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OSCILLOSCOPE CT 316

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

Ministry of Defence

FOR USE IN THE

ROYAL NAVY

ROYAL AIR FORCE

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GENERAL PURPOSE OSCILLOSCOPE CT316

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General description

1. The oscilloscope CT316 is a general purpose oscilloscope utilizing a 3-inch CRT for waveform measurements. Continuous variation of timebase speeds is provided in five overlapping ranges; the time taken for the spot to cross the tube face can be varied from 100mS to 1μS. A built-in calibrator generating 1 Mc/s, 100kc/s and 10kc/s waveforms is available for time measurement. The timebase can be triggered by positive or negative step pulses of 1V minimum amplitude or by a sine wave of not less than 5V RMS value and provision is made for delaying the start of the timebase from a minimum of 7μS to a maximum of 10mS after the initiating pulse. The timebase can also be made self-running at a low recurrence rate.

2. AC or DC signal input may be selected and the signal amplitude can be measured on a Y-shift meter with full-scale deflections of $\pm$500V, $\pm$100V, $\pm$30V, $\pm$10V, $\pm$3V and $\pm$1V. On the $\pm$500V, $\pm$100V, $\pm$30V ranges, the signal amplifier response extends from DC to 5Mc/s (3dB down point) and on the last three ranges the signal amplifier response extends from DC to 3Mc/s, 1·5Mc/s, and 750kc/s (3dB down points) respectively. The leading edge of the trigger pulse may be displayed by switching in a wideband, 0·6μS delay line.

3. Direct access is provided to both Y-plates, and a signal may be applied to the CRT cathode to modulate the beam current.

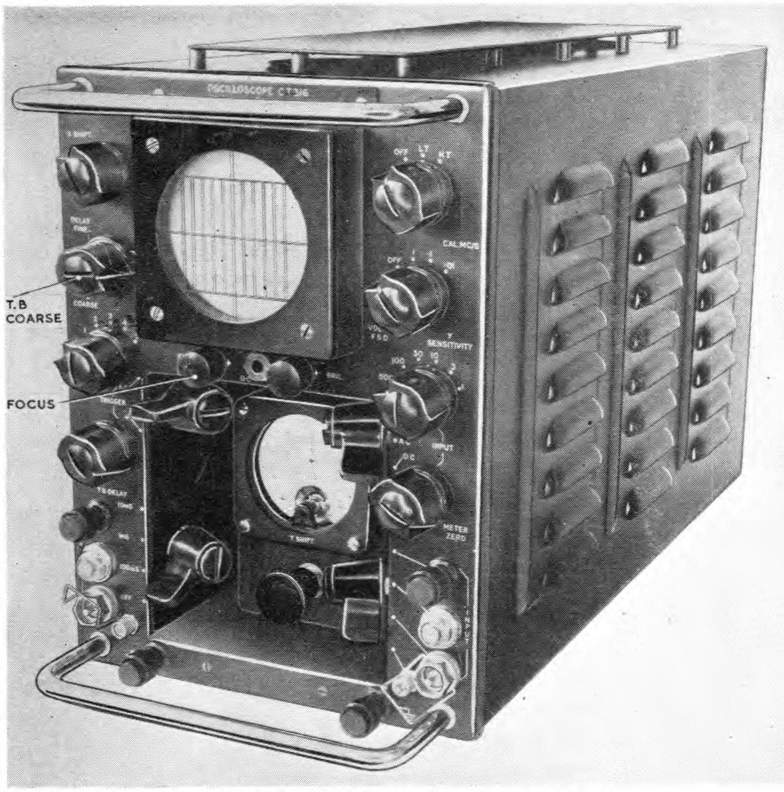


Fig. 1. General view of oscilloscope CT316

4. Power consumption is 100 watts at 200-250V, 40-60c/s.

5. The oscilloscope CT316 comprises the following items :—

(1) The oscilloscope (*Stores Ref. 10S/16605*)—A single unit in a rectangular metal case approximately 9 in. × 12 in. × 18 in. Weight 40 lb.

(2) Connector 9624 (*Stores Ref. 10HA/14023*)—A three-core cable 6 ft. 6 in. long with a socket for connecting to the oscilloscope and a 3-pin, 5-amp moulded plug for a 200-250V, 40-60c/s supply.

(3) Probe assembly 108 (*Stores Ref. 10AE/760*)—A frequency compensated attenuator with a loss of 20dB and low input capacitance.

Brief circuit description (*fig. 2*)

6. The block schematic of the oscilloscope is given in fig. 2. The trigger waveform is applied to a trigger amplifier which incorporates a phase inverter. After differentiation, the negative-going edge of the amplified trigger waveform is applied to a gate circuit. The gate circuit is operative only when any preceding timebase and its flyback have been completed. When operative, the gate circuit passes the trigger pulse to a pulse transformer, the output of which is fed either directly or via a timebase delay to an Eccles-Jordan bi-stable multivibrator. The resulting change of state of the Eccles-Jordan initiates the bright-up, the calibrator and the timebase waveforms. The timebase waveform is a positive-going triangular waveform fed to the X2 plate, and a corresponding negative-going waveform generated by the timebase paraphase amplifier is fed to the X1 plate for symmetrical deflection of the CRT beam.

7. Having deflected the beam across the face of the tube, the positive-going waveform reaches a pre-determined level at which it switches the Eccles-Jordan to its quiescent state; this terminates the timebase, quenches the calibrator

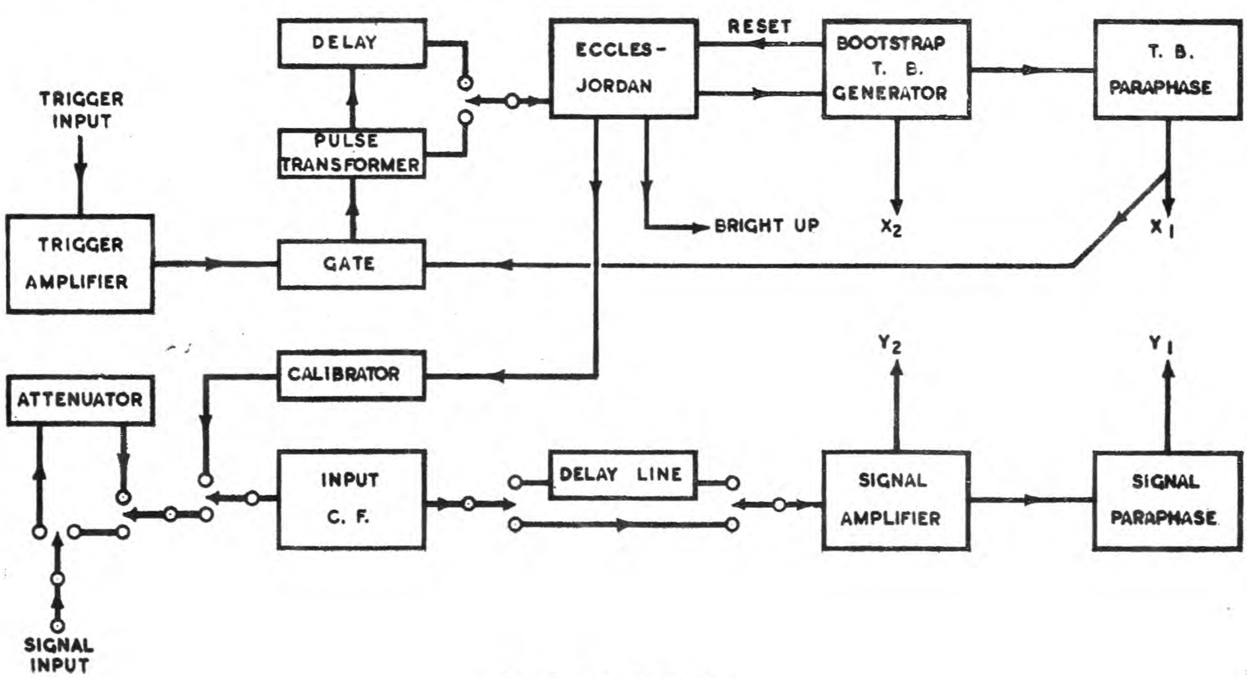


Fig. 2. Block diagram

and suppresses the flyback by removal of the bright-up waveform. The negative-going timebase waveform is applied to the gate circuit and renders it inoperative throughout both the timebase and the flyback periods. Thus it is impossible to re-trigger the oscilloscope until the operational sequence has been completed and all the circuits have returned to their quiescent states.

8. Although direct access to the Y-plates is provided, the wide frequency bandwidth of the signal amplifiers enables them to be used at all signal levels within the range of the instrument. Incoming signals are fed by AC or DC coupling either through frequency compensated attenuators or direct to an input cathode-follower. The cathode-follower supplies the signals from a low impedance source and at the correct DC level to a signal amplifier, again either direct or via the delay line. Variations in gain are effected by switching the feedback in the amplifier, the output of which is connected to the Y2 plate. A signal paraphase amplifier supplies an inverted signal to the Y1 plate for symmetrical deflection.

9. Amplitude measurements are made by applying to the input of the signal amplifier a backing-off voltage which is read on the calibrated Y-shift meter.

10. Time measurements are made by switching a calibrator to the input circuit and adjusting the timebase speed until the calibrator waveform corresponds to a whole number of divisions of the graticule on the CRT face. On switching off the calibrator, the signal is again displayed and its duration may be measured against the graticule.

DETAILED CIRCUIT DESCRIPTION

HT power supplies (*fig. 3 and 9*)

11. To avoid the complexity of stabilized HT lines, the circuits are designed to be largely independent of HT voltage and, where necessary, critical reference potentials are derived from a negative line stabilized by a simple neon stabilizer. The simplified diagram (*fig. 3*) shows that the HT transformer secondary supplies 400V-0-400V to two full wave rectifier valves V17 and V27. The rectified currents are separately smoothed to avoid modulation of the amplifier circuits by the fluctuating current demands of the timebase circuits. Most of the oscilloscope circuits are connected across the full 425V HT supply and are not shown in fig. 3. The constant-current balanced circuits, such as the Eccles-Jordan and the amplifier plus the paraphase amplifier, are returned to an intermediate earth point and their combined current flows through the resistance R to the negative line. The potential between earth and the negative line is determined by the neon stabilizer shunted across the resistance R to absorb any current fluctuations and to maintain the voltage drop across it at 105 volts. The power supply is thus a floating one with two separately smoothed HT lines approximately 300V positive with respect to earth and a stabilized supply held at 105V negative with respect to earth.

Trigger amplifier (*fig. 9*)

12. Trigger waveforms may be applied to the TRIGGER input terminal TL1 or to any of the TRIGGER input concentric plugs, all four being connected in parallel. The trigger input impedance is 3·2 megohms shunted by 30pF. Should it be necessary to terminate a cable with its characteristic impedance, the appropriate value resistor may be soldered between the input terminal or plug and the earth tag provided at the rear of the front panel.

13. The trigger amplifier V2 is a double-triode

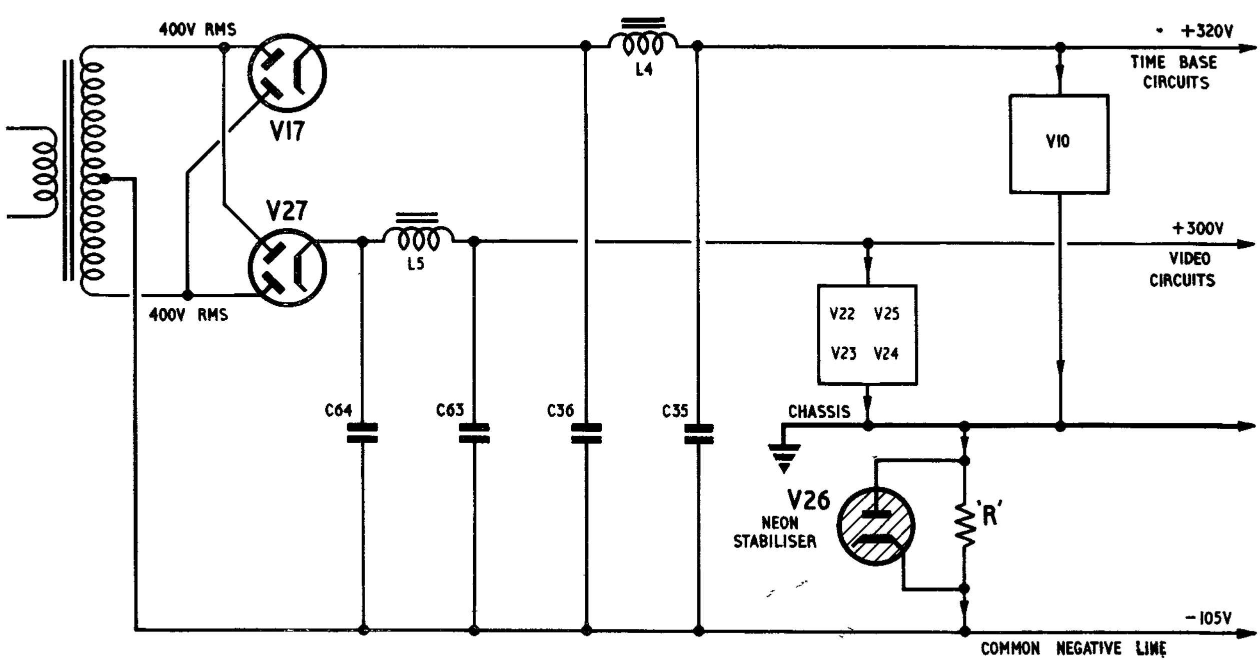


Fig. 3. Simplified diagram of power supplies

connected as a long-tailed pair amplifier with the 'tail' resistor R12 returned to the —105V line and the grids at earth potential. The trigger waveform is applied to V2A grid through an isolating capacitor C1 (rated at 1,000V DC) and a network comprising C2 in parallel with R5. Should a large positive-going signal drive V2A grid into grid current, the network prevents the input impedance falling below 1MΩ.

14. Amplified signals appear in opposite phase at the two anodes of the trigger amplifier V2 and the desired negative-going edge is selected by means of SW1/A (contact 2 or 3). The third position (contact 1) on switch SW1/B connects a capacitor C3 between a tapping on the V2A anode load and the grid of V2B, transforming the circuit into a cathode-coupled multivibrator. With no trigger input the relaxation time is 50mS, but if a sinusoidal waveform of not less than 5V RMS is applied the multivibrator changes state at the same frequency as the trigger signal. The multivibrator acts as a regenerative squarer. The oscilloscope may thus be triggered by positive or negative rectangular pulses, or synchronized with sinusoidal waveforms, or self run at a low recurrence rate.

Note . . .

The sensitivity of the trigger amplifier is such that erratic triggering may occur if the trigger waveforms contains spurious components of amplitude greater than the minimum triggering level. If this is the case, the trigger waveform should be applied to the TRIGGER *input connector via a series resistor with a shunt element connected to the* EARTH *terminal of such a value that the spurious components do not attain triggering level.*

Gate valve

15. After selection by SW1/A, the rectangular trigger waveform is differentiated by the network C8 and R21; the crystal diode V4 ensures that the junction of C8 and R21 does not go positive above —105V and only negative going edges are applied to the control grid of the gate valve V5. V5 is a short suppressor grid base pentode which, in the quiescent state, draws anode current through the primary winding of the pulse transformer T1. Interruption of the anode current by application of a negative voltage at the control grid produces negative-going pulses at the two secondaries which initiate the timebase, either directly or via a variable time delay. To make triggering impossible after the timebase has been initiated, a negative-going triangular wave is fed from the X1 plate to the suppressor grid of V5 rendering the gate valve inoperative during both the forward and flyback timebase periods. The 'gate' thereby remains 'shut' until the sequence of events has been completed and the quiescent conditions are restored.

Timebase delay

16. Direct or delayed initiation of the timebase is obtained by operation of the switch SW2. In position 1, SW2/B connects one secondary of the differentiating pulse transformer T1 to the Eccles-Jordan V10 via V7A. At the same time SW2/C inhibits the action of the timebase delay phantastron V1 by shorting its suppressor grid to the —150V line. In the other three switch positions of SW2 the conventional phantastron V1 is triggered by the negative-going pulse from the other secondary of the pulse transformer via the diode V3B to the anode of V1. The level at which the run-down commences is controlled by the FINE DELAY potentiometer RV1. The maximum available delay is changed by the COARSE DELAY switch SW2/A, which selects one

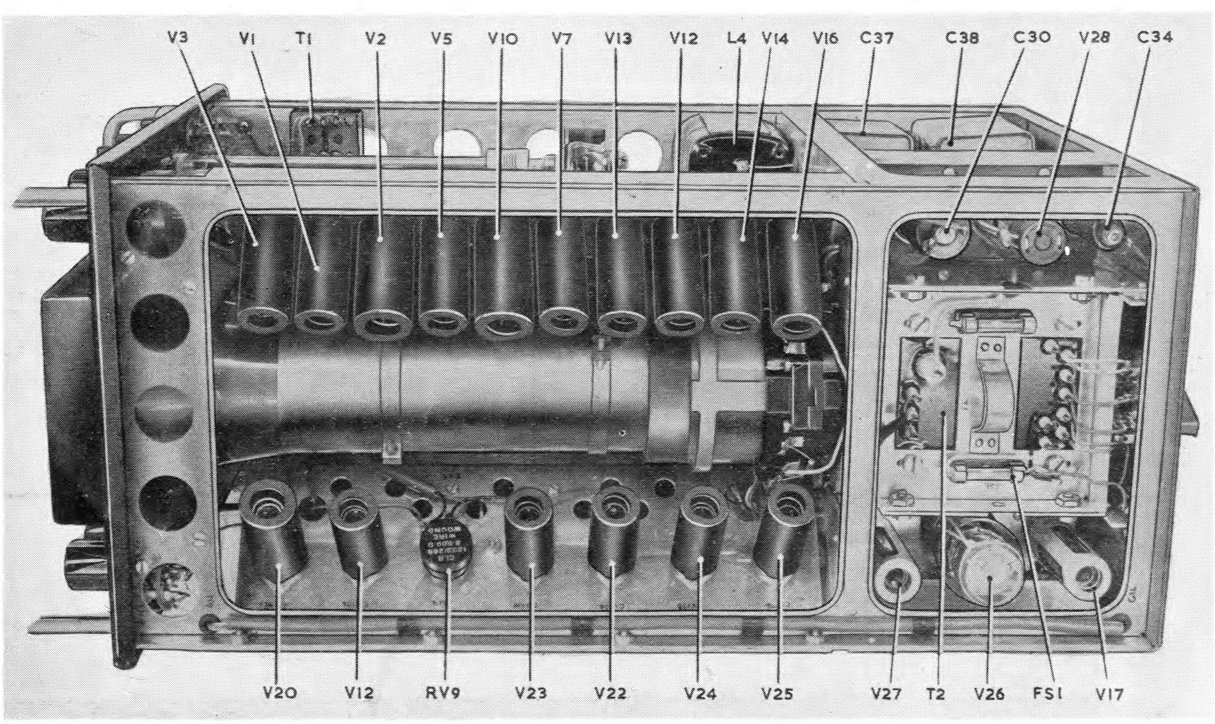


Fig. 4. Top view

of the ' Miller ' capacitors C6, C7 or C10. At the end of the run-down period (which determines the delay) the negative-going waveform from the screen grid of V1 is differentiated by C11 and R27 before being applied to the Eccles-Jordan pair V10 via SW2/B and V7A. Diode V3A determines the maximum grid potential of V1.

17. Both V1, the timebase delay valve, and V2, the trigger amplifier valve, are supplied from the 180V line with additional smoothing provided by R24 and C9.

Eccles-Jordan circuit

18. The double triode V10 is connected as an Eccles-Jordan bi-stable multivibrator. During the quiescent state, V10A is conducting and V10B is cut-off with its grid held at −12V by the crystal diode V11. Differentiated trigger pulses are fed direct or delayed from the switch SW2/B through V7A (which will pass only negative-going pulses) to V10A grid which begins to travel towards cut-off. Aided by the regenerative cross connections between the anodes and the opposite grids and by the ' speed-up ' capacitors C16 and C17, the change of state takes place very rapidly. The triode V10B now conducts and V10A is cut-off with its grid held at —12V by the crystal diode V9. This second state is maintained throughout the forward stroke of the timebase. The step function at the anode of V10B is used to initiate the timebase and the calibrator. The bright-up waveform is taken from the anode of V10A.

19. The Eccles-Jordan is reset by feeding a positive going triangular waveform (derived from the timebase) to the grid of V10A via the diode V7B. Commencing at −60V, this rising waveform attains earth potential at a time when the CRT spot has traversed the tube face. V7B now conducts and the positive-going waveform is applied to the grid of V10A causing the Eccles-Jordan to revert to its quiescent state. The crystal diode V8 prevents the grid of V10A from rising above earth potential. The two anodes return to their quiescent potentials, terminating the timebase, quenching the calibrator and suppressing the flyback by removing the bright-up waveform.

Bright-up waveform

20. In the quiescent state the grid of the CRT is effectively cut off and no beam current flows. The bright-up waveform is obtained from the anode of V10A. The potential of V10A anode rises sharply as the grid is driven to cut-off by the initiating pulse and remains high during the whole of the timebase period. This positive-going rectangular waveform is passed (through a network, R38 and C18 which offers a high impedance to hum frequencies without impairing the high rate of rise of the leading edge of the pulse) to the isolating capacitor C30 and thence to the grid of the CRT. Diodes V18 and V19 restrict the amplitude to 45V. Adjustment of the trace brightness during the forward stroke of the timebase is made by the brilliance control RV6 (BRIL). On completion of the timebase period the bright-up rectangular waveform terminates, thereby suppressing the flyback.

21. The beam current may be modulated during the timebase period by applying signals through the capacitor C34 to the resistor R61 in the circuit of the CRT cathode.

Timebase generator circuit

22. The timebase waveform is generated by a bootstrap circuit. In the quiescent state the switch valve V13 is conducting by virtue of the DC connection of its grid to a potential positive to its cathode (which is connected to the −105V line). The grid is held positive by the potentiometer R40, R41, connected between —365V line and the anode of V10B. The anode of V10B

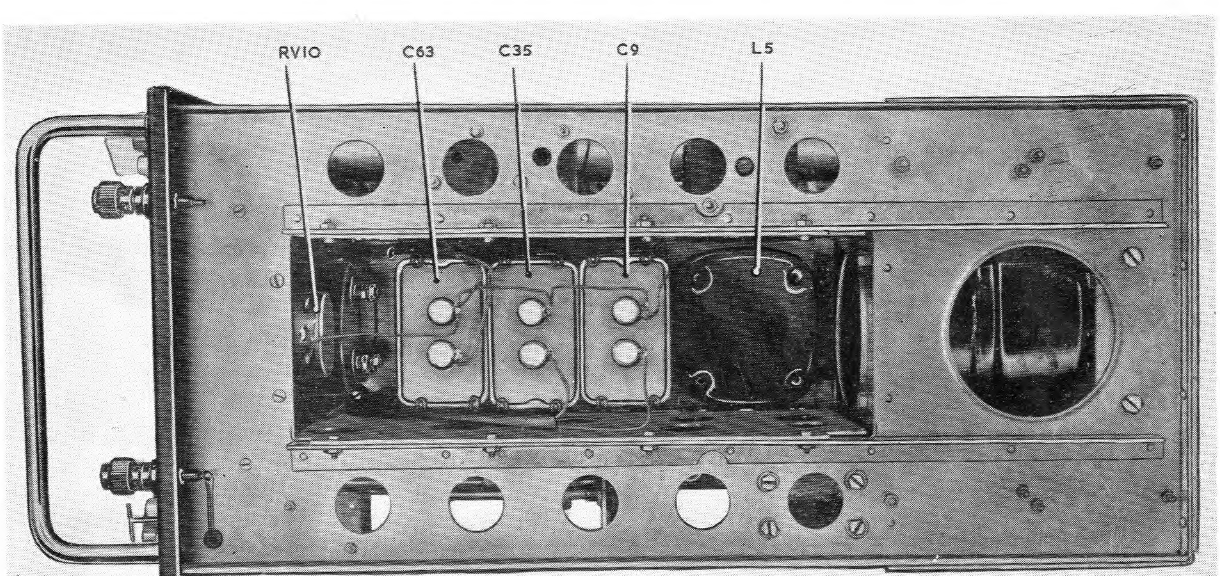


Fig. 5. Bottom view

drops when the Eccles-Jordan is triggered and the negative-going edge is passed via R40 and the speed-up capacitor C19 to the grid of the switch valve V13. The grid of V13 is driven below cut-off and is held at −125V (−20V below V13 cathode) by the diode V12A. The anode current for the switch valve V13 is drawn from the cathode of the cathode-follower V14 (via R45 and RV2). The grid of V14 being held at earth potential by the diode V12B causes the cathode of V14 to be held approximately 4V above earth i.e. approximately 109V above the cathode of the switch valve V13.

23. When the triggering pulse cuts off the switch valve V13, its anode voltage rises from its quiescent value of approximately −100V towards +4V (the potential of the cathode-follower V14). The rate of rise is determined by the value of the timebase capacitor (C23 to C26, or stray capacitance) selected by SW3 (T.B. COARSE) and the setting of the variable resistor RV2 (T.B. FINE) through which the charging current flows.

24. To prevent this rise being exponential, the rising voltage at the anode of V13 is fed via C21, R42 to the grid of the cathode-follower V14, causing V14 cathode to rise at the same rate. The voltage that the capacitors are striving to reach therefore increases and the voltage across the charging resistors R45 and RV2 remains approximately constant. The current through the charging resistance therefore remains constant and the timebase capacitor charges linearly.

25. Rising in a linear manner, the waveform at the cathode of the cathode-follower V14 is applied directly to the X2 plate. The timebase voltage reaches approximately 150V above earth before the timebase is terminated by the resetting of the Eccles-Jordan pair. The potential at the junction of the resistors R48 and R49 in the cathode circuit of V14 rises from −60V until it reaches earth potential when V7B conducts, resetting the Eccles-Jordan V10 to its quiescent state.

Timebase paraphase amplifier

26. Symmetrical deflection of the CRT beam along the X-axis is ensured by supplying the X1 plate from the paraphase amplifier V16. V16, a unity gain amplifier fed from the cathode-follower V14, reproduces the linear waveform as a negative-going sweep.

Calibrator

27. A shock-excited calibrator oscillator is used for measurement of timebase velocities. The high-Q tuned circuits L1-C67, C39, L2-C40, and L3-C41 are in the cathode circuit of V20A. In position 1 of the calibrator switch SW6/A the grid of the valve V20 is earthed and the cathode current is restricted to approximately 5mA by the cathode resistor R76. In other positions SW6/A removes the earth from the grid, SW6/B selects the tuned circuit to be connected in series with R76 and SW6/C applies the calibrator waveform to SW8/A at the input to the signal amplifier. The standing current of V20A flows through the selected circuit until the Eccles-Jordan changes from its quiescent state when a negative rectangular pulse is applied to V20A grid via the network R30, R31, with C15 as a speed-up capacitor. When V20A is cut-off, the energy stored in the tuned circuit is dissipated in the form of damped sinusoidal oscillations at the resonant frequency of the selected circuit. The crystal diode V6 ensures that V20A grid does not rise above earth at any time.

Signal input circuit

28. The signal to be examined may be applied to the INPUT terminal TL2 or to any of the three concentric plugs associated with it. Unlike the TRIGGER input, the signal inputs are not connected in parallel but are selected by means of the switch SW5.

29. The input impedance is 1·5 megohms shunted by 50pF. Provision is made at the rear of the front panel for connecting a matching impedance across the input and earth if required.

30. Choice of AC or DC feed is provided by SW7/A which is connected (via the calibrator switch SW6/C in the OFF position) to the attenuator switches SW8/A to /D. In position 1 of SW8 (corresponding to a Y-sensitivity of 500V) the attenuator comprises the resistors R70, R73 and R75, frequency corrected by capacitors C44 and C46. In position 2 of SW8 (corresponding to a Y-sensitivity of 100V) the attenuator comprises resistors R72 and R74 frequency compensated by C45. In the remaining four positions of SW8 the signal is applied directly to the grid of the cathode-follower V21.

Input cathode-follower

31. Attenuated to a suitable level, the signals are applied to the grid of the input cathode-follower V21 which provides a low impedance output for matching into the delay line and driving the signal amplifier. In position 1 of SW7/B the cathode of V21 is connected to the delay line via a matching resistor R86. The line is a distributed L and C type with a characteristic impedance of 1·6 KΩ and a delay of 0·6μS. The line is terminated in its characteristic impedance by R88 and AC coupled to the signal amplifier through C50 and SW7/C. In positions 2 and 3 of SW7 the amplifier input is connected to the junction of the resistors R83 and R84 in the cathode circuit of V21. The resistors R83 and R84 are of such values that the potential at their junction is that required by the amplifier. Fine adjustment of this potential is made by the preset RV7 which determines the screen voltage of V21 by adjusting the working point of the shunt stabilizer V20B.

Signal amplifiers

32. The signal amplifiers are basically ‘ anode followers ’. The amplifier proper is V23, a pentode with its cathode at earth and its control grid held at an appropriate potential negative to earth by means of the feedback resistor R96 between anode and grid and the tail resistor R97 between the grid and a negative potential on the Y-shift potentiometer RV10. The tapping on

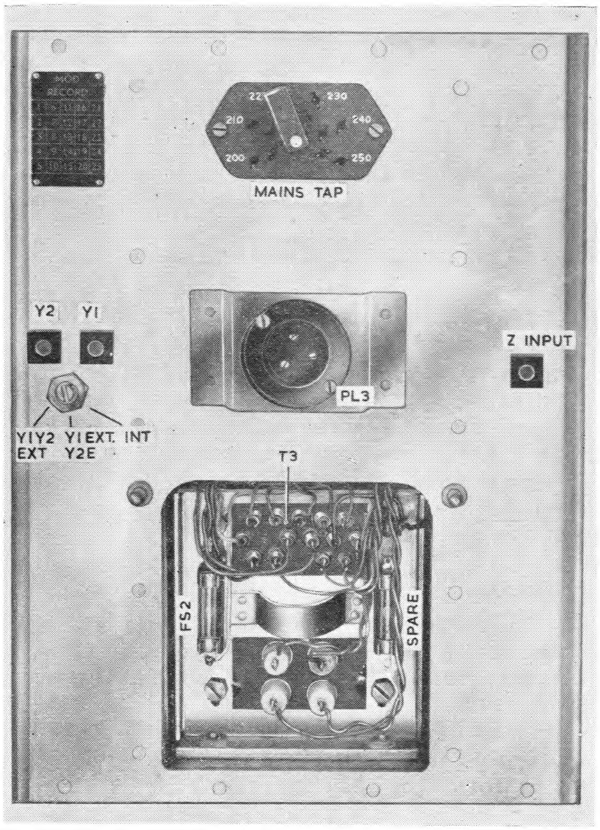


Fig. 6. Rear view

the input cathode-follower circuit (junction of R83 and R84) is adjusted to be at the same potential as the grid of the signal amplifier and therefore the connection of an ' input ' resistor between these two equipotential points has no effect under static conditions. The application of a signal to this resistor results in an inverted and amplified signal at the anode of V23. The gain of V23 depends on the ratio between the feedback resistor R96 and the input resistors. Thus by changing the input resistance by means of switches SW8/F and SW8/E the gain of the signal amplifier V23 can be varied. The same switch SW8/A and SW8/B by altering the input attenuation sets the Y-sensitivity of the instrument to between 500V and 1V in terms of the full scale deflection of the Y-SHIFT meter.

33. Consider first when the switch SW8 is set at its third position, giving a sensitivity of 30V full scale deflection. In this position the input attenuators are not in circuit and the input is applied directly to the cathode-follower V21 grid. The output of the cathode-follower V21 is applied via the input resistor (which is in this case R91 and has the same value as the ' tail ' resistor R97) to the signal amplifier V23. If the CRT trace is now deflected by a DC voltage applied to the input terminal, the application of an equal and opposite DC voltage to the tail resistor R97 from the Y-SHIFT potentiometer RV10 will restore the trace to its original position irrespective of the amplication in use. As there is a small attenuation in the cathode-follower, the Y-SHIFT meter is calibrated against a known input voltage by means of the meter calibrator preset RV9. Once calibrated on the 30V sensitivity, the full scale deflection of the Y-SHIFT meter on the other sensitivity ranges is subject only to a multiplying factor determined by the attenuator and the input resistor values, being independent of variation in the valve parameters.

34. High frequency response is maintained by preset capacitors across each input resistor. The correct adjustment of these capacitors is dealt with under Setting-up procedure, para. 55 (11)—55 (14).

35. As the CRT plates impose a considerable capacitive load on the anode circuit of V23, the usual resistive anode load is replaced by a valve V22, the use of which improves the frequency response and provides a greater maximum rate of change of output voltage for a given power consumption. (A conventional amplifier would need a low anode load and a high standing current for the rapid charging and discharging of the stray capacitance under transient conditions.) Although the standing current through the two valves in series is only 9mA, either is capable of drawing approximately 25mA when approaching zero grid bias. (The operation of the combination is analogous to a Class AB amplifier). A positive-going transient at the grid of the valve V23 produces sufficient anode current to discharge the stray capacitance, while a negative-going transient, by reducing the current flowing in R102 and so reducing the bias on V22, charges the stray capacities equally rapidly through the low impedance of V22. By this means a high rate of change of output voltage is obtained with considerable economy in power consumption.

Signal paraphase amplifier

36. Symmetrical deflection along the Y-axis is obtained by the use of a signal paraphase amplifier V24. The signal paraphase amplifier has unity gain and V25 forms its anode load. The manner of operation is exactly the same as the operation of the signal amplifier.

37. The Y-plates are connected via the switch SW4 to the cathodes of V22 and V25. The CRT anodes are held at the mean potential of the Y-plates by connection to the junction of the equal resistors R51 and R55.

OPERATION OF CONTROLS

Brilliance

38. The BRIL control RV6 varies the grid bias applied to the CRT. Clockwise rotation of this control increases the brilliance of the display. The BRIL control should be set to give just sufficient brilliance for the work in hand.

Focus

39. The FOCUS control RV5 varies the voltage applied to the second anode of the CRT. By adjustment of this control it is possible to pass through the focal point and obtain a trace which is a thin line.

X shift

40. Positioning of the trace along the X-axis is achieved by the X SHIFT control RV3 which adjusts the bias applied to the grid of the timebase paraphase amplifier valve V16. This determines the quiescent anode potential and thus the starting point of the trace on the face of the CRT. The range of adjustment is small and is centred about the left-hand edge of the graticule by the preset control RV4.

Timebase delay

41. The start of the timebase may be delayed by operation of the T.B. DELAY switch SW2 which gives a choice of 100μS, 1mS, or 10mS maximum delay after the initiating pulse. Intermediate delays (up to the maximum in each range) are provided by the continuously variable DELAY FINE control RV1. By means of these controls it is possible to move a narrow pulse occurring some distance along the trace to the start of the trace and then, by increasing the timebase speed to observe the shape of the pulse and to measure its duration.

Timebase speed

42. Continuous variation of the timebase speed (in each of the five overlapping ranges selected by the T.B. COARSE switch SW3) is provided by the T.B. FINE control RV2. The maximum speed gives less than 1μS, and the minimum speed at least 50mS, for the spot to sweep across the tube face.

Trigger selector

43. TRIGGER switch SW1 enables the positive or the negative-going edge of a triggering waveform to be used for initiating the timebase. With SW1 in the A.C. position the oscilloscope will self-run at a low recurrence rate and will trigger from sinusoidal waveforms of 5V minimum RMS value.

Calibrator

44. Operation of the CAL switch SW6 removes the input signal and applies the sinusoidal waveform from the calibrator to the amplifier input. The frequency of the output from the calibrator is pre-adjusted to be 1Mc/s, 100kc/s and 10kc/s and therefore the time of one complete cycle of the waveform is either 1μS, 10μS or 100μS respectively. By adjustment of the T.B. FINE and the X-SHIFT controls a whole number of cycles of the sine wave is made to coincide with the graticule on the CRT face, so that each division on the graticule represents one-tenth of the total time displayed. Switching off the calibrator restores the signal being examined and enables its duration to be measured against the graticule.

Y-sensitivity

45. The sensitivity of the signal amplifier is adjustable over a wide range by the Y-SENS control SW8. Attenuators are introduced for input signals having amplitudes of the order of 500V to 100V, while the gain is progressively increased for signals of the order of 30V, 10V, 3V and 1V. It is not necessary to know the actual gain in use at each position as the Y-sensitivity is expressed in terms of the full scale deflection of the Y SHIFT meter (*para. 33*).

Y shift

46. The trace may be shifted along the Y-axis by means of the Y SHIFT control RV10. Waveform amplitudes may be measured by noting the Y SHIFT meter reading when the upper and lower extremities of the waveform are made to coincide with a datum line on the graticule ; the total meter excursion multiplied by the full scale value given by the setting of Y-SENS control gives the amplitude in volts.

Meter zero

47. When measuring the amplitude of a waveform, one of its extremities is made to coincide with a datum line on the graticule by operation of the Y SHIFT control. The function of the METER ZERO control is to enable the Y SHIFT meter to be set at zero for this condition ; any subsequent movement of the trace by the Y SHIFT control is then registered on the Y SHIFT meter as a voltage positive or negative with respect to the datum.

DC level

48. This is a preset control RV7 located between the BRIL and FOCUS controls and is adjustable by means of a screwdriver passing through an aperature in the front panel. Its adjustment is covered in the setting-up procedure, para. 54(4) and 54 (5).

Input selector

49. The signal to be examined may be applied to the signal INPUT terminal or to any of the three concentric connectors. Unlike the TRIGGER input, the signal input connections are not connected in parallel but are selected by the INPUT SELECTOR switch SW5.

50. Provision is made at the rear of the front panel for terminating resistors to be fitted if required. The INPUT switch SW7 determines whether the signal is applied in an AC or DC manner or via the delay line.

Probe unit

51. The oscilloscope has an input impedance of 1·5 megohms shunted by 50pF. In circumstances where the signal is adversely effected by this capacitance, the probe unit provided should be used. The probe unit, a simple resistor attenuator with a frequency compensating capacitor, has an attenuation of 10 times. Its input capacitance is less than 15pF. When the probe is in use, it is important that there is no terminating resistor across the input connection (*para. 29*).

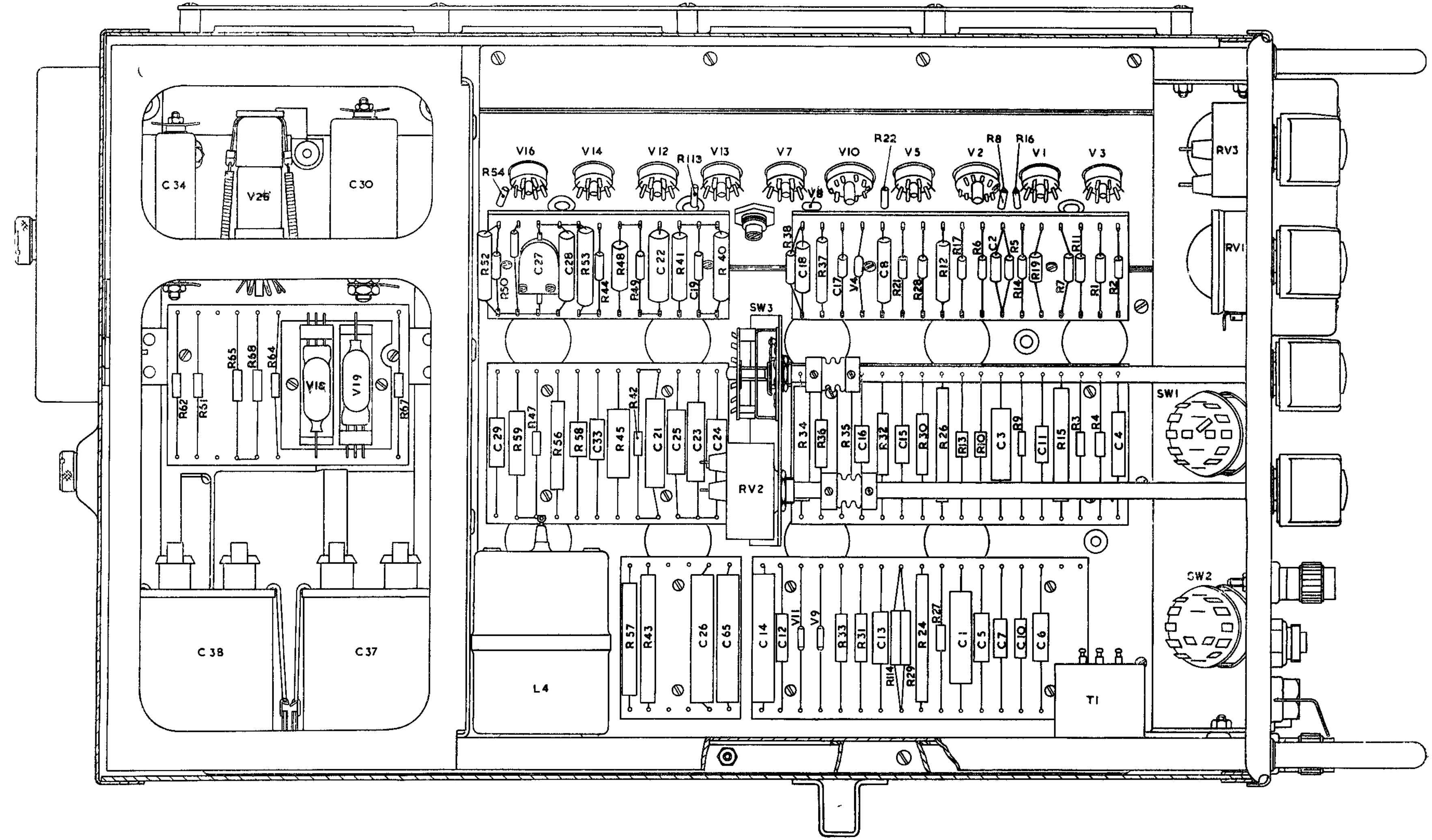


Fig. 7. Left-hand view

52. The following setting-up procedure is divided into two sections: (1) procedure and checks which may be carried out when first using the oscilloscope and (2) checks to be carried out only when suitable equipment is available. The procedure given below is sequential.

Setting-up procedure when first using the oscilloscope

53. The instrument is designed to operate from 200V-250V, 40c/s-60c/s supplies with a power consumption of 100 watts. The mains tap, which is located under a protective cover at the rear of the instrument, must be set to the correct position corresponding to the voltage of the supply. A spare fuse is provided on each mains transformer inside the instrument.

54. Proceed as follows :—

(1) Having adjusted the instrument to the voltage of the mains (*para. 53*), turn the mains switch from OFF to L.T. Allow about one minute for the heaters to reach their working temperature, then switch the mains switch to H.T.

Note . . .
When the instrument is not in use, but is to be kept ready for use, switch the mains switch to L.T. *The CRT will not then be damaged by a stationary spot.*

Self-running check

(2) Set the TRIGGER switch to A.C. Set the T.B. COARSE switch to position 1. Set the T.B. FINE control fully clockwise. Set Y SENS to 30 VOLTS and the INPUT switch to D.C. A trace should now be visible. The trace should increase in brightness with clockwise rotation of the BRIL control; focus to a sharply defined line when the FOCUS control is adjusted, and respond to the X SHIFT and Y SHIFT controls.

X shift check

(3) With other settings as above, rotate the X SHIFT control fully and note the displacement of the trace. The start of the trace should move equal amounts on either side of the left-hand edge of the graticule. If necessary, adjust the preset control RV4 located on the valve deck on the timebase side of the instrument.

DC level adjustment

(4) With other settings as above, connect the INPUT terminal to the EARTH terminal. Rotate the INPUT SELECTOR control to select the INPUT terminal. Set the Y SENS control to 30 VOLTS. Turn the Y SHIFT control until the trace coincides with the central horizontal line of the graticule. Check that the Y SHIFT meter can be set to read zero by operation of the METER ZERO control.

(5) Set the Y SENS control to 1 VOLT. Correct any vertical displacement of the trace by the preset control RV7 (adjustable by means of a screwdriver through an aperature in the front panel between the BRIL and FOCUS controls). Switch Y SENS to 30 VOLTS and re-adjust the trace. Repeat until no appreciable vertical movement takes place when Y SENS is changed from 30 VOLTS to 1 VOLT.

Setting-up procedure after repair or during calibration

55. Proceed as follows :—

(1) Carry out the procedure given in para. 54.

DC calibration check

(2) Switch the mains switch to L.T. Check the mechanical zero of the Y SHIFT meter. Adjust if necessary.

(3) Switch the mains switch to H.T. With other settings as given above, set the Y SENS control to 30 VOLTS. Set the trace on the central datum line of the graticule by operation of the Y SHIFT control and adjust the Y SHIFT meter to read zero by operation of the METER ZERO control.

(4) Disconnect the INPUT terminal from the EARTH terminal and apply a positive voltage of between 20V and 25V to the INPUT terminal. Restore the trace to the graticule datum line by operation of the Y SHIFT control and note the Y SHIFT meter reading. Repeat with the polarity of the applied voltage reversed. The Y SHIFT meter readings should not differ by more than 3 per cent and their mean value should agree with the value of the applied voltage as measured on an accurate sub-standard voltmeter.

Note . . .
The accuracy of the oscilloscope depends on the calibration of the Y SHIFT *meter and the adjustments given above should be made with the greatest care.*

(5) Repeat the procedure given in para. 55(3) and (4) with input voltages appropriate to the other ranges of Y sensitivity. The accuracy on these other ranges depends on the circuit constants and on the precision of the calibration on the 30 volt range.

Calibrator check

Note . . .
For this check a frequency standard (of at least 1 per cent accuracy), which provides a triggering pulse counted down from the output frequency, is required.

(6) Set the output frequency of the frequency standard to 1Mc/s, 100kc/s, or 10kc/s. Trigger the timebase at a suitable recurrence frequency rate (locked to the frequency standard output) by connecting the trigger output of the frequency standard to the TRIGGER connector of the oscilloscope. Switch CAL to the appropriate frequency. Adjust the timebase speed until the rings from the internal calibrator coincide with the vertical lines of the graticule.

Method I

(7) Switch CAL to OFF. Connect the output of the frequency standard to the signal INPUT

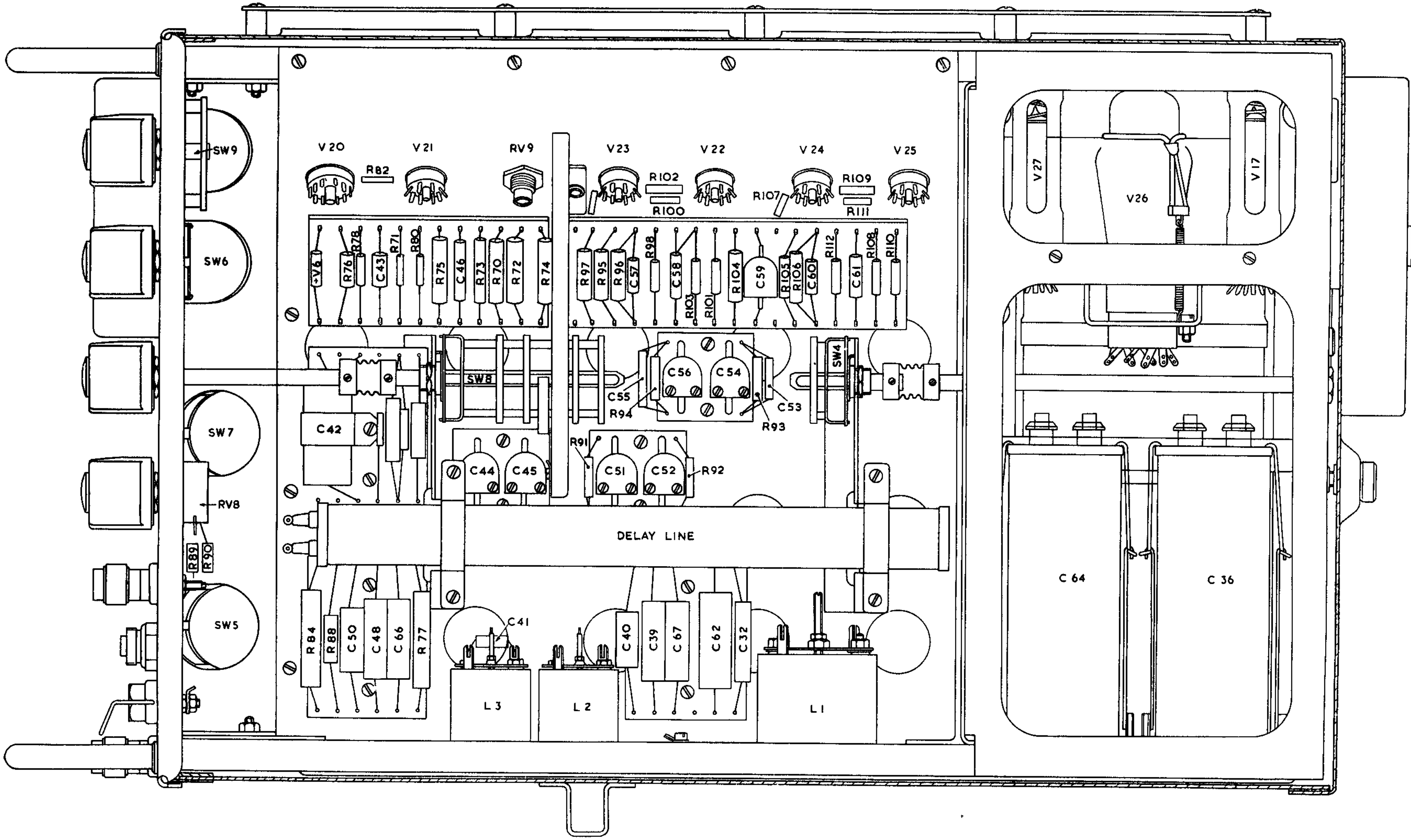


Fig. 8. Right-hand view

connector. The frequency standard output will now be displayed on the CRT and the oscillations should coincide with the vertical lines of the graticule as did the calibrator oscillations previously. If not coincident, the calibrator tuning inductor requires adjustment.

Method 2

(8) Connect the output of the frequency standard to Z MOD at the rear of the oscilloscope. (This gives intensity modulation of the CRT.) The calibrator rings should now be intensified at the same point on each cycle. If the Z modulation produces a wavy line, the calibrator tuning inductor needs adjusting.

(9) Measure the amplitude of the three internal calibrator waveforms by operation of the Y SENS, Y SHIFT, and the Y SHIFT meter in the normal way. The amplitudes of the waveforms should lie between 11V and 20V peak-to-peak initially, decaying to half the initial value at the 9th to 12th cycle.

Timebase paraphase amplifier check

(10) Trigger the timebase at a p.r.f. of 5kc/s. Set T.B. COARSE to position 4 and T.B. FINE fully counter-clockwise. Inspect the X2 waveform at V14 pin 2 or 6 on another oscilloscope. Inspect the X1 waveform at pin 5 of V16. The X1 waveform should be an inverted replica of the X2 waveform. Overshoot or undershoot of the trailing edge of the X1 waveform can be corrected by adjusting the variable capacitor C27.

Signal amplifier check

Note . . .

For this check the best possible square-wave generator is required, which gives a 50/50 waveform at a p.r.f. of 5kc/s with amplitude variable from 0·5V to at least 75V peak-to-peak.

(11) Connect the output of the square-wave generator to both the TRIGGER input and directly to the Y plate via SK3 and the switch SW4 set to EXTERNAL at the rear of the oscilloscope. Adjust the timebase speed until five cycles of the waveform are displayed. (The waveform must be effectively rectangular and without overshoot).

(12) Remove the input signal from the Y plates. Return switch SW4 to INTERNAL. Set Y SENS to 30 VOLTS and apply a 20V square wave to the signal INPUT. Inhibit the paraphase amplifier by connecting a 8μF capacitor from the junction of R104 and R105 to earth. Adjust C51 until the displayed waveform is an exact replica of the input waveform (previously inspected by connection to the Y plates direct).

(13) Remove the 8μF capacitor. This will double the amplitude of the displayed waveform by bringing the signal paraphase into operation. Adjust C59 until the displayed waveform is an exact replica of the initial waveform.

(14) At other settings of the Y SENS, adjust as below :—

Y Sens	Input	Adjust
10 VOLTS	5V	C52
3 VOLTS	1·5V	C54
1 VOLT	0·5V	C56
100 VOLTS	50V	C45
500 VOLTS	Max.	C44

Note . . .

Adjusted as above, the response of the signal amplifier should extend from DC to the frequencies shown below without the gain falling by more than 3dB.

Y Sens	Minimum bandwidth
500 VOLTS	5Mc/s
100 VOLTS	5Mc/s
30 VOLTS	5Mc/s
10 VOLTS	3Mc/s
3 VOLTS	1·5Mc/s
1 VOLT	750kc/s

Probe unit check

(15) Set Y SENS to 30 VOLTS. Apply a 20V square wave to the signal INPUT terminal. Note the display. Connect the probe connector to the oscilloscope. Set Y SENS to 3 VOLTS. The amplitude of the displayed waveform should now be the same as previously and the variable capacitor in the probe unit should be adjusted until the shape of the displayed wave is a replica of the display when the input was connected to the INPUT terminal.

Note . . .

When using the probe unit, the response will be that of the Y SENS *setting but the signal amplitude will be ten times that indicated on the* Y SHIFT *meter.*

Timebase delay check

(16) Connect a square wave of a p.r.f. 10kc/s, 1kc/s, or 100c/s to the signal INPUT. Set the T.B. COARSE to 100μS, 1mS, or 10mS corresponding to the p.r.f. respectively. It should be possible to traverse an entire cycle of the displayed waveform across the CRT face by operation of the T.B. FINE control.

Signal delay check

(17) Trigger the oscilloscope at a p.r.f. of 5kc/s. Switch CAL to 1Mc/s. Adjust the timebase speed and the X SHIFT so that one complete cycle is displayed. Setting the INPUT switch to DELAY should shift the start of the calibrator wave to the right slightly beyond the centre line of the graticule.

VOLTAGE MEASUREMENTS

Heater voltages

56. Measured with an AC meter accurate to 1 per cent, the heater voltages at the points stated below shall be within 7 per cent of their nominal value.

Heaters of V20	Nominal 6·3V RMS
,, ,, V3	,, 6·3V ,,
,, ,, V17	,, 6·3V ,,
,, ,, V18	,, 4·0V ,,
,, ,, V28	,, 4·0V ,,

Line voltages

57. Measured with a DC voltmeter with a resistance of not less than 500 ohms per volt and an accuracy of 1 per cent (model 7 Avo) the voltages with respect to earth at the points specified shall be within the limits given below.

Timebase HT line at C35	305 to 335V
Amplifier HT line at C63	280 to 310V
Extra smooth HT at C9	155 to 225V
Negative line at C62	—105·5 to —110·5V

EHT voltage

58. Measured with a DC voltmeter with a resistance of not less than 20,000 ohms per volt (Model 8 Avo), the voltage at the point specified below shall be within the limits shown.

EHT C38 to earth	—1860 to —2060V

With the BRIL control set to minimum (no beam current) the drop in voltage between C38 and C37 shall be between 275 to 410V.

Hum measurements

59. Measured with a valve voltmeter having an accuracy of 5 per cent, the hum at the points specified shall not exceed the values given below.

Timebase HT line at C35	1·8V RMS
Amplifier HT line at C63	0·18V RMS
Extra smooth HT at C9	70mV RMS

AIDS TO MAINTENANCE

60. To assist fault finding and maintenance, the approximate voltages (when the instrument is completely passive i.e. un-triggered either internally or externally) to be found at specified points in the circuit are given below. Unless otherwise stated all the voltages are with respect to earth.

Video side

Signal amplifiers

61. The Y2 voltage (at pin 2 of V22) and the Y1 voltage (at pin 2 of V25) vary between 60V and 210V with operation of the Y SHIFT control. Adjusted to equality they should lie between 120V and 145V and should be only very slightly effected by variation of the METER ZERO control. The voltage drop across R103 and R108 should be 5·5V to 7·5V and that across R102 and R109 should be 9V to 10V. At equality the slider of the Y SHIFT control should be at —70V to —80V with a total excursion between —30V and —105V. The excursion of the METER ZERO control should be between —55V and —85V.

Input cathode-follower

62. With the DC level correctly adjusted (*para. 54 (5)*), the cathode of V21 (pin 2) should be at 7V to 8V and the junction of R83 and R84 at —2·5V to —3·5V. Both these voltages will vary with the adjustment of the D.C. LEVEL control, which sets the screen of V21 (pin 7) at 145V to 165V with a total excursion of 120 to 220V.

Calibrator

63. The cathode of V20 (pin 3) should be at 3·8V to 4·2V.

Timebase side

Trigger amplifier

64. The cathodes of V2 (pins 3 and 8) should be at 1·8V to 2·2V. The anodes (pins 1 and 6) should be 25 to 35 volts below the level of the extra smooth HT line.

Gate valve

65. The anode of V5 (pin 5) should be at 165V to 185V and the screen (pin 7) at —55V to —65V.

Timebase delay phantastron

66. In this case the voltages stated are with respect to the —105V line. Cathode of V1 (pin 2), 25 to 30 volts ; screen of V1 (pin 7) 90 to 130 volts ; junction of R4 and R3 at 11 to 13 volts ; junction of R3 and R2 at 23 to 30 volts ; junction R2 and RV1 at 33 to 40 volts ; and the junction of RV1 and R1 at 210 to 230 volts.

Eccles-Jordan

67. V10 anodes (pin 6) 60V to 100V
(pin 1) 240V to 270V.
V10 grids (pin 7) earth
(pin 2) —12V.

Bootstrap switch valve

68. V13 anode (pin 5) —80V to —105V
V13 screen (pin 7) —15V to —60V.

Both V13 anode and screen potentials are dependent on the T.B. FINE control position.

Bootstrap cathode-follower

69. The cathode of V14 (pin 2) should be at 3V to 7V with the junction of R48 and R49 at —55V to —60V. Both are dependent on the setting of the T.B. FINE control.

Timebase paraphase amplifier

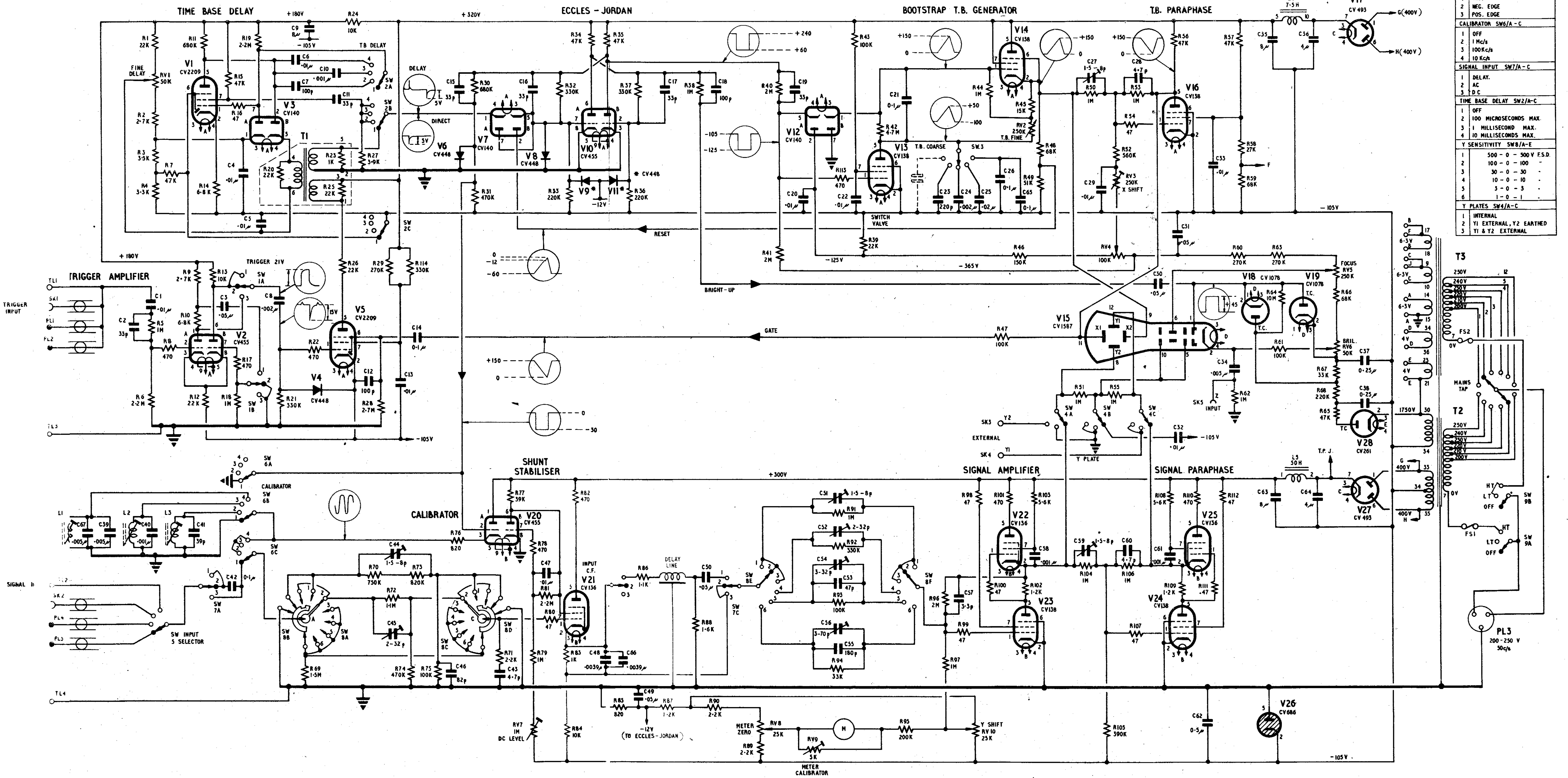
70. The anode of V16 (pin 5) should be at 60V to 180V with the screen (pin 7) at 140V to 170V, both being dependent on the position of the X SHIFT control.

Waveforms

71. The waveforms to be found at various points in the circuit are shown on the circuit diagram fig. 9.

5776 447285 7/54 865 C.B.&S.LTD. GP.30

SWITCH POSITIONS	
TRIGGER SW1/A-B	
1	A.C.
2	NEG. EDGE
3	POS. EDGE
CALIBRATOR SW6/A-C	
1	OFF
2	1 Mc/s
3	100Kc/s
4	10 Kc/s
SIGNAL INPUT SW7/A-C	
1	DELAY.
2	AC
3	D C
TIME BASE DELAY SW2/A-C	
1	OFF
2	100 MICROSECONDS MAX.
3	1 MILLISECOND MAX.
4	10 MILLISECONDS MAX.
Y SENSITIVITY SW8/A-E	
1	500 - 0 - 500 V F.S.D.
2	100 - 0 - 100 "
3	30 - 0 - 30 "
4	10 - 0 - 10 "
5	3 - 0 - 3 "
6	1 - 0 - 1 "
Y PLATES SW4/A-C	
1	INTERNAL
2	Y1 EXTERNAL, Y2 EARTHED
3	Y1 & Y2 EXTERNAL



General purpose oscilloscope C.T. 316 — circuit

Fig. 9

P 865 C.B.& S. LTD. GP.55