COSSOR

Double-beam

OSCILLOGRAPH

Model 1035 Mk III

CONTINUOUS DEVELOPMENT MAY RESULT IN MINOR CHANGES TO DESIGN.

COSSOR INSTRUMENTS LTD.

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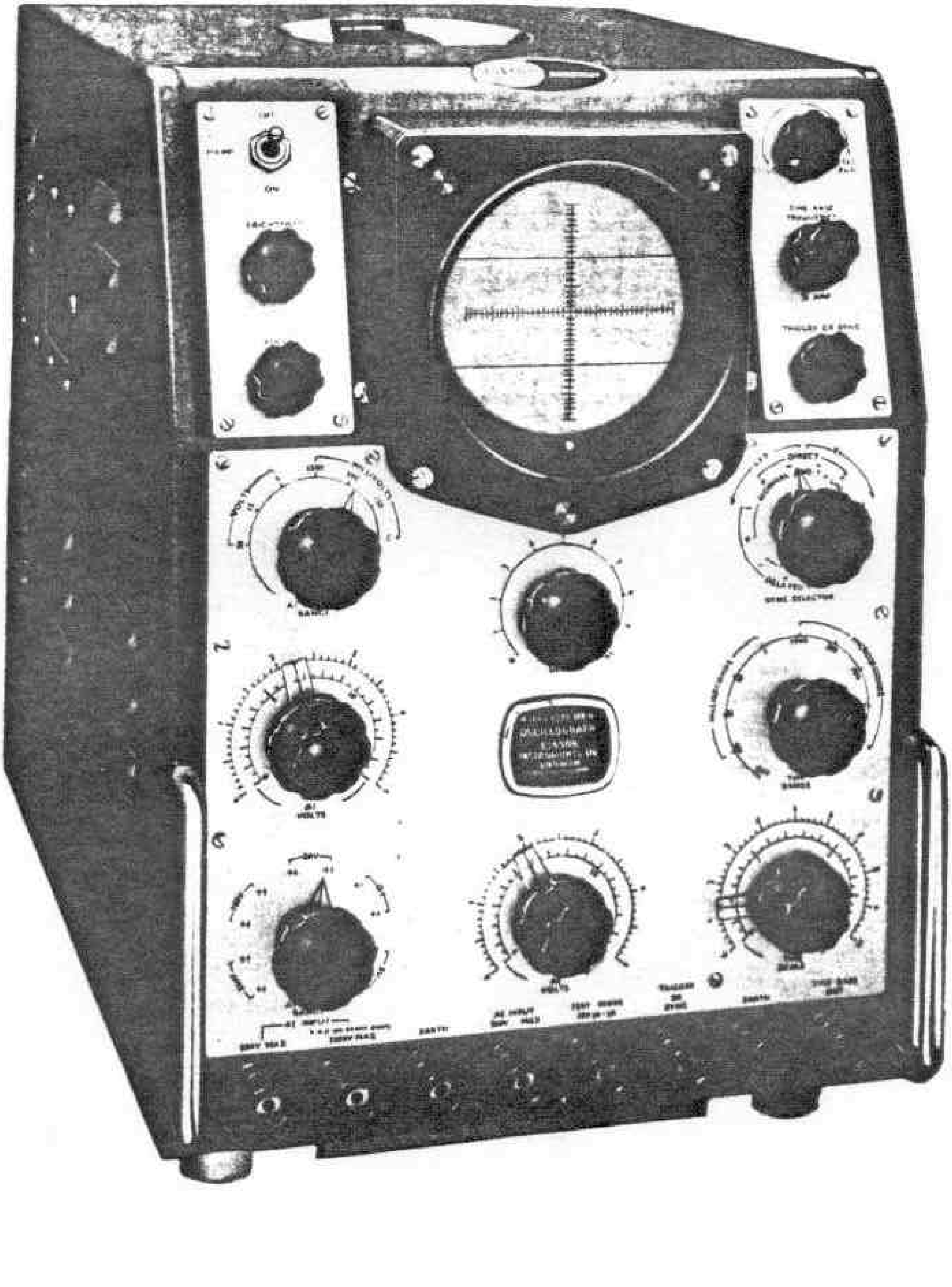


INTRODUCTION

The Oscillograph Model 1035 Mk III is a double-beam, general-purpose instrument covering a wide range of research and industrial applications. Modern circuit techniques are employed in the instrument which has a cathode-ray tube with a post-deflection anode. A high degree of display definition is obtained with freedom from flare.

Triggered or repetitive operation of the time-base is available and a variable time-base delay is provided. Other features are: the X amplifier of variable gain which ensures full amplitude of sweep on all ranges; provision for inverting the Y2 display for comparison purposes; trace bright-up for single-stroke working; direct and easy access to the X and Y plates; facilities for triggering from TV line or frame sync pulses. On the slower speed ranges, the time-base output can be used for driving frequency-swept oscillators.

SPECIFICATION

Cathode-ray Tube .. .. Cossor 4 in. (10 cm), double-beam. Type 93D with green fluorescence, operating at 2 kV (a3) and +ve 350 V p.d.a. with provision for increasing p.d.a. to 2 kV.

X sensitivity direct to plates 2·6 V/mm (0·38 mm/V).

Y sensitivity direct to plates 2·5 V/mm (0.4 mm/V).

Direct connections from X and Y plates and modulator are accessible on side terminal panels.

A1 Amplifier .. .. .. Maximum gain: 3000.

Frequency response: better than 5 c/s to 5 Mc/s (−30%) on all sensitivity ranges except on the 50 mV range which has a frequency limit of 1·5 Mc/s.

Directly calibrated voltage scale with separate zero adjustment (***measurement*** accuracy is better than 10 per cent).

Seven ranges:

Volts Range	Gain (nominal)	Frequency Response 30% down	50% down	Sensitivity	
50 V	x 3	5 Mc/s	7 Mc/s	10 V/cm	(1 mm/V)
15 V	x 10	5 Mc/s	7 Mc/s	3 V/cm	(3·33 mm/V)
5 V	x 30	5 Mc/s	7 Mc/s	1 V/cm	(1 cm/V)
1·5 V	x 100	5 Mc/s	7 Mc/s	0·3 V/cm	(3·33 cm/V)
500 mV	x 300	5 Mc/s	7 Mc/s	0·1 V/cm	(10 cm/V)
150 mV	x 1000	5 Mc/s	7 Mc/s	30 mV/cm	(33·3 cm/V)
50 mV	x 3000	1·5 Mc/s	2·5 Mc/s	10 mV/cm	(1 mm/mV)

Maximum input: 500 V d.c. Compensated input attenuator.

Input impedance: 0·43 MΩ, 25 pF to 1 MΩ, 25 pF depending on the gain setting. Rise-time on 50 V to 150 mV range is better than 0·1 μsec with less than 5 per cent overshoot, on the 50 mV range better than 0·2 μsec. An additional attenuator, 1 : 30, is available via a terminal on the front panel. Maximum input 1500 V. Input impedance: 27 MΩ, 5 pF.

A2 Amplifier .. .. .. Maximum gain: 30.

Frequency response: better than 5 c/s to 250 kc/s (−30%).

Directly calibrated voltage scale with separate zero adjustment (***measurement*** accuracy is better than 10 per cent).

Five ranges: 500 V, 150 V, 50 V, 15 V, 5V.

Phase reversal on all ranges without change in gain.

Input impedance: 1·5 MΩ, 50 pF to 0·5 MΩ, 60 pF.

Rise-time: 1 μsec, negligible overshoot.

Time-base .. .. ..

Repetitive or triggered operation.

Repetition frequency of free-running time-base continuously variable over 3·3 : 1 on each range by variation of the time-base amplitude.

Positive or negative Trigger or Sync.

Directly calibrated time scale with separate zero adjustment (*measurement* accuracy is better than 10 per cent).

Nine ranges:

100 msec	1000 μsec
30 msec	300 μsec
10 msec	100 μsec
3 msec	30 μsec
	10 μsec

Sweep expansion, continuously variable to better than 5 times on all ranges, giving a maximum spot velocity of 4 cm/μsec.

Time-base delay up to 10 times, at least, of the range in use except on the 100 msec and 30 msec ranges where the maximum delay is 100 msec.

Time-base output (on slower ranges) is available at high impedance at the X1 terminal.

Maximum time-base start time, 0·5 μsec.
Fly-back blacked out on all ranges.

Pulse bright-up facilities for single-stroke working, 10 msec and faster.

Trigger and Synchronization

Selected by switch for positive or negative, direct or delayed, trigger or sync from external source or, internally, from Y1 amplifier.

External trigger: 1 V r.m.s. to 5 Mc/s or 0·5 V peak-to-peak pulse and will sync from 10 Mc/s sine waves.

Internal trigger: 2 mm at 1 kc/s rising to 1 cm at 5 Mc/s or 2 mm pulse.

Test Waveform Voltage ..

10 V peak-to-peak (nominal).

Power Supply .. .. ..

Mains:	105 V to 115 V, 120 V to 130 V, 200 V to 215 V, 216 V to 234 V, 235 V to 255 V.
Frequency:	50 c/s to 100 c/s.
Consumption:	140 W.

Size and Weight .. ..

Height 16½ in.	(41·9 cm).
Width 11½ in.	(29·2 cm).
Depth 19¾ in.	(50·2 cm).
Weight 50 lb	(22·7 kg).

OPERATING THE OSCILLOGRAPH

Caution: The instrument will not operate and may suffer serious damage if connected to a d.c. supply or to a supply of a frequency less than 50 c/s.

Do not touch any part of the circuit while the mains supply is connected. The mains fuses are in the unswitched side of the mains and, therefore, will be live when the mains supply is connected, even though the instrument is switched off.

POWER SUPPLIES

Ensure that the mains selector, accessible by dropping the sliding panel at the rear of the instrument, is set to the range covering the voltage of the supply from which the instrument is to be operated.

If continuous operation from 105 V to 130 V supplies is required, replace the 3 A fuses with 5 A fuses.

Connect the cable lead to a suitable plug and insert this plug into the mains power socket. Move the On/Off switch to the ON position.

BRIGHTNESS AND FOCUS

Adjust the BRIGHTNESS and FOCUS controls to give suitable brightness and best definition.

Caution: When the +ve 2 kV p.d.a. is in use, avoid extreme brightness which will damage the fluorescent material of the screen.

GRATICULE

To rotate the graticule, use the thumb and one finger to grip the small pin located near the periphery and apply a turning movement. Position the graticule so that the two plain lines are horizontal and parallel to the trace on the CRT.

RAISING MEMBER

Use the adjustable raising member under the front of the instrument, as required, to provide a convenient viewing angle. To bring the raising member into use, grip one of the chromium handles and lift the front of the instrument. Release the raising member from its two spring clips and pull it fully forward.

Note: No difficulty will be experienced in reading the graticule but the raising member can be used to advantage when the instrument is operated at low eye-level, for example, in checks on location.

A1 AMPLIFIER

Voltage Measurements (500V Max)

Caution: The input to the amplifier must not exceed 500 V. The input attenuator provides a d.c. path to earth and, if this is likely to cause interference to the apparatus being tested, an external capacitor must be used.

Put the A1 VOLTS RANGE switch to a position such that the waveform to be measured is between 1 to 5 cm amplitude.

Set the cursor on the A1 VOLTS scale to zero.

Turn the small centre knob of the A1 VOLTS control to position the waveform (or portion of it) to be measured so that its base is coincident with the centre horizontal line of the graticule or other convenient index line.

Move the cursor so that the top of the waveform (or portion of it) is brought down to the horizontal line or other index line chosen.

If the A1 VOLTS RANGE switch is positioned at 5 or a multiple of ten of this figure, Volts or Millivolts, read the voltage direct from the **outer** scale of the A1 VOLTS control, placing the decimal point according to the gain setting.

If the A1 VOLTS RANGE switch is positioned at 15 or a multiple of ten of this figure, Volts or Millivolts, read the voltage direct from the **inner** scale of the A1 VOLTS control, placing the decimal point according to the gain setting.

Note: A negative-going signal gives an upward deflection of the trace. When measuring sine waves at frequencies much higher than 1 Mc/s, allowance should be made for the falling frequency response of the amplifier.

Voltage Measurement (1500V Max)

Caution: Up to 1500 V pk-to-pk a.c. or d.c. can be applied to the X30 terminal but connections to it must be screened from the A1 input terminal or the frequency compensation of the x 30 attenuator will be affected. If used with the 1·5 V and 0·5 V ranges, giving ranges of 45 V and 15 V, the accuracy of measurement will be reduced but these ranges can be used when the highest input impedance is required.

For higher voltage signals, use the X30 terminal in conjunction with the 50 V, 15 V and 5 V ranges, giving ranges of 1500 V, 450 V and 150 V. On the 1500 V and 150 V ranges, read the **outer** scale direct but on the 450 V range, multiply the 15 V scale **(inner)** reading by 30.

A2 AMPLIFIER

Caution: The input to the amplifier must not exceed 500 V. The input attenuator provides a d.c. path to earth and, if this is likely to cause interference to the apparatus being tested, an external capacitor must be used.

Put the A2 VOLTS RANGE switch to a position such that the waveform to be measured is between 1 to 5 cm amplitude.

Set the cursor on the A2 VOLTS scale to zero.

Turn the small centre knob of the A2 VOLTS control to position the waveform (or portion of it) to be measured so that its base is coincident with the centre horizontal line of the graticule or other convenient index line.

Move the cursor so that the top of the waveform (or portion of it) is brought down to the horizontal line or other index line chosen.

If the A2 VOLTS RANGE switch is positioned at 5 V or a multiple of ten of this voltage, read the voltage direct from the **outer** scale, placing the decimal point according to the gain setting.

If the A2 VOLTS RANGE switch is positioned at 15 V or a multiple of ten of this voltage, read the voltage direct from the **inner** scale, placing the decimal point according to the gain setting.

If required, use the A2 VOLTS RANGE switch to reverse the polarity of the displayed signal.

Note: Two positions of the range switch are provided for each gain setting giving choice of polarity. When the gain of the A2 Amplifier is equal to that of the A1 Amplifier (see page 27), selection of polarity allows the Y1 and Y2 displays to be overlapped and very small differences can be detected in signals which may appear to be identical.

TIME-BASE

Range Selection

For general use, choose a Time Range so that between 1 and 3 cycles of the input waveform appear on the screen.

If the rise-time of an edge of a signal is to be determined, choose a Time Range which is short compared to the time of one cycle of input. If necessary, use the time-base Delay control (see page 8).

To check droop or overshoot, select a Time Range position which is some ten or hundred times greater than the time of one cycle of the waveform to be observed.

Selection of Trigger or Sync

Turn the Trigger/Free Run control fully clockwise, causing the time-base to run. Rotate the control counter-clockwise to the point where the time-base stops and continue counter-clockwise rotation very slightly from this point.

Apply a signal and rotate the Trigger or Sync control clockwise until the time-base begins and is locked to the signal. Keep the amplitude of the Trigger or Sync to a minimum to avoid distortion although, because of limiting circuits in the sync amplifier, this distortion will not become excessive.

To apply a sync signal, use the SYNC SELECTOR switch:

in the first two positions (counting in a clockwise direction from the top right), to lock all signals except TV Frame synchronizing signals and to select the polarity of the sync signal;

in the second two positions for the same purposes but with time-base delay (see page 8);

in the last two positions to lock the time-base to the TV Frame sync signal derived from a composite waveform and, again, to introduce delay;

in the other three pairs of positions (counting in a counter-clockwise direction from the top left), to give the same facilities when an external signal is applied to the Trigger or Sync terminal on the front panel.

Note: It may be advantageous to use the external sync positions when attempting to synchronize high-frequency sine waves (5 Mc/s to 10 Mc/s) because, at high frequencies, the circuits used to reduce loading on the Y1 amplifier tend to cause increased attenuation. Under these circumstances, the Trigger/Free Run control should be adjusted so that the time-base is free-running, after which some adjustment of the Time-base Frequency control will be necessary.

X Amplifier

For visual examination of a waveform, set the cursor on the TIME SCALE to zero and obtain a stationary trace by operating the TIME-BASE FREQUENCY control. Move the desired part of the waveform to the centre of the screen by turning the small centre knob of the TIME SCALE control. Expand the waveform by using the X AMP control. Use the X AMP control also to offset the reduced amplitude resulting from operation of the TIME-BASE FREQUENCY control. Rotate these concentric controls simultaneously in order to maintain an almost constant sweep amplitude over most of the control range.

Time Measurements

Put the TIME RANGE to a position such that about 3 cycles of the signal appear on the screen. Use the TIME-BASE FREQUENCY control to obtain a stationary trace. Set the cursor on the TIME SCALE to zero. Turn the small centre knob of the TIME SCALE to bring the left-hand edge of the waveform to the centre vertical line of the graticule. Move the cursor so that the right-hand edge of the waveform is moved to the same index line.

If the TIME RANGE switch is positioned at 10 msec, 100 msec, 10 μsec, 100 μsec or 1000 μsec, read the time interval of the waveform direct from the **outer** scale, placing the decimal point according to the Time Range in use.

If the TIME RANGE switch is positioned at 3 msec, 30 msec, 30 μsec or 300 μsec, read the time interval of the waveform direct from the **inner** scale, placing the decimal point according to the Time Range in use.

Calculate the frequency of the applied signal from the equation: $f = \frac{1}{T}$

where f is the frequency in cycles per second and T is the time interval in seconds.

N.B. Time measurements which include the first 10 per cent of the trace should be avoided since some distortion, caused by sync input, Miller step or X amplifier, may be present. When using the X amplifier near maximum gain, any non-linearity observed on the trace will not affect the accuracy of measurement.

For approximate time measurements, turn the TIME-BASE FREQUENCY control fully counter-clockwise, this position giving a duration of sweep on all ranges within ±10 per cent of the nominal duration indicated by the TIME RANGE switch.

Adjust the X AMP control so that the time measurement can be made by simple inspection.

Note: Such measurements are particularly useful on the fastest range, the discrimination when measuring rise-time being about four times better than that available on the Time Scale.

Delay

Set the Trigger/Free Run control in the TRIGGER position (counter-clockwise). Put the Sync Selector switch to the appropriate position for the conditions in which it is desired to introduce delay (see page 7). Set the cursor on the TIME SCALE to zero.

Note: Since it is not possible to over-trigger in this condition, it is convenient to set the TRIGGER OR SYNC control fully clockwise.

Select a suitable Time Range, for example, if a pulse of 1 μsec and repetition rate of 1,000 c/s is being examined, put the TIME RANGE switch to 100 μsec.

Note: The DELAY control enables the start of the time-base to be adjusted at any time after the synchronizing pulse up to ten times, at least, the Time Range in use except on the 100 msec and 30 msec ranges.

Rotate the DELAY control so that the pulse succeeding the synchronizing pulse appears on the trace.

N.B. Unless the repetition rate is stable, the use of very long delays should be avoided. The maximum repetition rate at which the delay circuit can be driven is slightly less than 100 kc/s.

Use the X AMP control to expand the pulse fully which, in the example given, will become about ½ cm wide, allowing observation and time measurement on the Time Scale.

Turn the small centre knob of the TIME SCALE to bring the left-hand side of the waveform to the centre vertical line of the graticule.

Move the cursor of the TIME SCALE so that the right-hand side of the waveform is brought to the same index line. Read the time measurement as given on page 8.

Time-base Output

For driving frequency-swept oscillators, put the Trigger/Free Run control to FREE RUN, select a time range position of not less than 10 msec and connect the oscillator to the time-base output terminal on the front panel.

SIDE TERMINAL PANELS

Caution: Do not touch any link or terminal when the power is applied to the instrument. Switch off the power and allow 30 seconds, at least, before touching the links.

Left-hand Panel

To gain access to this panel, loosen the screw which has a slot, wide enough to accept the edge of a coin, and slide back the cover.

To connect the Y1 plate to the output of the A1 amplifier, position the Y1 link to the right.

To connect the Y1 plate to the Y1 terminal, position the Y1 link to the left.

Note: A 1 MΩ grid leak, returned to the shift (voltage measurement) control is in circuit and thus, if the Y1 terminal is fed via a capacitor, shift is still in operation.

If direct connection between Y1 plate and Y1 terminal without the 1 MΩ leak is required, remove the Y1 link and insert a plug of [illegible] in. diameter in the centre socket of the three exposed.

If necessary, apply a known voltage and note the deflection.

Note: When the Y1 plate is connected direct to the Y1 terminal, the sensitivity will be about 25 V/cm but this will vary with the mains voltage, the p.d.a. voltage and the CRT in use.

For normal working, position the upper link, coloured red, to the left (+ve 350 V p.d.a.).

When a much brighter trace is required and reduced sensitivity can be accepted, position the p.d.a. link to the right (+ve 2 kV).

Caution: Although the p.d.a. link is shrouded to give protection against inadvertent contact, the instrument must be switched off and 30 seconds allowed to elapse before the link is touched.

Right-hand Panel

To gain access to the panel, loosen the screw which has a slot, wide enough to accept the edge of a coin, and slide back the cover.

To connect the Y2 plate to the output of the Y2 amplifier, position the Y2 link to the right.

To connect the Y2 plate to the Y2 terminal, position the Y2 link to the left.

For normal working, position the fly-back suppression link (shrouded and coloured red) to the right (recurrent), when the time-base trace will be blacked out during the fly-back but the spot will be visible when stationary.

When the stationary spot at the left-hand side of the trace is undesirable, position the fly-back suppression link to the left.

Note: This position of the link is useful when the delay circuit is in use or when photographing single-stroke transients because the spot is blacked out and brightens up only during the forward stroke of the time-base.

For normal working, position the modulation link to the right (INT).

When it is required that external signals should control the brightness, position the modulation link to the left (EXT).

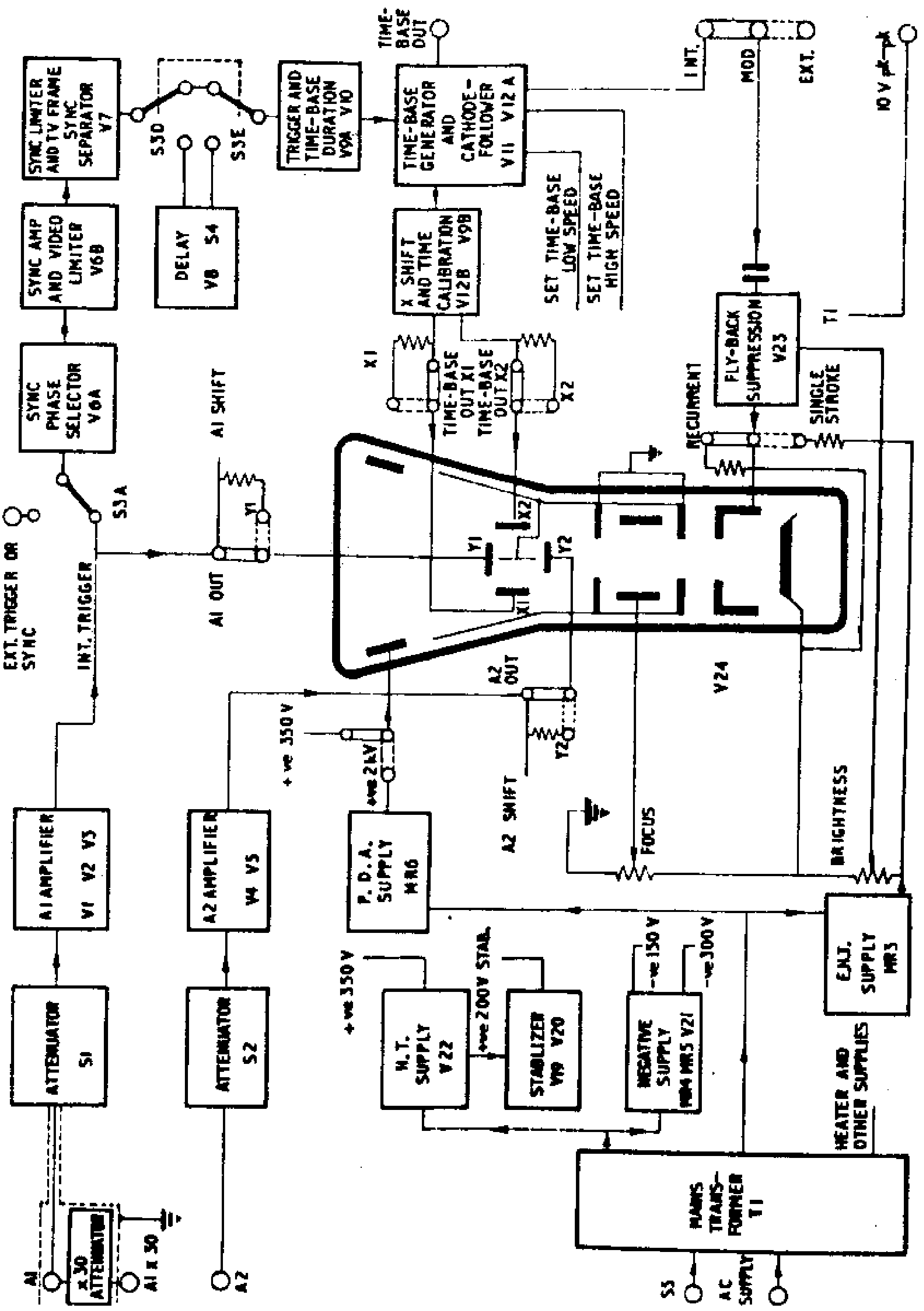
N.B. Voltages of the order of 40 V peak-to-peak are necessary for full modulation.

To connect the X1 plate to the output of the X amplifier, position the X1 link to the right. Similarly, position the X2 link to the right.

To connect the X1 plate to the X1 terminal, position the X1 link to the left. Similarly, position the X2 link to the left.

Note: Because the cathode-ray tube requires symmetrical X deflection, the X1 and X2 links should be used simultaneously.

When the external position is in use, move the TIME RANGE switch to OFF to stop the internal time-base. If the range of the X shift is insufficient, adjust the TIME-BASE FREQUENCY control to remedy it.



SYNC LIMITER AND TV FRAME SYNC SEPARATOR V7
SYNC AMP AND VIDEO LIMITER V6B
SYNC PHASE SELECTOR V6A
S3D
S3E
DELAY V8 S4
TRIGGER AND TIME-BASE DURATION V9A V10
TIME-BASE OUT
TIME-BASE GENERATOR AND CATHODE-FOLLOWER V11 V12A
X SHIFT AND TIME CALIBRATION V12B V9B
SET TIME-BASE LOW SPEED
SET TIME-BASE HIGH SPEED
INT.
MOD
EXT.
10 V
FLY-BACK SUPPRESSION V23
RECURRENT
SINGLE STROKE
T1
TIME-BASE OUT X1
TIME-BASE OUT X2
X1
X2
A1 SHIFT
S3A
EXT. TRIGGER OR SYNC
INT. TRIGGER
A1 OUT
Y1
Y2
A2 OUT
V24
+ve 350 V
+ve 2kV
A2 SHIFT
FOCUS
BRIGHTNESS
A1 AMPLIFIER V1 V2 V3
A2 AMPLIFIER V4 V5
P.D.A. SUPPLY MR6
E.H.T. SUPPLY MR3
ATTENUATOR S1
ATTENUATOR S2
+ve 350 V
+ve 200 V STAB.
H.T. SUPPLY V22
STABILIZER V19 V20
-ve 150 V
-ve 300 V
NEGATIVE SUPPLY MR4 MR5 V21
HEATER AND OTHER SUPPLIES
MAINS TRANS-FORMER T1
A1
x 50 ATTENUATOR
A1 x 50
A2
S5
AC SUPPLY

CIRCUIT FUNCTION

A block schematic diagram of the instrument is given at Fig. 1 (page 11).

CATHODE-RAY TUBE

A double-beam tube, V24, is used with a3 at 2 kV and only +ve 350 V p.d.a. applied for normal use. This gives a high degree of definition with freedom from flare. A p.d.a. voltage of +ve 2 kV can be applied when maximum brightness is required but some distortion at the ends of the traces will be present.

Because of slight variations in the assembly of the ' gun ' structure of the cathode-ray tube, there may be variations in the brightness of the two traces. The beam equalizer magnet, which is in the form of a circular clip, is positioned round the CRT clamp near the base of the tube to compensate for these variations. As the equalizer magnet is of spring steel and very light, no clamping is required, the elastic band being provided only for additional security against movement in transit.

A1 AMPLIFIER

This is a three-stage amplifier with heavy negative feedback. Valves, V1 and V2, are type M8083, chosen because of their consistent characteristics and close tolerance. The output valve, V3, is an EL822 which passes heavy anode current. Variable grid bias is provided for each valve.

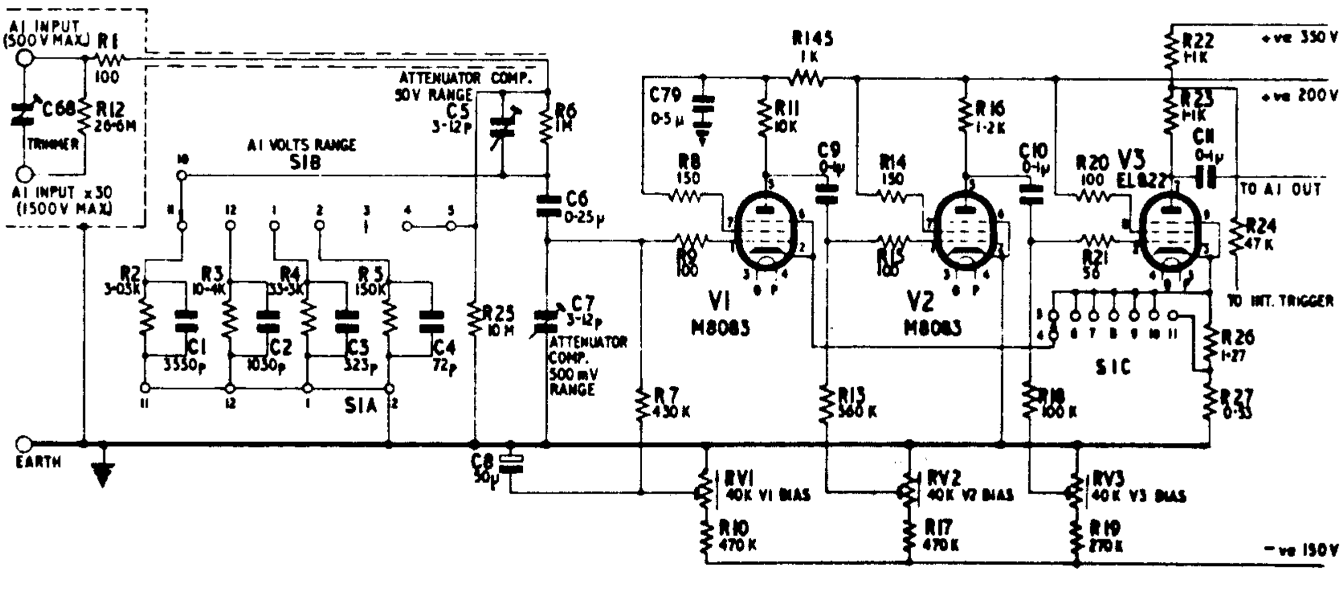


Fig. 2 *A1 Amplifier Circuit*

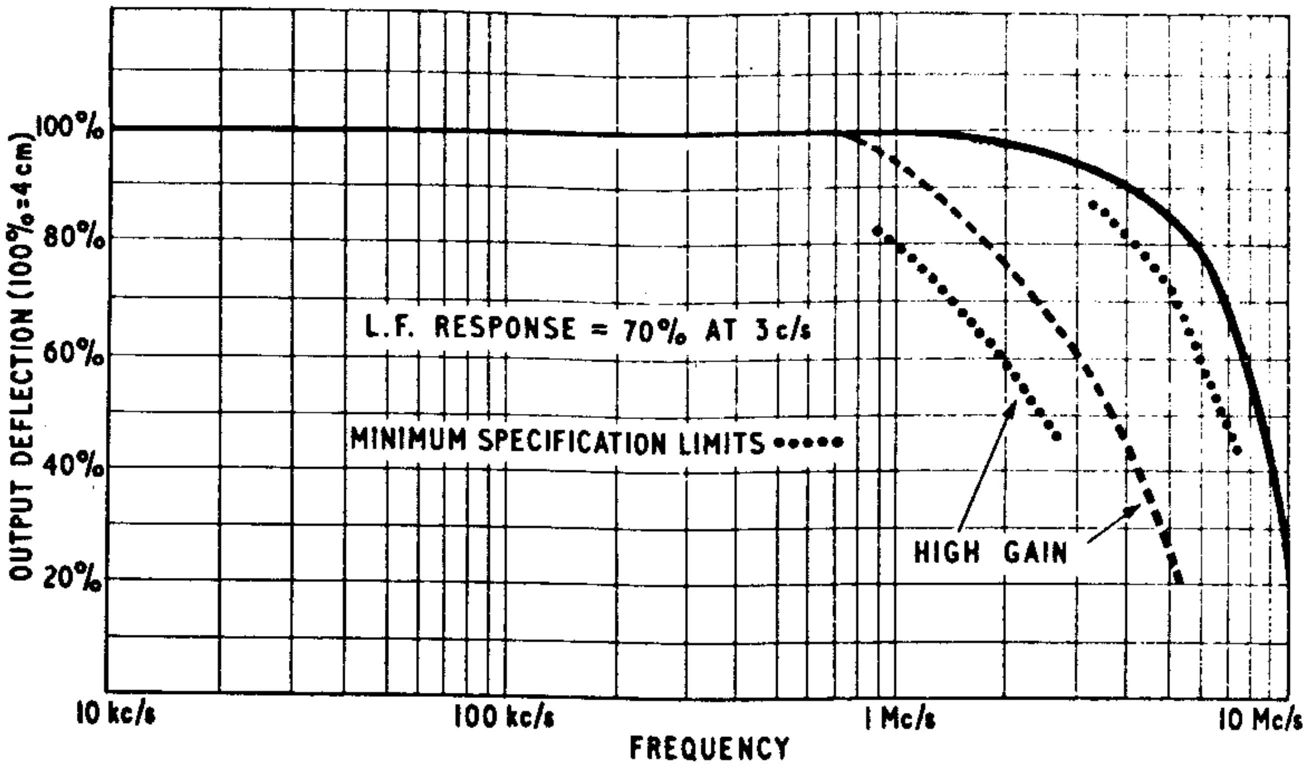


Fig. 3 *Response Curve for A1 Amplifier*

Feedback is provided from the cathode of V3 to the cathode of the first stage, V1. The feedback resistor is a metal film type, with double leads, and stud mounted so that the earth path is reduced to the minimum. The first and second stages and the screen of the output stage are fed from a stabilized +ve 200 V rail, whilst the output anode is supplied from the +ve 350 V rail.

The anode load of V3 consists of two H.S. resistors, R22 in series with R23, both rated at 2 W. This output load dissipates 3·6 W and the H.S. resistors give better performance than non-reactive wire-wound resistors. Also, the sync feed may be tapped off half-way down the load, thus reducing capacitative loading.

Seven fixed levels of pre-set gain are available selected by S1 the A1 VOLTS RANGE switch. The attenuator has resistors and capacitors, both of 2 per cent tolerance, for the fixed steps and a trimmer capacitor, C7, for adjusting the total input capacity of the amplifier to a standard value. There is another trimmer capacitor, C5, for adjusting the stray capacitance on the series resistor to a standard value. With this arrangement, a resistive path exists between the A1 Input terminal and earth, having a minimum value slightly above 1 MΩ.

Screened cable is used to connect the A1 Input terminal to the amplifier. A small series resistor, R1, in the input lead ensures that negative R cannot be built up when an inductance is connected across the input, and prevents oscillations occurring under these conditions. A further input terminal is provided and connected to a compensated attenuator, x 30. The X30 terminal may be used to measure voltages up to 1500 V peak-to-peak.

An arrangement of internal d.c. shift voltages is controlled by RV13, RV14 and RV15 in conjunction with the pre-set potentiometer, RV12. Potentiometer RV14 is the A1 VOLTS control which has a scale, allowing voltage measurement to be made of the input signal to the A1 amplifier. The accuracy of measurement is $\pm$ 10 per cent.

Because there are three stages in the amplifier, positive signals give a downward deflection of the trace. The response curves for the amplifier are given in Fig. 3.

A2 AMPLIFIER

The A2 amplifier comprises a long-tailed pair, V4 and V5, employing type M8083 valves. The long-tailed pair gives a useful improvement in linearity. The amplifier switching is arranged so that the input signal can be applied to either valve. Thus, phase reversal is provided, enabling the A1 and A2 displays to be overlapped so that differences in the displays can be detected.

The gain of the A2 amplifier can be adjusted to be equal to the gain of the A1 amplifier, thus facilitating the comparison of similar waveforms. For this purpose, a pre-set control, RV4, is inserted between the cathodes of V4 and V5. A wire-wound potentiometer, RV5, is included in the anode circuit of V5 and is pre-set to equalize the gain when the A2 VOLTS RANGE switch is in either the + ↑ or the + ↓ position.

The valves are fed from the +ve 350 V rail and the grids are returned to a point at about +ve 50 V, tapped from the +ve 200 V rail. Adequate decoupling is provided by R71 and C59a.

Five fixed levels of pre-set gain are available, selected by S2, the A2 VOLTS RANGE switch. As in the A1 amplifier, the attenuator has resistors and capacitors of 2 per cent tolerance for the fixed steps. Trimmer capacitor, C15, and trimmer capacitors, C17 and C78, give attenuator compensation for the series and shunt elements.

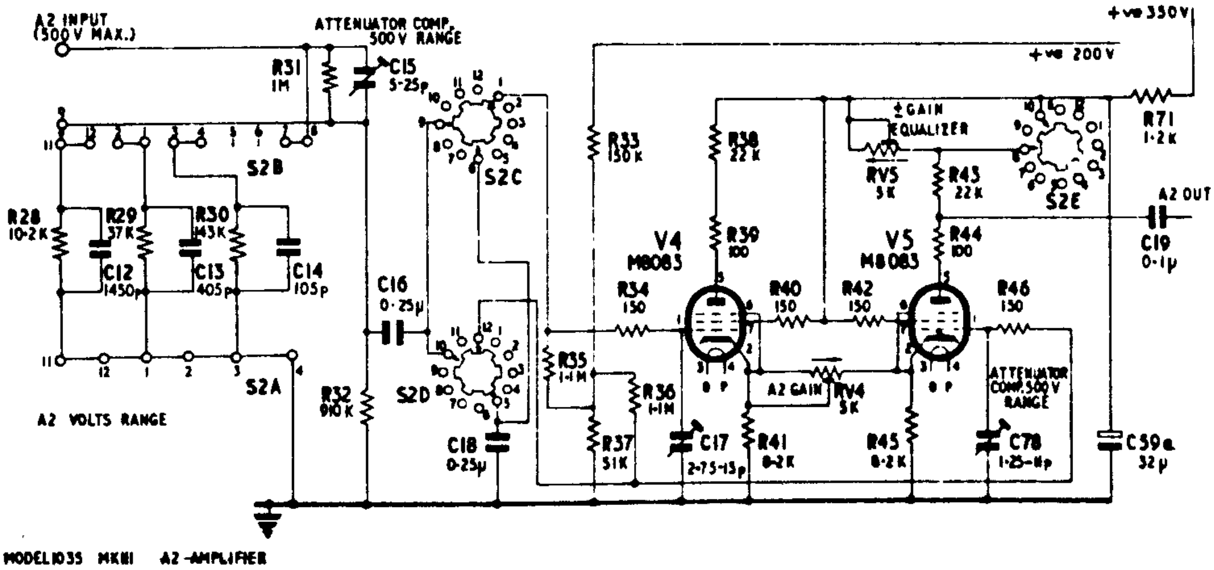


Fig. 4 ***A2 Amplifier Circuit***

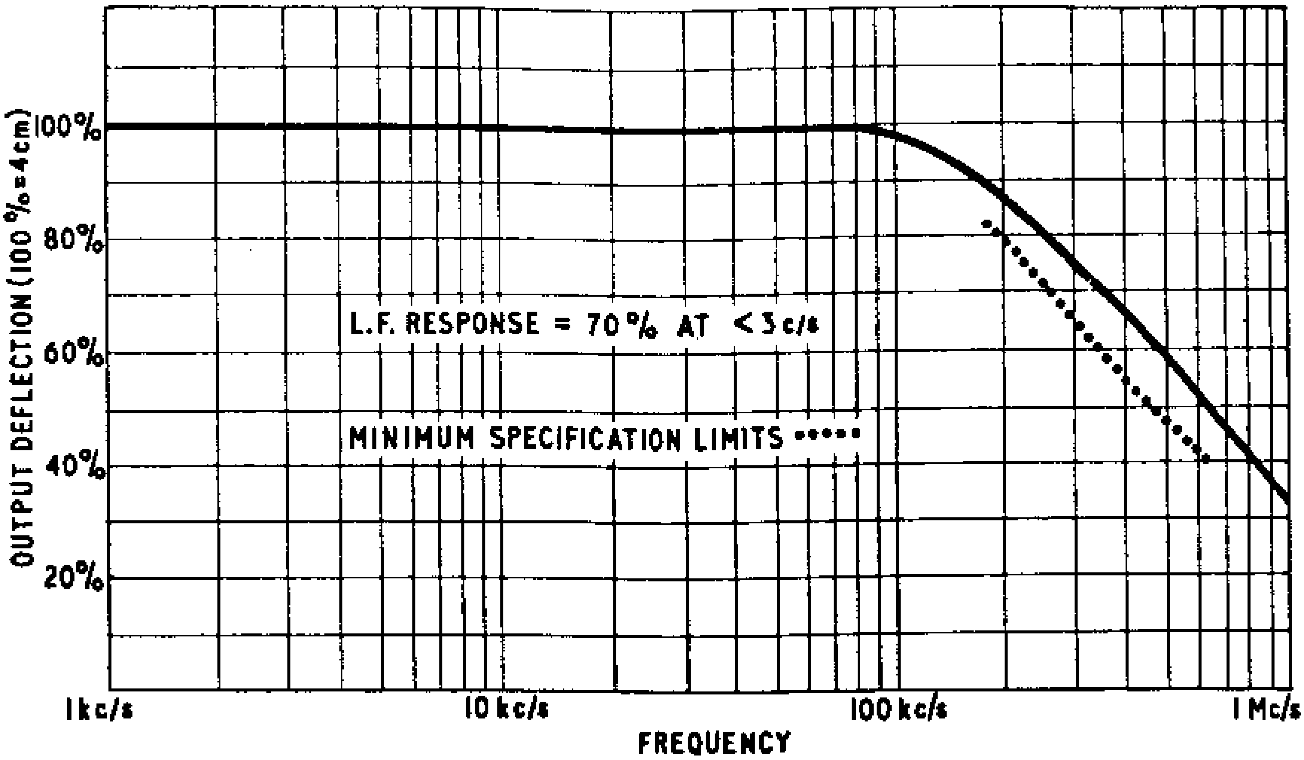


Fig. 5 *Response Curve for A2 Amplifier*

The input capacitor is placed after the attenuator because the input grid of the amplifier is not at earth potential and long leads, which are undesirable, would be necessary if the attenuator elements were returned to the bias point. This arrangement maintains a constant L.F. response but a resistive path, slightly above 1 MΩ, exists between the A1 Input terminal and earth.

An arrangement of internal d.c. shift voltages is controlled by RV7, RV8 and RV9 in conjunction with the pre-set potentiometer RV6. Potentiometer RV8 is the A2 VOLTS control which has a scale, allowing voltage measurement to be made of the input signal to the A2 amplifier. The accuracy of measurement is ±10 per cent. The response curves for the amplifier are given in Fig. 5.

TIME-BASE

Time-base Generator

A standard Miller circuit is employed for the time-base generator, the Miller valve, V11, having a short suppressor base (type 6F33). A cathode-follower, V12A, is connected in the anode-grid circuit to improve the fly-back and this allows a high value of anode load, R96, to be used, increasing the gain in the feedback loop but retaining the fly-back time at a reasonable figure. The anode load is returned to the +ve 350 V rail but other points in the time-base generator circuit are supplied from the +ve 200 V stabilized rail.

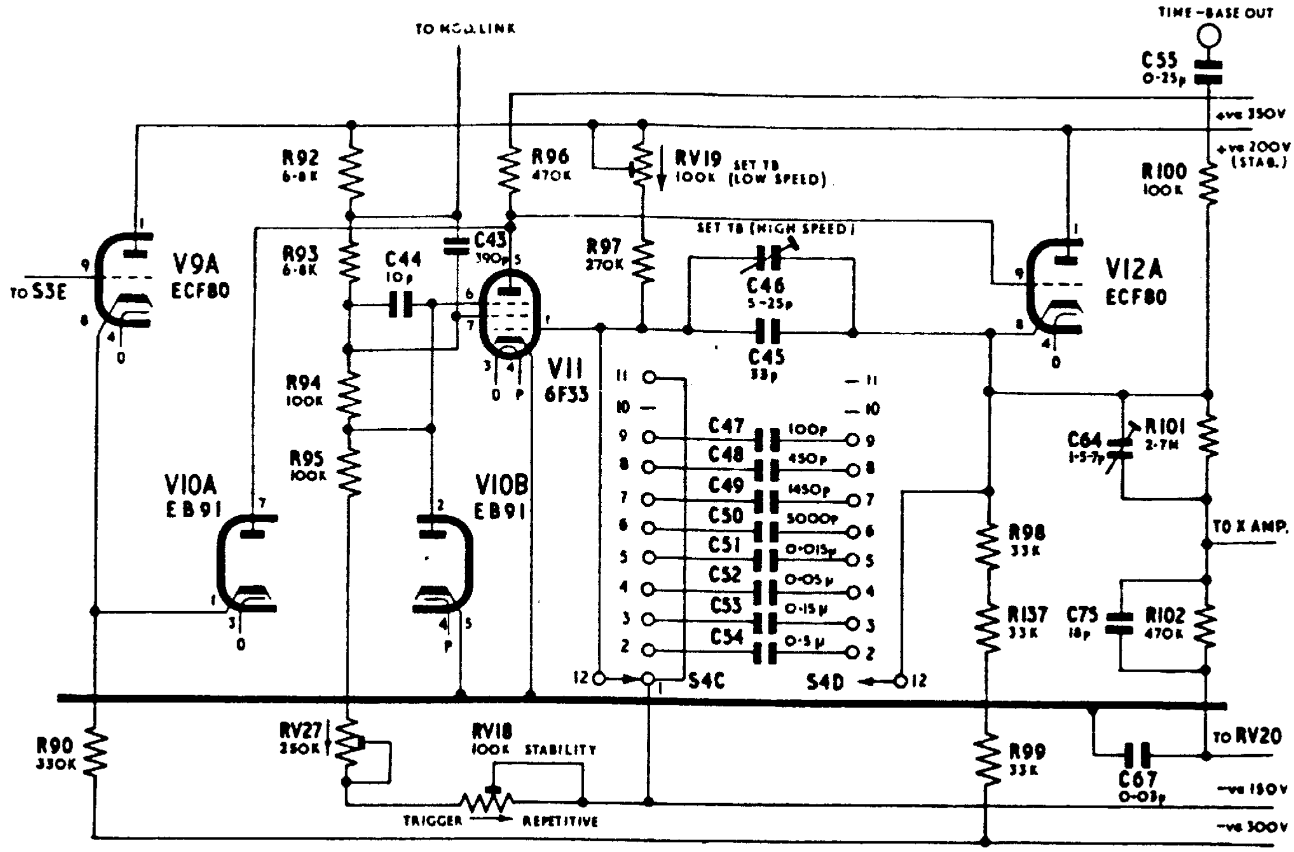


Fig. 6 *Time-base Circuit*

Because the screen of V11 is fed from the +ve 200 V rail, it ensures that the suppressor grid base and, hence, the Miller step are kept at the minimum. The screen is d.c. coupled to the suppressor which has a variable negative bias to provide for free-running or triggered operation. Two potentiometers are used for this purpose, RV27 which is a pre-set control and RV18, the TRIGGER/FREE-RUN control. The pre-set control avoids an excessively fierce control which, otherwise, would be required to cater for all valves.

The built-in diode (not shown) of the 6F33 valve has a high impedance and one half (V10B) of a double diode is connected to the suppressor grid of V11 to assist the built-in diode. This helps to maintain constant sync conditions. The other half (V10A) of the double diode holds the anode of V11 at a potential determined by the slider of RV17, the TIME-BASE FREQUENCY control; a cathode-follower, V9A, is inserted to give a low impedance. This potential controls the amplitude. of the time-base waveform and, because the rate of run-down is constant on all ranges, also determines the repetition rate.

Control of the ' topping ' voltage, instead of the ' bottoming ' voltage, is employed because it permits consistent control of the repetition rate at low frequencies. However, because the bottoming point of the anode varies from valve to valve and in order to have a range of control of 3·3:1, at least, the control potential has to be variable down to earth potential. The TIME-BASE FREQUENCY control, RV17, used for this purpose, makes it possible to reduce the time-base amplitude to zero and the position of this control should be checked, therefore, whenever the time-base appears to be inoperative.

Capacitors of 5 per cent tolerance are used in the time-base circuit and the trimmer capacitor, C46, is used on the fastest range. The nine ranges are selected by S4. The grid leak is variable to allow the sweep rates to be adjusted. The time-base output is taken from the cathode-follower V12A.

X Amplifier

The type 93D cathode-ray tube requires symmetrical deflection and shift. The X amplifier is provided for this purpose and also for sweep expansion. A long-tailed pair, V12B and V9B, comprises the amplifier, the pentode sections of the ECF80 valves being particularly suitable for this type of application. The triode sections of these valves are used in the time-base generator (see page 15).

Hivac miniature neons, type CC3L, are used to couple the amplifier anodes to the X plates. These neons are conveniently small and their low running voltage (60 V to 70 V) enables a free choice to be made of the total voltage drop. The total voltage drop is chosen to bring the X plates sufficiently close to earth potential to avoid distortions of the CRT trace. Shunt capacitors, C56 and C57, are included because the impedance rises with frequency. Series resistors, R106 and R115, prevent the occurrence of relaxation oscillations.

The cathode load of the amplifier is returned to the negative rail and, with 30 kΩ anode loads, R110 and R113, the voltage swing at each anode ensures that limiting takes place off the CRT screen. However, the gain is much higher than that required and the time-base input signal is attenuated, therefore, by the resistors R101 and R102.

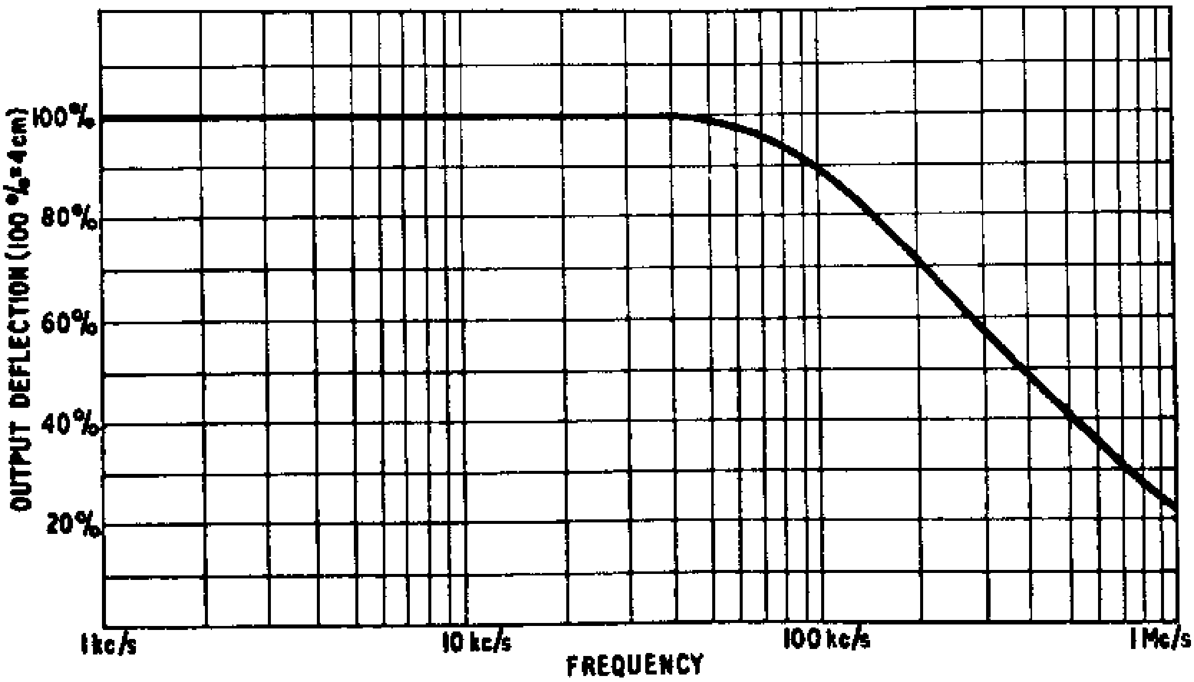


Fig. 7 *Response Curve for X Amplifier*

Capacitor, C64, is pre-set to compensate for the input capacity of the amplifier. The potentiometer, RV24, is used to control the gain and, since the input capacity tends to vary with the gain of the stage, C75 is used to stabilize the response by swamping this variation. In practice, C64 is adjusted to over-compensate the input attenuator slightly in order to improve the response over that shown in Fig. 7.

The shift voltage is fed into the same grid as the signal and the input attenuator provides a convenient means of doing this. It is arranged that the mean grid potential is about −ve 50 V and the screens of the amplifier are fed from the +ve 200 V stabilized rail. The X shift control RV21 and RV22 ganged, is used for zero setting and the potentiometer RV20 is used for time measurement, calibration being adjusted by shunting RV20 by RV23.

Sync Selector

The front wafer of SW3 selects the sync signal source either internal from the A1 output or external from the terminal on the front panel. A potentiometer, RV26, controls the amplitude of the input signal. This is the TRIGGER OR SYNC control, its relatively low value being chosen as a compromise between the requirement of high input impedance and good high-frequency response. High frequency compensation is provided by C76. The sync input which is not being used is earthed, in effect, by C70 to prevent stray coupling.

To prevent the change in the effective anode load of V3 exceeding 0·75 per cent, irrespective of the position of SW3, the internal sync is fed via R24 which is tapped half-way down the output anode load.

Sync Phase Selector

The input, internal or external, is passed to V6A which is used to give 180 deg. phase change, the appropriate phase being taken from either the anode or the cathode. Components, R89 and C71, provide decoupling necessary to prevent feedback via the H.T. rail because of the high gain of the succeeding stages.

Sync Amplifier and Limiter

The pentode section, V6B, of the ECF80 valve is employed as a limiter and is run with its screen, set by RV30, at about 50 V to give a short grid base. No bias is provided and the valve will tend to bias itself back when signals are applied. Therefore, composite TV video/sync signals with negative-going video content will have the video signals removed, provided the amplitude is not less than about 10 V peak-to-peak (about 1 cm display on the screen when the internal sync position is used).

TV Frame Sync Selector

The anode of V6B is directly coupled to the grid of V7A which has an anode load, RV72, of only 1·8 kΩ. Hence, the maximum output swing is restricted. The cathode of V7A is common with the cathode of V7B and is decoupled to earth by C32, the grid of V7B being held at about 110 V. Thus, for short duration signals, V7A acts as an amplifier with a low amplitude output but, for signals with a duration comparable with the time constant of R73, C32 (56 μsec), the cathode will follow the grid down, reducing the signal on the anode of V7A and allowing V7B to pass current.

At the end of the pulse, when the grid of V7A is taken positive again, C32 will charge up rapidly because of the low impedance presented by the cathodes of V7A and V7B and, as the cathode rises, V7B will be cut off, allowing the anode potential to rise. Thus, only the frame sync pulses will appear at the anode of V7B and the edges will be fast rising (see Fig. 8).

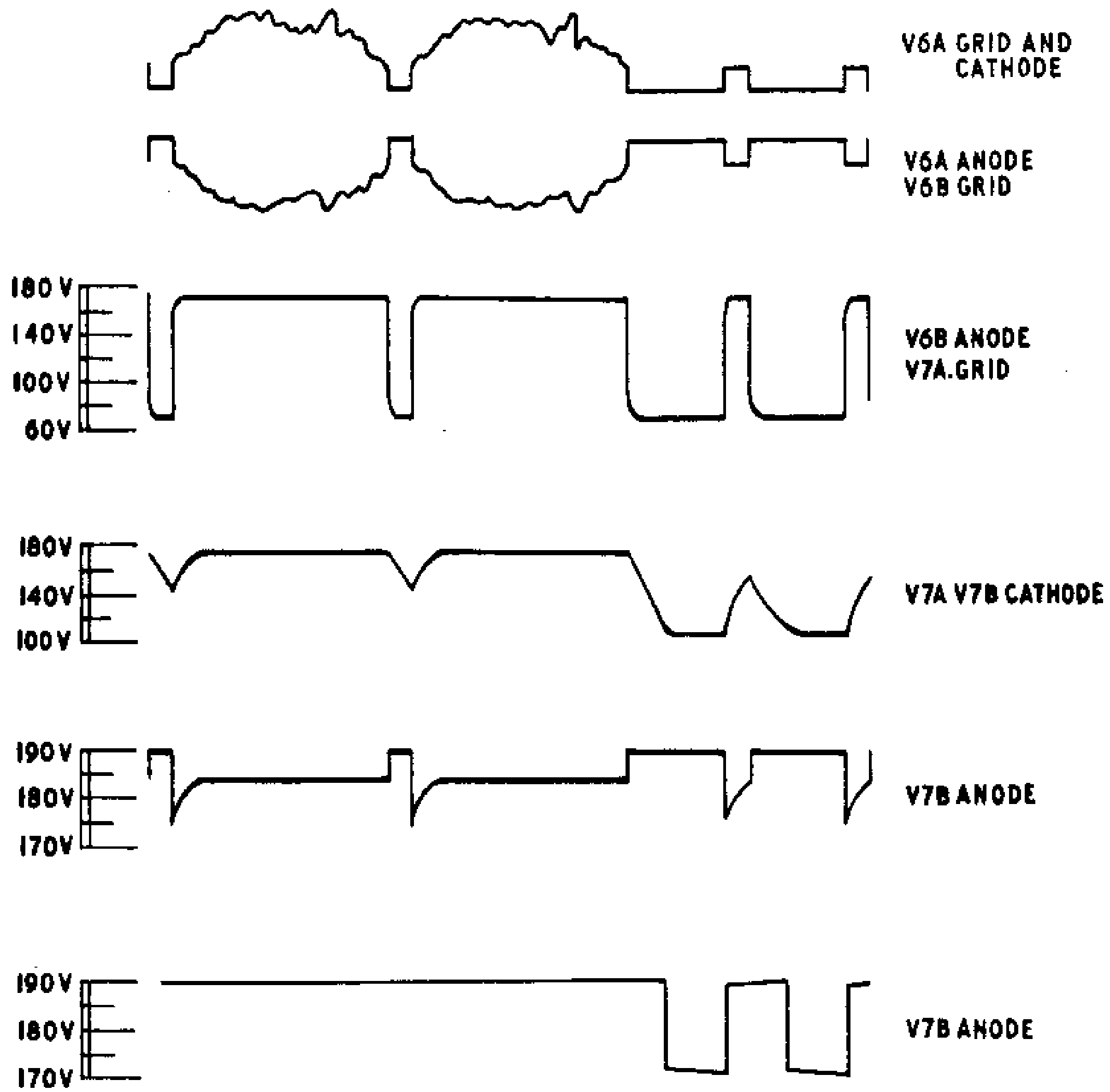


Fig. 8 *Waveforms in Sync Circuits with TV Input Signals*

Delay Circuit

When examining short pulses or fast edges, it is convenient, in the absence of signal delay, to be able to delay the start of the time-base by a time slightly less than that represented by the P.R.F. of the pulse. This enables the whole of the next pulse, including the start, to be displayed and measured. In this oscillograph, this facility is provided by generating a secondary sync pulse, delayed from the primary pulse, and using this secondary pulse to trigger the time-base. A double triode, V8, is employed for the delay circuit. The action is described with reference to the simplified circuit given at Fig. 9.

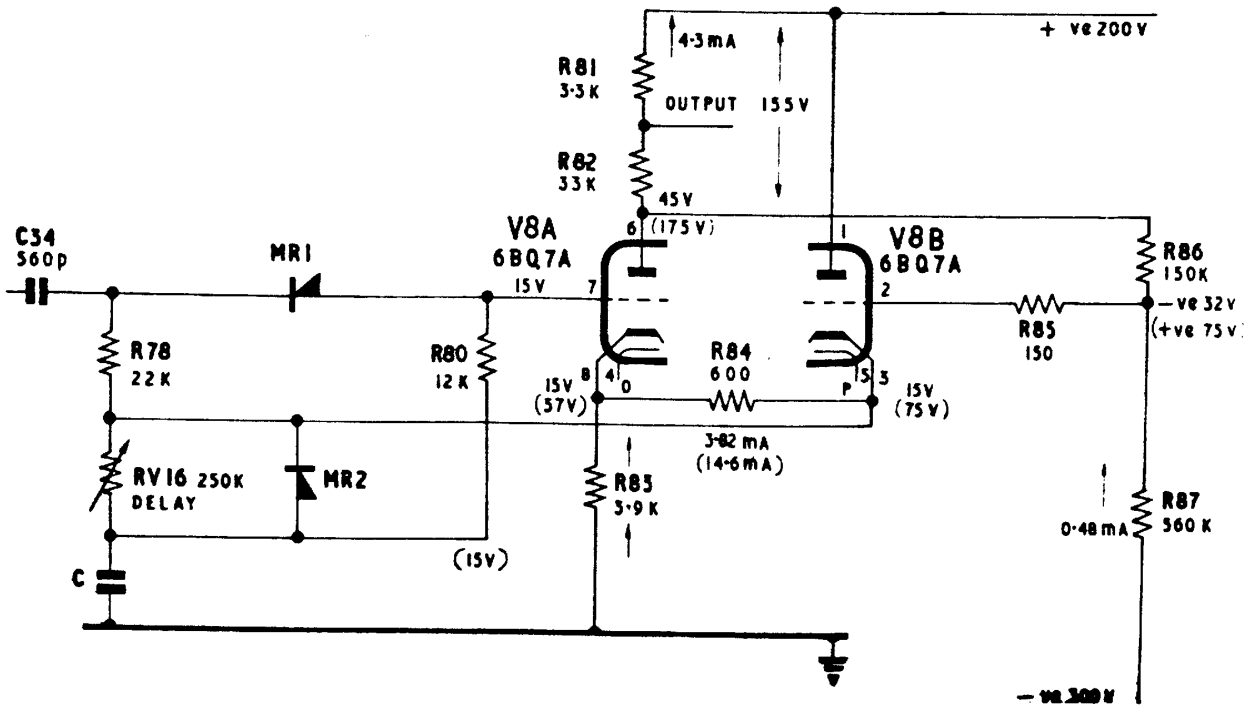


Fig. 9 *Simplified Circuit for Delay*

Initially, the voltage conditions are as indicated by the unbracketed figures, with V8A conducting and the grid of V8B biased to about 47 V with respect to its cathode. The cathodes of V8A and V8B are, therefore, at the same potential. A negative-going pulse on the grid of V8A will reduce the anode current and the resulting positive rise in anode potential will be transferred to the grid of V8B. When this rise approaches the cathode potential of V8B, current will pass in V8B, thus increasing the cathode potential of V8A and accelerating the change-over.

Meanwhile, the grid of V8A will have remained at or below +ve 15 V, the capacitor C having discharged to an extent determined by the amplitude and duration of the input pulse. However, this discharge is limited because the rise in potential of the cathode of V8B will cut off the diode MR1 and the capacitor C will be charging up through RV16, the DELAY control; the diode, MR2, will be out of conduction. The new conditions are indicated in Fig. 9 by the second set of figures in brackets.

The charging up of C will continue, whilst any subsequent trigger pulses are blocked by MR1 which will remain cut off until the charge on C approaches the cathode potential (about 57 V) of V8A. This will cause V8A to conduct and its anode potential will fall, causing V8B to be cut off. The fall in anode potential reduces the current which V8A can draw and conditions will revert to the original state, capacitor C discharging rapidly because MR2 conducts in the same direction.

The circuit produces a pulse having sharp edges, of well-defined duration and with a fair degree of freedom from the effects of further trigger pulses. The output is taken from a tap in the anode load in order to avoid over-triggering the time-base. Delay circuit capacitors are switched in conjunction with the Time Scale so as to give available delays of rather more than ten times the time-base ranges in use, but, because of possible variations, the value of RV16 is chosen relatively high so that the maximum delay can be nearly 20 times the time-base range in use. Jitter is less than one part in a thousand. Because of the finite recovery time of the circuit the maximum repetition rate is limited to less than 100 kc/s.

The delay is switched in circuit by S3d and S3e. When using the delay circuit, the time-base must be adjusted, of course, to the triggering mode.

Fly-back Suppression

Two modes are available (see page 10). In the recurrent (normal) mode, V23A limits the excursion of the grid in a positive direction to a potential determined by RV11, the BRIGHTNESS control. Thus, the spot will be blacked out only during the fly-back of the time-base because the square wave, generated by the screen of V11, is applied via C20 to the grid of the CRT. Components R135 and C21 serve to speed up the edges of the square wave.

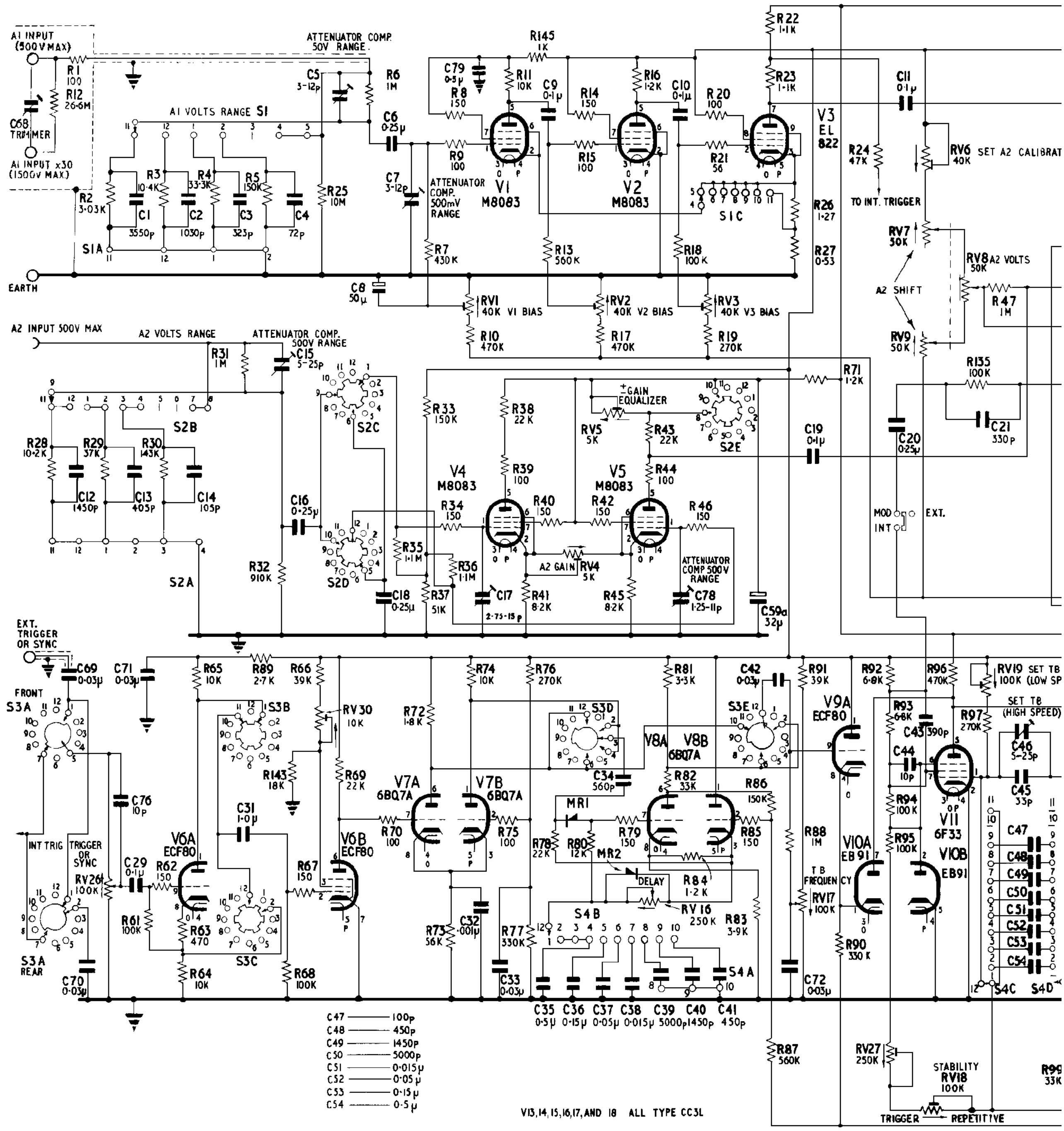
For some purposes, particularly the photographing of single-stroke transients, this suppression arrangement must be reversed and the trace brightened up only during the forward stroke of the time-base. With the link (see page 10) in the single-stroke position, the second diode, V23B, conducts and the grid of the CRT is held at a high negative potential with respect to its cathode, thus blacking out the spot. As before, when the time-base fires, a positive-going signal is fed to the grid of the CRT and the grid will rise to a potential determined by V23A and RV11, brightening up the spot to a pre-determined level. At low sweep speeds, this method of operation requires a very large value of coupling capacitor, C20, and hence, to avoid brightness changes along the trace, this method of operation should be restricted to sweeps of 10 msec or less.

POWER SUPPLIES

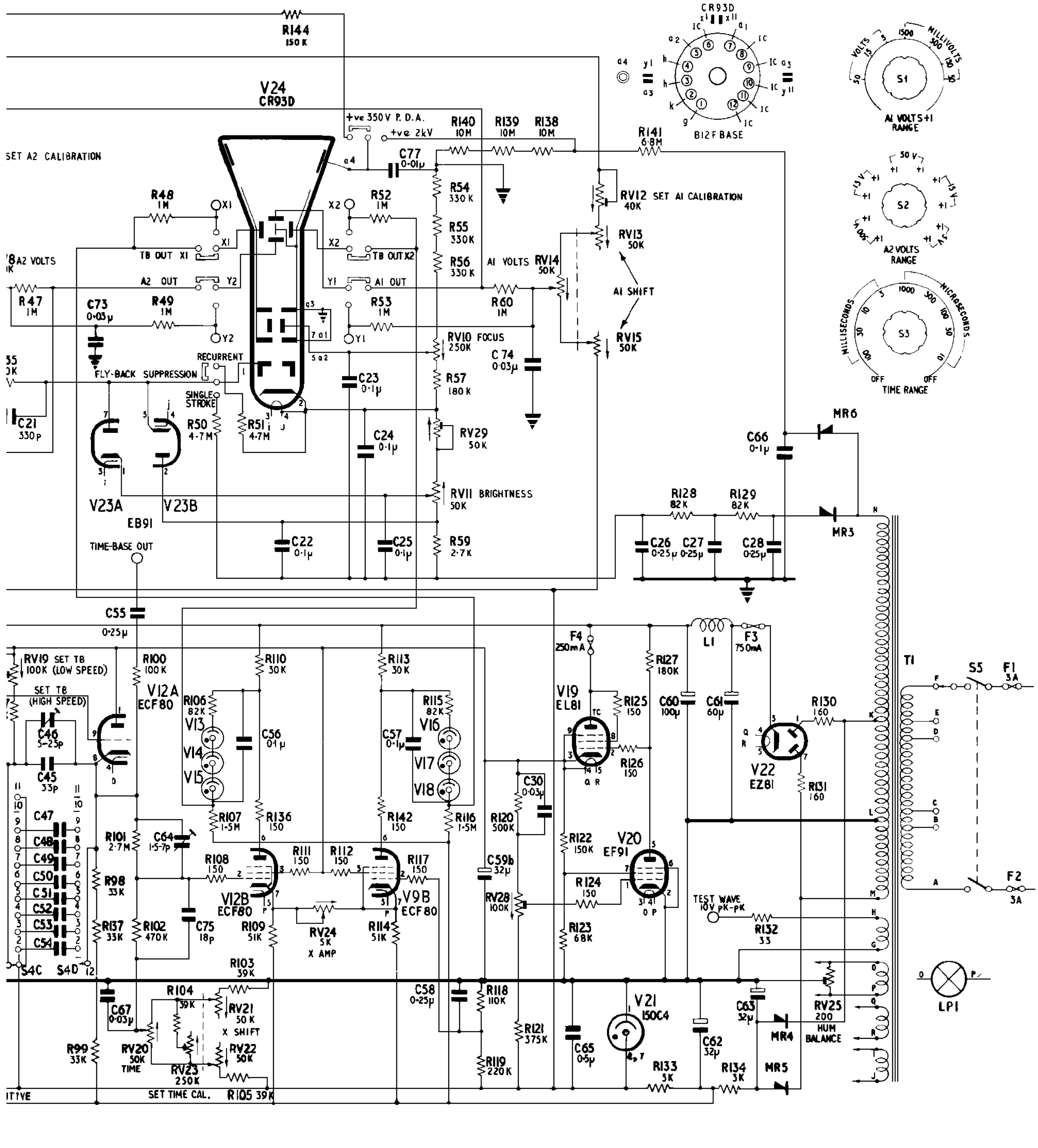
A single, oil-filled, C core transformer is employed to provide the power supplies for the oscillograph.

+ve 350 V Supply

The main H.T. supply, at about 350 V, 130 mA, is obtained from a full-wave rectifier, V22, a



CIRCUIT DIA



JIT DIAGRAM

type EZ81 valve. Series resistors, R130 and R131 in the anodes, limit the peak current into the 60 μF reservoir capacitor C61. A fuse F3, protects the rectifier and the transformer. It is rated at 750 mA to withstand surges. Smoothing is provided by L1, C60, resulting in very low hum level.

+ve 200 V Stabilized Supply

Most of the valves in the instrument are fed from a stabilized supply at about 200 V, 75 mA, provided by the stabilizer circuit V19, V20. A reference potential is provided by the resistor chain R120, RV28, and R121, between the +ve 200 V line and the −ve 150 V line (see below). Capacitor C30, provides increased gain to a.c. A type 6AM6 valve, V20, is employed as a shunt amplifier and, with only 50 V on its screen, it provides high gain in the 180 kΩ anode load, R127.

The series valve, V19, is type EL81, strapped as a triode. This valve supplies the necessary current with a 50 V drop across it and about 15 V bias on the grid. The ripple on this supply is only a few millivolts peak-to-peak and the impedance is only a few ohms. A 32 μF capacitor, C59, helps to take care of surges, for example, those generated by the time-base. A 150 mA fuse, F4, protects the circuit if a component failure occurs.

−ve 300 V and −ve 150 V Supplies

The total requirement of negative supply for Y1 and Y2 shift chains, bias at various parts, cathode-followers and long-tailed pairs is about 45 mA. This is provided by two metal rectifiers, MR4 and MR5, and simple R-C smoothing. Components, C63, R134 and C62 give adequate smoothing, the ripple being only 120 mV peak-to-peak. A further dropping resistor, R33, supplies V21, a neon stabilizer, type 150C4, which provides the −ve 150 V supply with even lower ripple, about 10 mV peak-to-peak which is adequate for bias purposes. Capacitor, C65, offers a low impedance at high frequencies.

−ve 2 kV Supply

The E.H.T. supply for the CRT is provided by a half-wave metal rectifier, MR3, with two-stage smoothing (C28, R129, C27, R128, C26), giving a ripple of only 1 V peak-to-peak. This degree of smoothing is required to avoid brightness modulation on the CRT.

+ve 2 kV Supply

The rectifier MR6, provides +ve 2 kV which is available for the p.d.a. when required. Because the current consumption is very low and is determined by the bleed resistor chain across C66, adequate smoothing is supplied by R141, C77, the ripple being not more than 0·5 V peak-to-peak.

Heater Supply

Only three heater levels are used in the instrument: (1) a main heater supply at earth potential; (2) a secondary heater supply at +ve 200 V; and (3) a supply at −ve 2 kV. This reduction of the number of heater windings of T1 is made possible by employing valves with high heater-cathode insulation. A potentiometer, RV25, is included across the main heater winding to minimize hum injected into the A1 amplifier from the heater supply.