sockets are AC connected to the plates through 0·25 μF condensers C46, C43 (*fig.* 9). The Y-shift controls are now always effective.

Position 3 (A1 A2)

41. In positions 3, A1 A2, a single stage of amplification is applied to each Y-plate. V9 (pentode CV9) is the A1 amplifier, and V10 (pentode CV9) the A2 amplifier. The amplifiers are conventional RC-coupled video-amplifiers, with 3,000-ohm anode loads and HF compensation supplied by the inductances L5, L6 and L7. The principal cathode bias resistors of 120 ohms are by-passed by 500 μF electrolytic condensers C36, C41. The variable resistors R38 and R48 are unby-passed cathode resistors which give a variable degree of negative feedback, and so provide the controls of A1 GAIN and A2 GAIN respectively. At the maximum gain settings, Y deflections greater than the screen diameter are obtainable without distortion.



2A1 HF MAX. ·O8V INPUT CUT OFF – 9c/s – 3 Mc/s
2A1 HF MIN. ·O8V " " " = 9c/s – 5·5 "
2A1 HF MAX. & CATHODE FOLLOWER " " = 9c/s – 2·9
2A1 MAX. 50M V INPUT " " = 80c/s – 550kc/s
A1 MAX. 1·OV INPUT CUT OFF = 2 Mc/s
A2 " 1·OV " " " = 550kc/s
X1 1·OV " " " = 400kc/s

Fig. 8. Frequency response of Y-amplifiers

Position 4 (2A1)

42. In position 4 of the switch S3 the two amplifier stages V9 and V10 are cascaded and the output is applied to the Y1-plate. Both the A1 GAIN and A2 GAIN potentiometers are now effective in controlling the gain of the combination which may be varied from 8 to 750 times. The Y2-plate is restored to AC connection to Y2 socket by means of wafer S3d; the A2 socket is now left unconnected.

Position 5 (2A1 HF)

43. In position 5 the amplifiers are still cascaded to Y1-plate. The frequency response is considerably improved (*fig.* 8), but the maximum gain is reduced to 60 times.

44. These changes are effected by the introduction of negative feedback from V10 anode via R46 and C38 to the cathode circuit of V9, switched in by wafer S3h. At the same time wafer S3g shorts out the A2 GAIN control, while the S3g short-circuits L6 and so increases the frequency at which frequency compensation of V9 stage takes effect.

45. In this position also the A2 socket is disconnected, and Y2 plate is AC connected to the Y2 socket by wafer S3d.

Y2 attenuator

46. In normal use the Y2 ATTEN. switch S6 is left in position 5, marked ÷ 1. If a waveform of excessively large amplitude is to be observed, however, it may be attenuated by a factor of 2, 4, 8, or 16 by S6 which selects the appropriate steps on the resistance chain R64–68. At high frequencies the stray capacitances across the resistors would tend to assume control, so the condensers C48–50 have been included to provide capacitive attenuation in the correct ratios at those frequencies. The attenuation steps are not, however, accurate above 100 kc/s.

47. The bottom of the attenuator chain R64–R68 is decoupled by a 0·1 μF condenser C51, and is returned to the slider of the Y2 SHIFT potentiometer R63. The shift setting therefore affects the accuracy of the attenuation steps on DC and very low frequencies, especially in the ÷ 8 and ÷ 16 positions.

Cathode-follower probe

(Probe assembly Type 2, 10AE/235)

48. The cathode-follower probe supplied as an accessory with the oscilloscope Type 13A comprises a miniature pentode V12 (CV 136) arranged in a cathode-follower circuit in a compact assembly at the end of a 3 ft. connecting cable. It is used for investigating circuits where operating conditions would be affected if a Y-plate or Y-amplifier and their input leads were connected directly. The input capacitance of the cathode-follower used here is less than 5 pF and the input resistance better than 5 megohms, compared with 80 pF and 3·3 megohms for direct Y-plate connection.

49. The PROBE SELECTOR switch S4 will switch the input from the cathode-follower probe to either Y-plate or to either amplifier; but in position 2 the input is connected to the CRT splitter plate to give equal and opposite deflections on the two traces.

WARNING

Voltages exist in this instrument which are dangerous to human life. In particular, the potential difference between the cathode-ray tube grid and the amplifier HT line is over 1600 volts. The oscilloscope must not be operated with the case off except when servicing it, and then the greatest care must be taken. Do not touch the tube connecting links at the rear until at least 10 seconds have elapsed after switching off. Always keep the cap provided over the 6-pole Mk. 4 fixed plug marked PROBE *on the front panel, when the probe is not in use.*

Preparations for use

1. After the oscilloscope Type 13A has been unpacked and all packing material removed, the general state of the instrument must be checked, and the mains transformer connections must be adjusted to suit the mains voltage in use. Most oscilloscopes supplied to the Service have been set by the manufacturer for 230 volts 50 c/s operation, but it is important to check this before switching on.

Mains transformer connections

2. To adjust the mains transformer connections, proceed as follows:—

(1) Release the two side clips and remove the front cover from the oscilloscope.

(2) Remove the viewing hood and graticule, and tilt the oscilloscope forwards on to the front panel protecting studs.

(3) Use a coin to unscrew the two case holding nuts at the rear, and remove the case.

(4) Turn the oscilloscope upside-down in order to obtain access to the underside of the power unit chassis. The connecting pins of the mains transformers T1 and T2 will be seen near the rear of the chassis.

(5) (a) *For 230 volts 50 c/s operation*, on each transformer strap pin 2 to pin 3 (*see fig.* 2). Use 20 S.W.G. connecting wire, P.V.C. covered, and make a sound soldered joint to each pin. Check that the mains leads are still connected to pins 1 and 4 of each transformer. (Brown and green leads for the HT transformer T1, and green and white leads for the LT transformer T2.)

(b) *For 115 volts 50 c/s operation*, on each transformer strap pin 1 to pin 3 and strap pin 2 to pin 4 (*see fig.* 2). Use 20 S.W.G. connecting wire, P.V.C. covered, and make a sound soldered joint to each pin. Check that the mains leads are still connected to pins 1 and 4. (Brown and green leads for the HT transformer T1, and green and white leads for the LT transformer T2.)

(6) While the case is off, check that all the valves and the CRT are undamaged and secure in their bases, and that all valve top-cap connectors are in position.

(7) Put back the case, the viewing hood and the graticule.

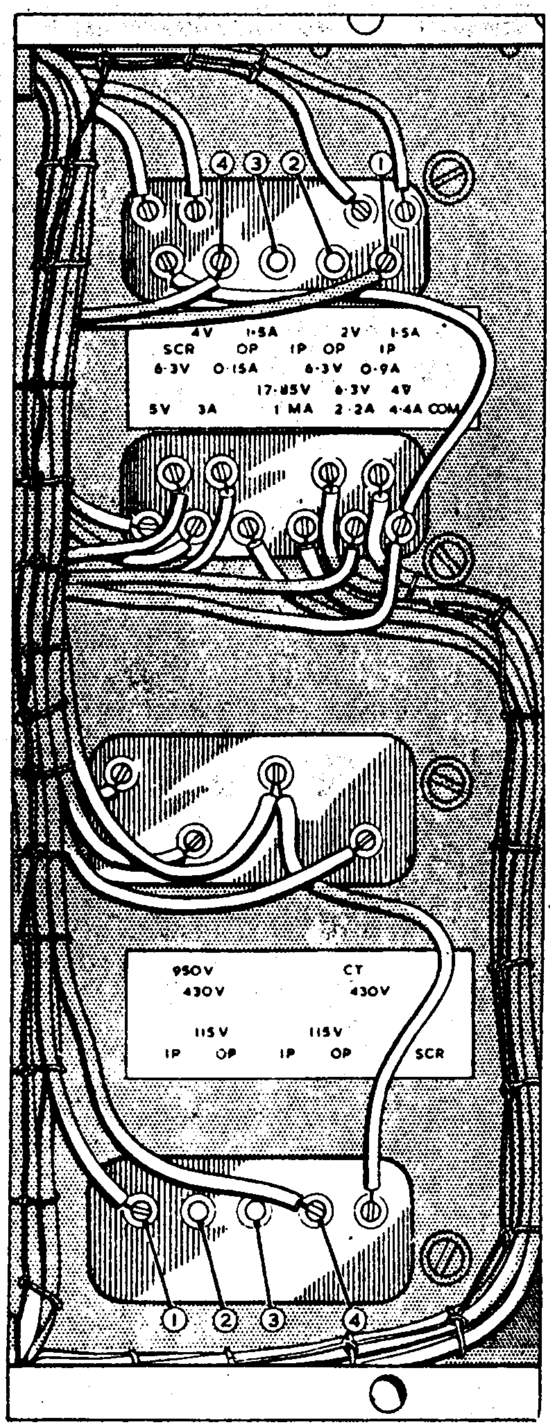


Fig. 2. Mains transformer connections

Mains fuses

3. 2 amp. cartridge fuses (fuse Type 13, 10H/10269) must be used for 230 volts operation, and 3 amp. cartridge fuses (fuse Type 28, 10H/1804) for 115 volts operation. Insert the correct fuses in the fuseholders on the front panel. Spare fuses are stored below the tube connecting panel at the rear of the instrument (*see fig.* 4).

Mains connector

4. The 3-core mains connector with its 3-pole Mk. 4 socket must next be removed from the front cover where it is stored, and fitted with a suitable 3-pin plug. The colour-coding of the cores is as follows:—

Phase	*Red*
Neutral	*Blue*
Earth	*Green*

Switching on

5. Plug in the mains connector, and turn the POWER switch S7 to LT. The lighting of the pilot lamp indicates that power is being supplied to transformer T2, and so to the valve and CRT heaters. Leave the oscilloscope in this condition for a warming-up period of one minute before proceeding further. If the presence of damp is suspected, leave for 30 minutes before proceeding further. Now turn S7 to HT.

Obtaining the traces

6. To obtain the Y1 and Y2 traces proceed as follows:—

(1) Plug in connectors to the Y1, Y2 and E sockets and clip their crocodile clips together to prevent hum voltages being picked up by the Y plates. The connectors will be found inside the front cover.

(2) Turn the BRILLIANCE control right down (counter-clockwise).

(3) Set the Y PLATE SELECTOR switch at AC.

(4) Turn the AMPLITUDE control about two-thirds of the way up; do not turn it right up as this stops the timebase at certain velocity settings.

(5) Set the TRIG. SYNC. switch to EXT. in order to obtain a free-running timebase.

(6) Turn up the BRILLIANCE control until the two traces become visible.

Note . . .

Do not use excessive brilliance or the screen of the CRT will be "burnt," especially if the timebase stops. If the workshop is brightly lit, use the viewing hood provided to improve the trace visibility.

(7) Adjust the FOCUS control until the sharpest possible traces are obtained.

(8) Position the traces suitably on the screen by means of the X SHIFT, Y1 SHIFT and Y2 SHIFT controls.

Examination of waveforms

7. A common use of the oscilloscope is to inspect a regularly recurring waveform; for example, a sine-wave or a square-wave, at the anode of a valve amplifier. Proceed as follows:—

(1) Check that the CAL. MARKERS and PROBE SELECTOR switches are both OFF, and that the Y PLATE SELECTOR is set to AC.

(2) Remove the Y2 trace from the screen by the Y2 SHIFT.

(3) Clip the connector from the oscilloscope E socket to the chassis of the equipment under test.

Note

Exceptionally, the chassis of the equipment under test may not be earthed. Since the oscilloscope E socket is connected to the mains earth, a large condenser, say 2 microfarad 400 volts DC wkg, should then be placed in series with the earth connector.

(4) After making sure that the equipment under test is switched off, clip the Y1 connector to the anode pin concerned, and switch on the equipment.

(5) Turn the TRIG. SYNC. switch to Y1, and turn up the SYNC. AMP. to about one-third of its maximum.

(6) Adjust the VELOCITY RANGE and FINE VELOCITY controls until two or three cycles of the waveform are brought to rest on the trace. If the picture exhibits "jitter," turn up the SYNC. AMP. until proper locking is obtained. Slight adjustment of the FLYBACK and AMPLITUDE controls will usually help to obtain a steady picture on the higher velocity ranges.

8. Any other waveform in the equipment may now be examined simultaneously with the first by using the Y2 connector. Although in correct time relation to the Y1 trace, the Y2 trace will be inverted for the reasons explained in Chap. 1, para. 12.

DC connection

9. Provided that the waveform to be examined has no large DC component which would shift the trace off the screen, it is better to use DC connection whenever possible, by turning the Y PLATE SELECTOR switch to DC.

Note . . .

The input condensers C43, C46, etc. are rated at only 500 volts DC working. If the DC component of the waveform to be examined is greater than this, place a 1 microfarad condenser (not electrolytic) of sufficiently high voltage rating in series with the connector lead, and revert to DC connection; do not attempt to use the amplifiers or the AC position.

Use of Y2 attenuator

10. If the amplitude is so great as to sweep the spot beyond the edge of the screen in each direction, apply the signal to Y2 socket and reduce the amplitude to a convenient level by using the Y2 ATTEN. switch. Any signal being displayed concurrently on the Y1 trace is not affected by the use of the attenuator.

11. Always return the Y2 ATTEN. switch to the ÷1 position after use, or misleading results will be obtained in subsequent work.

12. The attenuator is not suitable for accurate work on DC and very low frequency work voltages, for the reasons given in Chapter 1, para. 47.

13. The nominal attenuation ratios are subject to errors between adjacent steps of up to 10 per cent. at audio frequencies and up to 20 per cent. at 100 kc/s; above 100 kc/s the attenuator is suitable for qualitative work only.

Use of amplifiers

14. If the amplitude of the waveform under observation is inconveniently small, transfer the connectors to A1 and A2 sockets and set the Y PLATE SELECTOR to A1A2. Adjust the gain to a suitable level by A1 GAIN and A2 GAIN respectively.

15. If even more amplification of one waveform is required, apply it to A1 socket and switch the Y PLATE SELECTOR to 2A1. Both A1 GAIN and A2 GAIN now control the gain of the cascaded combination; care must be taken not to overload A2 by using excessive gain on A1, or distortion of the trace will be caused. Note that Y2 plate is now AC-connected to Y2 socket.

16. If amplification proves to be necessary when investigating IF or RF circuits, or irregular waveforms of high recurrence frequency, turn the Y PLATE SELECTOR to 2A1HF and apply the signal to the A1 socket. Although the maximum gain obtainable from the cascaded amplifiers is reduced, the frequency response at the higher frequencies is much improved in this position (*see fig.* 8, *Chap.* 1).

Precautions when using amplifiers

17. When full gain is being used with both amplifiers in cascade, care is needed to prevent hum and other unwanted signals being picked up on the connector leads. This trouble is especially marked when the work voltage comes from a high-impedance source. In this case use the cathode-follower probe unit.

18. Whenever amplifiers are being employed, use the minimum gain consistent with satisfactory observation of the waveform. Phase distortion, which can be serious at the lower frequencies, is reduced by keeping the gain as low as possible.

Loading of external circuit

19. When the impedance of the external circuit is high, the latter may be affected by the oscilloscope input resistance, which is about 3 megohms with direct connection and less with amplifiers when these are being used with full gain. At low frequencies only it is possible, but seldom desirable, to reduce this loading effect by placing a resistance of several megohms in series with the connector lead, and turning up the amplifier gain to compensate for the reduced input. At higher frequencies serious distortion of the waveform would be caused by this method, so the cathode-follower probe must be used instead.

20. During investigations into IF and RF tuned circuits, trouble may be experienced from the detuning effect of the oscilloscope capacitance of about 80 picofarads placed across the tuned circuits. To obviate this place a small capacitance (say 2 picofarads) in series with the connector lead concerned, and use increased amplifier gain to overcome the resultant loss of input. Alternatively, use the cathode-follower probe which has an input capacity of only 5 picofarads.

Use of cathode-follower probe

21. If, for example, the cathode-follower probe signal is to be displayed on Y1 trace, proceed as follows:—

(1) From its storage position inside the front cover remove the probe assembly with its connector and 6-pole free socket (*see fig.* 3).

(2) Remove the cap from the fixed plug marked PROBE on the front panel, and plug in the connector.

(3) Wait one minute for the probe valve heater to warm up.

(4) Disconnect any external circuit connected to Y1 socket.

(5) Turn the Y PLATE SELECTOR to the AC position.

(6) Turn the PROBE SELECTOR to Y1 position.

(7) Now use the metal prod on the probe assembly as an ordinary test prod for circuit investigation.

22. To connect the cathode-follower probe to Y2 or to amplifier A1 or A2, set the PROBE SELECTOR switch accordingly. In each case the Y PLATE SELECTOR must be set appropriately, and any external circuits previously connected to the corresponding socket must be removed.

23. To display the signals from the cathode-follower probe on both traces simultaneously, turn the PROBE SELECTOR switch to Y1Y2. The probe signals are now applied to the CRT splitter plate, so other waveforms can be simultaneously applied to Y1 and Y2 pates.

Fig. 3.
Front cover, showing cathode-follower probe

24. After using the probe, always return the PROBE SELECTOR switch to OFF, remove the probe connector, and put back the cap over the 6-pole fixed plug marked PROBE.

Sync. sources

25. For most purposes the timebase will be synchronized to the waveform being displayed on either Y1 or Y2 trace; and the TRIG.-SYNC. switch will accordingly be set to one of these positions, so that synchronization will be effected internally.

26. It may happen that the sync. circuit loads the external circuit too much when the above method is used. In these circumstances adopt one of the following three possible methods of synchronization:—

(1) Use the EXT. position on the TRIG.-SYNC. switch, and connect a lead from the SYNC. socket to the same point as the Y1 connector, but with a large resistor (say 2·2 megohms) in series.

(2) Use EXT. sync from a different stage in the equipment being tested, where loading by the sync. circuit will do no harm.

(3) Use the cathode-follower probe to connect to the external equipment, and revert to internal sync. (Y1 or Y2 as appropriate). Loading by the sync. circuit will have very little effect on the cathode-follower output.

Single-stroke and triggered operation

27. For observation of transients and pulse envelopes adopt single-stroke operation by applying a suitable trigger pulse of some 30 volts amplitude to the SYNC. socket and turning the TRIG.-SYNC. switch to +VE or −VE as appropriate. The trigger pulse should preferably be slightly advanced in time on the transient waveforms if the whole of the waveform is to be seen. In monitoring radar waveforms the main radar sync. pulse will often provide a suitable trigger source.

Use of CRT connecting links

28. For special applications of the oscilloscope connecting links are provided to give direct access to the cathode, grid, X1, X2, Y1, and Y2 electrodes of the CRT. The links, together with an earth terminal, are mounted on a panel behind the door at the back of the oscilloscope (*see fig.* 4).

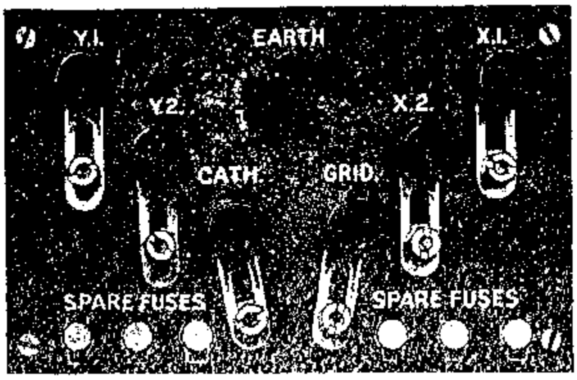


Fig. 4. CRT connecting link panel

29. The upper black insulated terminals are connected to the tube electrodes, and the lower terminals, which are smaller and slotted, go to the associated circuits. To make a direct connection to any one electrode, loosen both terminals, allow the link to drop, secure the link by tightening the cover terminal, and then make the connection to the upper terminal.

WARNING

The cathode and grid of the tube are at a high negative potential. Do not touch either link until at least 10 seconds have elapsed after switching off.

30. If brilliance modulation is required, proceed as follows:—

(1) Switch off the oscilloscope.

(2) After 10 seconds have elapsed open the GRID link as detailed in para. 29.

(3) Connect the brilliance modulation waveform through a condenser of at least 1,200 volts rating to the GRID terminal. Do not connect any leak resistor to the grid side of the coupling condenser; the 3·3 megohm resistor R75 is permanently connected across the link for this purpose.

31. When external brilliance modulation is applied in this way the BRILLIANCE control (potentiometer R77) continues to be effective, but the flyback blackout waveform from V4 anode does not.

Cathode connection

32. A condenser of at least 1,200 volts rating must also be used when making direct connections to the CRT cathode. In this case connect a resistor of about 100,000 ohms from cathode to negative EHT line in order to complete the cathode circuit; access to the negative EHT line is most easily obtained at the BRILLIANCE control (rear of front panel), at the junction of the 100 KΩ resistors R71 and R74.

Connection to deflector plates

33. When making direct connections to any deflector plate, include a leak resistor (say 4·7 megohms) down to earth if condenser coupling is used. If this is not done, the plate concerned will gradually accumulate electrons and so acquire an increasing negative charge, and the picture will drift off the screen.

Calibration markers

34. To measure the time duration of pulses or other waveforms, turn the CAL. MARKERS switch to the 1 μS or 10 μS position, when marker pips at the intervals selected will be displayed on both traces superimposed on the existing waveforms.

35. For waveforms of a low repetition frequency connect the 50 volts peak-to-peak 50 c/s sinewave from the 50 c/s socket to the Y2 plate to estimate time durations, remembering that one complete cycle is of 20 milliseconds duration.

External calibration markers

36. If the need arises to use time calibration markers from an external source adopt one of the following alternative procedures:—

(1) Apply the external calibration marker pulses to the CRT grid for brilliance modulation, as described in para. 30.

(2) Apply the external calibration marker pulses to the cathode-follower probe and set the PROBE SELECTOR to Y1Y2. The marker pulses are now applied to the CRT splitter plate, and the calibration pips will appear on both traces superimposed on the existing waveforms.

Calibration of Y deflection

37. When not using amplifiers it is sufficient for rough quantitative measurements to assume that 1 cm. deflection of either trace represents an amplitude of 30 volts peak-to-peak (i.e. about 11 volts r.m.s. for a sinewave).

Use of 50 c/s sinewave

38. For improved accuracy of calibration apply the 50 volts peak-to-peak sinewave from the 50 c/s socket to the Y plate concerned, note the resulting overall trace deflection in centimetres, and divide the latter into 50 in order to obtain the Y sensitivity in volts per centimetre.

External Y calibration

39. Both the above two methods are subject to error due to mains voltage fluctuations. For accurate quantitative work set the Y PLATE SELECTOR to DC and apply an external shift voltage which has been accurately measured by a voltmeter. Note the shift caused by this voltage, and so obtain an accurate deflection calibration.

40. When using amplifiers, use for calibration purposes a small external sinewave from a heater transformer or a beat frequency oscillator whose amplitude has been measured by a valve voltmeter; do not touch the amplifier GAIN control once the calibration has been carried out.