COSSOR

MODEL 1049
OSCILLOGRAPH
Mk II

Appologies for the quality of some of the pages as this was scanned from a ~20 year old photocopy of a photocopy

COSSOR

Model 1049

Double Beam Oscilloscope

MK. II.

The Mk II version of the Model 1049 Oscillograph differs from the Mk I only in the mains transformers and their connections. The new version of the instrument has an oil-filled C-core EHT transformer, and certain minor mechanical changes have been made to accommodate this. Otherwise there is no change; this book contains the new circuit diagram and parts list but in other respects the literature relating to the Mk I instrument applies to Mk II.

The Reference Number of this publication is ***TP132***

COSSOR INSTRUMENTS LIMITED
(The Instrument Company of the Cossor Group)
COSSOR HOUSE · HIGHBURY GROVE · LONDON, N.5
Telephone : CANonbury 1234 (33 lines). Cables : COSSOR LONDON
Telegrams : COSSOR, NORPHONE, LONDON Codes : "BENTLEY'S SECOND"

Printed in England TP134/12/56/10

SPECIFICATION

POWER RATING

Mains Volts—110, 125 or 207, 225 and 245. (Separate Instruments).
Mains frequency—50-100 c/s.
Power consumption—130 watts (approx.).
Stabilised for variations of up to ± 10% of input volts.
Stabilised H.T. Voltage :—
Tube—2 KV and 4 KV. Amplifiers, Time Base, etc.—650 volts.

DIMENSIONS

Height, including feet	16½ in. (42.0 cm.)
Width	12 in. (30.5 cm.)
Length, Knobs 2" extra	19¾ in. (50.1 cm.)
Weight	75 lb. (34 Kg.)

CATHODE RAY TUBE

Type 89 Double Beam 4" diameter " J " (blue) Screen.
Y sensitivity direct to Tube : 650 V ± 8% 3.1 volts/mm. D.C. (6.2 V at 4 KV).
X sensitivity direct to Tube : 750 V ± 8% 2.7 volts/mm. D.C. (5.4 V at 4 KV).
The output of the Amplifiers and Time Base and direct access to the Tube Plates and Anode, "E" (Chassis) and " Common " terminals is available at the side of the instrument.

TIME BASE

Repetitive, Triggered or Single Stroke operation.
Positive or Negative sync. and Trigger by continuously variable control.
Directly calibrated time scale with 9 ranges from 150 microseconds to 1.5 seconds.

SYNCHRONISATION AND TRIGGER

Switch selection for External sync. or Internal sync. from Y1 or Y2 signals.
Sync. input impedance, 2 megohms 20 pF.

Y1 D.C. AMPLIFIER

Gain—900, Five valves.
Frequency response—D.C. to 100 Kc/s. ± 15%.
Compensated for H.T. and Heater supply variations.
Fitted with directly calibrated Y shift control.
Input Impedance—0.5 to 0.75 megohm, 10 to 40 pF.

Y2 D.C. AMPLIFIER

Gain—25, Two valves.
Frequency response—D.C. to 100 Kc/s. ± 15%.
Fitted with switch attenuator calibrated in the following range of Y2 sensitivity :—

Volts per mm.	Volts per mm.
10.0	0.5
5.0	0.2
2.0	0.1
1.0	

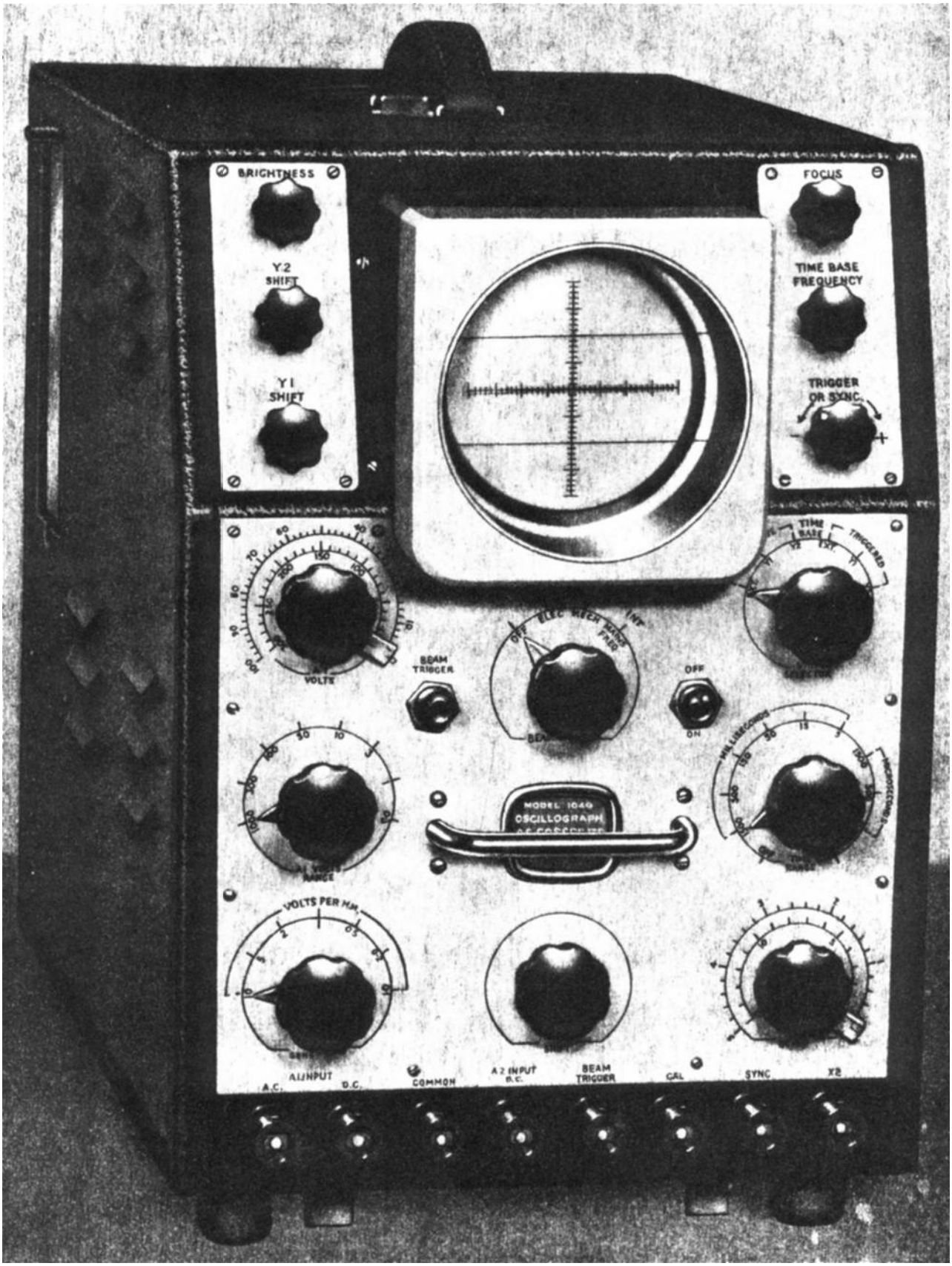
Maximum input—1,000 V D.C., or Peak A.C.
Input Impedance—0.5 to 1 megohm, 70 pF (Miller Effect).

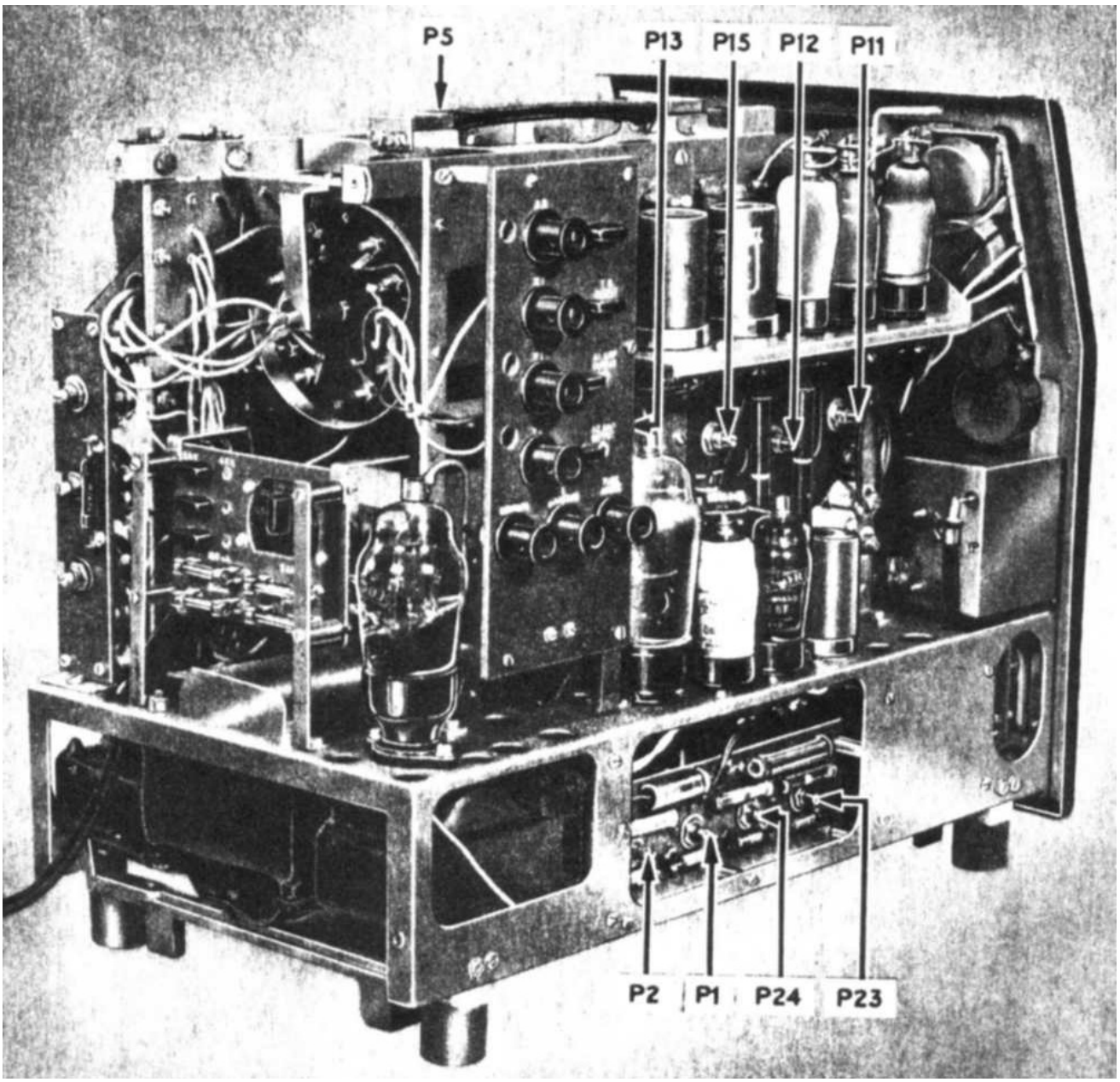
BEAM TRIGGER

H.F. circuit giving the following facilities :—

1. Beam Trigger off.
2. Electrical Beam Trigger enabling beam to be switched on and off by the application of D.C. to trigger terminal, and giving beam switching for time marking from an A.C. signal.
3. Mechanical Beam Trigger enabling beam to be switched by shorting " Beam Trigger " and " Common " terminals.
4. Mains Frequency Beam Trigger giving blackout pips at Mains Frequency.

Push-button also provided to facilitate photography and to permit inspection of the trace when required.


BRIGHTNESS
Y2 SHIFT
Y1 SHIFT
FOCUS
TIME BASE FREQUENCY
TRIGGER OR SYNC.
VOLTS
BEAM TRIGGER
OFF
ON
MODEL 1049
OSCILLOGRAPH
VOLTS PER MM.
A1 INPUT
A.C.
D.C.
COMMON
A2 INPUT
BEAM TRIGGER
CAL
SYNC
X2



Note : P.5 is the potentiometer on the sub-chassis nearest the front panel.

Illustration shows the interior of Model 1049 Double Beam Oscillograph with cover removed. The Tube Connection terminals and the Amplifier and Time Base Output sockets can be seen, as well as the Fuses and Mains Selector Links. The leather carrying handgrip is not mounted to the outer dust cover but directly to the chassis assembly which thus takes the full weight when the instrument is lifted.

TUBE AND AMPLIFIER CONTROLS.

The Brightness, Focus, Vertical Beam Shifts and two Time Base controls are mounted at the top of the front panel. Under these are located the A1 amplifier gain switch and its calibrated voltage scale, the A2 amplifier sensitivity switch, the X shift and, on the right, the main Time Base controls. The central control marked "BEAM TRIGGER" provides beam "on/off" switching or intensity modulation for Time co-ordination ; the adjacent push-button is provided to permit examination of the traces which may through operation of the beam-trigger system be occulted.

A1 AMPLIFIER

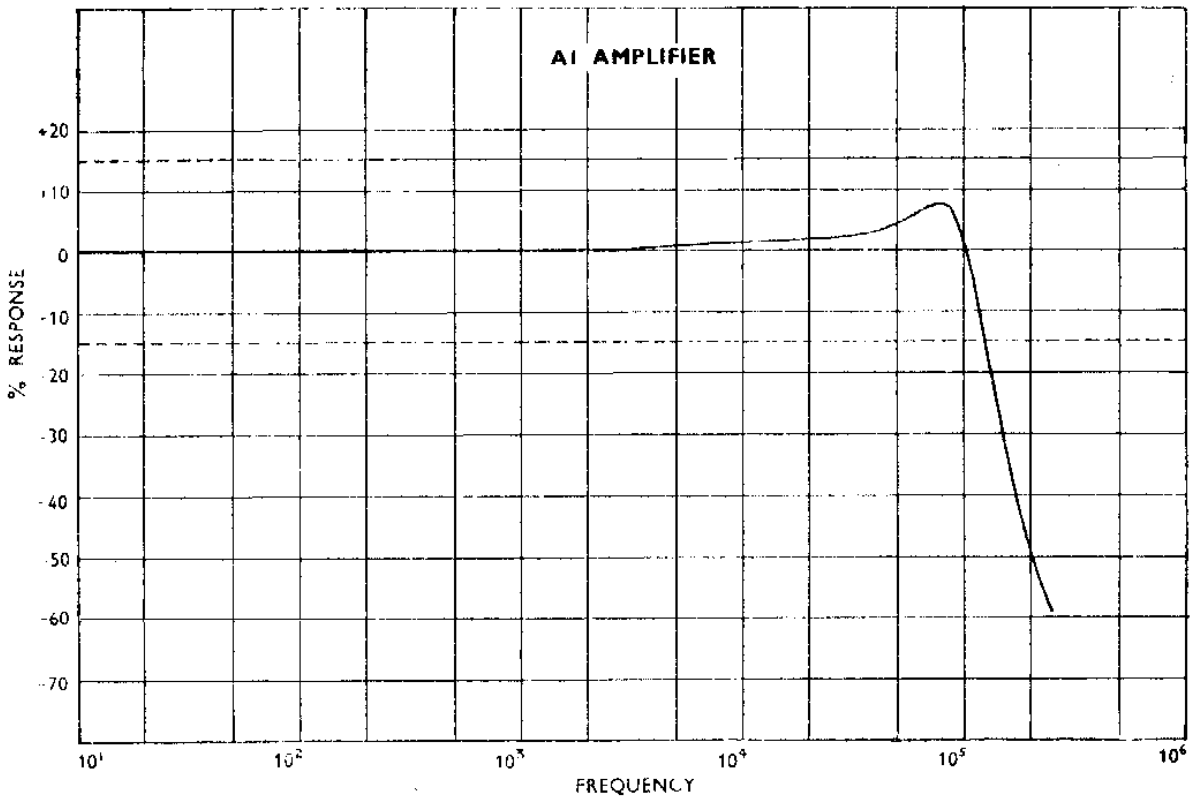
This amplifier comprises an input stage, compensated for heater variations, feeding into a phase-splitter which, in turn, drives the push-pull output stage. The maximum gain is 900 with a frequency response within -15% from zero to 100 Kc/s. Measurement of the Y1 signal is provided by a calibrated shift control operated in conjunction with the "A1 VOLTS RANGE" switch. Eight sensitivities are provided so that a full screen deflection is obtained with inputs of 300 millivolts up to 1,000 volts. The circuit is so arranged that no damage can result by applying up to 1,000 volts to the input in any sensitivity position of the Range switch. The calibration is valid when the tube operates at either 2 KV or 4 KV.

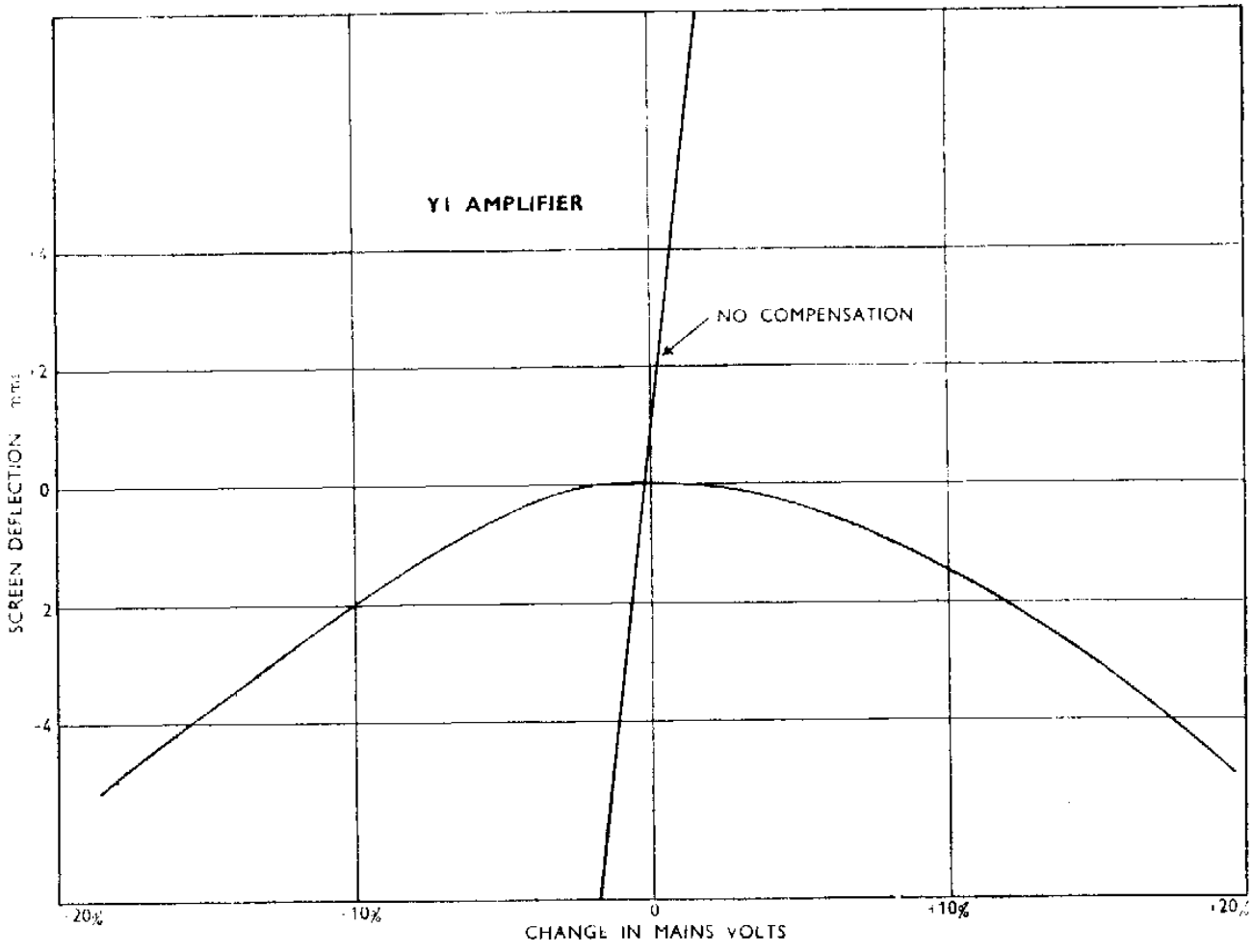
The measurement of input voltage is made by applying an internal D.C. shift potential to move the oscillogram bodily through a distance equal to the total amplitude of the applied signal. This comparative shift voltage must also, therefore, be equal to the peak-to-peak value of the input voltage and thus is a measure of it.

In practice, the measurement of the peak-to-peak voltage of an input signal is made as follows :—

Set the "A1 VOLTS" scale to zero. With the Y1 shift control, position the peak of the signal so that it is coincident with the horizontal datum line of the graticule. Now using the calibrated control, shift the trace until the lower peak reaches the datum line. The voltage of the signal is then read off directly from the dial. The inner scale is read when the "A1 VOLTS RANGE" switch is set to .3, 3, 30 and 300 volts and the outer on the other ranges.

Two front panel terminals are provided to the input of this amplifier. One is direct for a D.C. input and the other, for A.C. signals, is blocked by a .1mfd. condenser, the combination giving an input Time Constant of .05 seconds.


A1 AMPLIFIER
+20
+10
0
-10
-20
-30
-40
-50
-60
-70
% RESPONSE
10¹
10²
10³
10⁴
10⁵
10⁶
FREQUENCY


Y1 AMPLIFIER
NO COMPENSATION
+4
+2
0
-2
-4
SCREEN DEFLECTION
-20%
-10%
0
+10%
+20%
CHANGE IN MAINS VOLTS

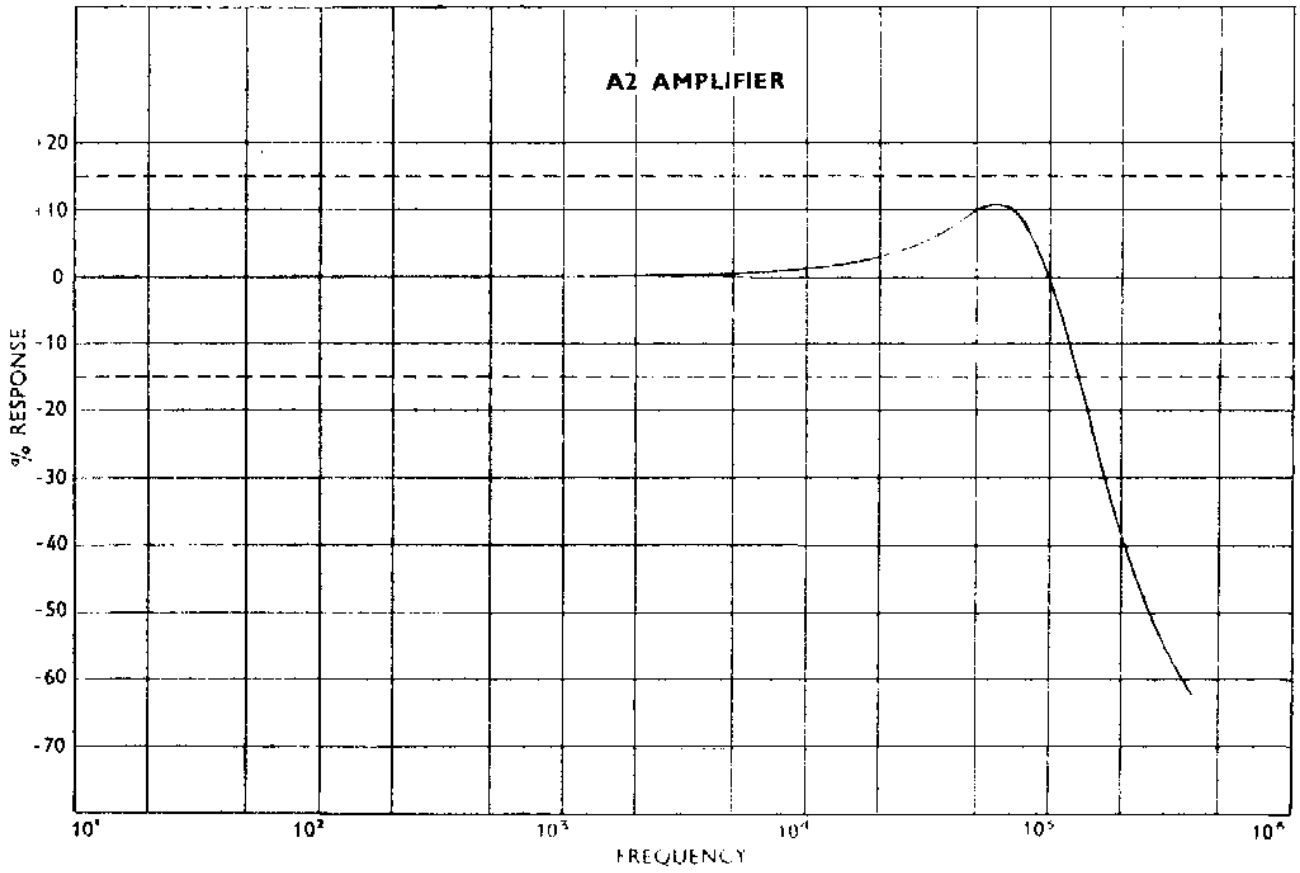
A2 AMPLIFIER

A single valve circuit, the A2 amplifier has a gain of 25 and a frequency response from zero up to 100 Kc/s within ±15%.

It is calibrated in terms of Tube deflection sensitivity at 2 KV and a seven-position gain switch (" A2 SENSITIVITY ") serves as a multiplier for measuring purposes.

To ascertain the peak-to-peak voltage of an applied signal its total amplitude is measured (in millimetres) with the calibrated graticule and multiplied by the factor indicated by the gain switch pointer. Since the deflectional sensitivity of the Tube is inversely proportional to its anode voltage, *this dial factor must first be multiplied by two when measuring Signals to this amplifier at the 4 KV setting of the E.H.T. supply.*

An independent Y2 shift control is provided and it will not affect the calibration of the amplifier.



TIME BASE

The Time Base is designed for repetitive, triggered or single-stroke operation and is direct-coupled throughout.

It can be synchronised or triggered from the Work voltage fed to either amplifier or from an external source applied between the " SYNC." and " COMMON " Terminals. In this instance a signal of approximately 10 volts R.M.S. (or 30 volts D.C.) is required to provide a satisfactory triggering or synchronising potential.

A switch (" SYNC. SELECTOR ") is provided to set the time base for synchronisation or triggering from any of these three channels as desired.

The continuously variable control " TRIGGER OR SYNC." has a centre zero point indicated when the red dot engraved in the knob is uppermost. The function of the control is to select the polarity of the synchronising or triggering pulse applied to the time base and, by adjustment of rotation of the knob, its amplitude. Thus, an anti-clock rotation will apply a negative signal of increasing voltage and a clockwise movement from zero a positive one.

To make possible the facility for the measurement of Time the circuit is *not* calibrated in terms of repetition rate as was formerly the custom but in actual spot traverse time across the screen. Thus, at the slow speed setting, the calibration indicates a scan duration of 1.5 seconds and, at the highest, 150 microseconds.

The repetition rate of the scan is, however, adjustable by means of the " TIME BASE FREQUENCY " control but this it does *without variation of the velocity of the spot.* It follows, therefore, that to maintain a constant spot velocity with a varying repetition rate will involve a change in sweep *amplitude* and, in practice, the trace length is, in fact, inversely proportional to the repetition rate of the time base.

When in the triggered condition, the spots will traverse the screen at the velocity indicated by the " TIME RANGE " switch and at the repetition frequency of the applied triggering signal.

In the fully anti-clock setting of the range switch the time base is inoperative while in its fully clockwise position an external scanning voltage may be applied to the X2 terminal via the .5 μF condenser and leak, the combination giving an input Time Constant of 1 second.

Time intervals along the horizontal axis of the traces may be measured directly by means of the calibrated X shift control " TIME SCALE " which is similar, in principle, to the voltage measuring system employed in the Y1 amplifier circuits.

For measurement, the trace must be resolved into a nearly stationary waveform by selection of the appropriate scanning speed with the " TIME RANGE " and " TIME BASE FREQUENCY " controls and locked quite stationary by the *minimum* rotation of the " TRIGGER OR SYNC." knob. The " TIME SCALE " is set at zero and the " X SHIFT " used to position the point of the trace from which the measurement is required, to the vertical datum line on the graticule. If, now, the " TIME SCALE " control is used to advance the oscillogram through the distance to be measured, the Time interval will be indicated directly on its dial, the inner scale being used on the 1,500, 150 and 15 millisecond and 1,500 and 150 microseconds time base ranges and the outer scale on other ranges.

CALIBRATION

A sinusoidal test waveform of 50 volts peak-to-peak is available at the " CAL " terminal.

GRATICULE

The measuring graticule is a circular transparent Perspex disc, $\frac{3}{16}$ in. thick and engraved co-incidently on both its faces with 8 cm. intersecting horizontal and vertical datum lines. Each is calibrated in centimetres and sub-divided into units of 2 millimetres. The graticule abuts the Tube face and is located between a machined seating in the bezel casting and the viewing hood. When mounted it is, however, free to rotate and a small pin has been provided at its periphery so that, with a finger and thumb, its rotation is simplified.

With the flat screen Tube, measurement accuracy is uniform over the entire screen surface, parallax errors have been eliminated by double engraving and the thickness of the graticule precludes any possibility of mechanical distortion.

BEAM TRIGGER

The beam-trigger provides a dual facility. It can be used as an electronic device for switching the beams on or off, or as an intensity modulating system for time-marking. At all settings, however, it must be remembered that the brightness of the beams is that to which the " Brightness " control pre-sets them and the switching system now to be described can only restore an occulted trace to that pre-set level.

The Control allows three operating conditions :

(1) Electrical Beam-Trigger (" ELEC.").

When arranged thus, the Tube traces are occulted and only restored to view at their pre-set intensity by the external application of a negative D.C. signal to the " BEAM TRIGGER " terminal, the positive " return " of this signal being taken to " COMMON ". The control is, practically, instantaneous in action and the effect

maintained as long as the voltage remains applied. There is *not*, however, as may be supposed, a *direct* connection from this terminal to the Tube grid. The switching potential affects the operation of a high-frequency oscillator circuit which, in turn, is responsible for the Tube bias excursions. There is, consequently, absolutely no possibility of a dangerous high-voltage shock from this point.

The system operates satisfactorily from an input of 12 volts D.C. but, if an A.C. signal of equivalent peak voltage is applied instead, then an intensity modulation of the beams occurs at the frequency of the applied A.C. A valuable feature is, thus, provided as the traces may be time-marked from a squaring-off circuit fed from an external sinusoidal oscillator feeding directly into the high-impedance input of this system. The modulation frequency range is zero to 80 Kc/s. per second.

(2) Mechanical Beam Trigger ("MECH.").

The facilities afforded the user at this setting of the "BEAM TRIGGER" switch are almost precisely similar to those obtained in the "ELECTRICAL" condition. Here, in place of an electrical potential, an external mechanical switch is used to effect the necessary beam-switching. The internal oscillator system of control is again used so that safety conditions are still met.

The beams are switched on for the duration of the applied short circuit and, here again, rapid switching from a contactor on a test machine will afford a co-ordinating modulation of the traces similar to the electrical time-marking method previously described. The electrical load imposed upon the external switch or contactor is 3 m A. at 60 V. and resistive.

(3) Mains Frequency Modulation ("MAINS FREQ.").

This condition has been included so that a simple and convenient time check can be made on the traces by modulating them at mains frequency. This is done internally and no external control is required in this setting.

"BEAM TRIGGER" PUSH-BUTTON

The push-button adjacent to the "BEAM TRIGGER" switch has been provided as an over-riding control of the beam-triggering system just described. When depressed, the traces are restored to the screen at an intensity pre-set by the Brightness control and, thus, observation of them is possible at any time irrespective of any external connections to the beam-trigger terminal.

POWER SUPPLIES

The instrument is designed to operate from standard mains voltages of 110-130 V or 200-250 V and is stabilised against variations of up to ± 10% of the mean values. The 650 V Positive supply rail feeding the Time Base and Amplifiers is obtained from a voltage-doubler system and electronically stabilised by a circuit incorporating a " Metrosil " bridge.

The Negative supply rail for the Cathode Ray Tube is obtained from a high-voltage Rectifier and stabilised at either 2 KV or 4 KV by the 650 V. Positive rail. The alternative Tube operating potential of 4 KV has been provided to make possible the high writing-speeds necessary for the observation and photography of certain transient phenomena.

Transition from the normal 2 KV operating condition to the 4 KV one is effected by transposing to the right the three plugs located in the panel behind the rear trap-door in the Case. It is almost unnecessary to stress that, during this operation, the Instrument *must* be switched off.

The power load is carried by three transformers, two of which (T1 and T3), supply the heater circuits and the third, (T2) the H.T. and E.H.T. rail potentials and Tube heater supply. To assure maximum reliability, no electrolytic condensers are employed anywhere in this Oscillograph.

FUSES AND MAINS SELECTOR

Two 3 amp. fuses are arranged in the primary circuit of the transformers and one (F3) in the high tension secondary of T2 feeding the Positive rail, rated at 500 mA. The fourth fuse, F5, is located in the primary of T2 and is rated at 2 amps. These components are held in clips mounted to the panel at the rear of the Instrument. Located also on this panel is the five-position Mains Selector Plug and care should be taken that it is set to the correct tapping before switching on the Oscillograph.

DIRECT CONNECTION TO THE TUBE PLATES

In certain cases, it may be desired to apply signals directly to the Tube Plates rather than through the internal amplifiers and access to these is through the side trap-door in the Case of the Instrument. In this circumstance, it is necessary to dissociate the Plates from the internal circuits of the Oscillograph by transposing the appropriate small plugs (located at the side of the terminals) to the vacant sockets provided.

It is most important to remember that when feeding directly into the Plates, *the return of the external circuit is made to the terminal* " TUBE ANODE " which, due to the D.C. coupling of the instrument, operates at a potential 325 volts *above* that of the return circuits of the Oscillograph designated " COMMON ".

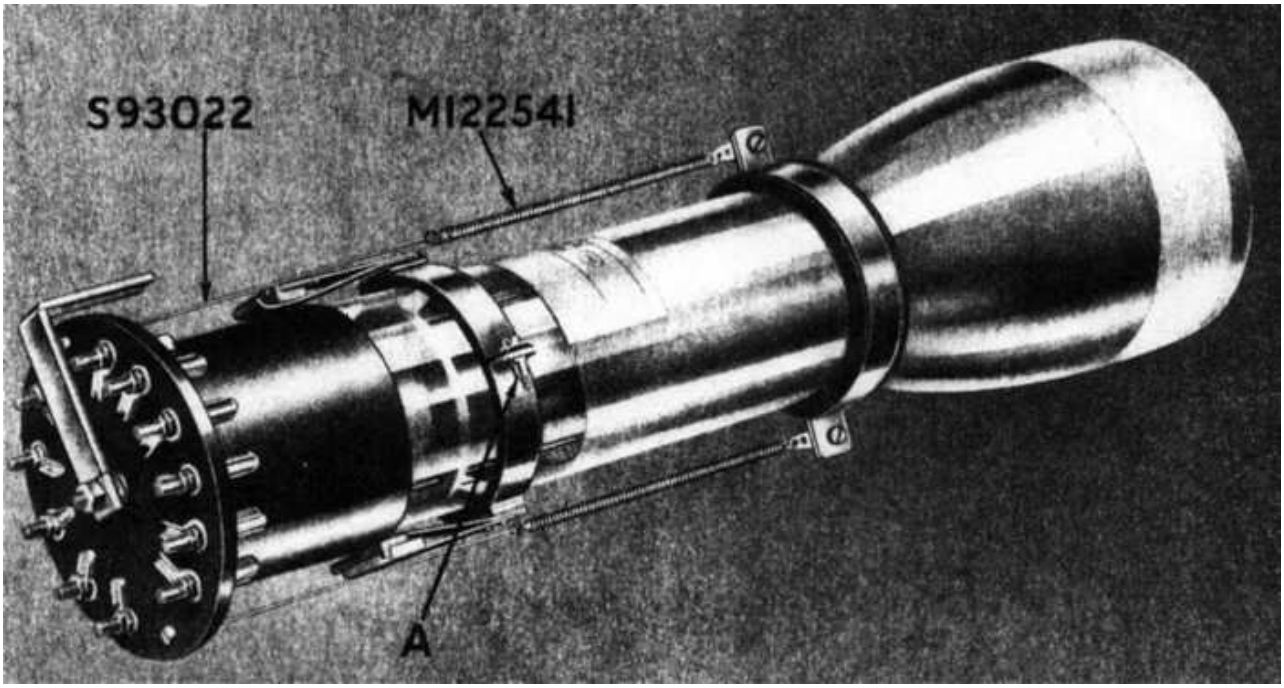
It will be appreciated, therefore, that external circuits fed directly to the Plates must remain isolated from the internal ones of the Oscillograph and that no connection may be made between the " TUBE ANODE " terminal and those marked " COMMON " (on side and front panels). The chassis and case of the Instrument are connected to the central terminal on the side panel (" E. (CHASSIS) ") and, normally, joined to the " COMMON " terminal by the wire link provided.

When connecting directly to the Plates, however, it is recommended that, as a precaution against shock to the operator, the " E. (CHASSIS) " and " TUBE ANODE " terminals *instead*, be linked so that the *body* of the Oscillograph can be at the potential of the return path of the external circuits.

BEAM BRIGHTNESS ADJUSTMENT

The Instrument leaves the works embodying a magnetic beam brightness adjusting device and is correctly set for equality of beam current when operating at 2 KV. The device, at the same time, offers to the user a means of equalising the brightness of both beams when the application of a signal of higher frequency and/or amplitude to one of them, results in a longer excursion of the spot.

The device consists of a brass, felt-lined clamping band in two similar halves from which extend symmetrically two holders, each housing a compensating magnet. The assembly is clamped around the neck of the tube with the magnets pointing towards its base and positioned, radially, so that one of them lies between the Tube-base contacts marked " A2 " and " Y2 ". The exact position will, of course, depend upon the degree of compensation required. The magnets are located with their like poles facing the same direction and if removed from their holders, care must be taken to replace them correctly. The beam brightness adjustment procedure for Model 1049 is as follows :—Remove the Case (see " Presentation "). Withdraw the four screws securing the aluminium casting to which the leather carrying handle is mounted. Access is now possible to an arcuate cover in the mu-metal screen. Remove this and slacken off the two clamp screws of the magnetic adjuster. With the Instrument switched on and the " BRIGHTNESS " control set so that the two traces are just visible, carefully slide the magnet assembly up and down the Tube neck until both beams are of equal brightness. Replace the arcuate cover in the mu-metal screen and re-check.



Note : Slacken screws "A" on either side of clamp to adjust Beam Brightness Device.

Should no further adjustments be necessary, tighten the clamp screws, replace handle casting and Case. If it is desired to correct for difference in beam brightness as the result of a greater trace length of one beam, the procedure already outlined is adopted, but in this circumstance the brightness adjustment is made with the appropriate signals applied to the input of the amplifiers. If these adjustments are made when the Oscillograph is operating at its 2 KV setting, they will have to be re-checked if, subsequently, the instrument is operated at 4 KV. Alternatively, the adjustment may be carried out initially so that at either setting of the Tube supply a reasonable compensation is maintained.

TERMINALS

All terminals fitted to the Instrument are of a new and patented design and permit the connection of two or more plain leads (under spring pressure) together with an independent, though simultaneous, union by a "crocodile" clip to the central spigot. To make a connection, depress the body of the terminal until its wire entry-hole is coincident with that in the metallic shank, insert the lead and release.

VIEWING HOOD

The cast aluminium Viewing Hood serves not only to locate the graticule but to secure a shielding of the Tube face from unwanted illumination. In the rear face of the Hood, a raised annulus has been machined so that, when mated to the Tube bezel casting, a light-tight joint is assured.

It is held in position by four split pins registering with corresponding sockets in the bezel casting and easily removed by gripping its two sides and exerting a *symmetrical* pull.

TILTING DEVICE

When this Oscillograph is standing on an average Laboratory bench, no difficulty will be experienced in reading the calibrated dials but it sometimes happens—particularly in cases where the Instrument is used for checks-on-location—that it must be operated at low eye-levels. A tilting device has, consequently, been provided so that the Front Panel may be inclined to a more convenient viewing angle.

" U "-shaped in appearance, it is fitted under the bottom tray of the Oscillograph and secured, when not in use, by two spring clips. To operate, raise the front of the instrument by means of the chromium handle on the panel, release the tilting device from its clips and pull it forward to its maximum extent.

PRESENTATION

The Model 1049 Oscillograph is business-like and attractive in appearance and finished in durable Black " leatherette " enamel. The front panel Escutcheons and Viewing Hood provide the necessary contrast in light Grey and exposed metal parts are chromium-plated. A leather carrying handle at the top of the Instrument, folding flat when not in use, is easily gripped by the provision of ample hand-room in the dished case of the Oscillograph.

The case is a light-gauge aluminium shell forming a top, sides and back and it is secured to the main structure by four screws in its back. To remove the case, withdraw the fixing screws, grip the rear between the palms of the hands, lift slightly, then retract it from the guide-channels in the bottom tray.

REPLACEMENT PARTS LIST

Description	Part No.
Transformer T1	MC413054
,, T2	KA29679
,, T3	MC413055
Choke L1	MC414013
Voltage Change Plug	M143503
Mains " On-Off " Switch	M153525
Side Panel Connector Plug	M143503
Tube Voltage Interchange Plug	M143503
Terminals	MC408035
Small Control Knob (with Indicator Dot)	MC469005/3
,, ,, ,, (without Indicator Dot)	MC469005
Large ,, ,,	MC469004
Switch Knob	MC469011
Transparent Cursor	M125521
Switch Pointer (Transparent)	M125527
Graticule	MC416050
Viewing Hood	MC408042
Tilting Member	MC416045
Leather Carrying Handle	M199572
Foot Casting (Front)	M151591/2
,, ,, (Back)	M151591/3
Rubber Feet	M164537
Fuse 3-Amp.	M157503/11
,, 500 mA.	M157503/15
,, 2-Amp.	M157503/4
Pilot Bulb Holder	M164500/2
Valve Retainer for 63 SPT.	MC408054
,, ,, ,, 185 BT—SU2150A —43 IU	M203504
,, Screen for SD6	M118527
Tube Retainer Link	S93022
,, ,, Spring	M122541
Main Escutcheon	M172531
Top Left Escutcheon	M172528
,, Right Escutcheon	M172528/2

VALVEHOLDERS

Cathode Ray Tube	MC408075
5-Pin High Voltage	M121516
B7G Button-Base Miniature	M121520
9-Pin Ceramic	M121522
International Octal	M121524

For prices and spares please apply to Service Dept., A. C. COSSOR Ltd., 51 Calthorpe Street, London, W.C.1. Telephone : TERminus 0077.

VALVE CHANGE PROCEDURE

As a result of the direct coupling of the Time Base and Amplifier circuits of this Oscillograph, it necessarily follows that a precise adjustment of relative D.C. levels is essential for their correct operation.

When certain valves are changed, therefore, it becomes necessary to re-set these D.C. levels by carrying out the alignment procedures to be described.

The instrument leaves the factory correctly adjusted and no attempt must be made to shift valves from their numbered positions.

Stabiliser Valves V3, V4

If either of these valves is changed proceed with the re-alignment as follows :—

1. Check Positive rail voltage (measured between cathode of V3 and " COMMON ") This should be 650V. Adjust this value with P2 (see annotated photograph, page 5).

2. Vary the input voltage to the Oscillograph by ±10% of the mean value to which the voltage change plug is set. These mean values are those indicated under paragraph " Power Rating " of the " Specification ".

3. Re-check that the Positive rail potential remains at 650V. If this varies by more than ± 2 volts, return to original mains voltage and make a small adjustment of P1, then re-set to 650 volts precisely with P2.

4. Increase the mains by 10% and re-check the rail. If the potential remains at 650V., the alignment is complete. If not, the entire procedure is repeated until, by compensating adjustments of P1 and P2 with variations of ±10% of the mean mains voltage, a steady positive rail of 650 volts is, within ±2 volts, attained.

Time Base Valves V7, V8

Conditions are less critical here and changing these valves will not, usually, upset the Time calibration. It is safer, however, to check this calibration on all ranges of the " TIME RANGE " switch. This is conveniently done by applying a signal of known frequency to either Amplifier and measuring the oscillogram upon the " TIME SCALE ". The reciprocal of the indicated Time will be the frequency of the applied signal.

The calibration is adjusted by P5 and should be set to give Time readings on all ranges to an accuracy of ±10%.

A1 Amplifier Valves V9, V10

These two valves provide a heater compensation system for this amplifier and the correct adjustment of their operating conditions is most important.

Should either or both valves be changed, they are re-aligned as under :—

1. Set the "A1 VOLTS" dial to zero (fully clockwise) and the "Y1 SHIFT" control to the mid-point of its rotation.
2. Adjust potentiometer P12 so that the Y1 spot (or trace) is coincident with the horizontal datum line on the graticule.
3. Increase the input mains volts of the Instrument by 10% of the mean value. At this new input voltage the trace should not deviate from the horizontal datum line by more than ±3 millimetres; if the movement is greater than this in an *upward* direction:-
4. Return mains voltage to its original value and adjust P11 so that the trace is and moved *upward* by about 2 centimetres.
5. Return it again to the datum line by operation of the potentiometer P12.
6. Repeat operation 3 and re-check.
7. Proceed with 4, if necessary, re-adjusting P11 then P12 so that no movement greater than ±3 millimetres occurs when the mains volts are raised by 10%.

   If, in Item 3, the spot (or trace) should move *downward*, then adjust P11 for a downward movement of approximately 2 centimetres instead and proceed.

   The entire procedure must now be repeated exactly but with a *decrease* of 10% of mean mains input voltage.

   If the valve V10 only is changed, the Instrument is now ready for use but if V9 is also replaced, either separately or with V10, further adjustments become necessary ; this time to check that the voltage measuring system of the Amplifier has not been impaired.

   In this case proceed with the following :—
8. With the "A1 VOLTS RANGE" switch set to a convenient position, inject an accurately-known D.C. signal into the input of the A1 Amplifier.
9. Measure this signal on the "A1 VOLTS" scale and, if necessary, adjust P13 until the scale indication is accurate.

   If the adjustment of P13 has upset the D.C. balance attained through operations 1—7 and the beam (in the absence of the applied D.C. calibration signal) is no longer within ±.3 millimetres from the horizontal datum line when the "A1 VOLTS" control is set to zero and the "Y1 SHIFT" to the mid-point of its rotation:-
10. Adjust P12 to bring the trace back to the datum line.
11. Re-apply the calibrating signal and check for measurement accuracy.

A1 Amplifier Valves V12, V13

If the output valves V12 or V13 require replacement, the correct setting-up procedure for the new valves is as follows :

1. Connect an electrostatic or D.C. valve voltmeter between the grid top-cap of V11 and the "COMMON" return circuit. Normal types of moving-coil or moving-iron instruments are quite unsuitable for this measurement as a result of their relatively low input impedance.
2. Adjust the "A1 VOLTS" or "Y1 SHIFT" controls so that the applied meter reads 83 volts.
3. Disconnect the Y2 plate from the "A2 AMP. OUTPUT" at the side panel terminal assembly. (See paragraph "DIRECT CONNECTION TO THE TUBE PLATES").
4. Connect anode pin of V13 to the Y2 side panel terminal.
5. Adjust potentiometer P15 so that the two traces (which move together) lie equidistantly from the horizontal datum line on the graticule.

A2 Amplifier Valve V21 and Cathode Ray Tube

The A2 Amplifier presents similar alignment problems but attention need only be directed towards the Amplifier valve V21, since the other—V22—is the Shift valve and its replacement will not interfere with the calibration system.

If V21 and/or the Cathode Ray Tube is changed, the following procedure is adopted:-

1. Set the "Y2 SHIFT" control to its fully clockwise position.
2. With the input of the Amplifier short-circuited, adjust P24 so that the Y2 trace disappears just off the bottom of the screen.
3. Return trace to centre of screen with the "Y2 SHIFT" control.
4. Inject a D.C. signal of accurately-known voltage into the input and measure its amplitude upon the vertical scale on the graticule and check that the sensitivity of the Amplifier is correct.

   If the reading is high :—
5. Remove the calibrating signal, short-circuit the input and adjust P23 so that the trace is moved approximately 1 centimetre downwards on the screen.
6. With P24, return the trace to the horizontal datum line.
7. Re-apply the test signal and repeat the procedure as above, alternately adjusting P23 and restoring with P24 until the desired accuracy is attained. If the sensitivity is found to be low instead of high, then P23 is adjusted so that, in operation 5, the trace is moved *upwards* instead of downwards.

P A R T S L I S T

Ref	Value	Rating	Part No
R1	68K ± 5%	2W	M.132510/41
R2	68K ± 5%	2W	M.132510/41
R3	680K ± 20%	1W	DR02/68420
R4	4.7M ± 20%	1W	DR02/47520
R5	470 ± 20%	1/2W	DR08/47120
R6	470 ± 20%	1/2W	DR08/47120
R7	47 ± 20%	1/2W	DR08/47020
R8	470 ± 20%	1/2W	DR08/47120
R9	390K ± 20%	1/2W	DR08/39420
R10	470K ± 20%	1W	DR02/47420
R11	390K ± 20%	1/2W	DR08/39420
R12	820K ± 5%	1W	M.132510/38
R13	560K ± 10%	1W	DR02/56410
R14	68K ± 10%	1/2W	DR08/68310
R15	1M ± 20%	1/2W	DR08/10520
R16	1M ± 20%	1/2W	DR08/10520
R17	33K ± 10%	1W	DR02/33310
R18	68K ± 5%	2W	M.132510/41
R20	6.8K ± 10%	1/2W	DR08/68210
R21	22K ± 10%	1/2W	DR08/22310
R22	150K ± 10%	1/2W	DR08/15410
R23	150K ± 10%	1/2W	DR08/15410
R24	680K ± 20%	1/2W	DR08/68420
R25	220K ± 20%	1W	DR02/22420
R26	220K ± 20%	1W	DR02/22420
R27	470 ± 20%	1/2W	DR08/47120
R28	82K ± 20%	2W	DR01/82320
R29	4.7K ± 10%	1/2W	DR08/47210
R30	270K ± 20%	2W	DR01/27420
R31	470 ± 20%	1/2W	DR08/47120
R32	1.8K ± 10%	1/2W	DR08/18210
R33	68K ± 20%	1/2W	DR08/68320
R34	220K ± 10%	1/2W	DR08/22410
R35	1.5M ± 10%	1/2W	DR08/15510
R36	1.8M ± 20%	1/2W	DR08/18520
R37	390K ± 10%	1/2W	DR08/39410
R38	330K ± 20%	1/2W	DR08/33420
R39	2.2M ± 20%	1/2W	DR08/22520
R40	47K ± 10%	1W	DR02/47310
R41	47K ± 10%	1W	DR02/47310
R42	33K ± 10%	1W	DR02/33310
R43	82K ± 10%	1W	DR02/82310
R44	560K ± 2%	2W	M.132510/31
R45	240K ± 2%	1W	M.132510/29
R46	62K ± 2%	1/2W	M.132510/27
R47	17.2K ± 2%	1/2W	M.132510/24
R48	5.6K ± 2%	1/2W	M.132510/22
R49	1.68K ± 2%	1/2W	M.132510/20
R50	560 ± 2%	1/2W	M.132510/19
R51	168 ± 2%	1/2W	M.132510/18
R52	270K ± 20%	1W	DR02/27420
R53	110K ± 5%	-	M.132516
R54	110K ± 5%	-	M.132516
R55	60K ± 10%	5W	M.132564/4
R56	150 ± 20%	1/2W	DR08/15120
R57	350 ± 5%	3/4W	M.132511/2
R58	9.5K ± 2%	.5W	M.132510/23
R59	30K ± 10%	5W	M.132564
R60	125K ± 5%	-	M.132516/2
R61	125K ± 5%	-	M.132516/2
R62	150 ± 20%	1/2W	DR08/15120

Ref.	Value	Rating	Part No
R63	135K ± 5%	-	M.132516/3
R64	135K ± 5%	-	M.132516/3
R65	150 ± 20%	1/2W	DR08/15120
R66	68K ± 10%	8W	M.132564/5
R67	75K ± 10%	8W	M.132564/6
R68	39K ± 5%	5W	M.132564/2
R69	56K ± 10%	5W	M.132564/3
R70	220K ± 10%	1/2W	DR08/22410
R71	470 ± 20%	1/2W	DR08/47120
R72	50K ± 5%	15W	DR43/50305
R73	1M ± 20%	2W	DR01/10520
R74	2.2M ± 20%	1/2W	DR08/22520
R76	3.3K ± 5%	2W	M.132511/5
R77	50K ± 5%	15W	DR43/50305
R78	470 ± 20%	1/2W	DR08/47120
R79	56K ± 10%	5W	M.132564/3
R80	56K ± 10%	5W	M.132564/3
R81	68K ± 10%	8W	M.132564/5
R82	3.3K ± 5%	2W	M.132511/5
R83	470 ± 20%	1/2W	DR08/47120
R84	470K ± 5%	1W	M.132510/36
R85	1M ± 5%	2W	M.132510/37
R86	1M ± 5%	2W	M.132510/37
R87	1M ± 5%	2W	M.132510/37
R88	1M ± 5%	2W	M.132510/37
R89	120K ± 10%	1/2W	DR08/12410
R90	330K ± 10%	1W	DR02/33410
R91	150K ± 10%	1/2W	DR08/15410
R92	1.5M ± 10%	1W	DR02/15510
R93	200K ± 10%	2W	DR01/20410
R94	3.3K ± 20%	1/2W	DR08/33220
R95	2.2M ± 10%	1W	DR02/22510
R96	560K ± 10%	1/2W	DR08/56410
R97	180K ± 10%	1/2W	DR08/18410
R98	120K ± 10%	1/2W	DR08/12410
R99	82K ± 20%	1/2W	DR08/82320
R100	390K ± 20%	1/2W	DR08/39420
R101	100K ± 20%	1/2W	DR08/10420
R102	47C ± 20%	1/2W	DR08/47120
R103	47K ± 20%	2W	DR01/47320
R104	100K ± 5%	-	M.132505/8
R105	220 ± 10%	1/2W	DR08/22110
R106	15K ± 10%	2W	DR01/15310
R107	1.5M ± 10%	1/2W	DR08/15510
R108	820K ± 10%	1/2W	DR08/82410
R109	220K ± 10%	1/2W	DR08/22410
R110	470 ± 10%	1/2W	DR08/47110
R111	220K ± 20%	1/2W	DR08/22420
R112	1M ± 20%	1/2W	DR08/10520
R113	680K ± 10%	1/2W	DR08/68410
R114	82K ± 10%	1/2W	DR08/82310
R115	470K ± 2%	1/2W	M.132510/30
R116	4.7K ± 2%	1/2W	M.132510/21
R117	9.5K ± 2%	1/2W	M.132510/23
R118	25K ± 2%	1/2W	M.132510/25
R119	51K ± 2%	1/2W	M.132510/26
R120	120K ± 2%	1/2W	M.132510/28
R121	470K ± 2%	1/2W	M.132510/30
R122	270K ± 20%	1/2W	DR08/27420
R123	470 ± 20%	1/2W	DR08/47120
R124	150K ± 20%	1/2W	DR08/15420

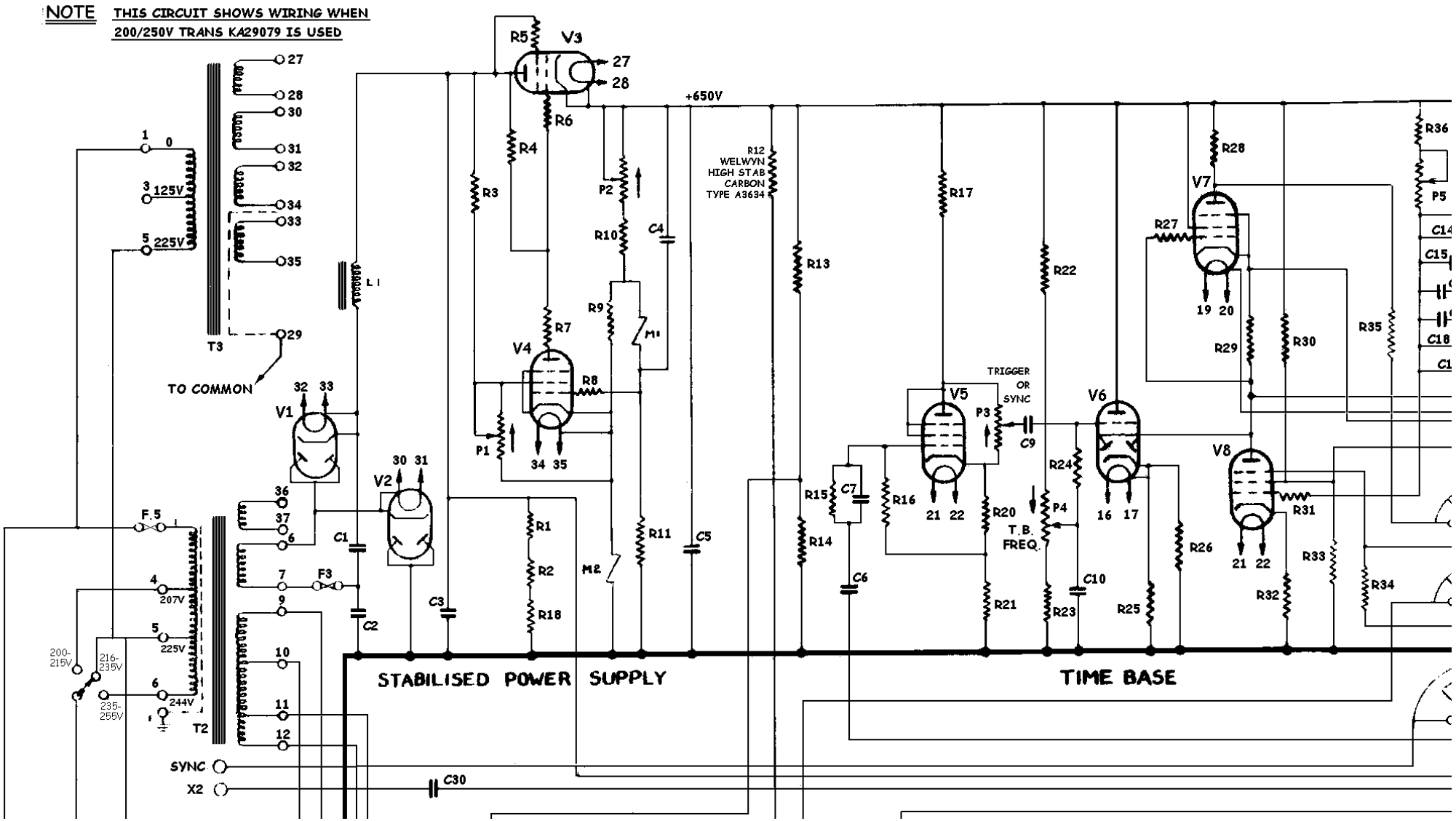
(contd)

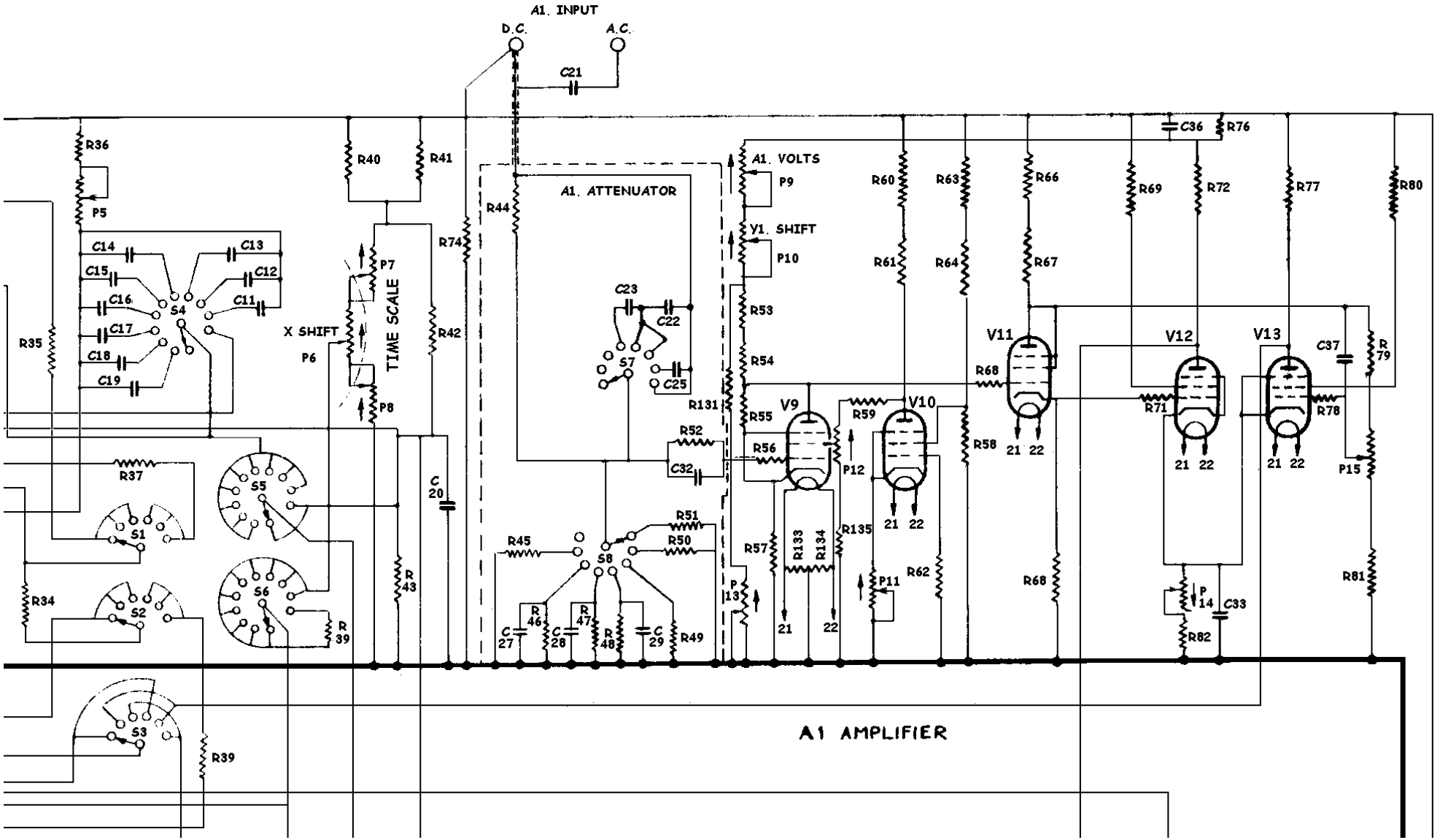
Ref	Value	Rating	Part No
R125	100K ± 20%	1/2W	DR08/10420
R126	100K ± 20%	1/2W	DR08/10420
R127	30K ± 5%	15W	DR43/30305
R128	150K ± 20%	1W	DR02/15420
R129	150K ± 20%	1W	DR02/15420
R130	180K ± 20%	1W	DR02/18420
R131	470K ± 5%	1W	M.132510/36
R132	680K ± 10%	1/2W	DR08/68410
M1	320μ A(B of 0.2)	130V	M.199573
M2	320μ A(B.of 0.2)	130V	M.199573
R135	15K ± 5%	7.5W	DR41/15305
S1	6 Posn	Front Bank	3 Pole M.154509
S2	"	Centre Bank	
S3	"	Rear Bank	
S4	11 Posn	"	
S5	"	Centre Bank	3 Pole M.154508
S6	"	Front Bank	
S7	8 Posn	Rear Bank	A1 Atten
S8	"	Front Bank	MC.460014
S9	ON-OFF	S.P.	M.153525
S10	Push Button	"	M.153527
S11	4 Posn	Left Side	2 Pole M.154510
S12	"	Right Side	
S13	7 Posn	Rear Bank	A2 Atten
S14	7 Posn	Front Bank	MC.460015
P1	1M	.5W	M.158519/2
P2	.5M	.5W	M.158519/3
P3	.25M	.5W	M.158519/6
P4	.25M	.5W	M.158519/6
P5	.5M	.5W	M.158519/3
P6	50K	4W	M.158520
P7	50K	4W	Dual Pot
P8	50K	4W	M.158522
P9	15K	4W	M.158520/10
P10	15K	4W	M.158520/10
P11	500	1W	M.158520/2
P12	30K	4W	M.158520/7
P13	2M	1.5W	M.158519/9
P14	2K	3W	M.158520/5
P15	15K	3W	M.158520/6
P16	.25M	1.5W	M.158519
P17	.25M	1.5W	M.158519
P18	.5M	1.5W	M.158519/3
P19	.5M	1.5W	M.158519/3
P20	1M	1.5W	M.158519/2
P21	.5M	1.5W	M.158519/7
P22	100K	1.5W	M.158519/5
P23	500	5W	M.158520/2
P24	50K	1.5W	M.158519/8
P25	100K	1.5W	M.158519/5
C1	4μF ± 20%	750V	M.129523
C2	4μF ± 20%	750V	M.129523
C3	6μF ± 20%	1500V	M.129527
C4	.1μF ± 20%	1000V	MC.105101
C5	.5μF ± 20%	1000V	M.129521
C6	.1μF ± 20%	1000V	MC.105101
C7	10pF ± 10%	350V	M.129580
C8	.01μF ± 20%	5000V	M.129508
C9	.1μF ± 20%	1000V	MC.105101

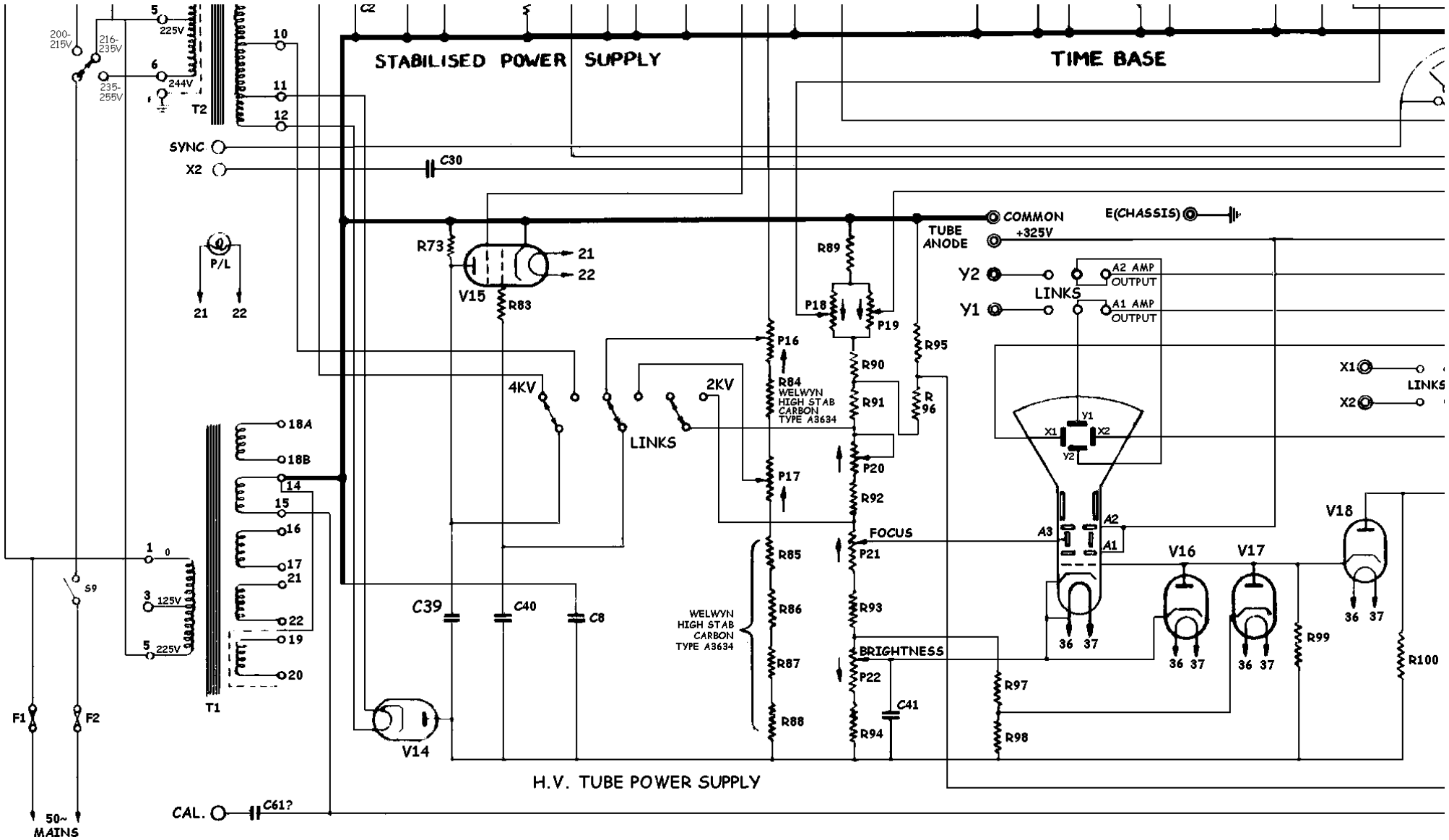
Ref	VALVE
V1	52 KU
V2	52 KU
V3	185 BT
V4	OM 6
V5	OM 6
V6	OM 4
V7	63 SPT
V8	63 SPT
V9	OM 5B
V10	OM 5B
V11	OM 6
V12	63 SPT
V13	63 SPT
V14	SU.2150A
V15	61 BT
V16	SD 6
V17	SD 6
V18	SD 6
V19	OM 6
V20	OM 6
V21	63 SPT
V22	61 BT
CRT	89 J

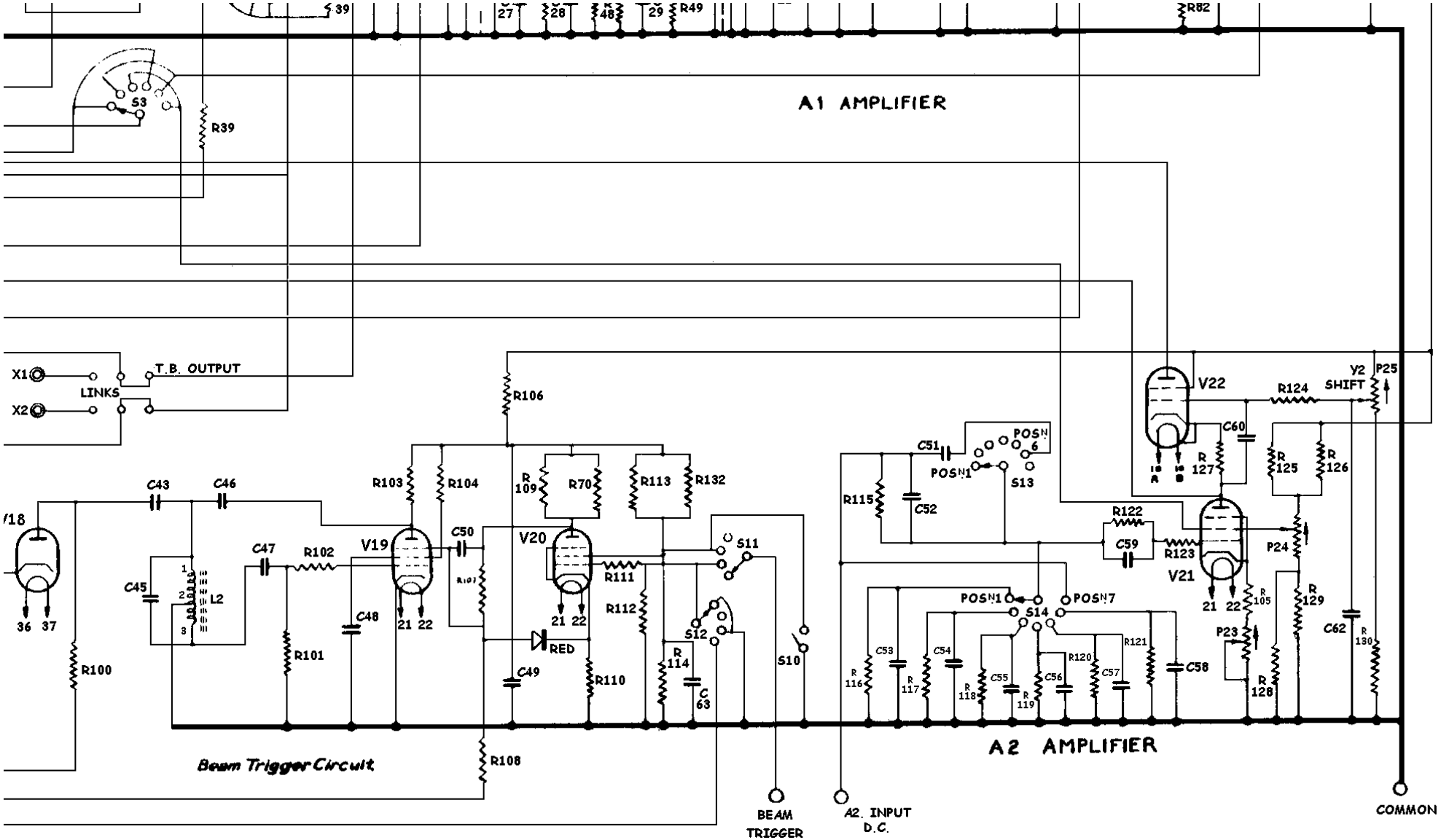
Ref	Value	Rating	Part No
C10	.1μF ± 20%	1000V	MC105101
C11	250pF ± 5%	500V	M.129526/4
C12	860pF ± 5%	500V	M.129526
C13	2700pF ± 5%	750V	M.129593/8
C14	9000pF ± 5%	750V	M.129593/3
C15	.026μF ± 5%	500V	MC.405013
C16	.09μF ± 5%	500V	MC.405011
C17	.26μF ± 5%	500V	MC.405012
C18	.9μF ± 5%	500V	MC.405016
C19	2.6μF ± 5%	500V	MC.405017
C20	.25uF ± 20%	500V	MC.105103
C21	.1uF ± 20%	1000V	MC.105101/2
C22	20pF ± 5%	500V	M.129579/16
C23	6.8pF ± 1/2pF	500V	M.129579/29
C25	27pF ± 20%	500V	M.129579/8
C27	120pF ± 5%	350V	M.129580/28
C28	560pF ± 5%	350V	M.129580/52
C29	470pF ± 5%	350V	M.129580/49
C32	.01μF ± 5%	350V	M.129580/97
C33	.01μF ± 5%	350V	M.129580/97
C35	220pF ± 5%	350V	M.129580/37
C37	220pF ± 5%	350V	M.129580/37
C38	.5μF ± 20%	1000V	M.129521
C39	.1μF ± 20%	6000V	M.129520
C40	.01μF ± 20%	5000V	M.129508
C41	.1μF ± 20%	350V	MC.105099
C43	100pF ± 2%	5000V	M.129519
C45	100pF ± 5%	350V	M.129580/25
C46	56pF ± 10%	350V	M.129512/17
C47	47pF ± 5%	350V	M.129580/14
C48	100pF ± 20%	750V	M.129587/2
C49	.001μF ± 20%	1000V	MC.105093
C50	120pF ± 10%	750V	M.129512/16
C51	68pF ± 5%	500V	M.129579/31
C52	47pF ± 2%	500V	M.129579/7
C53	5000pF ± 5%	350V	M.129580/101
C54	2400pF ± 5%	350V	M.129580/102
C55	820pF ± 5%	350V	M.129580/58
C56	390pF ± 5%	350V	M.129580/46
C57	120pF ± 2%	500V	M.129579/16
C58	47pF ± 2%	500V	M.129579/7
C59	.01μF ± 5%	350V	M.129580/97
C60	5.6pF ± 10%	500V	M.129579/27
C61	.5μF ± 20%	350V	MC.105104
C62	.01μF ± 20%	1000V	MC.105096
C63	470pF ± 10%	350V	M.129580/48
R133	47 ± 20%	1/2W	DR08/47020
R134	47 ± 20%	1/2W	DR08/47020
L1			MC.414013
L2			MC.430194
T1			MC.413054
T2	200-250V Trans		KA.29679
T3			MC.413059
F1		3 Amp	M.157503/11
F2		3 Amp	M.157503/11
F3		500mA	M.157503/15
F5	200-250V	500mA	M.157519
P.L	6.5V	.3A	M.201505

NOTE: For 100-130V Mains T2 is KA.29715
F5 is 2A, M.157503/4


NOTE
THIS CIRCUIT SHOWS WIRING WHEN
200/250V TRANS KA29079 IS USED
T3
T2
TO COMMON
125V
225V
207V
244V
200-215V
216-235V
235-255V
F.5
F3
L1
V1
V2
V3
V4
V5
V6
V7
V8
+650V
R12 WELWYN HIGH STAB CARBON TYPE A3634
TRIGGER OR SYNC
T.B. FREQ.
STABILISED POWER SUPPLY
TIME BASE
SYNC
X2
C30


A1. INPUT
D.C.
A.C.
C21
A1. ATTENUATOR
A1. VOLTS
P9
Y1. SHIFT
P10
X SHIFT
P6
TIME SCALE
P7
P8
S1
S2
S3
S4
S5
S6
S7
S8
V9
V10
V11
V12
V13
P5
P11
P12
P13
P14
P15
R36
R35
R34
R37
R39
R40
R41
R42
R43
R44
R45
R46
R47
R48
R49
R50
R51
R52
R53
R54
R55
R56
R57
R58
R59
R60
R61
R62
R63
R64
R66
R67
R68
R69
R71
R72
R74
R76
R77
R78
R79
R80
R81
R82
R131
R133
R134
R135
C11
C12
C13
C14
C15
C16
C17
C18
C19
C20
C22
C23
C25
C27
C28
C29
C32
C33
C36
C37
21
22
A1 AMPLIFIER


STABILISED POWER SUPPLY
TIME BASE
200-215V
216-235V
235-255V
225V
244V
T2
SYNC
X2
C30
P/L
R73
V15
R83
21
22
COMMON
+325V
E(CHASSIS)
TUBE ANODE
R89
P18
P19
Y2
Y1
A2 AMP OUTPUT
A1 AMP OUTPUT
LINKS
X1
X2
P16
R84
WELWYN HIGH STAB CARBON TYPE A3634
R90
R91
R95
R96
4KV
2KV
LINKS
P17
P20
R92
FOCUS
P21
R85
R86
R87
R88
R93
BRIGHTNESS
P22
C41
R94
R97
R98
C39
C40
C8
WELWYN HIGH STAB CARBON TYPE A3634
V14
18A
18B
14
15
16
17
19
20
T1
125V
S9
F1
F2
50~ MAINS
CAL.
C61?
A3
A2
A1
V16
V17
V18
36 37
R99
R100
H.V. TUBE POWER SUPPLY


A1 AMPLIFIER
A2 AMPLIFIER
Beam Trigger Circuit
S3
R39
X1
X2
LINKS
T.B. OUTPUT
R106
R103
R104
R109
R70
R113
R132
C43
C46
C45
L2
C47
R102
V19
C50
V20
R111
R112
S11
S12
S10
R114
C63
C49
R110
R108
R100
R101
C48
RED
36 37
21 22
BEAM TRIGGER
A2. INPUT D.C.
COMMON
C51
POSN 6
POSN1
S13
R115
C52
V22
R124
Y2 SHIFT
P25
C60
R 127
R 125
R 126
R122
C59
R123
V21
P24
R 105
R 129
P23
R 128
C62
R 130
POSN1
POSN7
S14
R 116
C53
R 117
C54
R 118
C55
R 119
C56
R120
C57
R121
C58