Instrument Serial Number STANDARDS LABORATORY

TELEQUIPMENT ®

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OSCILLOSCOPE

D1016A

INSTRUCTION MANUAL

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INTRODUCTION

The D1016A is a 20MHz, all solid state dual trace oscilloscope. An 8 x 10cm CRT provides a bright and clear display. The dual trace vertical system displays either channel separately, adds channels algebraically, alternates between channels or chops between channels at approximately 70kHz rate. Channel 2 can also be switched to become the horizontal amplifier to provide equal X–Y displays. The solid state design, using FET input circuitry, provides minimum drift and fast stabilization time.

The design of this instrument is subject to continuous development and improvement, therefore minor changes in detail from the information contained herein, may be incorporated. These changes which usually affect the Component Lists and Circuit Diagrams are described on Amendment Lists issued at regular intervals between reprints. Any Amendment List appertaining to this Manual is located in the pocket inside the back cover.

Throughout this Manual all references to the front panel controls are in full and in capital letters, e.g. INTENSITY.

In addition to the standard instrument, variations known as Options are available and are listed in Section 10 of this Manual.

SAFETY IN OPERATION

To enable the user to operate an instrument in the proper manner and with complete safety, it is essential that the following cautionary notices are understood and strictly observed.

1) For safety purposes a protective-ground (earth) connection by way of the power cord and plug is essential.

2) The CRT circuitry contains high voltage and therefore presents an electric shock hazard when the covers are removed.

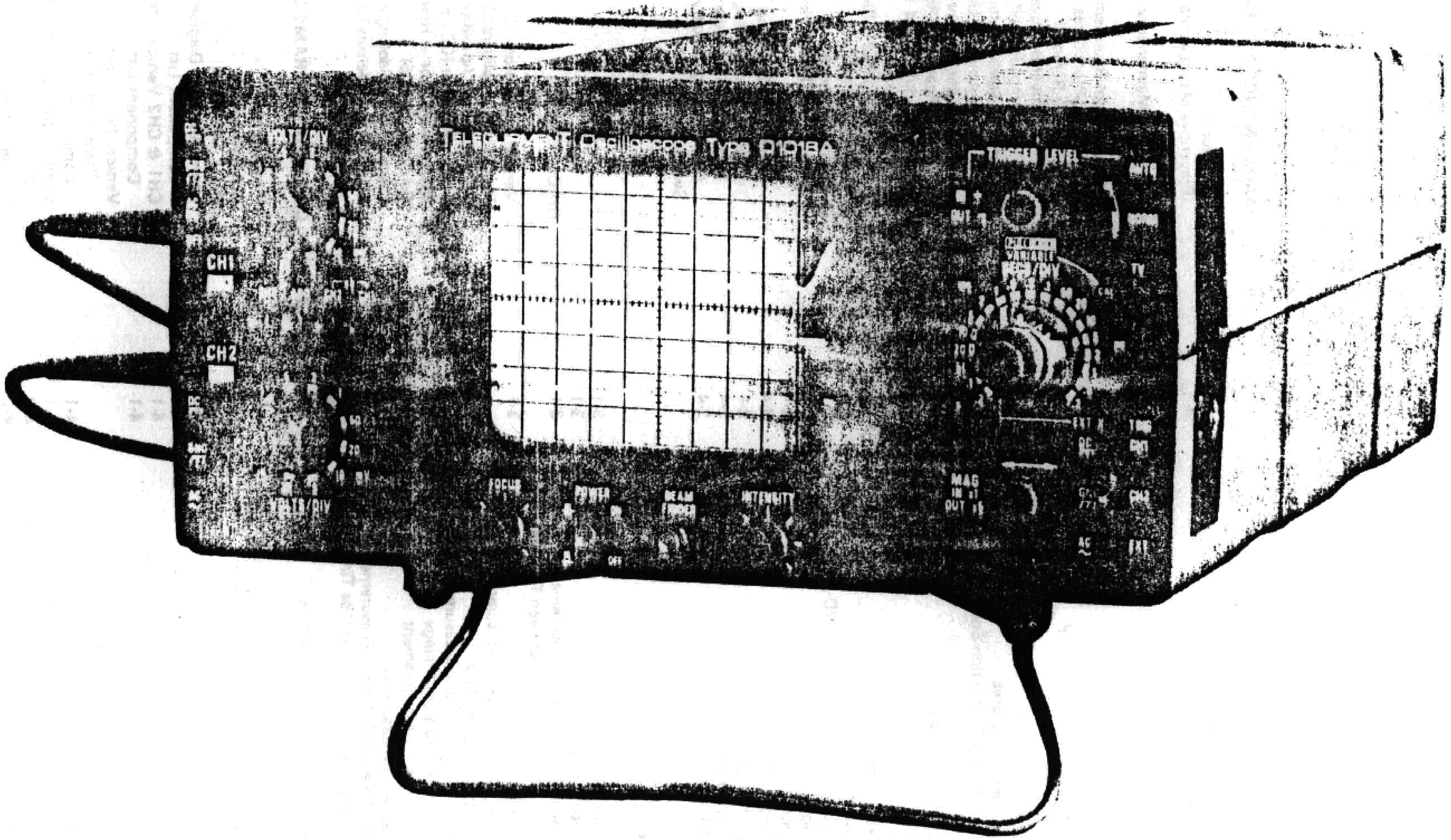
3) It is imperative that only **qualified** persons should attempt any servicing or calibration which necessitates removal of the covers.

4) Always consult TEKTRONIX if in doubt on any aspect of the instruments.

From time to time, changes to the instruments could be incorporated, due to the policy of continual development and improvement. These changes which usually affect the Parts List and Diagrams are described on Amendment Lists issued between manual reprints.
Any Amendment List appertaining to this Manual is located in the pocket inside the back cover.

NOTICE TO OWNER

If an instrument is to be returned to a Service Centre, please do not send loose items such as accessories unless they are suspected of being faulty. This will lessen the risk of damage during transit and also facilitate packing.
Please quote the instrument type number and serial number in any correspondence.


TELEQUIPMENT Oscilloscope Type D1016A
TRIGGER LEVEL
VOLTS/DIV
CH1
CH2
FOCUS
POWER
BEAM FINDER
INTENSITY
MAG

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World Wide Sales Service

SECTION 1
SPECIFICATION

1.1 CATHODE RAY TUBE (CRT)

	Rectangular flat faced CRT.
Display area	10 × 8 divisions (each division - 1.0cm)
Phosphor	P31
Overall accelerating potential	1.9kV
Z Blanking	+ 4V to + 20V d.c. coupled. Bandwidth >1MHz
Internal Graticule	Marked over 10 x 8cm Divs
Filter	Green

1.2 VERTICAL AMPLIFIERS

1.2.1 OPERATING MODES

CH2

CH1 and CH2 alternate from 1ms/div to 0.2μs/div.

CH1 and CH2 chopped from 0.2s/div to 2ms/div.

Chop or alternate selected automatically on SECS/DIV switch.
Add and subtract CH1 and CH2 algebraically.
X–Y Bandwidth is DC to 2.5MHz (–3db).
Phase error is <2° at 100kHz, lagging for X signal.

1.2.2 BANDWIDTH (–3db)

DC coupled	DC – 20MHz
AC coupled	8Hz – 20MHz
Risetime	17ns

1.2.3 VERTICAL DEFLECTION

Calibrated (12 steps 1.2.5 sequence)	5mV/div to 20V/div ±3%
Input impedance	1MΩ in parallel with 40pF approx.
Maximum Input Voltage	500V peak a.c. or d.c., continuous
Maximum Scan	Amplitude 8 divs. 5 divs at 20MHz
x5 Gain Sensitivity	1mV/div [bandwidth DC to 5MHz (–3db)]

1.3 HORIZONTAL DEFLECTION

1.3.1 SWEEP SPEEDS (19 steps in 1,2,5 sequence)

Normal	0.2μs/div to 0.2μs/div±3% over central 8 Divs.
x5 Gain	±5%.

A variable uncalibrated control provides continuous coverage between steps extending the slowest speed to 0.5s/div.

1.3.2 TRIGGER

Auto and Normal	Fully operational from 10Hz to 25MHz
Normal	Extends to 35MHz. Level control will select virtually any point on the wave form ± 4 divs about the mean d.c. level of the signal.

Automatic trigger on all repetitive waveforms >0.5 div and with mark space ratio <500 : 1. The level control will select any point on the waveform between 10% and 90% (approx) of the peak to peak value.

TV	TV field for sweep ranges 0.2s/div to 100µs/div and TV line from 50µs/div. to 0.2µs/div. (Level control inoperative).
Source	Internal. CH1 CH2 External All positive or negative.
Internal Sensitivity	0.5 div
External Sensitivity	120mV/25MHz

1.3.3 EXTERNAL X

Bandwidth	
DC coupled	DC to 2MHz approx. (–3db)
AC coupled	10Hz to 2MHz approx. (–3db)
Sensitivity	1V/div approx.
Input Impedance	280kΩ in parallel with 12pF approx.

1.4 CAL OUTPUT SOCKET

Output Voltage	500mV ±2% peak to peak
Frequency	At sweep repetition rate
Wave Shape	Vertical step approx in screen centre

1.5 GENERAL

1.5.1 POWER REQUIREMENTS

Mains	
Voltage	100V to 125V or 200V to 250V
Frequency	48Hz to 440Hz
Consumption	50VA approx.

1.5.2 SIZE

Height (stand retracted)	160mm
Width	300mm
Depth	420mm

1.5.3 WEIGHT

8kg

1.5.4 COOLING

Convection combined with Heatsink mounting.

1.5.5 TEMPERATURE RANGE (AMBIENT)

Operational	0°C to 40°C

SECTION 2
OPERATION

2.1 GENERAL

This section describes the various mechanical features and the purposes of the Control and Connection points, to enable the user to get full benefit from the facilities provided by the instrument.

2.2 MECHANICAL FEATURES

The instrument has been designed for general use but its lightweight construction makes it comparatively easy to handle and to carry.

2.2.1 HANDLE

This is hinged at both sides of the CRT bezel and folds back on top of the bezel when not in use.

2.2.2 TILT STAND

To position the instrument on the bench at a convenient viewing angle, a tilt stand is hinged on the underside of the case and folds flat when not in use.

2.2.3 FEET

To enable the instrument to stand firmly in two attitudes, feet are fitted on the underside and on the rear end.

2.2.4 CABLE STOWAGE

On the underside of the case four lugs are arranged as a wrap-around cable stowage with a clip to retain the end of the cable.

2.2.5 COOLING SYSTEM

Whilst in operation a number of the components inside the case generate heat which has to be dispersed quickly.

The method used is for the 'hot' components to be mounted adjacent to and on a large heatsink that also acts as a rear panel and as long as the free air surrounding the instrument does not exceed 40°C, there will be no danger from overheating. As an additional safeguard, ventilation slots are moulded into the top and bottom of the case and provide conventional convection cooling. These slots should never be covered so that the airflow is impeded whilst the instrument is in operation.

2.3 CONTROLS AND CONNECTION SOCKETS

The external controls and connectors are grouped according to their function; the majority of the controls appear on the front panels around the CRT display area.

The following descriptions define briefly their functions and also their locations.

2.3.1 CRT CONTROLS

(on centre front panel)

FOCUS	Rotary control for display definition.
POWER	Push/push switch for the instrument mains supply ON/OFF control.
BEAM FINDER	Push and hold control to bring the trace into the display area whilst adjusting the POSITION controls.
INTENSITY	Rotary control to vary the brightness of the display.

2.3.2 VERTICAL AMPLIFIERS CONTROLS

(on left front panel)

VOLTS/DIV CHANNELS 1 & 2	Rotary switch to select from a range of 12 values of attenuation for the input signal, calibrated in volts per division on the vertical (Y) axis. The white line on the knob indicates the setting position.
DC-GND-AC-OFF CHANNEL 1	Lever switch selects a suitable coupling for the input signal. a) In the DC position the signal is connected directly to the attenuator. b) In the GND position the input signal is disconnected and the input from the attenuator is grounded. This provides a zero d.c. level for reference purposes. c) In the AC position the signal is connected via a capacitor to the attenuator. d) In the OFF position, CH1 is isolated to allow the single trace of CH2 to be displayed.
DC-GND-AC CHANNEL 2	Similar to CH1 except for the omission of the OFF position.
– CH2	Push/push switch. The IN position inverts the polarity of the CH2 signal.
ADD	Push/push switch. The IN position adds both input signals together algebraically and the resultant sum is displayed. With – CH2 depressed the display is the algebraic difference between the signals. The OUT position cancels the addition or difference.
x5 (CH2 & CH1)	Push/push switch. The IN position increases the sensitivity of the VOLTS/DIV settings by 5 times the marked values. e.g. 5mV becomes 1mV.

Note 1
The maximum signal (a.c. and/or d.c) that can be accommodated without distortion or interaction between channels is less than ±8 divisions from the screen centre. This also applies when the trace is positioned off the screen by the vertical position control.

↕	Rotary control (concentric with the VOLTS/DIV switch knob) raises or lowers the display on the vertical (Y) axis. In the X-Y Mode CH1 position ↕ becomes the horizontal position control.

Note 2
The vertical position controls can balance out a d.c. component in the displayed waveform provided that the limitation of Note 1 above is observed.

2.3.3 TIMEBASE CONTROLS

(on right front panel)

SECS/DIV	Rotary switch to select from a range of 19 values of sweep speed calibrated in seconds per division on the horizontal (X) axis. The white line on the knob indicates the setting position. Sweep speeds are as indicated by the panel markings only when a) The ↔ position control is pushed in for x1 gain. b) VARIABLE control is set to the CAL position and pushed in. The extreme anticlockwise position is for EXT X mode to allow the input of an external X signal.

(continued) CHOP mode is selected from the range of speeds 0.2secs/div to 2ms/div; ALTERNATE mode is selected from the range of speeds 1ms/div to 0.2μs/div.

VARIABLE — Rotary control, (concentric with SECS/DIV switch) when pushed in enables sweep speeds to be selected between the setting of the SECS/DIV switch and the adjacent slower position. When pulled out, the control sets the trace for the X-Y mode and overrides all other modes.

◄► — Rotary control moves the display to the left (anticlockwise) or right (clockwise) on the horizontal (X) axis. It combines with a push/pull switch to set x1 gain when pushed in and x5 when pulled out.

In the X-Y mode the control has no purpose.

TRIGGER LEVEL — Rotary control to select the point on the signal waveform at which the sweep is triggered. It combines with a push/pull switch to change the polarity of the waveform. Push for positive (+) pull for negative (–).

AUTO-NORM-TV — Lever switch is part of the trigger-ing function. In the AUTO position, a stable display for almost any waveform is produced. The LEVEL control will give a small amount of horizontal adjustment. If a signal has insufficient amplitude or pulse repetition rate, a free running reference trace will appear.

In the NORM position, LEVEL control can be adjusted for triggering from any part of the leading edge of the displayed signal.

When TV is selected the trigger circuit acts as a sync separator to give field and line sync for TV frequency comparisons. The LEVEL control is inoperative in this mode.

DC-GND-AC or CH1-CH2-EXT — Lever switch with a dual purpose. In the EXT X mode, DC-GND-AC apply and provide selection of a suitable signal coupling.

In the TRIG mode CH1-CH2-EXT apply and provide a choice of triggering signal source when using a sweep speed.

2.3.4 REAR PANEL CONTROLS

ASTIG — Rotary control used in conjunction with the FOCUS control to obtain the best overall display definition.

TRACE ROTATE — Rotary control, to align the trace with the lines on the CRT graticule.

2.3.5 CONNECTION SOCKETS

(on left side)

CH1 INPUT — BNC connection for input signals to Channel 1 vertical amplifier.

CH2 INPUT — BNC connection for input signals to Channel 2 vertical amplifier.

⏚ — 4mm socket with direct connection to earth.

(on right side)

CAL 0.5V p-p (x10 PROBE ADJUST use 10mV/div) — 4mm connection provides a waveform signal for checking the calibration of the vertical channels. (When using Cal signal the trig should be switched to EXT).

TRIG OR EXT INPUT — BNC connection for either an external triggering signal, or an external input to the horizontal amplifier.

⏚ — 4mm socket with direct connection to the instrument earth.

(on left rear)

Z INPUT — 4mm socket for an input signal to blank the trace.
Level: +4V to 20Vpk.

2.4 CRT INTERNAL GRATICULE

(See Sect. 1 : 1)

The filter is a green tinted sheet of transparent material of high stability that is placed in front of the CRT faceplate.

2.5 OPERATING VOLTAGE

The instrument will operate from a line voltage source of either 100 to 125 a.c. volts or 200 to 250 a.c. volts with a frequency range of 48 to 440Hz.

To prepare the instrument for first time use or when changing to the alternative line voltage, the following procedure should be strictly observed.

1. Determine the line voltage level from which the instrument will operate.
2. Ensure that the instrument is not connected to a voltage source.
3. The Voltage Selection switches are visible through a window on the underside of the bottom cover.
4. Observe the setting of the range switch 234V – 117V.
5. If a change of range setting is necessary, lift off the top cover after loosening the four screws, then remove the bottom cover after loosening the four screws located through the feet.
6. Select the voltage range.
7. Set the voltage adjustment switch so that the supply voltage lies within the stated range.
   In the case of a supply voltage between 110 to 112V or 220V to 225V, the higher voltage range should be used.
8. Remove the flexible marked panel and change the fuse to suit the voltage ranges as follows: –
   234V requires a 'slow blow' 400mA × 20mm fuse
   117V requires a 'slow blow' 800mA × 20mm fuse
9. Re-fit the flexible panel.
10. Re-fit the bottom and top covers and secure with screws.
11. To alter the setting of the voltage adjustment switch, an access hole in the transparent window allows the use of a small screwdriver to move the switch.

2.6 POWER CORD

The three core power cord is wired in and leaves the instrument from the rear panel.

If the instrument is for use on the American continent a suitable three pin plug is fitted, otherwise a Euro Plug is fitted.

Colour Code

The three cores of the power cord are colour coded as follows: –

LINE .... Brown
NEUTRAL .... Blue
SAFETY EARTH (Ground)........ Green/Yellow

For safety reasons it is important that the earth wire is connected and if an extension lead is used it is essential that there is earth continuity.

2.7 FIRST TIME OPERATION

The following procedure will enable the user to become familiar with the instrument controls before attempting the more advanced techniques as described in Applications Section 3.

The warm-up time after switch-on is approximately 5 minutes, however more time should be allowed when the instrument is being used for the first time after removal from its packing or it has been in a cold atmosphere for any length of time.

2.8 SETTING THE CONTROLS

POWER	Off
INTENSITY	Central
FOCUS	Central
CH1 (VOLTS/DIV (DC-GND-AC-OFF	0.5V OFF
CH2 (VOLTS/DIV (DC-GND-AC	0.5V DC
CH1 (↕ CH2 (	Central
-- CH2 ADD x5 (CH1 & CH2)	All buttons out
SECS/DIV	0.2ms
TRIGGER LEVEL	Central
+	+
AUTO-LEVEL-TV	AUTO
SECS/DIV VARIABLE	In and fully clockwise
↔	In and central
CH1-CH2 EXT	CH2

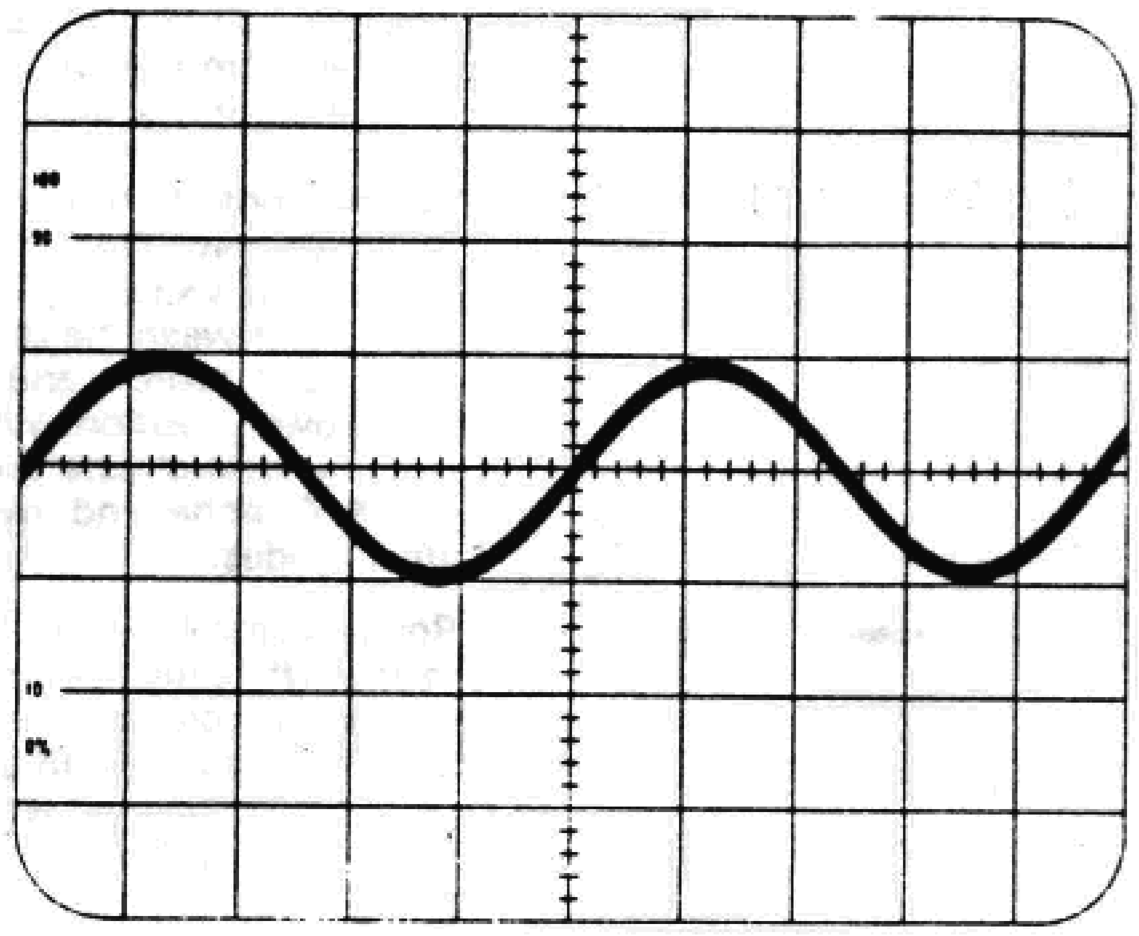
2.9 SWITCH-ON

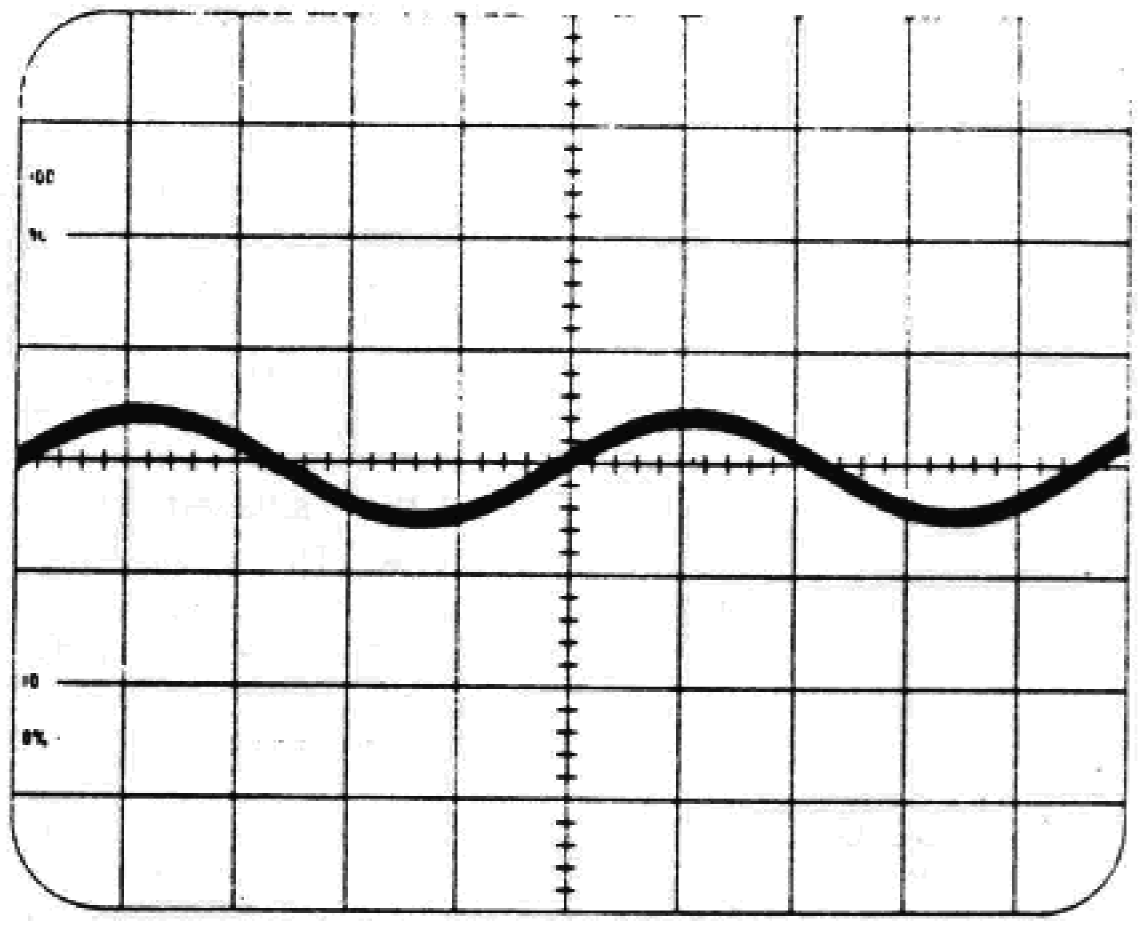
1. Ensure that the voltage selection settings are correct.
2. Push in the POWER ON/OFF switch.
3. Allow sufficient time for the trace to appear on the screen.
4. If the trace does not appear, press the BEAM FINDER switch and hold to bring the trace into the screen area. If no trace, increase intensity.
5. Centralize the trace with the ↔ and ↕ controls then release the BEAM FINDER switch.
6. Adjust the INTENSITY control until the trace brightness is at a suitable viewing level.
7. Adjust the FOCUS control for the best overall definition.
8. Adjust CH2 ↕ control to bring the lower edge of the trace level with the centre graticule line.
9. Align the trace with the horizontal graticule lines using the TRACE ROTATE control on the rear panel.
10. Connect a 1kHz input signal of 1V (approx) to the CH2 input socket.
11. The trace should have a height of 2 divisions (see fig. 2.1).
12. Switch CH2 VOLTS/DIV to 1 volt/div.
13. The trace should now have a height of 1 div (see fig. 2.2).
14. Turn the SECS/DIV anticlockwise step by step and notice that the sweep speed decreases.
15. Set the SECS/DIV switch to 0.2ms and observe the trace. (See fig. 2.1).
16. Set the SECS/DIV switch to 0.5ms and compare the waveform shape with that of the previous setting in step 15. (See fig. 2.3).
17. Pull out x5 switch and note that the sweep speed is now 5 times faster than the marked setting of 0.5ms. The actual speed will be 0.1ms.

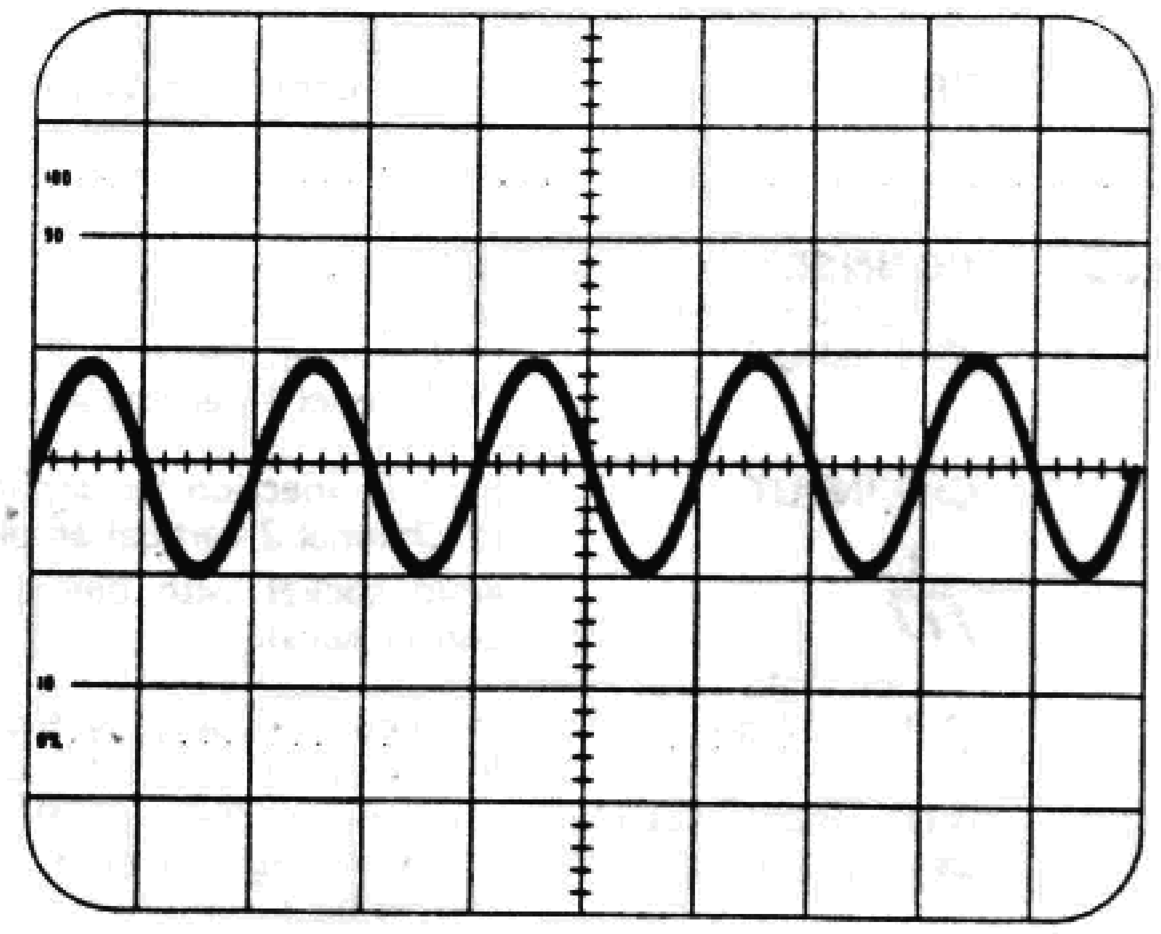
The user should now be familiar with the operation of the basic controls. The remaining controls for the more advanced facilities provided by this instrument are now described.

2.10 INPUT SIGNAL COUPLING DC-GND-AC

The switch selects the most suitable coupling for the incoming signal.
The DC position provides direct connection to the vertical amplifier for all frequency components of an input signal. The AC position suppresses with a capacitor the d.c. and low frequency components of a signal so that the a.c. components are displayed.

1V/div

0.2ms/div
Fig. 2.1

1V/div

0.2ms/div
Fig. 2.2

1V/div

0.5ms/div
Fig. 2.3

The Input Time Constant is 22ms (0.22s with 10MΩ probe).

The GND position earths the attenuator input so that the zero volt d.c. level can be determined.

2.11 TRIGGERING

This is the action of synchronising the starting point of the horizontal deflection of the timebase with the input signal waveform.

2.12 TRIGGER MODES

There are three modes (methods) of triggering, namely AUTO-NORM-TV.

2.12.1 In the AUTO mode triggering will occur on almost any type of waveform with voltgage LEVEL selection over most of the positive or negative going edge.

In the absence of a triggering signal a free running bright line trace will appear which can be used as a reference.

2.12.2 The NORM mode gives the LEVEL control a variable trigger point setting in selecting the triggering position especially on complex waveforms and lower frequency signals.

2.12.3 In TV mode triggering will occur on field and line sync pulses of TV signal waveforms. This is achieved by setting the SECS/DIV switch from 0.2secs/div to 100µs/div for field, and 50µs/div to 0.2µs for line.

The polarity + or − should be set to coincide with the polarity of the TV waveform. The LEVEL control is inoperative in the TV position.

2.13 TRIGGER SOURCE

A choice of three waveform sources is available by setting of lever switch CH1-CH2-EXT.

2.13.1 The CH1 and CH2 positions allow the sweeps to be triggered internally and are suitable for most applications. The trigger signals are derived from the vertical amplifiers.

2.13.2 The EXT position allows a signal from an outside source to trigger the sweep.

2.14 X-Y DISPLAY

This facility allows two input signals to be examined for phase difference and frequency measurement by a display of Lissajous figures.

In this mode one signal is fed into CH1 input for the horizontal deflection and the other signal is fed into CH2 input for the vertical deflection.

It is advisable to feed the 'reference' signal to CH2, when phase measurements are being made.

2.15 CHOP and ALTERNATE Modes

Although the CRT is a single beam type the instrument is designed to display two traces. This is achieved by sharing the display time between the two signals.

2.15.1 In the CHOP mode the CRT beam switches between the two traces and displays a part of each waveform in turn at the lower sweep speeds of 0.2s/div to 2ms/div.

2.15.2 The ALTERNATE mode is more suitable for the faster sweep speeds of 1ms/div to 0.2µs/div and the full waveform is displayed in turn.

2.16 EXT X

In this mode any signal applied to EXT X appears on the X axis when the SECS/DIV switch is set fully anti-clockwise to the EXT X position. The lever switch selects the coupling DC-GND-AC.

SECTION 3
APPLICATIONS

3.1 GENERAL

3.1.1. This instrument is for general purpose use and has been designed to provide facilities for a wide range of applications.

3.1.2 One of the commonest uses for an oscilloscope is the display of repetitive waveforms. By suitable adjustment of the controls it is possible to look at a fraction of one cycle or a number of cycles.

3.1.3 The dual channel facility provided by the D1016A oscilloscope enables two waveforms to be displayed simultaneously for comparison.

3.1.4 There are two ways of connecting a signal to an oscilloscope. The first is by direct connection of a screened cable with correct impedance matching and the second way is by means of a high impedance probe connected via a screened cable.

3.1.5 Probes can have inbuilt attenuation and can be selected to suit the size of the signal voltage. The attenuation factors can be from 1:1 to 100:1 for very small signals to large signals. The most commonly used probe has an attenuation factor of 10:1, and has an input resistance of 10MΩ when connected to the oscilloscope.

3.2 PROBE ADJUSTMENT

Before using a x10 or x100 probe it is advisable to check the setting for the correct frequency response. The following procedure is suitable for a 10:1 probe:—

1. Set the SECS/DIV switch to 5ms/div.
2. Connect probe connector to the CH2 input and the probe tip to the CAL socket centre with earth clip connected to the ground socket.
3. Set Trig source to EXT.
4. Set VOLTS/DIV switch to 10mV.
5. Set variable SECS/DIV control to CAL.
6. The display should be a step response at 5 Divs.
7. Adjust the probe trimmer for best obtainable square + ve corner.

3.3 PEAK TO PEAK VOLTAGE MEASUREMENT

AC — Symmetrical waveform

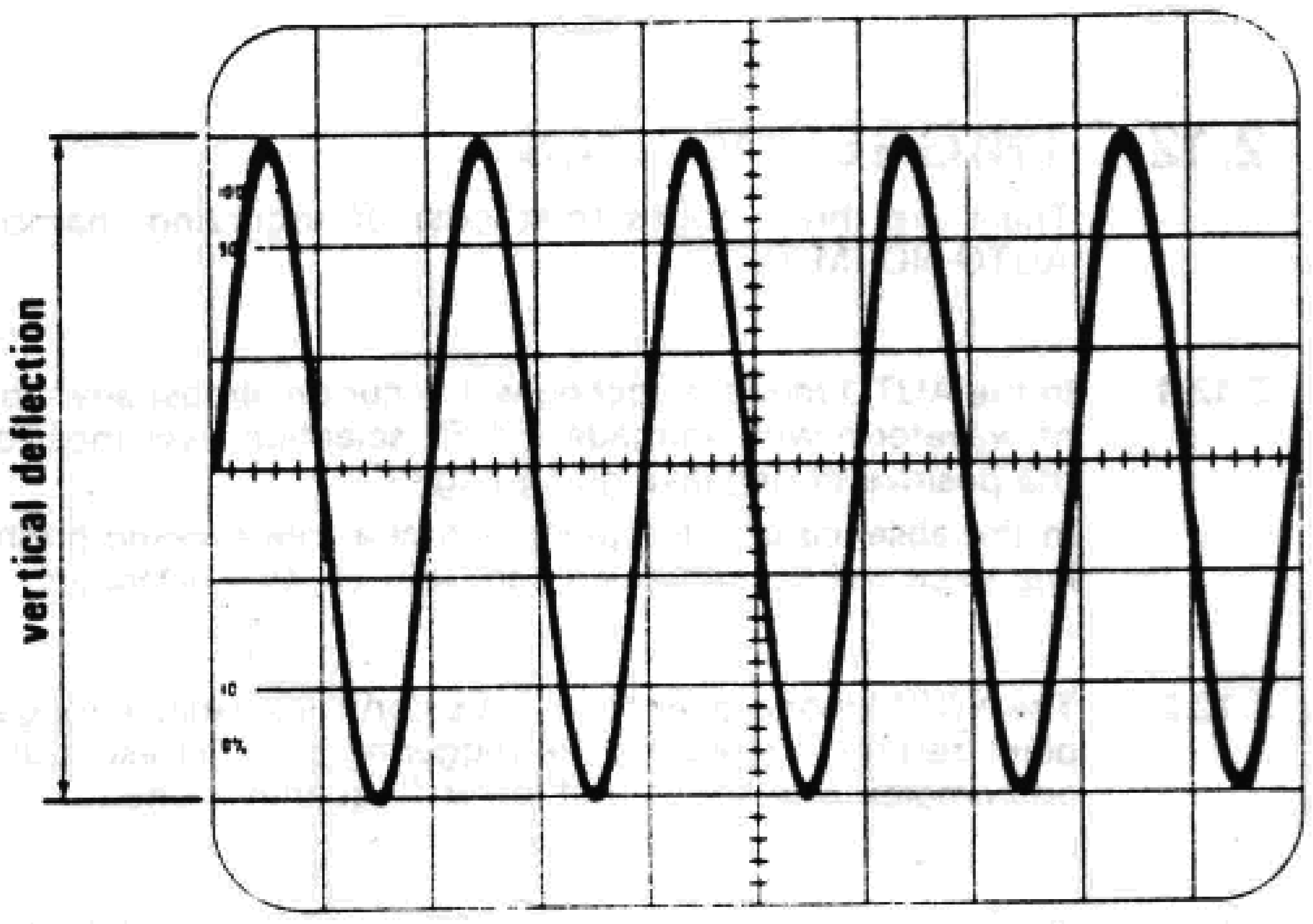
1. Connect the waveform to be measured to the CH2 input.
2. Set the VOLTS/DIV switch to display about 5 or 6 divisions of the waveform.
3. Set the DC-GND-AC switch to AC.
4. Set the SECS/DIV switch to display several cycles of the waveform.
5. Use the ↕ position control to set the lower edge of the waveform on one of the lower graticule lines so that the top edge of the waveform is in the graticule area.
6. Measure the vertical amplitude (div) of the signal on the screen.
7. Multiply the amplitude in step 6 by the VOLTS/DIV setting and by the attenuation factor of any probe used.

EXAMPLE
Assume a vertical deflection of 5.9 divisions using a x10 attenuation probe and a VOLTS/DIV setting of 0.05 volts per division.

∴Peak to Peak Voltage =

Vertical Deflection X VOLTS/DIV (Setting) X Attenuator Factor (probe)

for the example
Peak to Peak voltage = 5.9 X 0.05 X 10
= 2.95 volts



3.4 VOLTAGE MEASUREMENT BETWEEN TWO POINTS ON A WAVEFORM

Proceed as in 3.3 substituting the two measurement points for the peaks and setting the lower point on one of the lower graticule lines.

3.5 INSTANTANEOUS VOLTAGE MEASUREMENT WITH REFERENCE TO GROUND

To make a measurement of the DC level at a specified point on a waveform use the following procedure.

1. Set the DC-GND-AC switch to GND.
2. Use the ↕ position control to centre the trace.
3. Set the DC-GND-AC switch to DC.
4. Set the CH1-CH2-EXT to CH2
5. Set the TRIG LEVEL control to the AUTO position.
6. Connect the waveform to be measured to the CH2 input.
7. Establish the polarity of the measured voltage. If the measurement point is above the centre line the voltage is positive. If the measurement point is under the centre line it is negative.
8. If the waveform is repetitive use the SECS/DIV and ↔ controls to display at least one cycle.
9. Set the DC-GND-AC switch to GND.
10. Set the trace to the lowest graticule line or other suitable reference line, using the ↕ position control, if the point to be measured is positive. Set to highest or other suitable graticule line if the point to be measured is negative. AFTER THIS DO NOT ADJUST THE ↕ POSITION CONTROL.
11. Set the DC-GND-AC switch to DC.
12. Measure the distance in divisions from the reference line to the point to be measured.
13. Multiply the measurement in step 12 by the VOLTS/DIV switch setting and any probe attenuation factor.

EXAMPLE
Assume that the vertical distance measured is +2.7 divisions with a VOLTS/DIV setting of 200mV and the probe attenuation factor is x1

∴Instantaneous voltage =

Vertical distance (divisions) X (with polarity) X VOLTS/DIV (Setting) X Probe Attenuator factor

For the values given

Instantaneous voltage = +2.7 X 1 X 0.2 X 1
= +0.54 volts

3.6 INSTANTANEOUS VOLTAGE MEASUREMENT WITH REFERENCE TO A DC VOLTAGE

Proceed as in 3.5 but in step 9 set the input switch to DC and feed in the reference voltage to the input. Step 11a will be to remove the reference voltage, and re-connect the waveform.

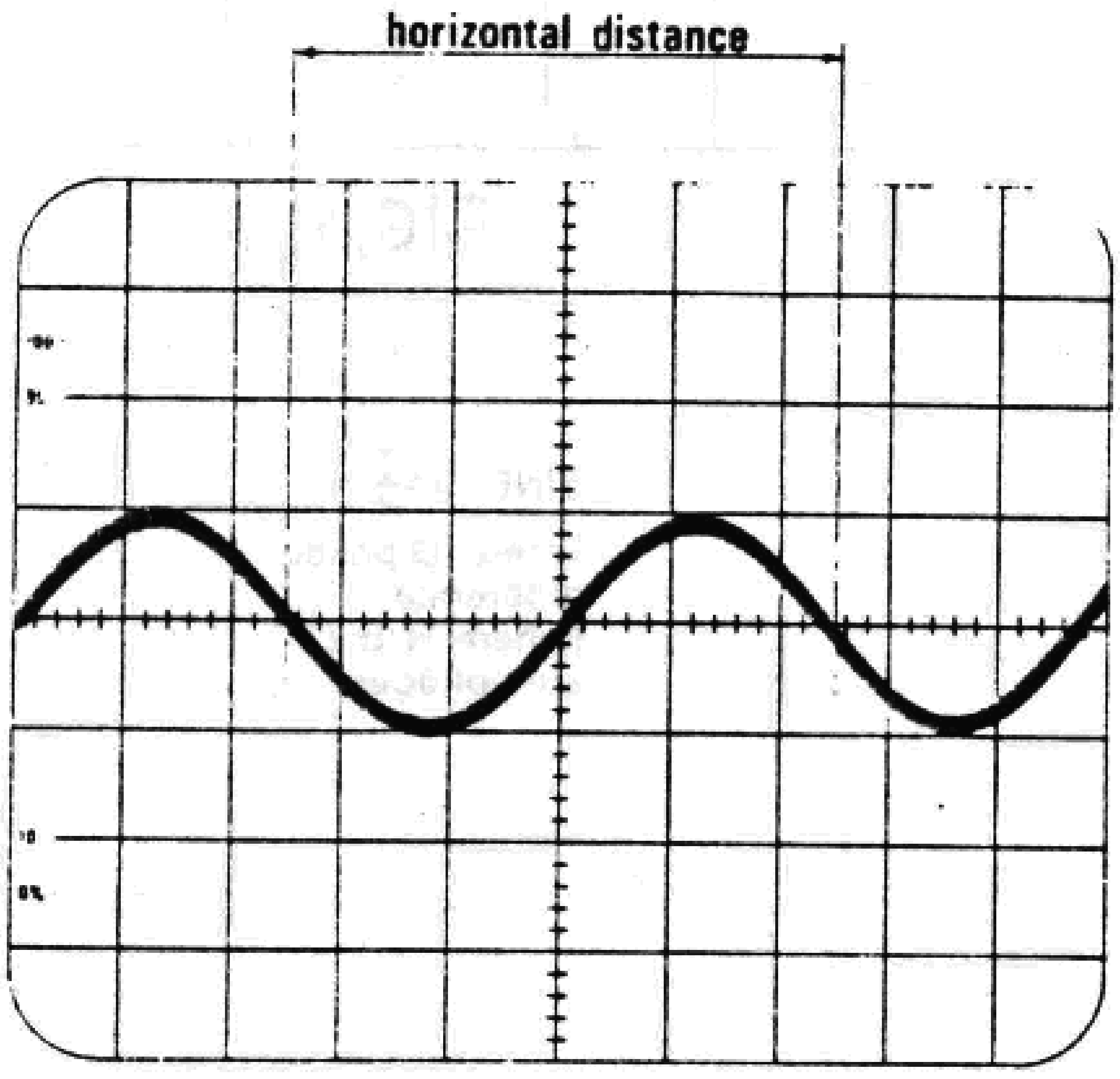
Note:
The oscilloscope can be used as in paragraphs 3.3, 3.4, 3.5 and 3.6 to resolve an a.c. waveform with d.c. level. The latter is established first at some reference point on the a.c. waveform and the a.c. component can then be measured more accurately by expanding the signal with the switch set to AC.

3.7 TIME DURATION MEASUREMENT

1. Connect the waveform to be measured.
2. Set the VOLTS/DIV switch to display a suitable vertical amplitude of the waveform.
3. Set the SECS/DIV and LEVEL controls to display the appropriate portion of the waveform to measured over the maximum number of horizontal graticule divisions possible, keeping well inside the graticule limits.
4. Use the ↕ position control to move the trace so that the measurement points are on the horizontal centre line.
5. The ↔ position control is used to move the start of the measurement period to a convenient reference point.
6. Ensure VARIABLE control is fully clockwise.
7. Measure the distance (divs) between the measurement points.
8. Multiply the measurement in step 7 by the setting of the SECS/DIV switch.

EXAMPLE
If the distance between the points is 5 divisions with the SECS/DIV control on 0.2ms/div.

Time duration = horizontal distance (divisions) X SECS/DIV setting
= 5 X 0.2ms
= 1.0ms



3.8 FREQUENCY MEASUREMENT

The time duration technique shown in 3.7 can be used to establish the frequency of a periodically recurrent waveform. The start of two adjacent cycles is taken as the measurement points and the time duration between these points established. The frequency is the reciprocal of the time duration.

EXAMPLE
If one cycle occupies 5 divisions with the SECS/DIV switch on 0.2ms/div

Time Duration = Horizontal distance (divs) X SECS/DIV (setting)

for the example

Time duration = 5 × 0.2ms
= 1.0ms

Frequency = $\frac{1}{\text{Time duration}}$
= $\frac{1}{1.0 \times 10^{-3}}$
= 1kHz

Note:
During Time or Frequency measurements, resolution can be enhanced if the signal is displayed over at least 6 divisions vertically, but not more than ±2 divisions vertically off screen.

3.9 RISE AND FALL TIME MEASUREMENTS

Rise time measurements employ the same basic techniques as time duration measurements. Rise time t is the time required by the leading edge of a waveform to rise from 10% to 90% of the waveform amplitude. The procedure is as follows: –

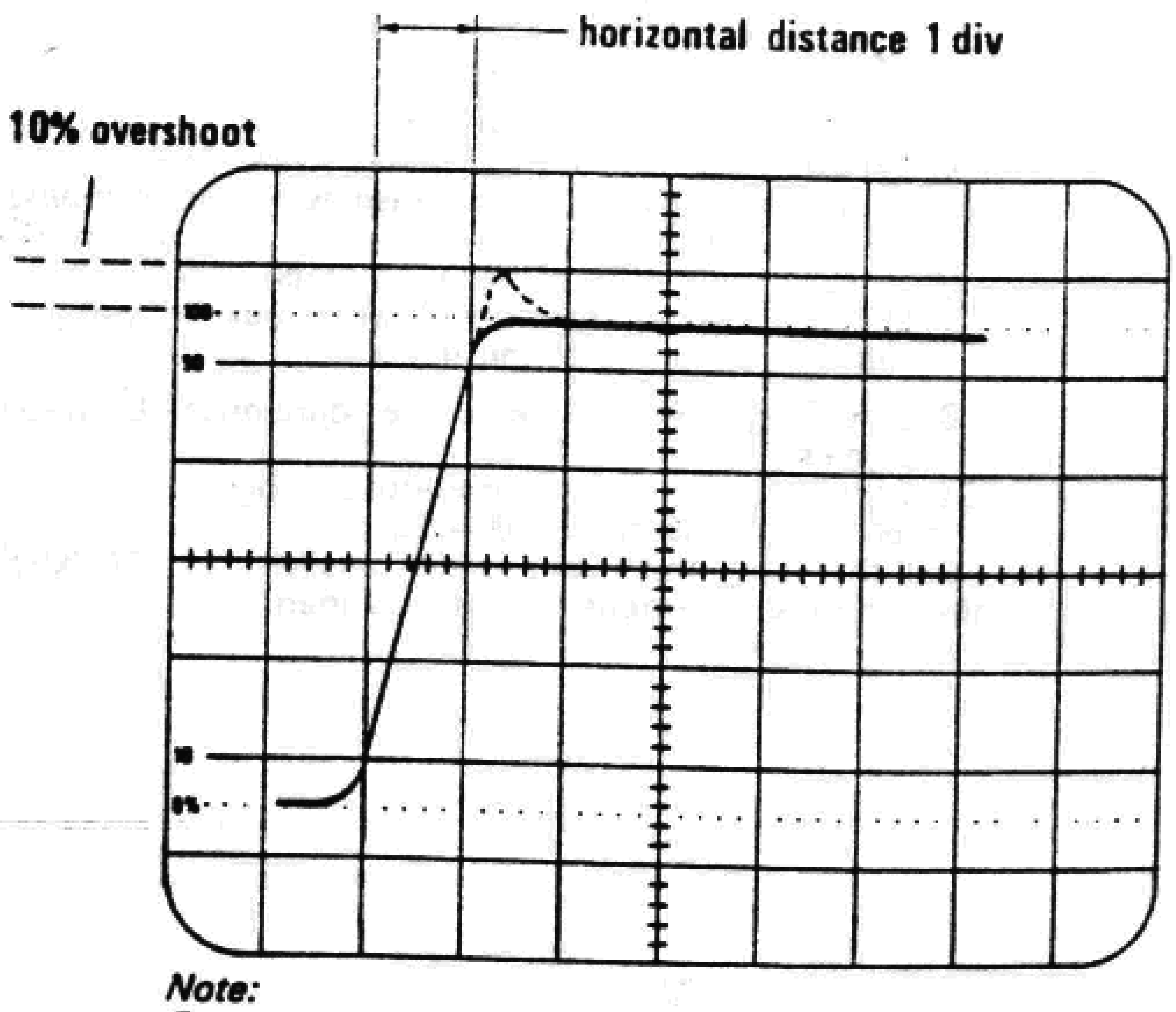
1. Connect the waveform to either input.
2. Set the DC-GND-AC switch to AC.
3. Set the VOLTS/DIV switch to display 4 to 8 divisions amplitude.
4. Centre the display about the centre horizontal line.
5. Set the trigger controls to obtain a stable display.
6. Set the SECS/DIV switch so that the 10% and 90% points of the waveform lie within the centre 8 divisions horizontally.
7. Determine the 10% point of the waveform and use the ↔ and ↕ position controls to set this point to a convenient graticule point.
8. Determine the 90% point and estimate the horizontal distance in graticule divisions between the 10% and 90% points of the waveform.
9. Multiply the distance obtained in step 8 by the setting of the time divisions switch. If the result is close to the rise time of the instrument it is necessary to apply a correction factor (See 3.10).
10. Fall time is the time required by the trailing edge of a waveform to fall from 90% to 10% of a waveform amplitude. The procedure is similar to steps 1 to 9.

EXAMPLE
Assume that the horizontal distance between the 10% and 90% points is 1 division and the SECS/DIV switch is set to 20ms.

Rise time = horizontal distance (divs) X SECS/DIV setting

for the example

Rise time = 1 X 20ms
= 20ms



Note:
For users convenience the 10% and 90% points are marked on the graticule for a 5 division amplitude signal.

3.10 CORRECTION FORMULA FOR FAST RISE TIME WAVE FORMS

When the rise time of the oscilloscope is of the same order as the rise time of the waveform being measured it is necessary to apply a correction formula as follows: –

$$\text{Actual Rise time (tra)} = \sqrt{\left(\text{Measured Rise time (trm)}\right)^2 - \left(\text{Oscilloscope Rise time (tro)}\right)^2}$$

EXAMPLE
Assume the rise time found by the method given in 3.9 is 40ns. The oscilloscope rise time is approximately 17ns applying

$$\text{Actual rise time} = \sqrt{40^2 - 17^2} = \sqrt{1600 - 289} = \sqrt{1311} \approx 36.2\text{ns}$$

NOTE It should not be necessary to apply the correction to waveforms having a rise time greater than 200ns. Also the quoted rise time is the maximum figure and the actual rise time could be considerably better than this. This would mean that a calculated rise time would be in error. If it is necessary to work to great accuracy it would be necessary to measure the bandwidth of the instrument and calculate the rise time as follows:

$$\text{Rise time} = \frac{350}{\text{Bandwidth (MHz)}}\ \text{ns}$$

3.11a PHASE DIFFERENCE MEASUREMENT

The following method is for the measurement of phase difference between two sinewave signals for signals above 100kHz.

1. Connect one signal to CH1 input.
2. Connect the other signal to CH2 input.
3. Set both DC-GND-AC switches to DC.
4. Set Trigger Level switch to AUTO.
5. Set Trigger source switch to CH2.
6. Adjust controls for maximum height of display and equal disposition about the horizontal centre line.
7. Adjust the LEVEL control so that a selected point on one waveform lies on the horizontal centre line.
8. Adjust SECS/DIV switch until the half cycles of the waveforms measure 4 divisions on the horizontal centre line.
9. Each division $\frac{180^\circ}{4\text{ divs}} = 45^\circ$
10. Measure the distance in divisions between the corresponding points on each waveform on the horizontal centre line and multiply by the degrees per division.

3.11b PHASE MEASUREMENT USING X – Y FACILITY

1. Pull X – Y switch.
2. Connect X signal to CH1 Input.
3. Connect Y signal to CH2 Input.
4. Set *both* Input selector switches to DC or AC.
5. Adjust controls for maximum display height, *centralise* trace – as in Fig. 1.
6. Measure height 'H' of trace, (in volts).
7. Measure central intercept I at a max (in volts) vertically at centre of the trace.
8. $\text{Sine}^{-1}\left(\frac{I}{H}\right) = \emptyset =$ phase angle difference between signals.

EXAMPLE (Fig. 1) same attenuator settings.
$H = 60\text{mm}$, $I \simeq 30\text{mm}$ $\therefore$ $\emptyset = 30^\circ$

9. If the frequency of measurement is less than 100kHz, then the measurement error is less than 2°.

PHASE MEASUREMENT

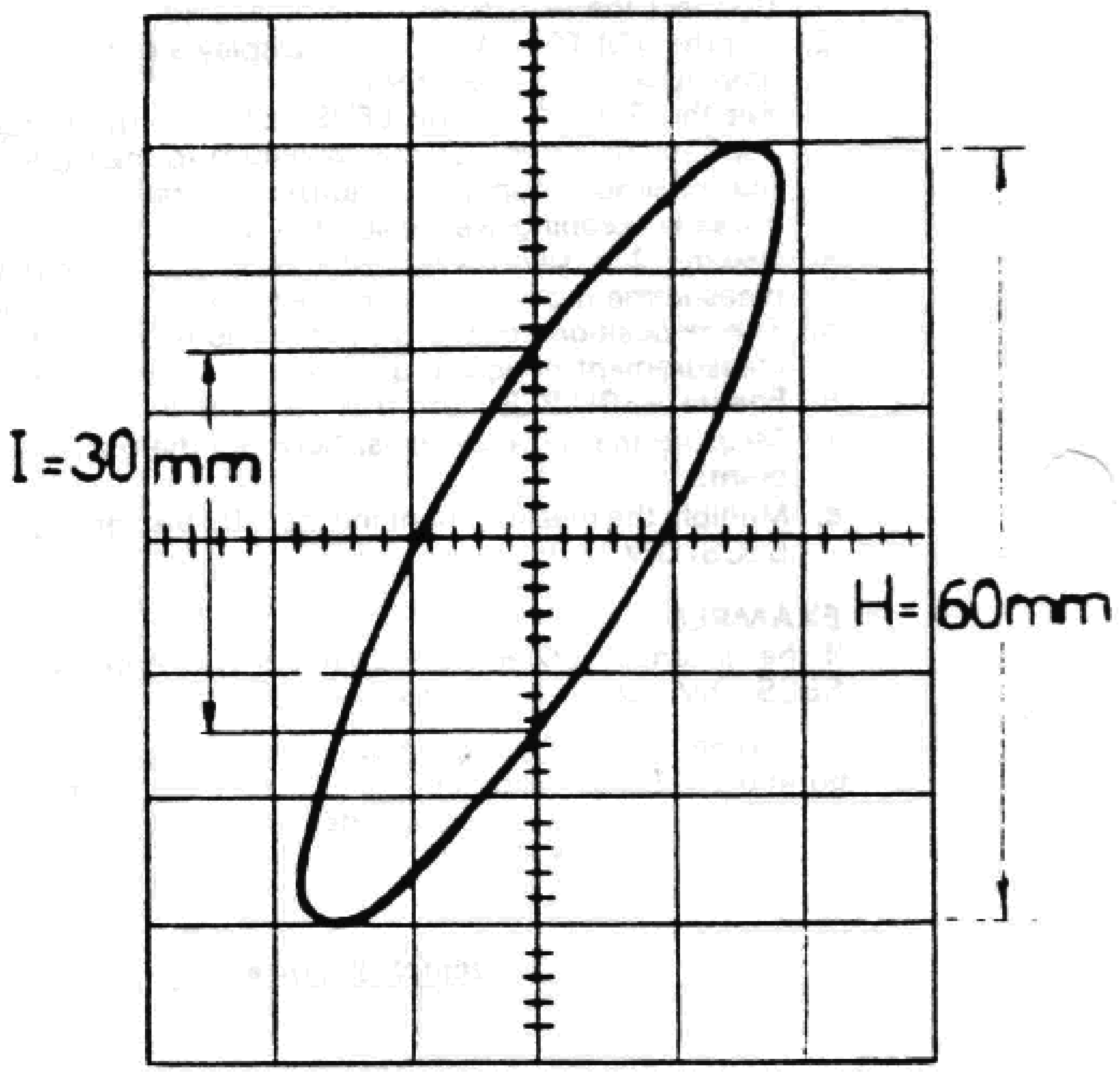


FIG. 1

SINE $\emptyset = \frac{I}{H}$
where $\emptyset$ phase difference
(where H & I are voltages)

SECTION 4

RE-CALIBRATION

4.1 INTRODUCTION

4.1.1. GENERAL

The solid state design of the instrument makes frequent adjustment of the internal preset components unnecessary. The appropriate part of the re-calibration procedure should be carried out, whenever the instrument fails to meet its specification, or whenever a defective component is replaced. Section 4 should be helpful in deciding which part of the circuit requires adjustment. It is advised that isolated adjustments are not made, because of the risk of interaction with settings made in earlier checks.

Due to the complex nature of the instrument only qualified persons should attempt the re-calibration procedure.

In order to re-calibrate the instrument it will be necessary to remove the top and bottom covers. This will expose high voltage areas, therefore care must be taken when the instrument is connected to the a.c. line source.

4.1.2 CALIBRATOR

The internal 500mV calibration signal is used to check the vertical amplifier sensitivities and probe compensations.

4.1.3 TOOLS AND EQUIPMENT

To carry out the whole calibration procedure, the following tools and equipment are required: –

Low capacitance trimming tool (for preset capacitors).

Small screwdriver (for preset potentiometers).

Time-mark Generator providing markers of 5ms and 5µs. Accuracy to be within 0.1%.

Squarewave Generator, providing outputs of 1kHz and 10kHz, 25mV to 100V.

Squarewave Generator, providing an output of 1MHz with rise time less than 2ns.

Coaxial cable and terminating resistor, for the above. (50Ω)

Monitor Oscilloscope complete with x1 and x10 passive probes.

Passive Probe, x10 attenuation, suitable for input capacities of 30 to 50pF.

Digital Voltmeter 2.5V d.c. to 2500V d.c.

Sinewave Generator, 1kHz, 10kHz and 50kHz.

Coaxial leads allowing the same signal to be connected to both channels of the oscilloscope.

NOTE: Input signal values are peak to peak.

4.2 RE-CALIBRATION PROCEDURE

4.2.1

1) Ensure that no external leads are connected.
2) Remove top and bottom covers.
3) Connect to a suitable a.c. line voltage and switch on.

4.2.2 INITIAL SETTINGS

Set the controls on the front panels as follows: –

CH1-DC-GND-AC-OFF	GND
VOLTS/DIV	5mV
↕	mid position
CH2-DC-GND-AC	GND
VOLTS/DIV	10mV
↕	mid position
ADD, CH2, x5 CH1, x5 CH2	out
LEVEL	mid-position
± slope	in
AUTO-NORM-TV	AUTO
SECS/DIV	1ms
↔	mid-position
CH1 CH2 EXT	CH2
VARIABLE/X-Y	fully clockwise and pushed in
x5	in
FOCUS, INTENSITY	Adjust for a well defined display of suitable intensity.

4.2.3 D.C. SUPPLY LINE VOLTAGES (R418)

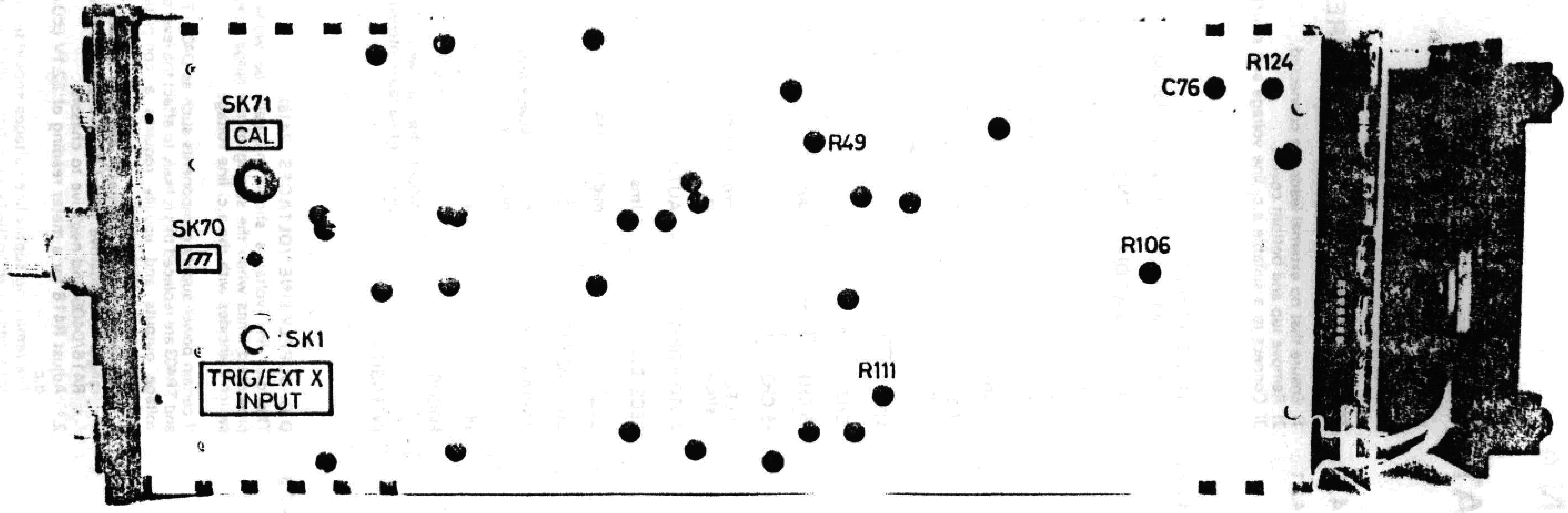
The d.c. line voltages should normally be within the prescribed limits when the setting of the range selection switch coincides with the a.c. line voltage.

If certain power supply components such as D405, TR401 and TR403 are replaced this is likely to affect the level of the voltage outputs and usually requires a complete re-calibration of the instrument.

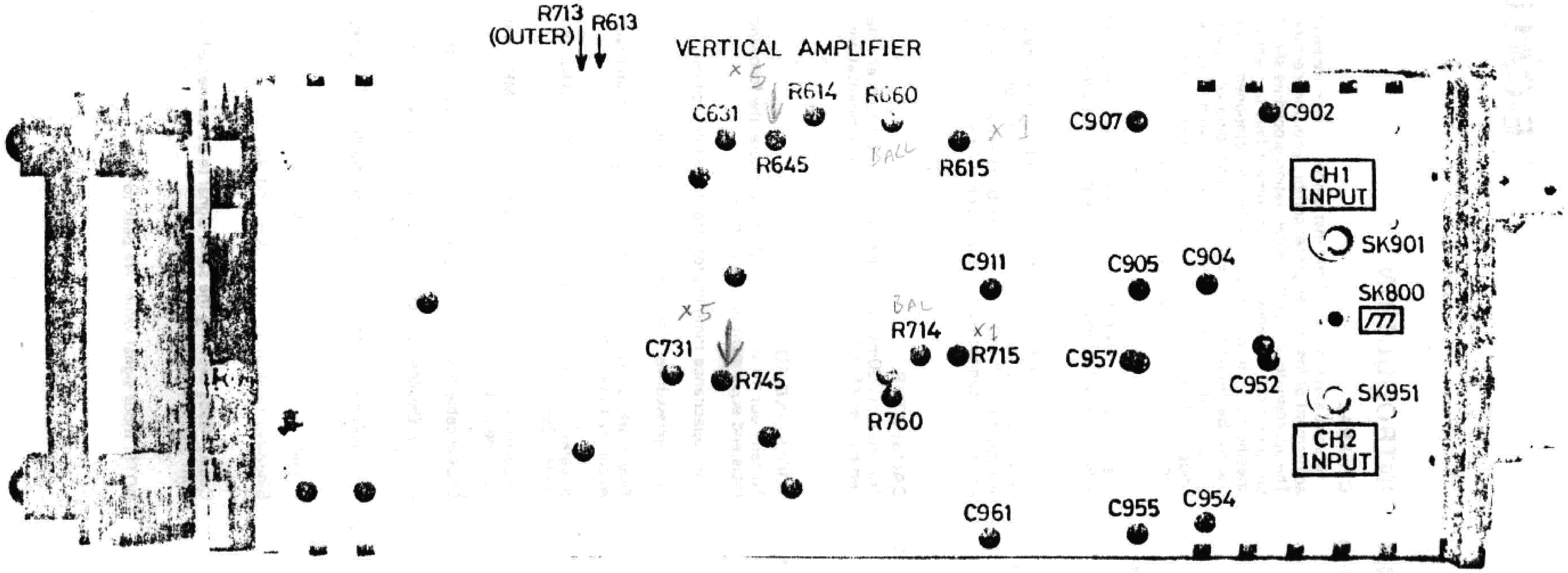
1. Connect a digital voltmeter set to a suitable d.c. range, with positive to +22V, available at junction R416/D405 and negative to chassis.
2. Adjust R418 for a meter reading of 22.1V (±0.05V) d.c.
3. The remaining supply line voltages should be within the limits shown in the table, although these need not be checked unless a fault is suspected.

Supply Line	Limits
- 22V	- 22.2V to - 22.6V
+ 175V	+ 170V to + 180V
-1K8V	±50V

HORIZONTAL AMPLIFIER



VERTICAL AMPLIFIER



These voltages must be maintained over the full range of a.c. line voltages according to the specification.

4.2.4 CRT CONTROLS

1. Apply 0.1ms markers to CH2 input and switch CH2 to DC coupling.
2. Adjust CH2 VOLTS/DIV to obtain approximately 1 to 2 divs of display.
3. Adjust FOCUS and ASTIG (rear panel) to obtain an optimum trace definition.
4. Remove marker signal.
5. Position the trace centrally on the screen.
6. Adjust the TRACE ROTATION to align the trace with the horizontal graticule lines. (Note that if the CRT has been changed, it may be necessary to reverse the trace rotation coil leads from the CRT to the power supply e.c.b. (PC280).
7. Turn INTENSITY fully clockwise and trigger source to NORM so that no sweep runs.
8. Adjust R444 on PC280 so that a spot is just visible near the centre of the CRT.
9. Set trigger source to AUTO and adjust INTENSITY for normal brightness of display.

4.2.5 VERTICAL AMPLIFIER

All adjustments and references apply to PC279 except where otherwise stated.

2.5.1. CH1 AND CH2 GAIN, FET OFFSET & VOLTS/DIV BALANCE

1. Set CH1 and CH2 VOLTS/DIV to 50mV.
2. Set CH1 and CH2 DC-GND-AC to GND.
3. Set SECS/DIV to 0.5ms.
4. Adjust FET BALANCE R660 (CH1) whilst rotating the FET Gain R615 over its full range for zero trace shift. When this is achieved, FET BALANCE R660 should not be disturbed.
5. Set CH1 DC-GND-AC to DC.
6. Apply 250mV 1KHz squarewave signal to CH1 INPUT.
7. Connect the monitor oscilloscope via the x10 probe to R630 (trigger output) and adjust R615, to obtain a 210mV-220mV peak to peak squarewave on the monitor oscilloscope.
8. Remove the probe from R630 and adjust R645 for 5 divs display.
9. Adjust FET BALANCE R760 (CH2) whilst rotating the FET GAIN R715 over its full range for zero trace shift. When this is achieved, FET BALANCE R760 should not be disturbed.
10. Set CH2 DC-GND-AC to DC.
11. Apply 250mV 1kHz squarewave signal to CH2 INPUT.
12. Connect the monitor oscilloscope via the x10 probe to R730 (trigger output) and adjust R715 to obtain a 210mV-220mV peak to peak squarewave on the monitor oscilloscope.
13. Remove the probe from R730 and adjust R745 for 5 divs display.
14. Remove the signal from both CH1 and CH2 INPUTS.
15. Set both CH1 and CH2 DC-GND-AC to GND.
16. Adjust R614 for no vertical trace movement when CH1 VOLTS/DIV is rotated between 20mV and 50mV.
17. Adjust R714 for no vertical trace movement when CH2 VOLTS/DIV is rotated between 20mV and 50mV.

4.2.6. x5 GAIN BALANCE

Pre-sets are mounted on daughter board PC253.

1. Adjust R613 for no trace movement when pressing CH1 x 5 IN and OUT alternately.
2. Repeat for CH2 by adjusting R713.
3. Centralise both traces. Connect Monitor 'scope probe to R824, the Y-output emitter resistor. Trim R616 (next to R613) for the smallest visible signal.

4.2.7 VERTICAL AMPLIFIER INPUT COMPENSATION

1. Set SECS/DIV to 0.2ms.
2. Set CH2 DC-AC-GND to DC and VOLTS/DIV to 5mV.
3. Apply 25mV 1kHz squarewave to CH2 INPUT.
4. Adjust C961 for a square corner.
5. Increase signal amplitude to 250mV and VOLTS/DIV to 50mV.
6. With C955 set to mid-position to minimise interaction, adjust C954 for a square corner.
7. Increase signal amplitude to 2.5V and VOLTS/DIV to 0.5V.
8. Adjust C955 and C957 for a square corner.
9. Repeat steps 5 and 6. If it is necessary to re-adjust C955 re-check steps 7 and 8.
10. Switch CH2 DC-AC-GND to GND and remove the signal from CH2 INPUT.
11. Change trig source to CH1.
12. Apply 50mV 1kHz squarewave to CH1 INPUT.
13. Set CH1 DC-AC-GND-OFF to DC and VOLTS/DIV to 10mV.
14. A locked trace should now appear on the screen.
15. Adjust C911 for a square corner.
16. Increase signal amplitude to 500mV and CH1 VOLTS/DIV to 100mV.
17. With C905 set to mid-position to minimise interaction, adjust C904 for a square corner.
18. Increase the signal amplitude to 5V and CH1 VOLTS/DIV to 1V.
19. Adjust C905 and C907 for a square corner.
20. Repeat steps 16 and 17. If it is necessary to re-adjust C904 repeat steps 18 and 19.
21. Remove signal from CH1 INPUT.
22. Apply 500mV 1kHz squarewave via a x10 probe to CH1 INPUT.
23. Set CH1 VOLTS/DIV to 10mV and DC-GND-AC to DC and adjust the probe compensation for a square corner.
24. Increase signal amplitude to 5V and CH1 VOLTS/DIV to 100mV.
25. Adjust C902 for a square corner.
26. Set CH2 DC-AC-GND to DC and trig to CH2.
27. Apply 500mV 1kHz squarewave to CH2 INPUT via a x10 probe and set VOLTS/DIV to 10mV.
28. Adjust probe compensation (if necessary) for a square corner.
29. Increase signal amplitude to 5V and VOLTS/DIV to 100mV.
30. Adjust C952 for a square corner.
31. Remove probe.

4.2.8. X-Y GAIN

The following adjustments are on PC245.

1. Apply 50mV 1kHz squarewave to CH1 INPUT with VOLTS/DIV set 10mV, and DC coupling.
2. Position the signal so that the bottom edge is 3 divisions below the graticule centre and the top edge is 2 divisions above the graticule centre.
3. Pull VARIABLE to X-Y position.
4. Adjust R124 for 5 divs of horizontal deflection.
5. Use CH1 shift control to place spot 3 div to left of centre line and 2 div to right of centre line.

4.2.9 VERTICAL AMPLIFIER HIGH FREQUENCY COMPENSATION

1. Set both Input Selector switches to GND and centralise traces so that they appear as a single horizontal line, after at least 10 minutes warm-up. Set Time Base to 2mS/div, Trigger on Auto and External.
2. Connect a.c. coupled Probe of Monitor Oscilloscope to the live end of R824. This is the tail resistor of the Y-Output cascode arrangement and is found at the bottom left-hand edge of PC280, seen from the front, and is easily accessible. The Monitor should be at 10mS/div and near maximum sensitivity.
3. Identify R616. This is nearest the CRT on the daughter board of PC279, next to the x5 balance controls. Adjust R616 until the rough squarewave on the monitor becomes a horizontal line, with small disturbances at the crossing points of the 'square' wave. This operation equalises operating conditions between CH1 and CH2 on the Pre-Amplifier.
4. Before attempting the High Frequency compensation of the Output stage, it would be useful to understand the function and effect of each of the trimmers that are to be adjusted. These are as follows:–
   (i) Trimmers C731, C631 on PC279. These affect the leading edge of the pulse and should be set initially just above minimum. Used to equalise CH1/CH2 response.

(ii) C822 also adjusts leading edge of Output Stage (O.S.) Initially set half way, so that clockwise rotation increases capacitance as verified by the increased meshing of the blades.

(iii) C841 will finally adjust the 'tilt' of the response immediately after the rise time, affecting the latter to some extent. Set up initially as C822. C841 operates in conjunction with R841 trimmer.

(iv) R841 trimmer increases response clockwise, as does R845. Initial setting on both is half-way, visually.

(v) R845 affects the response tilt for slightly longer than R841/C841.

(vi) Finally, Inductor L404 affects 'tilt' after rise time for a still longer period than (v). Its function is to permit a horizontal response that is flat – for a step or square input waveform – and the tilt caused by adjustment of L404 is visible for several mm. at 200nS/div sweep speed.

5. CH1 selector off, CH2 at 10mV/div centralised 50Ω termination at input, a.c. coupled.

Sweep at 0.5μS/div. Trigger CH2, Auto, centralised, polarity same as that of Generator, which should have an output rise-time of at most 5nS. It is always good practice to connect a 50Ω attenuator of between 10 and 20 db to the 50Ω termination, if enough signal is available. The generator should be set to a square-wave of 1MHz or an equivalent repetition rate if a Pulse Cen^r. is used. Adjust Generator for between 4-5 vertical divisions.

6. At this point and depending on the relative settings of the 7 variable controls detailed above, there should be a pulse response with an overshoot or undershoot, and also with a clearly identifiable very fast edge which visible slows down towards the corners of the pulse. Use the shift control to move each corner towards the first and eight division, vertically, and observe pulse corner shape. If this varies appreciably, then the 'response', as set, is already too fast. If there is no variation, then the corner will need squaring and optimising, as follows:–

(i) Re-centralise trace. Trim C882 and R845 alternatively to square corner of response with only 1-2mm of ringing.

(ii) Adjust C841 and R841 alternatively, trying to 'fill in' and flatten ringing of (i) above. If there is no ringing, optimise corner.

(iii) Repeat (i) and (ii). Adjust C731 on PC279 to bring up and square corner still further.

(iv) Finally, flatten any curvature in horizontal part of response by adjusting L404. With correct adjustment, L404 core should be clear of former by approximately 1.5mm - 2mm.

(v) Look up item 3.9 "Rise & Fall Time Measurements", at the figure demonstrating overshoot. As shown there, the *pivot point* of the overshoot is some 8mm long. Expand sweep x5, to give 40nS/div sweep speed. In comparison with the figure, the 'pivot point' of L404 would be about 20mm whilst that of R845/C822 would be about 4mm.

(vi) Repeat adjustment of the 4 trims on PC280 by small amounts, to optimise corner and reduce overshoot. Use Y-Shift to examine trace corners towards edge of screen vertically. A small change – reduction – in the squareness of both corners at about ½ and 7½ divisions denotes optimum setting. A bigger change or none denotes too fast or too slow a setting respectively. At the correct setting, the –3db bandwidth (over 5.7 to 4 divisions) should be between 24 and 26MHz.

(vii) Connect signal to CH1, 10mV/div, a.c. coupled, and set trigger to CH1. Adjust C631 for correct response as detailed above. C731 may require a small readjustment either way, if optimum response from CH1 is above or below spec. to equalise responses for the two channels.

For the individual user, optimum adjustment may depend on whether pulses or continuous sinusoidal waves are most likely to be monitored and measured. If use is made of the full allowance of ±1mm of trace abberations in 5 divisions (2%) then the bandwidth may be extended by about 2MHz, to over 25MHz. If pulses are being looked at in detail, then a good square corner response is better, but this may drop bandwidth to about 23MHz.

It should be said, finally, that if signals outside the quoted bandwidth of the instrument are being looked at such as, say, 27MHz for Radio Control or C.B., then utilising the x5 channel gain control will always give a bigger signal on the CRT, even though the response against frequency will be anything but flat.

4.2.10 INTERNAL CALIBRATOR (R106)

1. Connect CAL out to CH1 INPUT.
2. Set VOLTS/DIV to 100mV and TIME/DIV to 1ms.
3. Set trigger source to EXT to free run Time base.
4. Adjust R106 (on PC245) to display 5 divs signal amplitude.
5. Calibrator can be used, in the 10mV/Div positions, to calibrate probes.
6. Remove Cal signal connection.

4.2.11 SWEEP ACCURACY (R111 and C76)

1. Apply 5ms markers to CH2 INPUT with SECS/DIV set to 5ms and adjust VOLTS/DIV for 2 to 3 vertical divisions of display.
2. Adjust R111 for 1 marker per division over centre 8 divisions.
3. Change to 5μs markers with SECS/DIV set at 5μs.
4. Adjust C76 (PC245) for 1 marker per division over centre 8 divisions.

4.2.12a TRIGGER SENSITIVITY (R49)

1. Apply a 50kHz sinewave of .60mV amplitude to CH2 INPUT, with trigger set to +ve slope. SECS/DIV to 10μs.
2. Check that with VOLTS/DIV set to 20mV, there is a display of 3 divisions peak to peak.
3. Set VOLTS/DIV to 0.2V (to provide a display of 3mm amplitude).
4. Via a x10 probe, connect a monitor 'scope to the anode of D17 on PC245.
5. Set monitor scope controls for 2μs/div sweep and 50mV/div sensitivity, internal triggering and +ve slope.
6. Using the monitor 'scope horizontal control, position the leading edge of the square waveform displayed to coincide with the extreme left hand graticule line.
7. Adjust R49 on PC245 to ensure that when the LEVEL control is rotated alternately fully clockwise and then fully anticlockwise, the falling edge of the squarewave displayed on the monitor 'scope moves an equal distance to the left and then to the right of the centre graticule line.
8. Repeat step 7 but set the trigger slope to –ve.
9. Optimise the setting of R49 by minimising errors in steps 7 and 8.

4.2.12b H.F. TRIGGER SENSITIVITY (R49)

1. Apply 25MHz signal to CH2 Input, a.c. coupled, to display 5mm pk – pk.
2. Set Trigger Selector to CH2.
3. Set Trigger mode to AUTO (If difficulty is experienced turn control to manual).
4. Sweep Speed at max. 200nS/div.
5. Polarity –ve.
6. Adjust R49 on PC245 whilst varying the LEVEL CONTROL for optimum triggering. Revert to AUTO and check.
7. Switch Polarity to +ve and repeat step 6.
8. The optimum setting is the one that gives about equal sensitivity on both +ve and –ve trigger slope selection.

SECTION 5

MAINTENANCE AND FAULT-FINDING

5.1 INTRODUCTION

This section contains information on preventive and corrective maintenance and dismantling procedures.

Exploded views of the instrument together with a mechanical component list are included to enable the parts used in the assembly to be identified.

5.2 PREVENTIVE MAINTENANCE

5.2.1 GENERAL.

This is an important part of the maintenance of the instrument because if done regularly and properly, the instrument should perform more efficiently, and costly corrective maintenance could possibly be avoided.

5.2.2 Preventive maintenance consists of the following:-

(a) Regular visual checks for loose parts or connections; broken connections especially on circuit boards; transistors not seated in holders correctly; signs of components overheating such as scorch marks (the reason should be investigated).

(b) Regular removal of dust and dirt from both the exterior and the interior, particularly on electrical components.

(c) Electrical moving parts such as spindles in their bushes or bearings should be given a slight smear of silicon grease.

5.3 CORRECTIVE MAINTENANCE

5.3.1 GENERAL

Corrective maintenance concerns repair and component replacement. This work will require a certain amount of dismantling described in a later part of this section.

5.3.2 COMPONENT REPLACEMENT

The majority of the components used in the manufacture of this instrument are listed either on the Mechanical Component List or the appropriate Electrical Component List.

To order a replacement part, it is essential that the following information be given to the Tektronix Field Office or the local representative.

(a) Instrument Type.

(b) Serial Number.

(c) Description and Circuit Reference for electrical components.

or

(d) Description and Item Number (if shown) for mechanical components.

(e) Part Number.

For some of the standard electrical components it is possible to obtain them from a local source, provided that they are known to be direct replacements, both physically and electrically.

The majority of the electrical components are mounted on circuit boards, therefore it is essential that standard soldering techniques are used. After replacing an electrical component, it will normally be necessary to re-calibrate the instrument over that portion of the circuit affected. (refer to Section 4 Re-calibration).

5.4 DISMANTLING PROCEDURES

The following procedures provide access to various parts of the instrument to enable mechanical and electrical components replacement to be achieved as easily as possible.

A figure in a circle refers to the item number shown on the Mechanical Assembly and Component List.

Interconnection Diagram 10 shows the electrical connections between boards etc., and is useful for identifying the leads mentioned in the procedures.

Before starting to dismantle any part of the instrument, make certain that is is not connected to the line voltage supply. Re-assembly procedures are a reversal of the dismantling procedures.

5.4.1 TOP COVER REMOVAL

Remove the four top screws (110) and lift off the cover.

5.4.2 BOTTOM COVER REMOVAL

After removal of the Top Cover, remove the four screws (114) located through the feet and lift off the cover. The feet (1) (2) are retained in position by their own fixing screws (113).

5.4.3 VERTICAL AMPLIFIER UNIT REMOVAL (PCB279)

1. Remove the two screws and washers (87) (122) through the top and bottom of the chassis assembly (34) at the front end.
2. Remove the two screws (115) from the top flange of the chassis assembly securing the shield (17).
3. Support the unit and separate from the chassis to expose the track side of PC279. If it is necessary to completely detach this unit from the instrument, continue this procedure.
4. Disconnect the ribbon lead from the rear of PC279 via the plug PL401a and socket.
5. Unsolder the flying trigger lead from connections (17) and (18) on PC279.
6. On D1011 unsolder X-Y lead from connections (26) and (27) on PC279.
7. Detach 3 way ribbon lead joining PC279 to PC280. This lead supplies drive signals to the Y output stage.

5.4.4 ELECTRICAL SHIELD (VERTICAL UNIT) REMOVAL

1. Remove ring nut (19) located between CH1 and CH2 input sockets.
2. Remove 2 x 3mm nuts earthing PCB to shield electrical.
3. At the rear end compress the two plastic lugs (22) and carefully lift off the shield to expose the interior of the unit.

5.4.5 HORIZONTAL AMPLIFIER UNIT REMOVAL

1.–2. } Similar to 5.4.3.

3. Support the unit and separate from the chassis to expose the track side of PC245.
   If it is necessary to completely detach this unit from the instrument continue this procedure.
4. Disconnect the ribbon lead from the rear of PC245 via the plug PL402a and socket.
5. Unsolder the flying trigger twin lead from connections (17) and (18) on PC245.
6. Unsolder coaxial lead from connections (30) and (31) on PC245.
7. Unsolder twin lead from connections (34) and (36).
8. On D1011 unsolder X-Y twin lead from connections (26) and (27) on PC245.

5.4.6 ELECTRICAL SHIELD (HORIZONTAL UNIT) REMOVAL.

1. Remove the ring nut (19) located between the CAL socket and the TRIG or EXT X INPUT socket.
2. At the rear end compress the two plastic lugs (22) and carefully lift off the shield to expose the interior of the unit.

5.4.7 HEATSINK REAR PANEL REMOVAL

1. Remove four screws (110) and gently pull the panel away from spacers (38) to expose PC280.
2. Remove the two screws and washers (106) (121) securing the power cord clamp (36).
3. Disconnect the leads to the power transistor TR402 by gently pulling off the socket.

5.4.8 POWER SUPPLY BOARD PC280 REMOVAL

1. Unscrew and remove the four fixings (108).
2. Loosen the set screws (103) in the rear of the FOCUS and INTENSITY shaft couplings (56).
3. Slide the power cord grommet (37) from the open-ended slot in PC280.
4. Disconnect the TRACE ROTATE coil leads from PC280.
5. Unsolder the remaining leads as shown on the Interconnection Diagram 10.
6. The board is now completely detached from the instrument.

5.4.9 CRT REMOVAL

1. Pull of the CRT base.
2. Disconnect the TRACE ROTATE coil leads on PC280.
3. On the top side of the CRT, disengage the clamp spring arms (60) from the chassis sides.
4. Lift off the clamp (59).
5. Remove the two screws and washers (109) (122) securing the neck clamp to the chassis. Holes in PC280 allow access to the screw heads.
6. The CRT complete with mu-metal shield can now be lifted out of the chassis.
7. Remove the mu-metal screen by unwrapping the insulating tape and withdrawing the CRT.

5.4.10 MAINS BOARD PC247 REMOVAL

This board contains line voltage adjustment switches and fuses.

1. Remove the presspahn cover.
2. Remove the rear screw (113).
3. Remove the two screws (113) located on either side of the two plastic shaft extensions (55) for BEAM FINDER and POWER ON/OFF.
4. Lift the board gently so that the shaft extensions disengage from their respective switches. Note that the movement is restricted by the group of wires soldered to the board. Refer to Interconnection Diagram 10 if the board is to be completely removed from the instrument.

5.4.11 FRONT BEZEL REMOVAL

1. Pull off FOCUS and INTENSITY knobs (54).
2. Remove four screws (102) located in the corners of the bezel (42).
3. Pull handle out straight and lift off bezel.

5.4.12 HANDLE REMOVAL

1. Remove the bezel.
2. Remove the retaining clips and washers (48) (124) securing the handle ends.
3. Spring out the handle side arms and lift clear of the instrument.

5.5 POWER SUPPLY FAULT-FINDING AND REPAIR

The power supply circuitry has been specifically designed for these instruments, therefore the following information is required to facilitate fault diagnosis.

5.5.1 EQUIPMENT

Dual beam monitor oscilloscope
D.M.M/Multimeter with a sensitivity of 20kΩ/volt
Variac/Variable a.c. power supply with 4-6Ω resistor, 25W
or
External power supply output of 27V d.c. at 2A, with current limiting facility at approximately 1.5A.
Ohmeter

5.5.2 SUPPLY NOT OPERATING

(a) Non-operation of the power supply clearly implies a faulty component either in the inverter circuitry or the voltage regulating loop around transistors TR401-402-403. Should any of the transistors be low resistance — because of a short circuit or high temperature, then it is likely that fuse FS402 will have blown, as well as one or both of the inverter transistors TR404-405. The remaining components in this part of the power supply are less likely to suffer damage except for resistor R400 which will be overloaded if pulled low by diode D410 and a low or zero +22V rail.

(b) If the faulty component(s) causing non-operation are on the output side of inverter transformer T402, then the supply may not be operating because it has been 'shut-off' by a low +22V rail as mentioned previously. This situation in turn could be due to faulty rectifiers or storage and filter capacitors on the Power Supply board (PC280), or to a fault on Y AMP board (PC279) or X AMP board (PC245). Removal of the connecting plug to these boards one at a time should indicate whether the fault lies outside the Power Supply itself. In particular Ohmeter measurements on the pins carrying the rails to the Y and X boards should be made, to avoid re-damaging the power supply after fault-finding.

5.5.3 SUPPLY MALFUNCTIONING

If the power supply is producing some output but not establishing the correct rail potentials, then a partial failure of the components referred to in 5.5.2 is likely to be the case.

5.5.3.1 FAULT-FINDING PROCEDURE

(a) The three way connector to the Darlington transistor TR402 should be disconnected. In its place between the collector and emitter terminals, a 25W 4-6Ω resistor is connected by running leads off the power supply, to provide a semi-constant current feed to the inverter.

(b) After identifying and replacing the faulty component(s) that appear to have caused the failure of the supply in the first instance, the instrument should be connected to the Variac at minimum setting and switched on. The D.M.M. or Multimeter and/or the monitor oscilloscope is then connected between chassis and the various rails, starting at reservoir capacitor C401. The Variac setting is slowly advanced. If no reading or a low reading is obtained on the meter and/or if the oscilloscope indicates half-wave rather than full-wave ripple across C401, then rectifier diodes D401-404 and C401 should be examined.

(c) Assuming that (b) is in order then the meter and oscilloscope should be connected respectively to the +22V rail and the taps of the inverter transformer (pins 9 or 10). As the Variac is advanced to approximately 25% of line voltage, the inverter should begin to function and rail voltages should appear but at reduced values. The preceding steps have served to bypass the power supply regulating loop and if there is no fault in the rest of the instrument, the Variac can be advanced to nearly full line voltage, until the +22V rail reads correctly. Correct readings should then exist on all the other rails, and the fault has been cleared or else lies within the regulator loop. If the fault has *not* been cleared, then the Y and X boards should be disconnected *one at a time*, to determine whether the fault lies in these, since removal of all loading from the power supply can cause the inverter to function erratically.

(d) The monitor oscilloscope may also be connected across the 4-6 Ω resistor, at the terminal corresponding to the collector of the Darlington transistor (246/19). The waveform produced by a correctly functioning inverter with correctly established rails consists of a wave voltage of approximately 25µs period, with a mark-space ratio of the order of 5 : 1. Should this be erratic or uneven, the components around the primary and secondary of inverter transformer T402 should be examined. (See Fig a. at bottom of page).

(e) When the previous step has resulted in the clearing of any power supply or Y and X board faults, the 4-6Ω resistor should be removed and the Darlington 3-pin connector should be re-inserted. Again the instrument should be switched on progressively through the Variac and the +22V rail monitored by the Multimeter. The oscilloscope should be connected to the collector of TR402 and, if dual beam, to pins 9 or 10 of TR402, as before. Note that a certain amount of ripple will be visible together with inverter waveforms, amounting to about 4-5 volts peak to peak. this is quite normal.

(f) If the regulating loop is functioning correctly, then all rails should be established and the same waveform should appear at TR402 collector, including mains ripple. (See Fig. a).
Note that the most convenient place to probe this collector is at the anodes of diodesD414-415, near the inverter transistors.
If the power supply is *not* functioning correctly when the loop is re-established, after 'external' faults have been cleared by the procedure described (a) - (c), then the faulty component *must* be associated with transistors TR401-403. The three-way socket to the Darlington transistor may also be faulty.

(g) Finally, when all faults have been cleared, the Variac should be set at the centre voltage of the instrument setting in use and the +22V rail adjusted via R418 to within 0.1V of its rated value.

5.5.4 C.R.T. BLANKING CIRCUITRY

(a) The description of the operation of the Blanking circuitry should be read and used as a guide in fault-finding this part of the circuit. A dual-beam service oscilloscope is essential for the verification of blanking and unblanking signals to terminals PL401b/10 and PL401b/5 respectively; both these are negative. The chop-blank waveform consists of a 3V 1µs signal from the Y board (PC244) the unblanking signal is a low from the time base lasting for the duration of the sweep.

(b) If the CRT is completely blanked, when the blanking circuitry is functioning correctly, the components around the grid-cathode of the CRT should be checked, together with coupling capacitors C422 and C423.

(c) If the CRT is not blanking and assuming that the pulses in (a) above are present, then the fault is most likely to be in the Blanking circuit and in IC401, in particular.

5.6 SWITCH CONTACTS

CLEANING SWITCH ASSEMBLIES

CAUTION

Do NOT use acetone, MEK, MIBK, bensol, toluoul, carbon tetrachloride, trichiene, methyl alcohol, methylene chloride, sulphuric acid or Freon TC-TE-TF-22-TA-12, to clean the switch contacts. Damage may result. Check the contents of spray coolants and cleaners before using.

When maintenance is necessary due to accumulated dirt and dust on the contacts observe the following precautions: Clean the switch contacts with isopropyl alcohol or a solution of one part Kelite to twenty parts of water. If these are not available petroleum ether, white kerosene or a solution of 1% Joy detergent and 99% water may be used.

ALL REQUESTS FOR REPAIRS OR REPLACEMENT PARTS SHOULD BE DIRECTED TO THE TEKTRONIK FIELD OFFICE OR REPRESENTATIVE IN YOUR AREA.

THIS PROCEDURE WILL ASSURE YOU THE FASTEST POSSIBLE SERVICE.

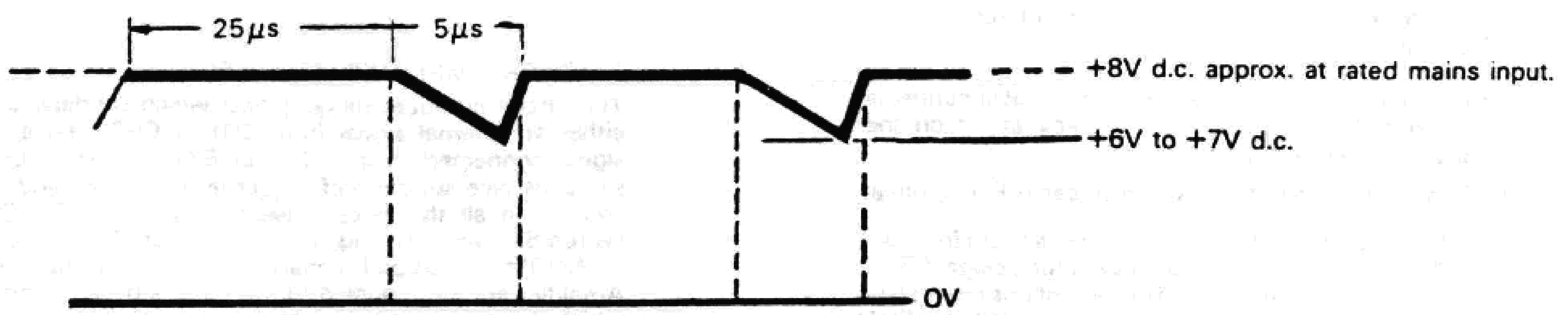


Fig. a. NOTE: a rectangular wave, shown dotted implies a fault in C405, or a dry joint at its terminals.

SECTION 6

CIRCUIT DATA

6.1 VERTICAL ATTENUATORS (Circuit 2)

Since CH1 and CH2 attenuators are similar, this description is for CH1 with CH2 circuit references in brackets.

The vertical input signal is coupled to the attenuators via the input switch — DC (direct coupling) — GND (the amplifier input is grounded, not the signal input) — AC (via a d-c blocking capacitor C903 (C953); CH1 has the additional OFF position.

The attenuator is basically composed of 2 sections, a 0.9 divider R911 (R961) and R908 (R958) and a potential divider chain CM901 (CM951). The use of a 0.9 divider permits a small coupling capacitor (C909/C959) to be connected to the gate of the F.E.T. (TR601b/701b).

The energy in C909/C959 when charged/discharged from a high d.c. voltage is thus kept too small to damage the input of the F.E.T.

In the 5, 10 and 20mV positions R911 (R961) and R908 (R958) form a 0.9 divider which is compensated by C909 (C959) and C911 (C961). R910 (R960) brings the input resistance to 1MΩ on these ranges.

Thick film network CM901 (CM951) forms a 0.09 divider in 50, 100 and 200mV/div; 0.009 divider in 0.5, 1 and 2V/div; 0.0009 divider in 5, 10 and 20V/div. Compensation is provided by C904 (C954), C905 (C955) and C907 (C957). C902 (C952) adjusts the input capacitance of the main potential divider to equal that of the 0.9 divider.

R901 (R951), R903 (R953), R913 (R963) and R914 (R964 minimise high frequency ringing.

6.2 VERTICAL PRE-AMPLIFIERS (Circuit 3)

CH1 and CH2 amplifiers are very similar so a description is given for CH2, with the differences noted. CH1 circuit references are shown in brackets.

The input signal from the attenuator is applied to TR701b (TR601b) which converts the input into a push-pull signal with TR701a (TR601a). R715 (R615) sets the F.E.T. stage gain, R714 (R614) sets their d.c. balance for the gain switching. R760 (R660) are provided to balance out variations in the dual F.E.T.s

Variable Vertical gain. (If fitted).

(a) A 1k0 potentiometer R720 CH2 (R620 CH1) is fitted between R715 CH2 (R615 CH1) F.E.T. set gain, and the thermistor and resistor (thermal compensator) R717, R719 CH2 (R617, R619 CH1).

(b) The 1k0 potentiometer has a dual push-pull switch operation. The Vertical gain is activated by pulling the control knob 'OUT' as per front panel legend.

(c) Full clockwise rotation of the control gives the calibrated gain as set with the VOLTS/DIV switch. Anti-clockwise rotation of the control reduces the Vertical Amplifier Gain.

(d) When the switch is pushed 'IN' the variable control is in-operative, and does not have any effect on the calibrated gain setting.

NOTE: Fitting this Variable control would upset H.F. response.

IC701a (IC601a) and IC701b (IC601b) are a shunt feedback push-pull amplifier feeding the gain switching stage IC701c (IC601c) and IC701d (IC601d). The gain of this latter stage is x1, x2 and x5 depending on the position of CH2 (CH1) attenuator switch. The x5 collector gain switching is also done in this stage.

IC702a (IC602a) and IC702c (IC602c) are emitter followers driving the cascode signal multiplexing stage IC702d (IC602d), IC702e (IC602e) and TR602-605 & TR702 & 705. Trigger pick off occurs from this stage. R745 (R645) is the channel vertical gain adjustment asnd C731 (C631) adjusts the high frequency response. The collector output currents are transposed when the -CH2 switch is depressed, and the vertical position current is also applied to these collectors.

The output from TR702/TR705 (CH2) and TR602/TR605 (CH1) is applied to TR820 and TR823 (Diagram 4), a pair of emitter followers driving the output cascode amplifier comprising TR821, TR822, TR810 and TR811.

The conduction of transistor TR602-TR605, TR702-TR705 is controlled by the channel switching bistable IC771a and IC77b.

In the CH1 OFF mode, TR702 and TR705 conduct passing CH2 signal to the output amplifier; TR603 and TR604 conduct blocking CH1 signal from the output. When the CH1 is multiplexed off screen, the stage currents flow through resistors R627, R628, R639, R648. The latter two are used to connect CH1 as the 'X' Channel in the X-Y mode, by forcing the multiplexed stage into the condition described above, through the X-Y mode switch interlocks.

Note: When in the dual trace mode, both channels are continuously active up to the multiplexing stage. Large signals and/or a dc offset on either channel may interact with the other channel even though the trace is off the screen and not being displayed (alternate mode).

In the ADD mode TR602 and TR605 and TR702 and TR705 conduct, so that the sum of CH1 and CH2 signals is applied to the output, to ensure correct d.c. levels, TR770 also conducts in this mode.

In the dual trace mode at sweep speeds of 1ms/div and faster, an alternate pulse is applied to IC771e via D775. This causes the bistable to switch alternately at the end of each trace, thus alternately displaying CH1 then CH2. At sweep speeds of 2ms and slower, an emitter coupled multivibrator IC771c and IC771d, running at about 140kHz drives IC771e via D776. This causes the bistable to switch at a frequency of 70kHz displaying CH1 for 14µs and then CH2 for 14µs. To ensure that the transients are not seen when switching between channels, a blanking signal is taken from IC771d to the blanking amplifier.

6.3 VERTICAL OUTPUT AMPLIFIER (Circuit 4)

Emitter followers TR820 and TR823 drive the output cascode amplifier TR821, TR822, TR810 and TR811. R826 sets the gain, whilst adjustments of C822, C841, R841, R845 and L404 optimise the high frequency corner. When the BEAM FINDER is depressed, the current in this stage is reduced, restricting the deflection to within the graticule area.

6.4 TRIGGER AMPLIFIER (Circuit 5)

This circuit produces trigger pulses which are derived from either an internal signal from CH1 or CH2, and external signal connected to the TRIG or EXT X INPUT. Control switches give selection of trigger level polarity, and signal source. In all the sweep speed positions of SECS/DIV switch S2, when the trigger source switch S1 b and c is set to NORM,. push-pull signals from CH2 of the Vertical Amplifier are a.c. coupled to both bases of IC1c and IC1d which form a long-tailed pair. In the EXT position the signals from TR1 are a.c. coupled to the base of IC1d and the base of IC1c is a.c. coupled to ground.

The polarity switch S4 selects the sweep triggering for either a positive or negative-going signal. In the positive position the signal from the collector of IC1d is coupled to the shunt feedback stage IC1e via D4, and in the negative position the signal from the collector of ICc is coupled via D5.

The output from IC1e is directly coupled to a second long-tailed pair IC1a and IC1b and collector of IC1a is directly coupled to shunt feedback stage TR2.

When SECS/DIV switch S2 is set to EXT X position coupling switch S1a is available to select DC, AC or GROUND. The signal from the EXT TRIG/EXT X socket SK1 is fed to the base of TR76 in the horizontal amplifier via emitter follower TR1. When S1a is set to DC, the voltage at SK1 may be up to ±0.3V with a shunt impedance of 280k due to resistor and transistor tolerances. Therefore take care when this input is coupled to high impedance circuits. For example, if the EXT X socket is connected to CH1 or CH2, and d.c. coupled, vertical deflections of up to ±0.25V will be produced, which on high sensitivity ranges above 50mV/div means that the trace will be deflected off the screen. A lower impedance source will lessen the amount of deflection, but no deflection will occur when either input is a.c. coupled.

Switch S3 selects three modes of trigger operation — AUTO NORM and TV.

In the AUTO position the output of IC2c is at 0V and diodes D13 and D14 are off. The voltage across the LEVEL control R33 is equal to the peak to peak value of the output voltage at the collector of TR2 minus the base emitter voltages of the two peak rectifier transistors TR3 and TR4. This means that the range of the LEVEL control is 1V approximately less than the peak to peak value of the output voltage at TR2. The triggering point can only be adjusted to within 0.5V of either peak of the waveform regardless of its size or shape. The timebase will always trigger automatically provided that the signal is larger than 0.5 div in internal trigger mode or 120mV in external trigger mode. The peak rectifiers operate successfully with waveforms up to 1000:1 mark/space ratio.

In the NORM mode, the output of IC2 is at +5V and diodes D13 and D14 are conducting, therefore the LEVEL control varies the voltage at the base of IC1b from +1.2V to +3.5V. This enables the output voltage swing of the trigger amplifier to be selected from any point on the triggering waveforms up to ±4divs on internal trigger and ±0.8V on the external trigger from the mean level.

The TV position directly connects the output of the negative peak rectifier TR4 to the base of IC1b to ensure that TR4 only conducts during the sync pulses of the TV signal. The collector waveform of TR4 displays sync pulses only with all the picture information removed.

For sweep speeds up to 100μs/div the sync pulses are integrated by R39 and C25 which gives a greater output from the broader field pulses. Separation of the line and field pulses is improved by passing them through CMOS inverters IC2a and IC2b.

For sweep speeds faster than 100μs/div the sync pulses are fed directly to the input of IC2a through D9 and C25.

The output from emitter TR2 or IC2b is fed to a Schmitt trigger circuit TR5 and TR6 which provides a fast positive-going edge to trigger the timebase circuit.

6.5 SWEEP GENERATOR — HORIZONTAL AMPLIFIER (Circuit 6)

The output from the Schmitt trigger circuit is fed to the clock input of a D type flip flop, IC3b, with its D input permanently connected to +5V and both S and $\overline{CLR}$ are high in the NORM position of S3. The first positive going edge at the clock input will give a positive going output at $\overline{Qb}$, and a negative going edge at $\overline{Qb}$ cuts off the discharge transistor TR73 to allow the timing capacitors C74, C76 and C77 to be charged by a constant current from the collector of TR72. The value of the constant current is determined by the emitter resistors of TR72 which are switched by the SECS/DIV control S2. The voltage at the collectors of TR72 and TR73 therefore rises linearly and is fed via source follower TR74 and diode D78 to the base of TR75 which is normally bottomed and therefore holds Sa of IC3a high during the sweep. When diode D78 conducts and cuts off TR75, Sa goes low and makes $\overline{Qa}$ low, clearing IC3b and makes $\overline{Qb}$ go high turning on TR73 which in turn discharges the timing capacitors. At the same time, Qb goes low, cutting off D76 which allows the hold-off capacitors C79 and C78 to discharge through R95 and eventually clears IC3a, making $\overline{Qa}$ high; the timebase is then ready for the next triggering edge.

In the AUTO & TV positions of S3 when no triggering waveform is present, the peak rectifiers TR3 and TR4 are non-conducting and D15 is cut off; in this condition when $\overline{Qa}$ and $\overline{CLRb}$ go high at the end of the hold-off period, TR71 is cut off and $\overline{Sb}$ goes low. This makes $\overline{Qb}$ go low and restarts the sweep which free runs in the absence of trigger signals. When a trigger signal big enough to operate the Schmitt trigger is present at TR2 collector, the average current through the peak rectifiers TR3 and TR4 is sufficient to make D15 conduct and cut off D70; this bottoms TR71 and switches IC3b from the free running condition to the triggered conditions.

The timebase at the output of source follower TR74 is fed via D81 to an emitter follower TR76 and is then mixed with the horizontal position voltage at the base of shunt feedback stage TR77. The gain of this stage can be increased 5 times by operating S5 which increases the value of the feedback resistor. The output of TR77 is fed via S66 to the base of IC4d which, together with IC4c forms a long tailed pair. The collectors of IC4c & d feed the emitters of TR79 and TR81 which form a cascode long tailed pair to drive the X plates.

When either S2 is in the EXT X position or S6 is in the X Y positions, D72 is cut off and the current through R70 flows into both D73 and D71. This cuts off tr71 which brightens up the trace by making $\overline{Qb}$ low and also stops the trace by turning on the discharge transistor TR73. In the EXT X position a signal fed into the EXT/EXT X socket is fed via TR1 to the base of TR76.

In the X-Y position the base of the output cascode long tailed pair is connected to the collector of TR79, and the emitter and base of TR79 are fed with a push-pull signal from CH1 output of the Vertical Amplifier and the sensitivity is set up by R124.

6.6 CALIBRATOR (Circuit 6)

IC4a and IC4b are a Schmitt trigger circuit to which is fed the sweep waveform at the output of TR74. The Schmitt is arranged to give a positive-going output at the collector of IC4a at approximately halfway up the sweep waveform. The output at IC4a collector is accurately attenuated by an adjustable attenuator to give an output amplitude of 250mV at SK71. The temperature coefficient of the attenuator is arranged to compensate for the temperature coefficients of the +5V supply and the bottoming potential of IC4a. When using the calibrator to set up the Vertical Amplifier sensitivities or to adjust probe compensations it is essential that no trigger signals are fed to the timebase or the trace will flicker. This can be accomplished by setting the trig source switch to EXT. For adjusting probe compensations, set the sweep speed to 5ms/div.

6.7 POWER SUPPLY BLANKING AND CRT (Circuit 7)

The Power Supply provides the instrument with smoothed regulated supplies of +22V d.c., −22V d.c., +170V d.c., −1800V d.c. and 6.3V for the CRT heater. The supply is fed from a toroidal line transformer T401. S401 is the front panel ON-OFF switch and fuse FS401 protects against malfunction at line voltages. S402 selects 234 or 117 volt operation, while S403 has HI-LO positions for high and low mains respectively.

The secondary of T401 charges reservoir capacitor C401 through bridge rectifier D401, 2, 3, 4.

The tapping from rectifiers D401 and D403 supplies current to the front panel LED indicator. Inverter transformer T402 operating at approximately 20kHz provides the requisite d.c. supplies and CRT heater voltage. The primary of the inverter is driven by power transistors TR404 and TR405, the current feedback being provided by toroidal transformer T403 through which the collector currents of the power transistors pass in antiphase. A positive feedback 4 turn base to base winding produces a 4 : 1 current step down to enable oscillation. This winding is in series with diodes D414 and D415 which 'catch' negatively, thus forcing the other end of the winding to drive the current into the base of the power transistors.

R425 is the starting resistor. The positive feedback winding of T403, together with C408, maintains the correct frequency of oscillation.

The current to the inverter circuit is supplied by a Power Darlington transistor TR402, which dissipates heat through the rear heatsink of the instrument. This constant current is generated in the loop consisting of TR402, emitter resistor R409, and transistors TR401 and TR403 with reference zener diode D405.

The +22V d.c. supply from the rectified output of the inverter is compared to the zener reference in the resistor chain R416 trimming pot R418 and resistor R417 and the loop adjusts the current to the inverter circuitry to ensure correct operation.

At the positive terminal of reservoir capacitor C401 there is, approximately, a mean d.c. potential of 29V with a ripple content at twice line frequency of 4V peak to peak. Zener diode D428 smoothes this voltage to avoid injecting ripple into the loop in series with the regulating circuit, as this would appear on all d.c. supply lines. The 4V peak to peak ripple which exists at the centre top of the inverter transformer also exists at the output of the constant current regulator loop, and the collector of TR402, hence the resultant voltage across the inverter transistors is smoothed d.c. R418 adjusts the output of all the supply lines but is referenced to the +22V supply. Posistor (+ve temp-coefficient resistor) R415 when cold has a value of approximately 40Ω and provides start-up current for the loop. In operation, its resistance and temperature rise so that it does not pass significant current in parallel with TR402.

C405, a 4μ7 electrolitic capacitor is connected across the feed to the primary circuit of the inverter. Its function is to store charge during the 'off' part of each inverter half cycle to prevent Darlington TR402 from bottoming and saturating. Such a condition imposes very heavy current spikes on the inverter transistors TR404, TR405 at the start of each 'on' half period and can destroy them. This is one reason why the instrument should not be held at a line voltage appreciable lower than rated — by using a Variac for example. Warning is given by the audible erratic operation of the inverter circuit.

Protection against failure of the supply is threefold:

(i) Short term, i.e. a momentary short circuit of any supply line, is absorbed by the constant current feed to the inverter; current is limited and so are fault currents.

(ii) A permanent fault whilst the instrument is operating will result in a heavy current demand from the supply. The supply current, however, is limited by catching zener diode D400, and R403, thus limiting the voltage to the base of TR402, with resistor R409 regulating the current to a value that will blow the fuse FS402 if the fault doesn't clear in approximately 30 seconds.

(iii) A fault such as (ii) existing at switch on, especially at the +22V line which supplies most of the circuitry of the instrument, will pass current through D410 and prevent voltages from rising around the regulator loop. In particular, emitter current through TR401 will be severely limited therefore the Darlington transistor TR402 will not be energised. This will prevent further damage being caused by the inverter turning on.

BLANKING AND INTENSITY CONTROL

This circuitry is built around a 5 transistor array IC401, and the resistors and diodes around the grid-cathode path of the CRT.

(i) If IC401 were removed or inactivated, the brightness of the trace would be set by the INTENSITY control, R445, through resistor R458.

(ii) with no signal to the instrument and the time base stopped, IC401 sits as follows:

(a) Collector pin 14 bottomed because of bias through R402.

(b) Collector pin 11 low, because of bias through R401, etc., from the +22V line. Diode D406 and D407 ensure that collector pin 11 does not saturate, by diverting excess base current into the collector (pin 11).

(c) This keeps the output of emitter follower (IC401c) pin 7 low.

(d) If emitter follower pin 7 was high, current through R421 would bottom IC401b and then clamp the base of IC401a

(e) Approximately 2V peak to peak of inverter waveform is fed to pin 2, (base) of IC401a through R431 and R432, when not clamped as in (d) above.. When the clamp is removed IC401a is switched on-off at inverter frequency between +22V and 0V through load resistor R423. This is the C.R.T. blanked condition.

(f) When the time base is triggered, a −ve pulse is fed to terminal 402b/9 cutting of IC401d and allowing emitter follower IC401c to rise rapidly. This rapid rise of voltage towards the +22V line at pin 7 as described has two effects: firstly it is coupled directly through to the grid of the CRT via C423 and unblanks; secondly it is coupled to the base of IC401b (pin 4) clamping the base of IC401a as described in (d), and stopping the squarewave across R423. In any case, D411 holds R423 high and the CRT stays unblanked.

(h) At the end of the time base stroke 402b/9 goes high and cuts off IC401d. The drop in voltage at the emitter (pin 7) of IC401c is assisted to retain speed by direct pull-down by IC401d through diode D408, and the CRT is cut off.
Simultaneously, after some small delay because of C427, transistor IC401a is allowed to generate the 22V squarewave at inverter frequency. This small delay is required to permit a relative soft start to the 22V square-wave which could otherwise, if base pin 2 of IC401a was on a +ve half cycle of the inverter, pull R423 down rapidly showing patterning of the trace at certain time base speeds and repetition rates. As in (c) the signal is d.c. restored and maintains the grid to the C.R.T. in the cut-off condition, until the next triggering of the time base.

(i) External blanking at levels of +4V to +20V is obtained by injecting a signal into SK404, leading to the base of TR406. The latter acts as an emitter follower for the external blanking signal and also buffers SK404 from the fast transients around IC401. R428, R405 and D435 protect TR406 and C404 is a small speed-up capacitor. Thus the external blanking is TTL compatible.

SECTION 7

CIRCUIT DIAGRAMS & COMPONENT LISTS

7.1 INTRODUCTION

Each circuit diagram has a reference number, for example **(Circuit 4)** is the Vertical Output Amplifier. To minimise the risk of misinterpretation of component values on circuits and lists, the decimal point has been replaced by the multiplier or sub-multiplier of the standard unit. For example, a resistor of 2.2 megohms is shown as 2M2; similarly, a capacitor of 1.8 picofarads is shown as 1p8.

Each circuit diagram includes a component reference table to assist in locating a particular component on the circuit. Component references are divided into blocks of numbers appropriate to each major sub-circuit.

The blocks are shown on the following table: –

Reference From	To	Circuit	CCT No.
1	60	Trigger Amplifer	5
61	100	Sweep Generator – Horizontal Amp – Calibrator	6
400	500	Power Supply – CRT – Blanking	7
600	809	Vertical Pre-Amplifier and Channel Switching	3
810	850	Vertical Output Amplifier	4
901	920	CH1 Vertical Attenuator	2
951	970	CH2 Vertical Attenuator	2

The following abbreviations are listed on the component lists and refer to the types of resistors and capacitors.

ABBREVIATIONS

BM	Button mica
C	Carbon
CP	Carbon preset
CV	Carbon variable
CER	Ceramic
CF	Carbon Film
CT	Ceramic Trimmer
CM	Cermet thick film
CMP	Cermet preset
E	Electrolytic
Ge	Germanium
MF	Metal Film
MO	Metal Oxide
PC	Polycarbonate
PE	Polyester
PP	Polypropylene
PPT	Polypropylene Trimmer
PS	Polystyrene
SM	Silver mica
WW	Wire-wound
WWP	Wire-wound preset
WWV	Wire-wound variable

In order to give a basic introduction to the instrument circuitry and the relationship between the major sub-circuits, a block diagram, designated **Diagram 1** and description is included. Each block bears the title and number of a major sub-circuit.

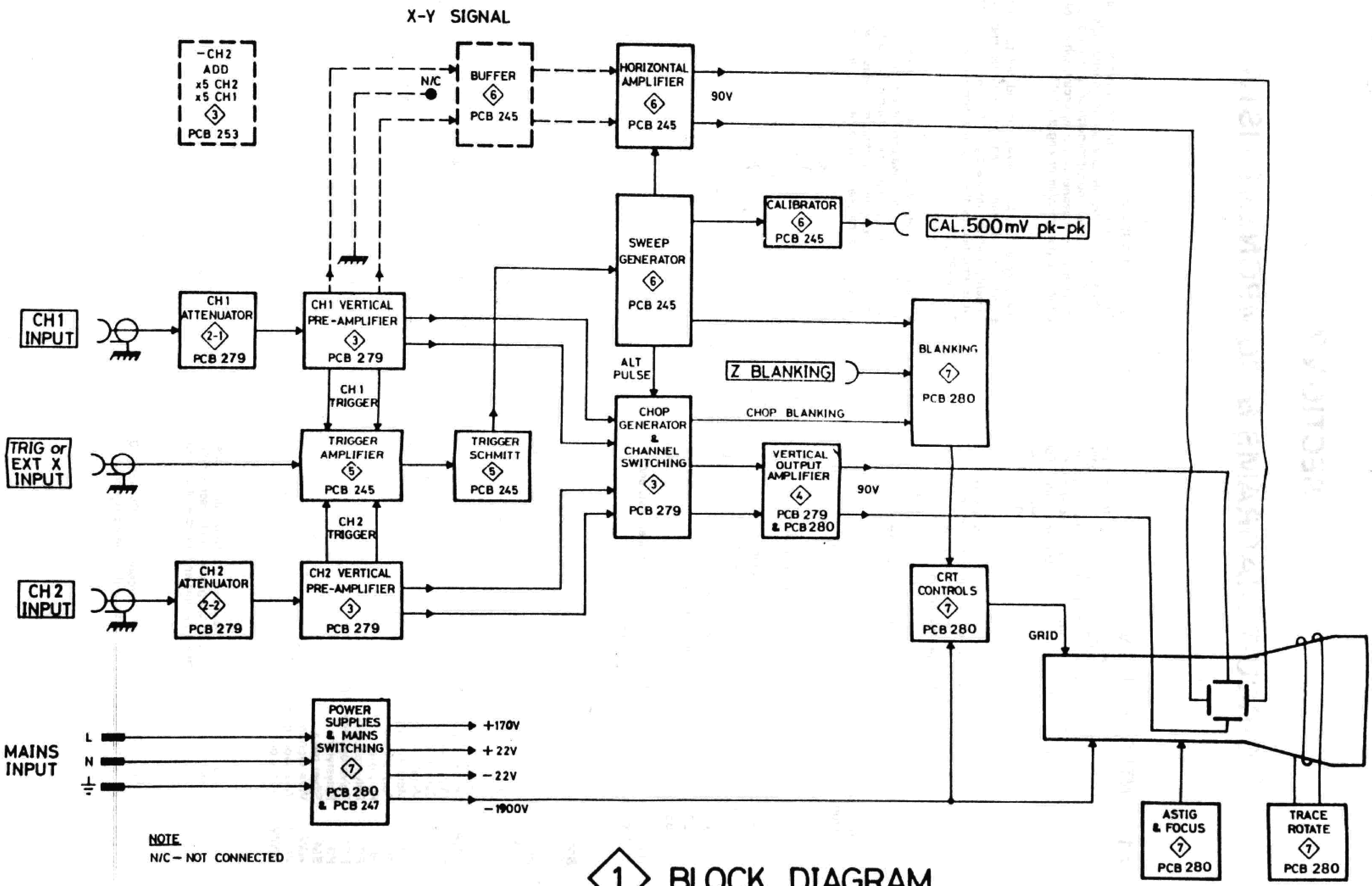
At the end of this section, Interconnection Diagram 10 shows the wiring arrangements within the instrument.

7.2 BLOCK DIAGRAM 1

Diagram 1 shows the circuit functions in block format. The vertical signal to be viewed is applied to either CH1 or CH2 INPUT and is then routed through an attenuator and pre-amplifier to the channel switching circuit, which feeds the vertical output amplifier driving the CRT.

The selected signal is picked off and fed to the trigger amplifier and Schmitt, so that the sweep generator can be triggered from the vertical signal. The sweep generator output is amplified by the horizontal amplifier and applied to the X plates.

A blanking signal, which lasts for the duration of flyback, hold off and time spent waiting for a trigger signal, comes from the sweep generator circuit and is fed to the blanking amplifier. Blanking for the chop transients is achieved by the path from the channel switching to the blanking amp.



NOTE
N/C – NOT CONNECTED

1 BLOCK DIAGRAM

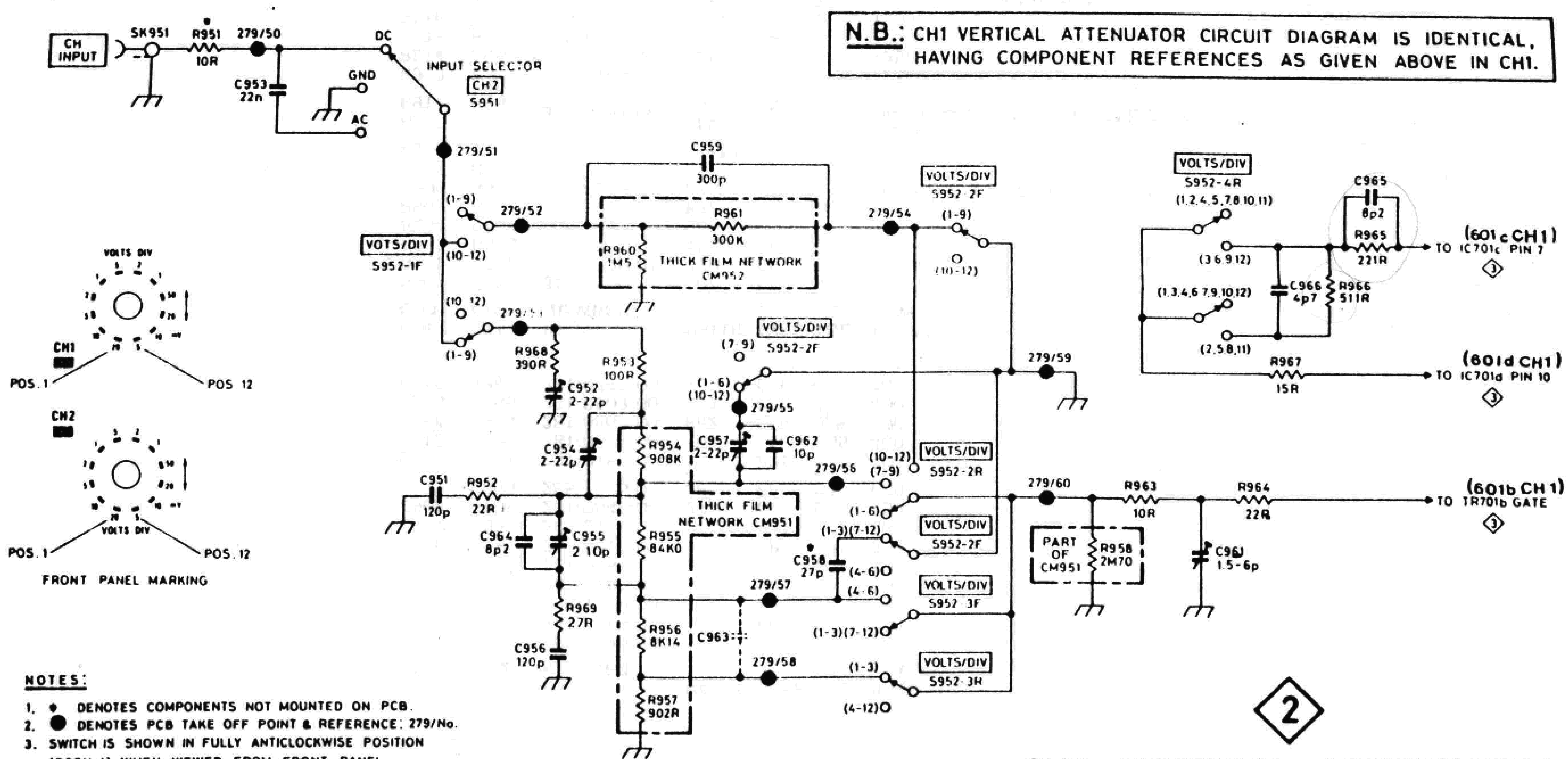
Circuit 2:

CIR. CH1	REF. CH2	PART NUMBER	VALUE	TYPE	TOL %	RATING V
C901	C951	285-0870-01	120p	PP	2.5	500
C902	C952	281-0155-01	2-22p	PPT		500
C903	C953	285-1179-00	22n	PE	20	630
C904	C954	281-0155-01	2-22p	PPT		500
C905	C955	281-0154-00	2-10p	PPT		400
C906	C956	285-0870-01	120p	PP	2.5	500
C907	C957	281-0155-01	2-22p	PPT		500
C908	C958	281-0848-00	27p	CER	5	50
C909	C959	285-1225-00	360p	PP	2.5	600
C911	C961	281-0156-00	1.6-5.5	PPT		400
C912	C962	281-0804-00	10p	CER	0p5	400
C914	C964	281-0803-00	8p2	CER	0p5	400
C915	C965	281-0803-00	8p2	CER	0p5	400
C916	C966	281-0745-00	4p7	CER	0p5	400

CIR. CH1	REF. CH2	PART NUMBER	VALUE	TYPE	TOL %	RATING W	
R901	R951	317-0100-01	10R	CF	5	125m	
R902	R952	317-0220-01	22R	CF	5	125m	
R903	R953	317-0101-01	100R	CF	5	1[illegible]m	
R904	R954		908K				
R905	R955		84K0				
R906	R956	307-0632-01	8K14	CM			Thick Film Networks CM901 & CM951
R907	R957		902R				
R908	R958		2M70				
R910	R960	307-0631-00	1M5	CM			Thick Film Networks CM902 & CM952
R911	R961		300K	CM			
R913	R963	317-0100-01	10R	CF	5	125m	
R914	R964	317-0220-01	22R	CF	5	125m	
R915	R965	325-0371-00	221R	MF	1	100m	
R916	R966	325-0216-00	511R	MF	1	100m	
R917	R967	317-0150-01	15R	CF	5	125m	Select on test
R918	R968	317-0391-01	390R	CF	5	125m	
R919	R969	317-0270-01	27R	CF	5	125m	
	S951	See Section 8					SW Lever (DC-GND-AC) 3 Pos 1 Pole
S901		Parts List					SW Lever (DC-GND-AC-OFF) 4 Pos 2 Pole
S902	S952	260-2101-00					Rotary (VOLTS/DIV)
SK901	SK951	131-2268-01					Socket (CH2/CH1 INPUT)

RESISTORS	CH2	951		952 968	969	960 953 954	955 956 957	961		958 963	964 967 965 966
	CH1	901		902 918	919	910 903 904	905 906 907	911		908 913	914 917 915 916
CAPACITORS	CH2	953	951	964	956	952 954 955		959 957 961	962 958		961 966 965
	CH1	903	901	914	906	902 904 905		909 907 911	912 908		911 916 915
MISC.	CH2	SK951	S952-1F	S951				CM952 CM951	S952-2F	S952-2R S952-2F S952-3F S952-3H S952-2F (CM951)	S952-4R
	CH1	SK901	S902-1F	S901				CM902 CM901	S902-2F	S902-2R S902-2F S902-3F S902-3H S902-2F (CM901)	S902-4R
PCB 279 ●		50	51	52 53				55	57 58 56	54 59 60	

N.B.: CH1 VERTICAL ATTENUATOR CIRCUIT DIAGRAM IS IDENTICAL, HAVING COMPONENT REFERENCES AS GIVEN ABOVE IN CH1.



NOTES:

1. • DENOTES COMPONENTS NOT MOUNTED ON PCB.
2. ● DENOTES PCB TAKE OFF POINT & REFERENCE: 279/No.
3. SWITCH IS SHOWN IN FULLY ANTICLOCKWISE POSITION (POSN. 1) WHEN VIEWED FROM FRONT PANEL.
4. REFER TO ◈ FOR INTERCONNECTION ROUTES.

② CH2 VERTICAL ATTENUATOR

Circuit 3:

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL %	RATING V
C600	281-0710-00	10n	CER	+80-20	250
C601	281-0868-00	10n	CER	20	25
C603	281-0710-00	10n	CER	+80-20	250
C604	281-0710-00	10n	CER	+80-20	250
C606	281-0868-00	10n	CER	20	25
C607	SELECT ON TEST (S.O.T.)				
C610	281-0868-00	10n	CER	20	25
C631	281-0155-01	2-22p	PPT		500
0632	285-0854-01	100p	PP	2.5	500
C700	281-0710-00	10n	CER	+80-20	250
C701	281-0868-00	10n	CER	20	25
C703	281-0710-00	10n	CER	+80-20	250
C704	281-0710-00	10n	CER	+80-20	250
C706	281-0868-00	10n	CER	20	25
C707	SELECT ON TEST (S.O.T.)				
C731	281-0155-01	2-22p	PPT		500
C732	281-0868-00	10n	CER	20	25
C770	281-0734-00	100n	CER	+80-20	30
C771	281-0745-00	4p7	CER	0p5	400
C772	281-0847-00	22p	CER	5	50
C773	281-0848-00	27p	CER	5	50
C774	281-0744-00	6p8	CER	0p5	750
C775	281-0870-00	470p	CER	10	50
C776	281-0868-00	10n	CER	20	25
C777	281-0839-00	33p	CER	5	50
C778	281-0847-00	22p	CER	5	50
C779	290-0707-00	22µ	ELEC	+100-10	25
C781	281-0734-00	100n	CER	+80-20	30
C782	281-0868-00	10n	CER	20	25
C800	290-0707-00	22µ	ELEC	+100-10	25
C801	290-0627-00	22µ	ELEC	+100-10	40

S.O.T. (C607, C707): 1P0-3p3

281-0705-00 1p0 CER 0p1 500
281-0676-00 2p2 }
281-0678-00 3p0 } CER 0p25 400
281-0735-00 3p3 }

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION	TYPE	RATING
D601	152-0483-00	30V	C1844	Si	300mV
D603	152-0062-01	75V	1N914	Si	75mA
D604	152-0062-01	75V	1N914	Si	75mA
D701	152-0483-00	30V	C1844	Si	300mV
D703	152-0062-01	75V	1N914	Si	75mA
D704	152-0062-01	75mV	1N914	Si	75mA
D770	152-0416-00	8V2	Zener BZY88C8V2	Si	400mV
D771	152-0062-01	75V	1N914	Si	75mA
D772	152-0062-01	75V	1N914	Si	75mA
D773	152-0062-01	75V	1N914	Si	75mA
D774	152-0062-01	75V	1N914	Si	75mA
D775	152-0062-01	75V	1N914	Si	75mA
D776	152-0062-01	75V	1N914	Si	75mA

CIR. REF.	PART NUMBER	DESCRIPTION
FB800	276-0597-00	Ferrite Bead Mullard FX1115 (See Interconnection Diagram 10)

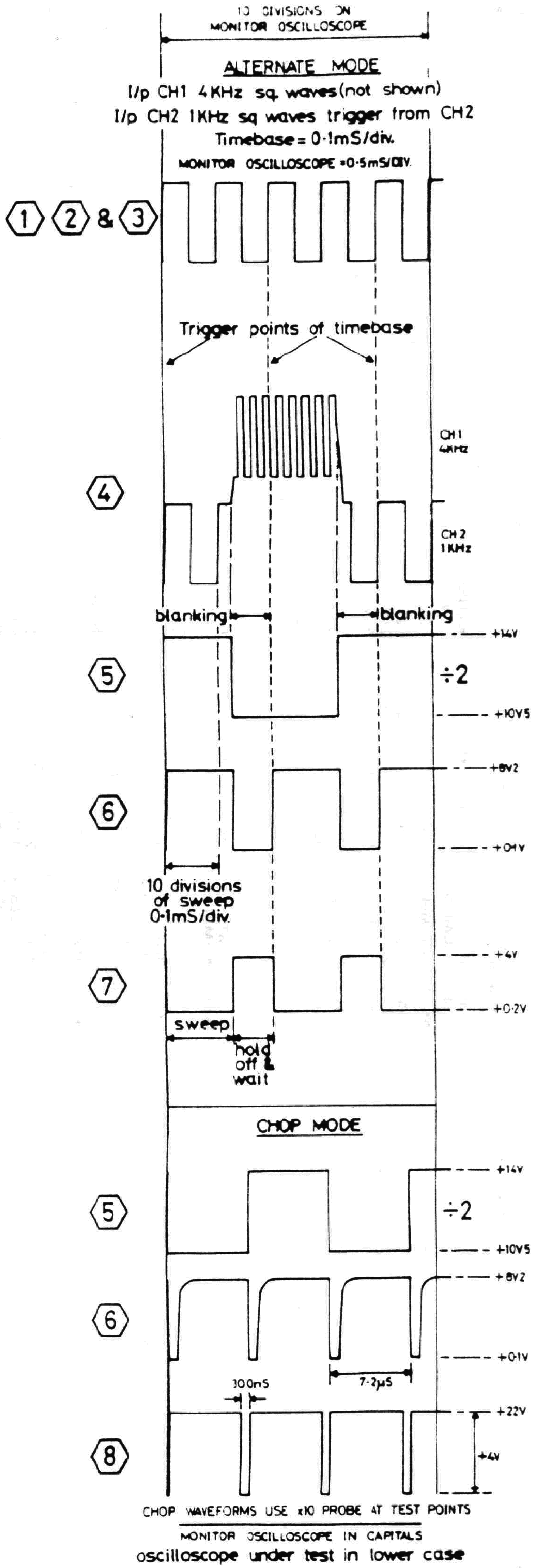
CIR. REF.	PART NUMBER	DESCRIPTION	
IC601	156-0197-04	5 Transistor Array RCA CA3086	(Special Selection)
IC602	156-0197-02	5 Transistor Array RCA CA3086	(Special Selection)
IC701	156-0197-04	5 Transistor Array RCA CA3086	
IC702	156-0197-02	5 Transistor Array RCA CA3086	
IC771	156-0197-02	5 Transistor Array RCA CA3086	

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION
L800	108-0932-00	160 H	Inductor
L801	108-0932-00	160 H	Inductor

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL %	RATING W
R600	325-0233-00	1K0	MF	1	100m
R601	325-0338-00	1K5	MF	2	100m
R602	325-0343-00	820R	MF	2	500m
R603	325 0347-00	24K	MF	2	100m
R604	325 0289-00	383R	MF	1	100m
R605	325-0295-00	1K50	MF	1	100m
R607	325-0295-00	1K50	MF	1	100m
R609	325-0346-00	560R	MF	2	100m
R611	325-0293-00	1K07	MF	1	100m
R612	317-0390-01	39R	CF	5	125m
R613	311-1665-00	100R	CP	20	50m
R614	311-1656-00	4K7	CP	20	50m
R615	311-2019-00	330R	CP	20	50m
R616	311-1653-00	220R	CP	20	50m
R617	307-0258-00	130R	THR	20	500m
R618	325-0295-00	1K50	MF	1	100m
R619	317-0820-01	82R	CF	5	105m
R621	325-0289-00	383R	MF	1	100m
R622	325-0295-00	1K50	MF	1	100m
R623	325-034 -00	24K	MF	2	100m
R624	325-0343-00	820R	MF	2	500m
R625	325-0338-00	1K5	MF	2	100m
R626	317-0683-01	68K	CF	5	125m
R627	317-0101-01	100R	CF	5	125m
R628	317-0101-01	100R	CF	5	125m
R629	317-0220-01	22R	CF	5	125m
R630	317-0151-01	150R	CF	5	125m
R631	317-0330-01	33R	CF	5	125m
R632	317-0182-01	1K8	CF	5	125m
R633	317-0820-01	82R	CF	5	125m
R634	317-0330-01	33R	CF	5	125m
R635	317-0680-01	68R	CF	5	125m
R636	325-0365-00	1K3	MF	2	100m
R637	317-0241-01	240R	CF	5	125m
R638	317-0391-01	390R	CF	5	125m
R639	317-0241-01	240R	CF	5	125m
R640	317-0181-01	180R	CF	5	125m
R641	325-0345-00	820R	MF	2	100m
R642	311-2022-00	2K2	CV	20	250m
R643	325-0365-00	1K3	MF	2	100m
R644	317-0681-01	680R	CF	5	125m
R645	311-1653-00	220R	CP	20	50m
R646	317-0391-01	390R	CF	5	125m
R647	325-0345-00	820R	MF	2	125m
R647	325-0345-00	820R	MF	2	125m
R648	317-0271-01	270R	CF	5	125m
R649	317-0820-01	82R	CF	5	125m
R650	317-0151-01	150R	CF	5	125m
R651	317-0330-01	33R	CF	5	125m
R652	325-0338-00	1K5	MF	2	100m
R653	317-0820-01	82R	CF	5	125m
R654	317-0182-01	1K8	CF	5	125m
R655	317-0220-01	22R	CF	5	125m
R656	317-0330-01	33R	CF	5	125m
R657	325-0367-00	8K25	MF	2	100m
R658	325-0367-00	8K25	MF	2	100m
R660	311-1649-00	470K	CP	20	50m
R700	325-0233-00	1K0	MF	1	100m
R701	325-0338-00	1K5	MF	2	100m
R702	325-0343-00	820R	MF	2	500m
R703	325-0347-00	24K	MF	2	100m
R704	325-0289-00	383R	MF	1	100m
R705	325-0295-00	1K50	MF	1	100m
R707	325-0295-00	1K50	MF	1	100m
R709	325-0346-00	560R	MF	2	100m
R711	325-0293-00	1K07	MF	1	100m
R712	317-0390-01	39R	CF	5	125m
R713	311-1655-00	100R	CP	20	50m
R714	311-1656-00	4K7	CP	20	50m
R715	311-2019-00	330R	CP	20	50m
R716	317-0101-01	100R	CF	5	125m
R717	307-0258-00	130R	THR	20	500m
R718	325-0295-00	1K50	MF	1	100m
R719	317-0820-01	82R	CF	5	125m
R721	325-0289-00	383R	MF	1	100m
K722	325-0295-00	1K50	MF	1	100m
R723	325-0347-00	24K	MF	2	100m
R724	325-0343-00	820R	MF	2	500m
R725	325-0338-00	1K5	MF	2	100m
R726	317-0683-01	68K	CF	5	125m
R729	317-0220-01	22R	CF	5	125m
R730	317-0151-01	150R	CF	5	125m

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL. %	RATING W
R731	317-0750-01	75R	CF	5	125m
R732	317-0182-01	1K8	CF	5	125m
R733	317-0820-01	82R	CF	5	125m
R734	317-0330-01	33R	CF	5	125m
R735	317-0470-01	47R	CF	5	125m
R736	325-0365-00	1K3	MF	2	100m
R737	317-0241-00	240R	CF	5	125m
R738	317-0391-01	390R	CF	5	125m
R740	317-0181-01	180R	CF	5	125m
R741	325-0345-00	820R	MF	2	100m
R742	311-2022-00	2K2	CV	20	250m
R743	325-0365-00	1K3	MF	2	100m
R744	317-0102-01	1K0	CF	5	125m
R745	311-1653-00	220R	CP	20	50m
R746	317-0391-01	390R	CF	5	125m
R747	325-0345-00	820R	MF	2	100m
R748	317-0101-01	100R	CF	5	125m
R749	317-0470-01	47R	CF	5	125m
R750	317-0151-01	150R	CF	5	125m
R751	317-0330-01	33R	CF	5	125m
R752	325-0338-00	1K5	MF	2	100m
R753	317-0820-01	82R	CF	5	125m
R754	317-0182-01	1K8	CF	5	125m
R755	317-0220-01	22R	CF	5	125m
R756	317-0330-01	33R	CF	5	125m
R757	325-0367-00	8K25	MF	2	100m
R758	325-0367-00	8K25	MF	2	100m
R759	317-0101-01	100R	CF	5	125m
R760	311-1649-00	470K	CP	20	50m
R763	317-0122-01	1K2	CF	5	125m
R764	317-0220-01	22R	CF	5	125m
R765	317-0220-01	22R	CF	5	125m
R766	317-0220-01	22R	CF	5	125m
R767	317-0220-01	22R	CF	5	125m
R771	317-0122-01	1K2	CF	5	125m
R772	317-0223-01	22K	CF	5	125m
R774	317-0223-01	22K	CF	5	125m
R775	317-0682-01	6K8	CF	5	125m
R776	317-0331-01	330R	CF	5	125m
R777	317-0132-01	1K3	CF	5	125m
R778	317-0222-01	2K2	CF	5	125m
R779	317-0725-01	7K5	CF	5	125m
R781	317-0102-01	1K0	CF	5	125m
R782	317-0163-01	16K	CF	5	125m
R783	317-0163-01	16K	CF	5	125m
R784	317-0752-01	7K5	CF	5	125m
R785	317-0222-01	2K2	CF	5	125m
R786	317-0273-01	27K	CF	5	125m
R787	317-0331-01	330R	CF	5	125m
R788	317-0183-01	18K	CF	5	125m
R789	317-0133-01	13K	CF	5	125m
R790	317-0223-01	22K	CF	5	125m
R791	317-0162-01	1K6	CF	5	125m
R792	317-0152-01	1K5	CF	5	125m
R793	317-0751-01	750R	CF	5	125m
R794	317-0472-01	4K7	CF	5	125m
R795	317-0472-01	4K7	CF	5	125m
R796	317-0182-01	1K8	CF	5	125m
R797	317-0332-01	3K3	CF	5	125m
R798	317-0562-01	5K6	CF	5	125m
R799	317-0832-01	82K	CF	5	125m
R801	317-0184-01	180K	CF	5	125m
R802	317-0822-01	8K2	CF	5	125m
R803	317-0101-01	100R	CF	5	125m
R818	317-0560-01	56R	CF	5	125m

CIR. REF.	PART NUMBER	DESCRIPTION	TYPE
S601		x 1 x 5 CH1	
S701	260-1938-00	x 1 x 5 CH2	
S702		– CH2	
S703		ADD	
SK800	355-0529-00	Socket (GND)	
TR601$^{a}_{b}$	151-1125-00	Fet Dual SU2603M	NFE
TR602	151-0680-01		NPN
TR603	151-0680-01		NPN
TR604	151-0680-01		NPN
TR605	151-0680-01		NPN
TR701$^{a}_{b}$	151-1125-00	Fet Dual SU2603M	NFE
TR702	151-0680-01		NPN
TR703	151-0680-01		NPN
TR704	151-0680-01		NPN
TR705	151-0680-01		NPN
TR770	151-0320-01	MPS6518	PNP



10 DIVISIONS ON MONITOR OSCILLOSCOPE
ALTERNATE MODE
I/p CH1 4KHz sq. waves(not shown)
I/p CH2 1KHz sq waves trigger from CH2
Timebase = 0·1mS/div.
MONITOR OSCILLOSCOPE = 0·5mS/DIV.
1 2 & 3
Trigger points of timebase
4
CH1 4KHz
CH2 1KHz
blanking
blanking
+14V
5
÷2
+10V5
+8V2
6
+0·4V
10 divisions of sweep 0·1mS/div.
+4V
7
+0·2V
sweep
hold off & wait
CHOP MODE
+14V
5
÷2
+10V5
+8V2
6
+0·1V
300nS
7·2µS
+22V
8
+4V
CHOP WAVEFORMS USE x10 PROBE AT TEST POINTS
MONITOR OSCILLOSCOPE IN CAPITALS
oscilloscope under test in lower case

Circuit 4:

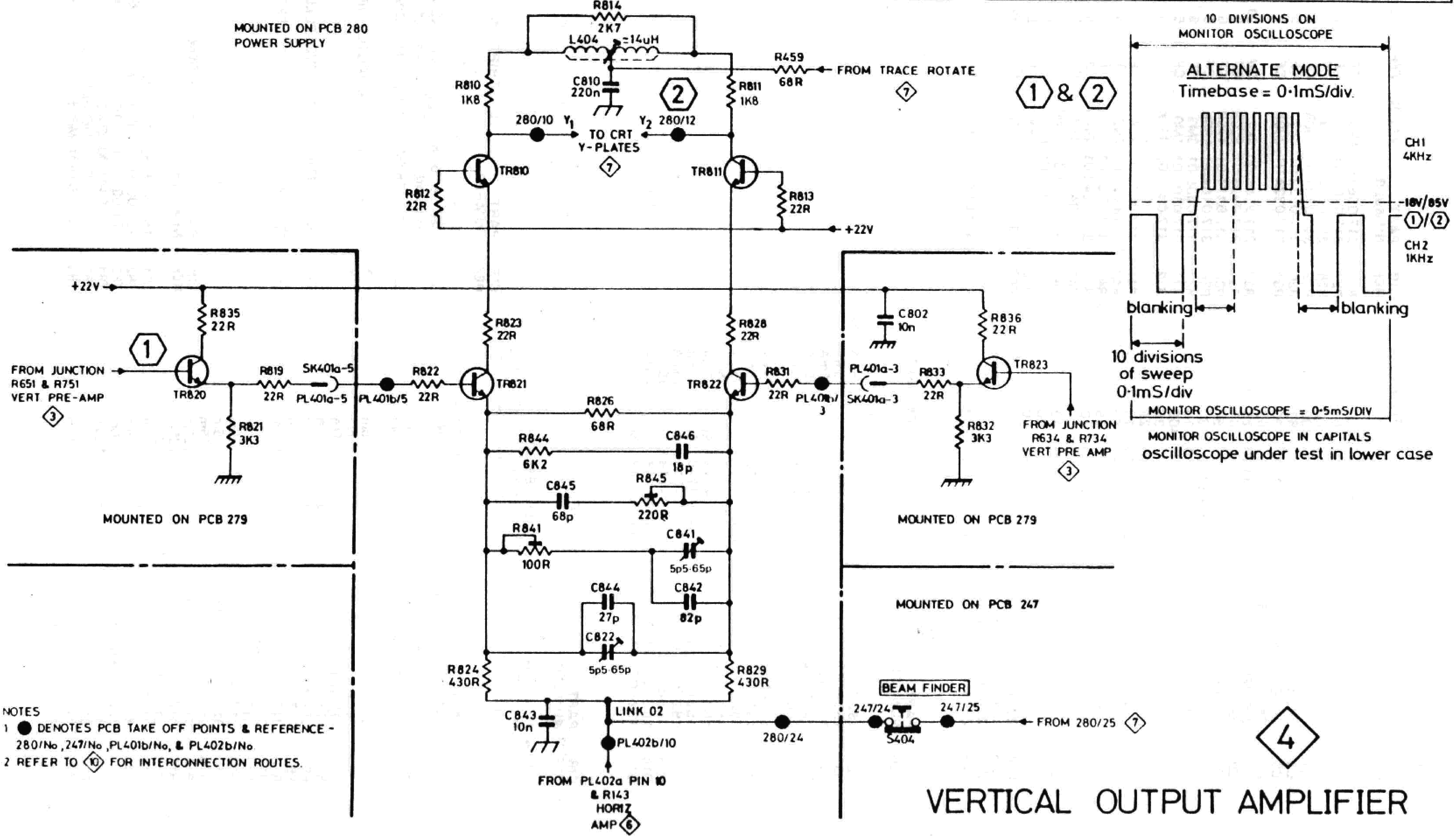
CIR. REF.	PART NUMBER	VALUE	TYPE	TOL. %	RATING V
C461	281-0868-00	10n	CER	20	25
C802	218-0868-00	10n	CER	20	25
C810	285-0795-00	220n	PE	20	250
C822	281-0229-00	5p5-65p	PPT		400
C841	281-0229-00	5p5-65p	PPT		400
C842	281-0860-00	82p	CER	5	400
C843	281-0868-00	10n	CER	20	25
C844	281-0848-00	27p	CER	5	50
C845	281-0857-00	68p	CER	5	50
C846	281-0832-00	18p	CER	5	400

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL. %	RATING W
R459	301-0680-01	68R	CF	5	500m
R810	308-0840-00	1K8	WW	5	8
R811	308-0840-00	1K8	WW	5	8
R812	317-0220-01	22R	CF	5	125m
R813	317-0220-01	22R	CF	5	125m
R814	317-0272-01	2K7	CF	5	125m
R819	317-0220-01	22R	CF	5	125m
R821	317-0332-01	3K3	CF	5	125m
R822	317-0220-01	22R	CF	5	125m
R823	317-0220-01	22R	CF	5	125m
R824	325-0368-00	430R	MF	2	500m
R826	325-0335-00	68R	MF	2	100m
R828	317-0220-01	22R	CF	5	125m
R829	325-0368-00	430R	MF	2	500m
R831	317-0220-01	22R	CF	5	125m
R832	317-0332-01	3K3	CF	5	125m
R833	317-0220-01	22R	CF	5	125m
R835	317-0220-01	22R	CF	5	125m
R836	317-0220-01	22R	CF	5	125m
R841	311-1870-00	100R	CP	20	50m
R844	317-0622-01	6K2	CF	5	125m
R845	311-1777-00	220R	CP	20	50m

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION
L404	114-0413-00	14 H	Inductor, adjustable.

CIR. REF.	PART NUMBER	DESCRIPTION	TYPE
TR810	151-0676-00	Motorola BF467	NPN
TR811	151-0676-00	Motorola BF467	NPN
TR820	151-0317-01	Mullard	NPN
TR821	151-0680-00	Mullard	NPN
TR822	151-0680-00	Mullard	NPN
TR823	151-0317-00	Mullard	NPN

RESISTORS	835	821	819	822	812	810 823 824	84. 841	814 826	845	811 828 829	459 813	831	833	832	836
CAPACITORS							845 843	810 844 822	846 841 842					802	
MISC	TR820	SK401a-5 PL401a-5				TR810 TR821		L404		TR811 TR822			S404 SK401a-3 PL401a-3		TR823
PCB 280 ●			PL401b/5				10	PL402b/10	12		24	PL401b/3			
PCB247 ●													24		25



NOTES
1 ● DENOTES PCB TAKE OFF POINTS & REFERENCE - 280/No, 247/No, PL401b/No, & PL402b/No.
2 REFER TO ⑩ FOR INTERCONNECTION ROUTES.

VERTICAL OUTPUT AMPLIFIER

Circuit 5

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL %	RATING V
C1	285-0946-00	470n	PE	20	250
C2	285-1014-00	1µ0	PE	20	63
C3	281-0802-00	6p8	CER	±0p5	400
C4	281-0800-00	3p9	CER	±0p5	400
C5	285-1078-00	1µ5	PE	20	63
C6	281-0734-00	100n	CER	+50-25	30
C7	285-1078-00	1µ5	PE	20	63
C8	290-0792-00	47µ	ELEC	-100-10	25
C9	285-1078-00	1µ5	PE	20	63
C10	281-0867-00	4n7	CER	20	50
C11	281-0734-00	100n	CER	+50-25	30
C12	290-0663-00	470µ	ELEC	+100-10	10
C13	281-0801-00	5p6	CER	0p5	400
C14	281-0734-00	100n	CER	+50-25	30
C15	290-0707-00	22µ	ELEC	-100-10	25
C16	290-0756-00	100µ	ELEC	+100-10	16
C17	281-0734-00	100n	CER	+50-25	30
C18	290-0707-00	22µ	ELEC	+100-10	25
C19	290-0663-00	470µ	ELEC	+100-10	10
C21	290-0627-00	22µ	ELEC	+100-10	40
C22	281-0734-00	100n	CER	+50-25	30
C23	281-0734-00	100n	CER	+50-25	30
C24	281-0710-00	10n	CER	+80-20	250
C25	281-0839-00	33p	CER	5	50
C26	281-0855-00	47p	CER	5	50
C27	281-0710-00	10n	CER	+80-20	250

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION	TYPE	RATING
D2	152-0062-01	75V	1N914/1N4148	Si	75mA
D3	152-0062-01	75V	1N914/1N4148	Si	75mA
D4	152-0062-01	75V	1N914/1N4148	Si	75mA
D5	152-0062-01	75V	1N914/1N4148	Si	75mA
D6	152-0062-01	75V	1N914/1N4148	Si	75mA
D7	152-0800-00	75V	BZX/79C/3VO		
D8	152-0062-01	75V	1N914/1N4148	Si	75mA
D9	152-0062-01	75V	1N914/1N4148	Si	75mA
D10	152-0062-01	75V	1N914/1N4148	Si	75mA
D11	152-0062-01	75V	1N914/1N4148	Si	75mA
D12	152-0062-01	75V	1N914/1N4148	Si	75mA
D13	152-0062-01	75V	1N914/1N4148	Si	75mA
D14	152-0062-01	75V	1N914/1N4148	Si	75mA
D15	152-0062-01	75V	1N914/1N4148	Si	75mA
D16	152-0062-01	75V	1N914/1N4148	Si	75mA
D17	152-0062-01	75V	1N914/1N4148	Si	75mA

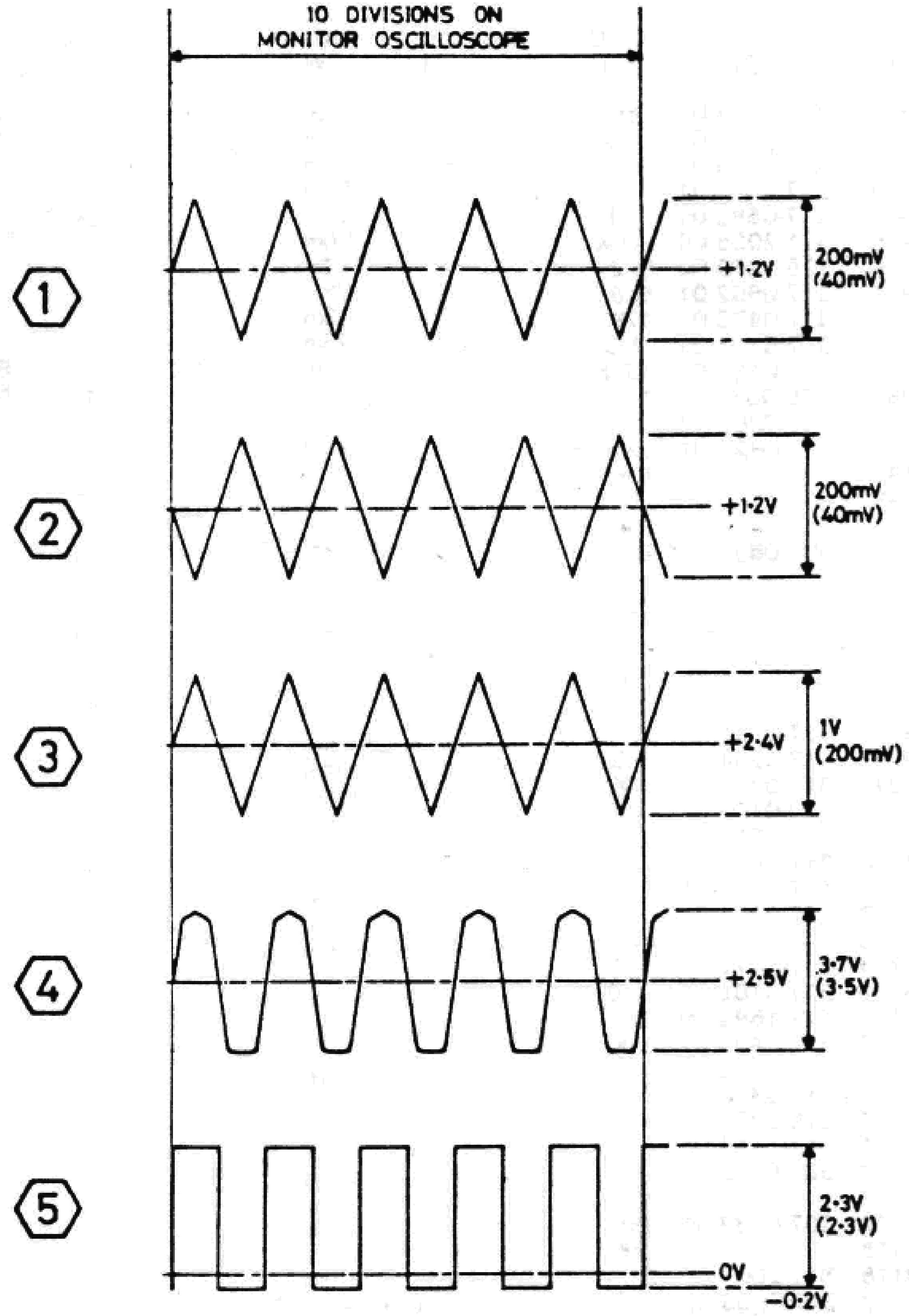
CIR. REF.	PART NUMBER	DESCRIPTION
FB13-4	276-0752-00	Ferrite Bead BP53-8H
IC1	156-0197-02	5 Transistor Array RCA CA3086
IC2	156-0745-00	CMOS HEX Inverter RCA CD4069

CIR. REF.	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING W
R1	317-0101-01	100R	CF	5	125m
R2	317-0472-01	4K7	CF	5	125m
R3	317-0470-01	47R	CF	5	125m
R4	317-0134-01	130K	CF	5	125m
R5	317-0184-01	180K	CF	5	125m
R6	315-0245-01	2M4	CF	5	250m
R7	317-0222-01	2K2	CF	5	125m
R8	317-0104-01	100K	CF	5	125m
R9	317-0333-01	33K	CF	5	125m
R10	317-0102-01	1K	CF	5	125m
R11	317-0272-01	2K7	CF	5	125m
R12	317-0330-01	33K	CF	5	125m
R13	317-0105-01	1MO	CF	5	125m
R14	317-0101-01	100R	CF	5	125m
R15	317-0392-01	3K9	CF	5	125m
R16	317-0104-01	100K	CF	5	125m
R17	317-0101-01	100R	CF	5	125m
R18	317-0242-01	2K	CF	5	125m
R19	317-0154-01	150K	CF	5	125m
R20	317-0101-01	100R	CF	5	125m
R21	325-0348-00	10K	MF	2	100m
R22	317-0272-01	2K7	CF	5	125m
R23	317-0912-01	9K1	CF	5	125m
R24	317-0133-01	12K	CF	5	125m
R25	317-0821-01	820R	CF	5	125m

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL %	RATING V
R26	317-0562-01	5K6	CF	5	125m
R27	317-0102-01	1KO	CF	5	125m
R28	317-0392-01	3K9	CF	5	125m
R29	317-0101-01	100R	CF	5	125m
R30	317-0822-01	8K2	CF	5	125m
R31	317-0334-01	330K	CF	5	125m
R33	311-2066-00	4K7	CV	20	250m
R34	317-0821-01	820R	CF	5	125m
R35	317-0471-01	470R	CF	5	125m
R36	317-0184-01	180K	CF	5	125m
R37	317-0335-01	3M3	CF	5	125m
R38	317-0105-01	1MO	CF	5	125m
R39	317-0334-01	330K	CF	5	125m
R41	317-0273-01	27K	CF	5	125m
R42	317-0622-01	6K2	CF	5	125m
R43	317-0331-01	330R	CF	5	125m
R44	317-0242-01	2K4	CF	5	125m
R45	317-0432-01	4K3	CF	5	125m
R46	317-0104-01	100K	CF	5	125m
R47	317-0681-01	680R	CF	5	125m
R48	317-0562-01	5K6	CF	5	125m
R49	311-1654-00	10K	CP	20	50m
R51	317-0163-01	16K	CF	5	125m
R52	317-0183-01	18K	CF	5	125m

CIR. REF.	PART NUMBER	DESCRIPTION
S1b (a, c)	(See Section 8 Parts List)	Lever DC-GND-AC CH1-CH2-EXT 3 Pos 3 Pole
S2	260-1936-02	Rotary (SECS/DIV) ASSY
S3b (a, c)	(See Section 8 Parts List)	Lever (AUTO-NORM-TV) 3 Pos 3 Pole
S4	(Part of R33)	TRIG LEVEL-PULL to close
SK1	131-2268-01	Socket (TRIG/EXT × INPUT)

CIR. REF.	PART NUMBER	DESCRIPTION	TYPE	RATING
TR1	151-0445-00	ZTX214C	Si	PNP
TR2	151-0320-01	MPS6518	Si	PNP
TR3	151-0317-01	BC109C	Si	NPN
TR4	151-0445-00	ZTX214C	Si	PNP
TR5	151-0320-01	MPS6518	Si	PNP
TR6	151-0320-01	MPS6518	Si	PNP



All waveforms measured with CH1 off &
CH2 1KHz triangular waves 5div. & 1div. display.
Values in brackets are for 1div. display.
Timebase = 1mS/div.
MONITOR OSCILLOSCOPE = 0·5mS/DIV.

MONITOR OSCILLOSCOPE IN CAPITALS.
oscilloscope under test in lower case

Circuit 6

CIR. REF.	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING W
R70	317-0683-01	68K	CF	5	125m
R71	317-0124-01	120K	CF	5	125m
R72	317-0333-01	33K	CF	5	125m
R73	317-0273-01	27K	CF	5	125m
R74	317-0682-01	6K8	CF	5	125m
R75	311-2025-00	100K	CV	20	250m
R76	325-0370-00	8K2	MF	2	100m
R77	317-0562-01	5K6	CF	5	125m
R78	317-0473-01	47K	CF	5	125m
R79	317-0105-01	1M0	CF	5	125m
R80	317-0184-01	180K	CF	5	125m
R81	325-0311-00	11K3	MF	1	100m
R82	325-0300-00	38K3	MF	1	100m
R83	317-0824-01	820K	CF	5	125m
R84		10K			
R85		15K1			
R86		25K3			
R87	307-0634-01	50K5	CM	Film Network CM71	
R88		153K			
R89		257K			
R91		517K	MF	1	100m
R92		1M55			
R93	307-0634-01	2M59	CM	Film Network CM71	
R94		5M19			
R95	317-0133-01	13K	CF	5	125m
R96	317-0334-01	330K	CF	5	125m
R97	317-0273-01	27K	CF	5	125m
R98	317-0103-01	10K	CF	5	125m
R99	317-0333-01	33K	CF	5	125m
R100	317-0433-01	43K	CF	5	125m
R101	317-0224-01	220K	CF	5	125m
R102	317-0335-01	3M3	CF	5	125m
R103	317-0473-01	47K	CF	5	125m
R104	317-0472-01	4K7	CF	5	125m
R105	317-0105-01	1M0	CF	5	125m
R106	311-1692-00	22K	CP	20	50m
R107	317-0433-01	43K	CF	5	125m
R108	317-0303-01	30K	CF	5	125m
R109	317-0822-01	8K2	CF	5	125m
R110	315-0301-01	300R	CF	5	250m
R111	311-1656-00	4K7	CP	20	50m
R112	325-0369-00	4K64	MF	1	100m
R113		4K3			
R114	307-0633-01	39K	CM	Film Network CM72	
R115		15K			
R116	311-2067-00	22K	CV	20	250m
R117	307-0633-01	12K15	CM	Film Network CM72	
R118	301-0563-02	56K	CF	5	500
R119	307-0633-01	3K6	CM	Film Network CM72	
R120	317-0563-01	56K	CF	5	125m
R121	307-0633-01	18K9	CM	Film Network CM72	
R122	317-0101-01	100R	CF	5	125m
R123	317-0471-01	470R	CF	5	125m
R124	311-1706-00	470R	CP	20	50m
R125	325-0344-00	75K	MF	2	500m
R127	317-0470-01	47R	CF	5	125m
R128	317-0103-01	10K	CF	5	125m
R129	308-0825-00	5K1	WW	5	5
R131	317-0101-01	100R	CF	5	125m
R132	325-0335-00	68R	MF	2	100m
R133	317-0101-01	100R	CF	5	125m
R134	317-0182-01	1K8	CF	5	125m
R135	317-0101-01	100R	CF	5	125m
R136	317-0270-01	27R	CF	5	125m
R137	325-0336-00	680R	MF	2	500m
R138	308-0825-00	5K1	WW	5	5
R139	317-1470-01	47R	CF	5	125m
R141	325-0335-00	68R	MF	2	100m
R142	317-0101-01	100R	CF	5	125m
R143	317-0821-01	820R	CF	5	125m
R144	317-0220-01	22R	CF	5	125m
R145	317-0101-01	100R	CF	5	125m

CIR. REF.	PART NUMBER	DESCRIPTION
S5	(Part of R116)	× 1 × 5
S6	(Part of R75)	X-Y
SK70	355-0529-00	Socket (GND)
SK71	131-2275-00	Socket (CAL OUT 250mV)

CIR. REF.	PART NUMBER	DESCRIPTION	TYPE
TR71	151-0320-01	MPS6518	PNP
TR72	151-0445-00	ZTX214C	PNP
TR73	151-0242-00	2N3904	NPN
TR74 a/b	151-1125-00	FET Dual SU2603M	NFE
TR75	151-0320-01	MPS6518	PNP
TR76	151-0320-01	MPS6518	PNP
TR77	151-0242-00	2N3904	NPN
TR78	151-0676-00	BF467	NPN
TR79	151-0320-01	MPS6518	PNP
TR81	151-0676-00	BF467	NPN

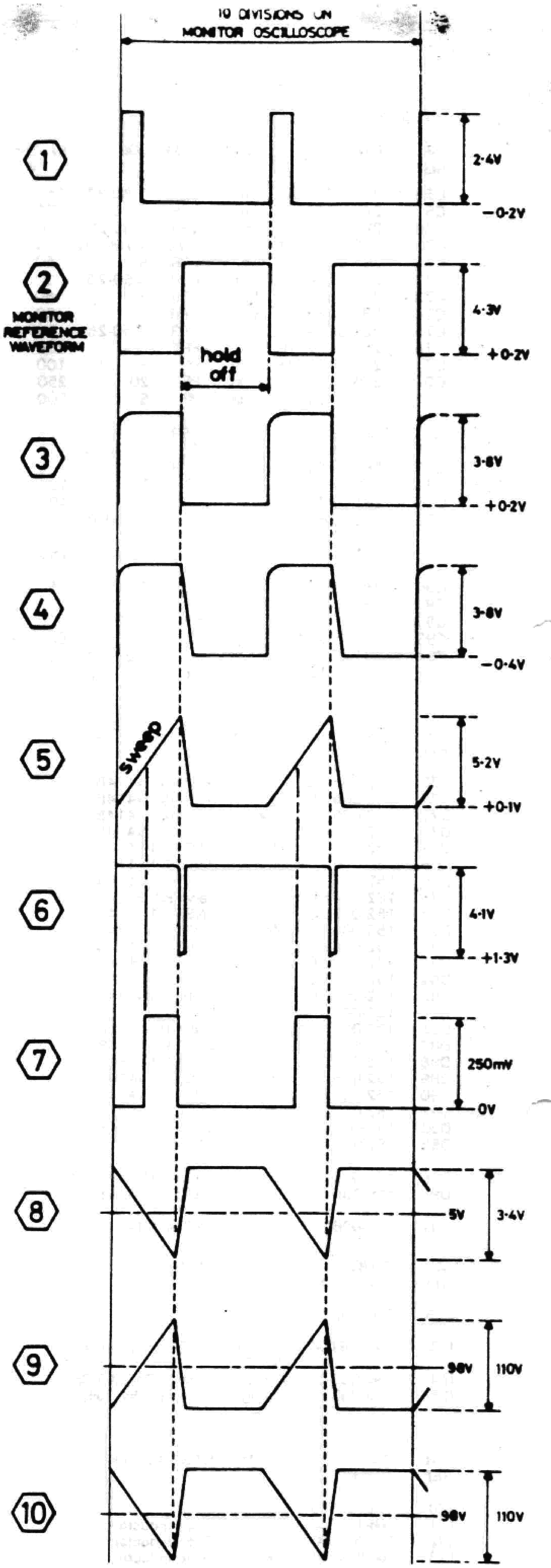
Circuit 6

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL %	RATING V
C66	281-0710-00	10n	CER	+80-20	250
C67	281-0710-00	10n	CER	+80-20	250
C68	281-0710-00	10n	CER	+80-20	250
C70	290-0784-00	100µ	ELEC	+100-10	25
C71	281-0839-00	33p	CER	5	50
C72	281-0734-00	100n	CER	+50-20	30
C73	281-0845-00	15p	CER	5	50
C74	281-0859-00	75px2	CER	5	400
C75	281-0734-00	100n	CER	+50-25	30
C76	281-0157-01	5p5-65p	PPT		500
C77	285-1181-00	220n	PC	5	100
C78	285-0796-00	100n	PE	20	250
C79	285-1080-01	220p	PP	5	500
C81	281-0868-00	10n	CER	20	25
C82	290-0792-00	47µ	ELEC	+100-10	16
C83	281-0843-00	10p	CER	5	50
C84	285-0779-00	470n	PE	20	100
C85	281-0803-00	8p2	CER	0p5	400
C86	290-0784-00	100µ	ELEC	+100-10	25
C88	281-0710-00	10n	CER	+80-20	250
C90	281-0857-00	68p	CER	5	50
C91	285-0827-01	240p	PP	5	500
C92	281-0734-00	100n	CER	+50-20	30
C93	281-1080-01	220p	PP	5	500
C94	281-0734-00	100n	CER	+80-20	30
C95	281-0710-00	10n	CER	+80-20	250

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION	TYPE	RATING
D70	152-0062-01	75V	1N914/1N4148	Si	75mA
D71	152-0062-01	75V	1N914/1N4148	Si	75mA
D72	152-0062-01	75V	1N914/1N4148	Si	75mA
D73	152-0062-01	75V	1N914/1N4148	Si	75mA
D74	152-0062-01	75V	1N914/1N4148	Si	75mA
D75	152-0062-01	75V	1N914/1N4148	Si	75mA
D76	152-0062-01	75V	1N914/1N4148	Si	75mA
D77	152-0545-00	10V	Zener BZY88C10		400mW
D78	152-0062-01	75V	1N914/1N4148	Si	75mA
D79	152-0062-01	75V	1N914/1N4148	Si	75mA
D80	152-0062-01	75V	1N914/1N4148	Si	75mA
D81	152-0062-01	75V	1N914/1N4148	Si	75mA
D82	152-0545-00	10V	Zener BZY88C10	Si	400mW
D83	152-0062-01	75V	1N914/1N4148	Si	75mA
D85	152-0468-00	150V	BAX16		200mA
D86	152-0062-01	75V	1N914/1N4148	Si	75mA
D87	152-0062-01	75V	1N914/1N4148	Si	75mA
D88	152-0062-01	75V	1N914/1N4148	Si	75mA
D89	152-0062-01	75V	1N914/1N4148	Si	75mA
D90	152-0062-01	75V	1N914/1N4148	Si	75mA
D91	152-0372-00	13V	Zener BZY88313		400mW
D92	152-0062-01	75V	1N914/1N4148	Si	75mA
D93	152-0468-00	150V	BAX16		200mA
D95	152-0062-01	75V	1N914/1N4148	Si	75mA
D96	156-0062-01	75V	1N914/1N4148	Si	75mA
D97	157-0062-01	75V	1N914/1N4148	Si	75mA

CIR. REF.	PART NUMBER	DESCRIPTION
FB6	276-0752-00	Ferrite Bead BP53-BH
IC3	156-0388-00	Dual D Type Flip Flop Texas 74-LS74
IC4	156-0259-03	Transistor Array RCA CA3083
IC5	156-1192-00	Voltage Regulator +5V T092

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION
L70	108-1003-00	12µH	Fixed Inductor
L71	108-1027-00	220µH	Fixed Inductor
L72	108-1027-00	220µH	Fixed Inductor
L73	108-0780-00	56µH	Fixed Inductor
L75	108-0932-00	160µH	Fixed Inductor
L76	108-0932-00	160µH	Fixed Inductor



All waveforms measured with CH1 off & CH2 200Hz sine waves 5div. display.
Timebase = 0·2mS/div.
MONITOR OSCILLOSCOPE = 1mS/DIV.

MONITOR OSCILLOSCOPE IN CAPITALS.
oscilloscope under test in lower case

CIR. REF.	PART NUMBER	VALUE	TYPE	TOL %	RATING V
C400	281-0868-00	10n	CER	20	25
C401	290-0624-01	2n 2	ELEC	+100-10	40
C403	281-0839-00	33p	CER	5	50
C404	281-0843-00	10p	CER	5	50
C405	290-0960-00	4μ7	ELEC	+100-10	63
C406	281-0867-00	4n7	CER	20	50
C408	285-1182-00	220n	PE	20	100
C409	281-0779-00	2n0	CER	+70-20	2k0
C410	281-0869-00	10n	CER	+80-20	2k0
C411	281-0779-00	2n0	CER	+70-20	2k0
C412	290-0556-00	22μ	ELEC	+100-10	25
C413	290-0556-00	22μ	ELEC	+100-10	25
C414	290-0836-00	1u0	ELEC	+100-10	250
C415	281-0869-00	10n	CER	+80-20	2k0
C416	281-0869-00	10n	CER	+80-20	2k0
C417	281-0682-00	20n	CER	+40-20	2k0
C418	290-0784-00	100μ	ELEC	+100-10	25
C419	290-0784-00	100μ	ELEC	+100-10	25
C420	290-0627-00	22μ	ELEC	+100-10	40
C421	290-0837-00	22μ	ELEC	+50-10	250
C422	281-0779-00	2n0	CER	+70-20	2k0
C423	281-0779-00	2n0	CER	+70-20	2k0
C424	285-0915-00	100n	PE	20	100
C425	285-0915-00	100n	PE	20	100
C427	281-0866-00	1n0	CER	10	50
C461	281-0868-00	10n	CER	20	25

CIR. REF.	PART NUMBER	VALUE	DESCRIPTION
FS401	159-0167-00	400mA	Fuse 5 × 20mm DLY (240V)
FS401	159-0168-00	800mA	Fuse 5 × 20mm DLY (110V)
FS402	159-0170-00	1.25A	Fuse 5 × 20mm Quick Action (250V)
IC401	156-0197-02		5 Transistor Array RCA CA3086
L401	108-0932-00	160μH	Fixed Inductor
L402	108-0932-00	160μH	Fixed Inductor
L403	108-0932-00	160μH	Fixed Inductor
L404	(Supplied with CRT)		Coil TRACE ROTATE
LP401	150-1072-00		LED Fairchild FLV150 Red
PL401a	131-2382-00		Connector Male (2 × 5 way)
PL401b	175-2216-01	(Part of)	Connector Male 10 way
PL402a	131-2382-00		Connector Male (2 × 5 way)
PL402b	175-2216-01	(Part of)	Connector Male 10 way
PL407	See section 8 Parts List		Plug Mains/Power Cord Assy.

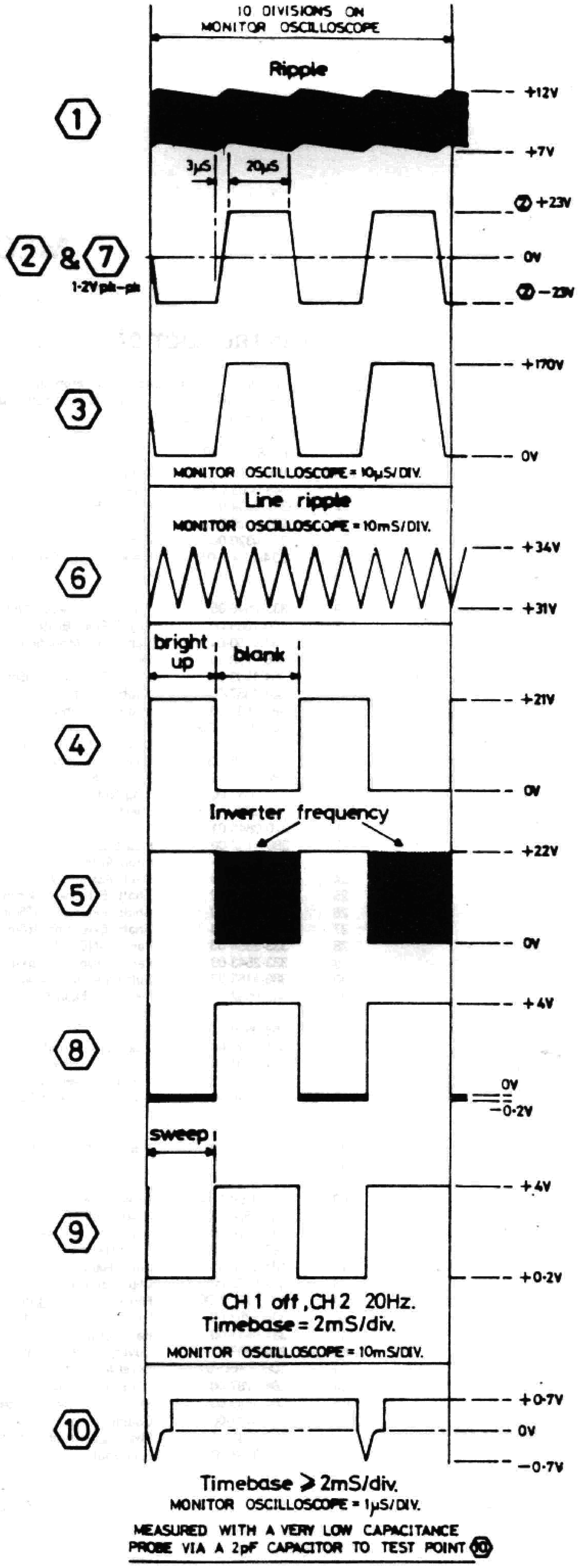
CIR. REF.	PART NUMBER	VALUE	DESCRIPTION	TYPE	RATING
D400	152-0348-00	6V2	Zener BZY88C6V2	Si	400mW
D401	152-0707-00	50V	GP20A	Si	2A
D402	152-0707-00	50V	GP20A	Si	2A
D403	152-0707-00	50V	GP20A	Si	2A
D404	152-0707-00	50V	GP20A	Si	2A
D405	152-0348-00	6V2	Zener BZY88C6V2	Si	400mW
D406	152-0062-01	75V	1N914/1N4148	Si	75mA
D407	152-0062-01	75V	1N914/1N4148	Si	75mA
D408	152-0062-01	75V	1N914/1N4148	Si	75mA
D410	152-0062-01	75V	1N914/1N4148	Si	75mA
D411	152-0062-01	75V	1N914/1N4148	Si	75mA
D413	152-0062-01	75V	1N914/1N4148	Si	75mA
D414	152-0737-00	150V	BYX36	Si	1A
C415	152-0737-00	150V	BYX36	Si	1A
C416	152-0708-00	200V	BA157	Si	400mW
C417	152-0708-00	200V	BA157	Si	400mW
C418	152-0708-00	200V	BA157	Si	400mW
C419	152-0708-00	200V	BA157	Si	400mW
C420	152-0743-00	1k3/1k6	BY133	Si	1A
C421	152-0743-00	1k3/1k6	BY133	Si	1A
C422	152-0743-00	1k3/1k6	BY133	Si	1A
C423	152-0743-00	1k3/1k6	BY133	Si	1A
C424	152-0726-00	56V	Zener BZX79 C56	Si	80mA
C425	152-0468-00	150V	BAX16	Si	200mA
C426	152-0062-01	75V	1N914/1N4148	Si	75mA
C427	152-0062-01	75V	1N914/1N4148	Si	75mA
C428	152-0354-00	12V	Zener BZY88C12	Si	400mW
D430	152-0709-00	50V	RGP10A	Si	300mA
D431	152-0709-00	50V	RGP10A	Si	300mA
D432	152-0709-00	50V	RGP10A	Si	300mA
D433	152-0709-00	50V	RGP10A	Si	300mA
D434	152-0472-00	5V6	Zener BZY88C5V6	Si	400mW
D435	152-0062-01	75V	1N914/1N4148	Si	75mA

CIR. REF.	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING W
R 0	317-0182-01	1k8	CF	5	125m
R401	317-0183-01	18k	CF	5	125m
R402	317-0104-01	100k	CF	5	125m
R 3	317-0511-01	510R	CF	5	125m
R 5	317-0473-01	47k	CF	5	125m
R406	317-0332-01	3k3	CF	5	125m
R 3	317-0123-01	12k	CF	5	125m
R 9	308-0805-00	0R47	WW	10	1
R 0	317-0221-01	220R	CF	5	125m
R411	317-0332-01	3k3	CF	5	125m
R412	317-0472-01	4k7	CF	5	125m
R413	303-0751-01	750R	CF	5	1
R 4	317-0392-01	3k9	CF	5	125m
R 5	307-0647-00	40R	THR	15R	25°C
R416	317-0272-01	2k7	CF	5	125m
R417	317-0512-01	5k1	CF	5	125m
R418	311-2036-00	2k2	CP	20	50m
R 9	317-0431-01	430R	CF	5	125m
R	317-0223-01	22k	CF	5	125m
R423	317-0103-01	10k	CF	5	125m
R 5	317-0103-01	10k	CF	5	125m
R428	317-0473-01	47k	CF	5	125m
R4	317-0273-01	27k	CF	5	125m
R4	317-0473-01	47k	CF	5	125m
R432	317-0392-01	3k9	CF	5	125m
R433	317-0273-01	27k	CF	5	125m
R434	317-0102-01	1k0	CF	5	125m
R435	317-0102-01	1k0	CF	5	125m
R436	317-0680-01	68R	CF	5	125m
R437	301-0685-02	6M8	CF	5	500m
R438	311-2031-00	1M0	CP	20	75m
R439	317-0105-01	1M0	CF	5	125m
R4	317-0102-01	1k0	CF	5	125m
R4	311-2076-00	22k	CP	20	75m
R443	317-0223-01	22k	CF	5	125m
R444	311-1779-00	1M0	CP	20	50m
R4	311-2031-00	1M0	CP	20	75m
R4	317-0103-01	10k	CF	5	125m
R448	317-0184-01	180k	CF	5	125m
R451	301-0561-01	560R	CF	5	500m
R4	311-2077-00	470R	WW	20	2
R4	301-0471-01	470R	CF	5	500m
R456	317-0273-01	27k	CF	5	125m
R4	317-0225-01	2M2	CF	5	125m
R4	303-0391-01	390R	CF	5	1
R461	307-0757-00	1R0	C	5	125m
R462	317-0122-01	1k2	CF	5	125m
R4	307-0757-00	1R0	C	5	125m
R4	317-0104-01	100K	CF	5	125m

CIR RE	PART NUMBER	DESCRIPTION
S401	260-1940-00	POWER ON/OFF
S402	260-1429-01	Slider (RANGE)
S4	260-1429-01	Slider (HI-LO MAINS)
S4	260-1940-00	BEAM FINDER
SK401a	175-2216-01 (Part of)	Connector Female 2 × 5 way
SK402a	175-2216-01 (Part of)	Connector Female 2 × 5 way
SK 4	131-2349-00	Socket (Z MOD)
SK406	136-0357-00	Socket (CRT)

CIR. REF.	PART NUMBER	DESCRIPTION
T401	120-1199-01	Mains
T402	120-1198-01	Inverter
T403	120-1200-00	(Toroid) Drive

CIR. REF.	PART NUMBER	DESCRIPTION	TYPE
TR401	151-0320-01	MPS6518	PNP
TR402	151-0675-00	Darlington TIP120	NPN
TR403	151-0320-01	MPS6518	PNP
TR404	151-0681-00	µEC1843	NPN
TR405	151-0681-00	µEC1843	NPN
TR406	151-0242-00	2N3904	NPN
V401	154-0854-00	CRT Mullard 58619GY/93 (Internal Grat.)	



MONITOR OSCILLOSCOPE IN CAPITALS.
oscilloscope under test in lower case

SECTION 8

MECHANICAL ASSEMBLY

8.1 INTRODUCTION

The Mechanical Parts are referenced on the Exploded Views 1 and 2 as item numbers, and can be used for ordering replacement parts.

8.2 PARTS LIST

Item	Part No.	Description
1	348-0603-01	Foot L/H
2	348-0604-01	Foot R/H
3	348-0605-00	Flipstand, Cabinet
4	344-0320-00	Clip, Power Cord
5	334-3541-01	Marker Ident. Ser. No.
6		
7		
8	333-2546-05	Panel, Front Vert. Amp.
9	200-1885-00	Bezel, Push-Button
10	386-4150-04	Sub-Panel Moulding
11	366-1788-00	Push Button
12	384-1535-01	Shaft, Extension 185mm
13	366-1387-00	Knob Assembly
14	366-1535-00	Knob Assembly
15	384-1179-00	Shaft Extension 9.4" long
16	376-0192-00	Coupling 6mm — ⅛"
17	337-2625-03	Shield, Electrical
18	386-4151-03	Panel, BNC 'Y'
19	220-0840-00	Ring Nut
20	337-3003-00	Shield Electric (21.22)
21	220-0845-01	Nut, Spire
22	386-4152-00	PCB Support
23	366-1241-00	Knob Assembly
24	366-1238-00	Knob Assembly
25	384-1142-22	Shaft, Extension 38mm
26	384-1142-23	Shaft, Extension 135mm
27	384-1142-24	Shaft, Extension 168mm
28	333-2554-03	Panel, BNC 'X'
29	333-2543-09	Panel, Front Timebase
30	386-4153-02	Sub Panel Moulding
31	342-0532-00	Insulator (Elec.)Disc
33	358-0609-00	Bush
34	441-1491-01	Chassis Assembly
35	214-2904-10	Heat Sink, Rear Assy
36	343-0815-01	Clamp, Power Cord
37	358-0610-00	Grommet, Power Cord
38		
39		
40	407-2318-00	Bracket, Transformer Mtg.
41		
42		
43	331-0547-14	Filter Green
44	352-0554-00	Holder, LED
45	367-0270-00	Handle Assembly
46	367-0271-00	Grip, Handle
47	101-0049-00	Trim, Handle
48	344-0323-00	Clip, Retaining
49	376-0210-00	Flexible Coupling 6mm "
50	334-2752-00	Label (Mod Record)
51	381-0411-00	Bar, Support
52	200-2359-02	Cover, Voltage Selector
53	200-2460-01	Bezel Marked
54	366-1787-00	Knob Assembly
55	384-1535-00	Shaft, Extension 267.5mm
56	376-0191-00	Coupling
57	384-1536-01	Shaft, Extension Assy
58	348-0162-00	Grommet

Item	Part No.	Description
59		
60		
61		
62	401-0454-01	Rotor Assembly
63	401-0453-01	Rotor Assembly
64	407-2243-01	Bracket, BNC
65	214-2892-00	Spring Detent
66	380-0580-00	Housing
67	131-2268-01	Connector, BNC Assy.
68	355-0529-00	Post, Earthing
69	337-2630-00	Screen, Input Socket
70	352-0474-00	Fuse Holder
71	401-0455-01	Rotor Assembly
72	407-2311-01	Bracket, BNC
73	131-2275-00	Connector, (CAL) Assy.
74	407-2332-00	Bracket, Pot Mounting
75	337-2631-00	Shield, Electrical-Atten.
76	384-1599-00	Shaft
77	337-2627-00	Shield, CRT
78	348-0606-00	Shockmount, CRT
79	343-0812-00	Collar, Clamping CRT
80	348-0620-00	Foot, Cabinet/Heatsink
81		
82	437-0266-04	Cabinet, Top Assembly
83	437-0266-03	Cabinet, Bottom Assembly
84		
85	358-0611-01	Bush - Z MOD Skt
86	252-0632-00	Foam Self-Adhesive 50m L.G.
87	213-0822-00	Screw, Special
88	343-0805-00	Cable, Clamp
89	210-0297-02	Tag, Earthing
90	214-3147-00	Heatsink
91	161-0131-00	Power Cord Assy. (Euro Type)
	161-0124-01	Power Cord Assy. (USA Type)
92		
93	384-1598-00	(Shaft Trace Rotn)
94		
95		
96		
97		
98	384-1597-00	Shaft (ASTIG)
99		
100	213-0843-01	Screw, M2×6mm Pan
101	213-0831-00	Screw, M2×10mm Pan
102	213-0837-00	Screw, M2.5×5mm Pan Blk.
103	213-0248-00	Screw, M3×3 Hex Skt Drive
104	213-0832-00	Screw, M3×8mm Pan
105	213-0833-00	Screw, M3×8mm Ch. Slot
106	213-0857-00	Screw, M3×16mm Pan
107	213-0825-00	Screw, M4×8mm Pan
108	213-0213-00	Screw, M4×40mm Pan Blk.
109	213-0836-00	Screw, M4×30mm Pan
110	213-0826-00	Screw, M4×80mm Pan Blk.
111	213-0830-00	Screw, M6×40mm Hex
112	213-0847-00	Screw, S/T No. 2×¼" Chem
113	213-0829-01	Screw, S/T No. 4×¼"
114	213-0827-01	Screw, S/T No. 8×1"
115	213-0828-01	Screw, S/T No. 8×½"
116	220-0846-00	Nut M2
117	220-0847-00	Nut M3
118	220-0848-00	Nut M4
119		
120	210-1313-00	Washer, M2 Crinkle
121	210-1314-00	Washer, M3 Crinkle
122	210-1311-00	Washer, M4 Crinkle

SECTION 9

WIRED ASSEMBLIES

9.1 INTRODUCTION

The Wired Assemblies referred to in this section are the circuit boards and switch assemblies.

9.2 CIRCUIT BOARDS

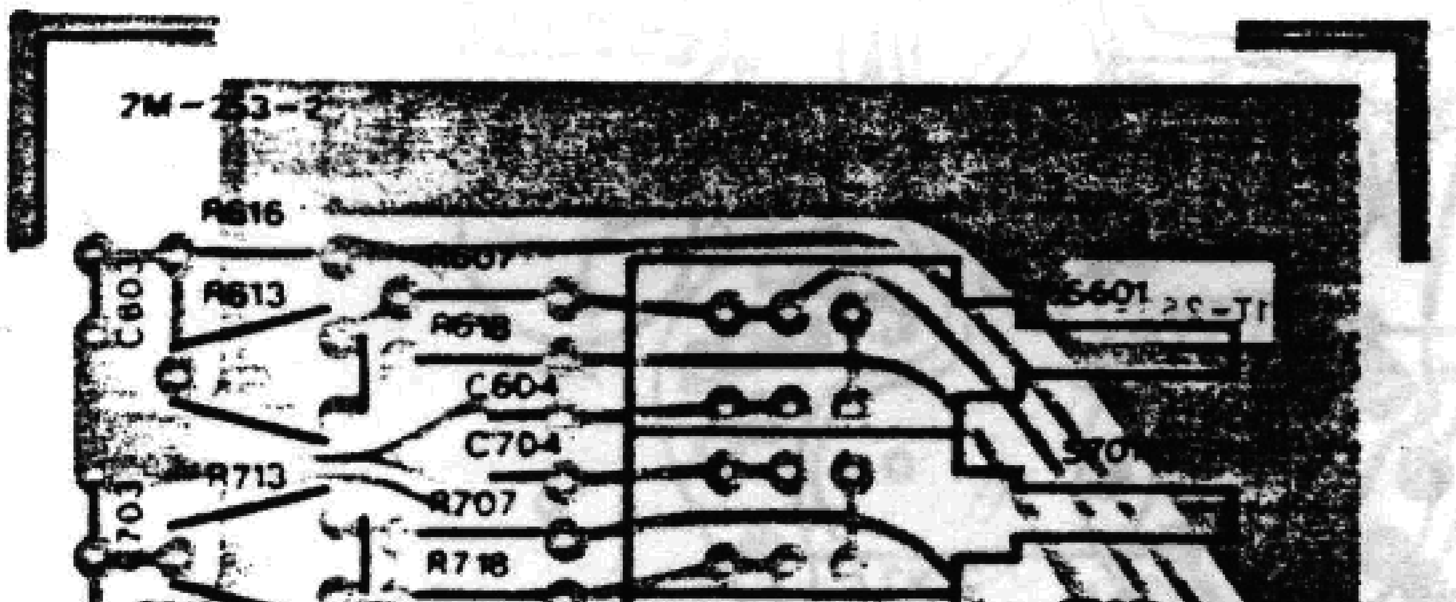
9.2.1 All boards are single sided and are shown full size in three colours, as follows:–

a) Component references printed on the component side are shown in BLACK.

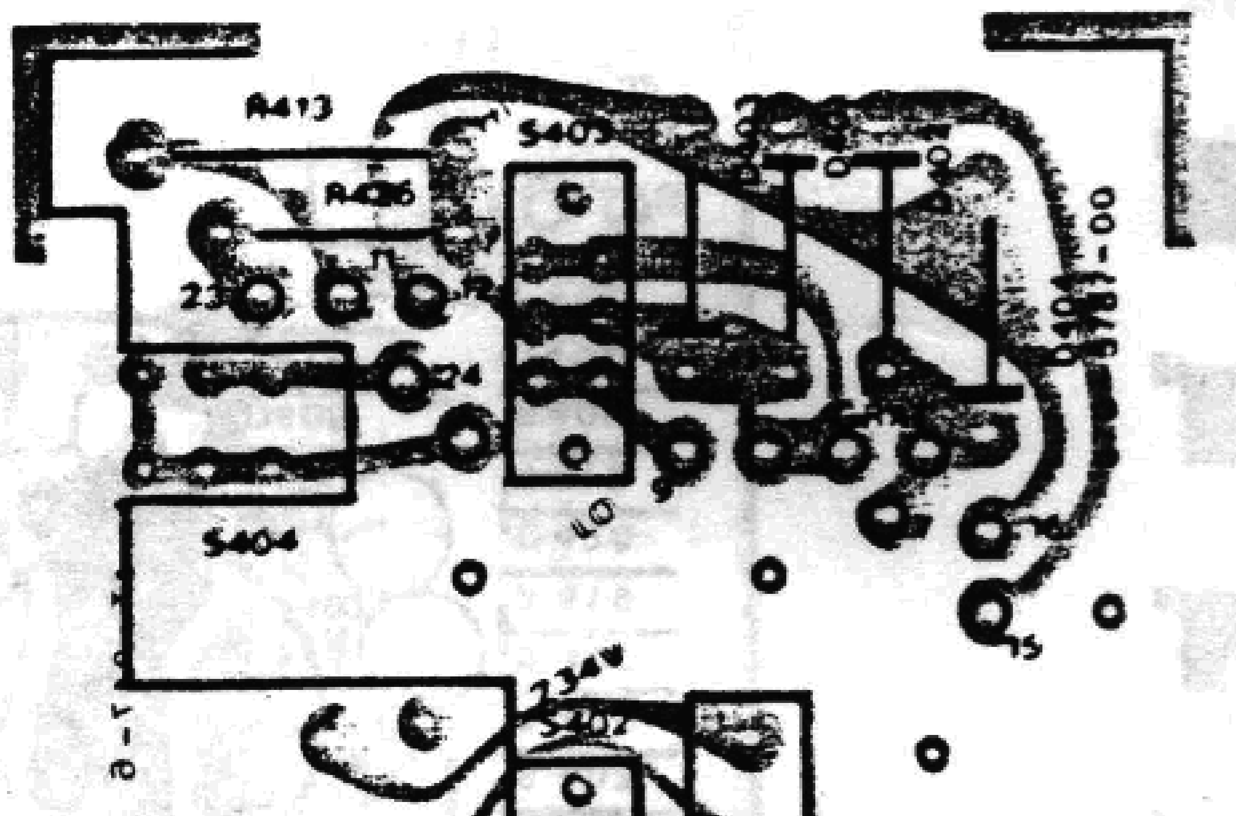
b) The track as viewed through the board from the component side is shown in BLUE.

9.3 PCB NUMBERS

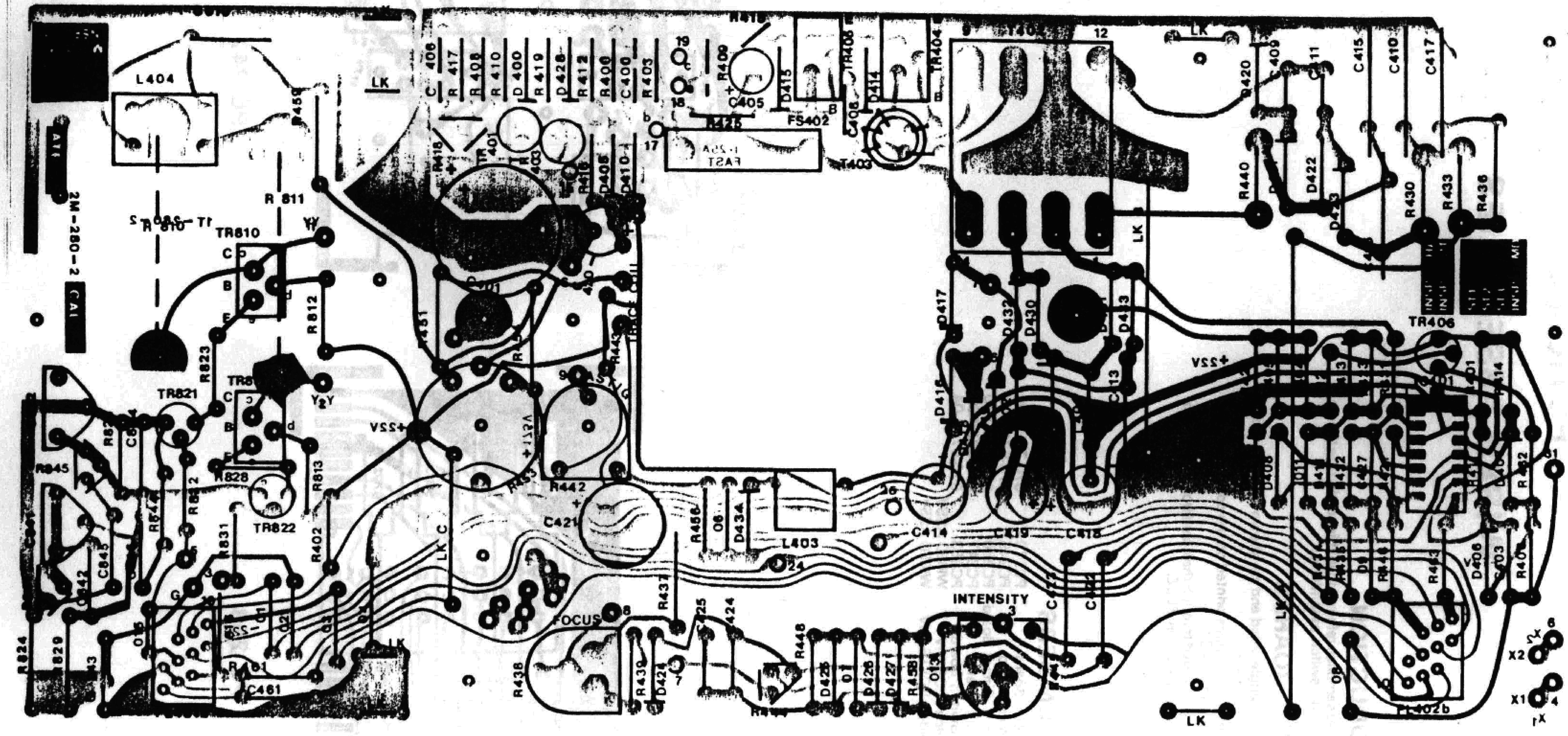
Y Amp Circuit Board	PC279	670-7589-00
X Amp Circuit Board	PC245	670-5781-02
Power Supply Circuit Board	PC280	670-7590-00
Mains Circuit Board	PC247	670-5787-00
Volts/Div Switch Board	PC253	670-5788-04
Rotary Switch SECS/DIV	WIRED ASSY	
Rotary Switch VOLTS/DIV	WIRED ASSY	



PC 253



PC 247


L404
2M-280-2
R 811
R 810
TR810
TR821
TR822
R812
R813
R823
R828
R831
R402
R845
C845
+22V
+22V
LK
LK C
C 406
R 417
R 408
R 410
D 400
R 419
D428
R412
R400
C400
R403
R409
C405
R425
FS402
T403
TR408
TR404
D414
D415
R442
C421
R456
D434
L403
C414
C419
C418
INTENSITY
FOCUS
R438
R439
D424
R437
R448
D425
D426
D427
R458
D417
D432
D430
D433
C413
D416
R440
D422
D423
D420
R430
R433
R436
C415
C410
C417
TR406
R414
D408
R443
D406
C403
PL402b
X1
X2
C461
TRACE COIL

PC 280

SECTION 10

STANDARD OPTIONS AND ACCESSORIES

10.1 INTRODUCTION

A Standard Option is an extra or an alternative feature usually incorporated into the standard instrument at the manufacturing stage, and marketed on the same terms as a standard instrument.

A number of accessories are available for purchase to increase the facilities of the instrument.

10.2 STANDARD OPTIONS

If the standard instrument has been supplied with one or more of the Standard Options listed below, the appropriate technical data must be used in conjunction with the standard manual information.

Option 4 P7 CRT (Part Number 154-0826-03) and Amber Graticule (Part Number 331-0547-12).

Option 6 For operation on 115V line voltage and fitted with USA power cord (Part Number 161-0124-01)

10.3 ACCESSORIES

	Part Number
Front Protection Cover	016-0439-01
Viewing Hood (Supplied with INST)	016-0647-01
Camera Adaptor for type C5B Camera	016-0646-00
Probe Type TP1 (X1, 1.5m)	010-0291-00
TP2 (X10, 1.5m)	010-0292-00
TP2 (X10, 1.8m) [redacted])	010-0292-02
TP2 (X10, 3.0m)	010-0292-03
TP3 (X100, 1.5m)	010-0293-00
TP4 (Detector, 1.5m)	010-0294-00
TP5 (X1/X10 Switchable 1.2m)	010-0295-00
TP5 (X1/X10 Switchable 3m)	010-0295-01
Replaceable Probe Tip	015-0328-00

10.4 RACK MOUNTING

Front-entry rack-mounting versions of the standard instruments are available as D1010R. A supplement to this standard manual is supplied, (Part Number 070-2903-00).

TELEQUIPMENT

MANUAL AMENDMENT LIST

INSTRUMENT D1016A	MANUAL PART NUMBER 070-3904-01		ISSUE 1	AMENDMENT LIST 1
S.O. NUMBER	BATCH NUMBER	DATE November 1981.		PAGE 1 OF 1

DESCRIPTION OF AMENDMENT	STARTING SERIAL NUMBER 782551

Page 7-3 (cct2)

C909, C959 Should read:-PN 285-1243-00 300p PP 2.5 500.
C911, C961 Should read:-PN 281-0154-00 2-10p PPT 400.

Page 7-4 (cct3)
R613 Should read:-PN 311-1655-00
TR602-605/702-706 Should read:- PN 151-0680-00 (SELECTED BFR54 PHILIPS)

Page 7-6 (cct4)
TR821,823 Should read:-PN 151-0680-00 (SELECTED BFR54 PHILIPS)

Page 7-8 (cct5)
R18 Should read:- Value 2K4
R24 Should read:-PN 317-0123-01

Page 7-10 (cct6)

R91 Delete MF 1 100m
TR74 Should read:-PN 151-1118-00
C93 Should read:-PN 285-1080-01

Page 9-1 (WIRED ASSEMBLIES)

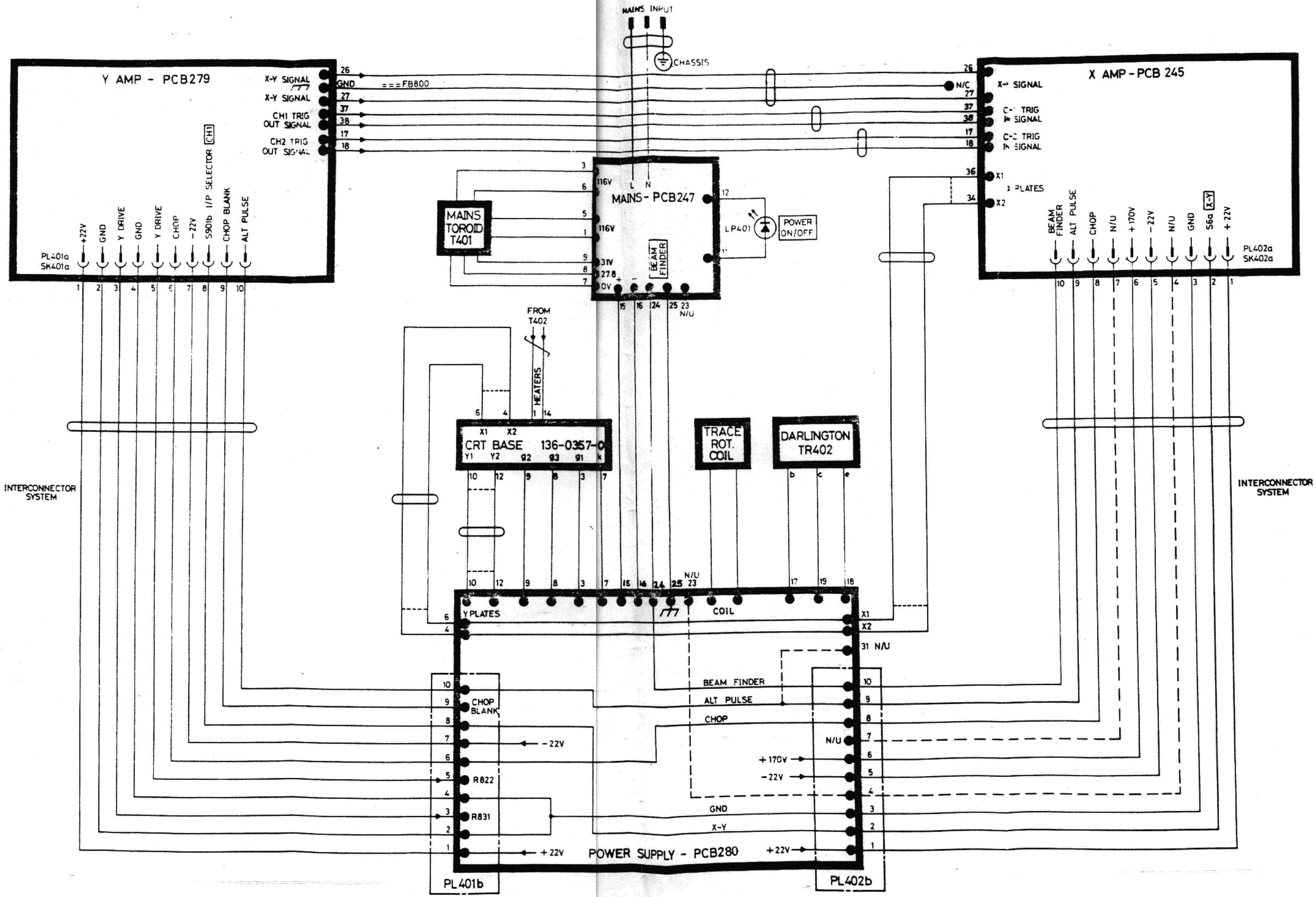
9.3 PCB NUMBERS.

PC253 Should read:-PN 670-5788-01
Add. Rotary Switch SECS/DIV WIRED ASSY PN (262-1013-01

Page 7-12

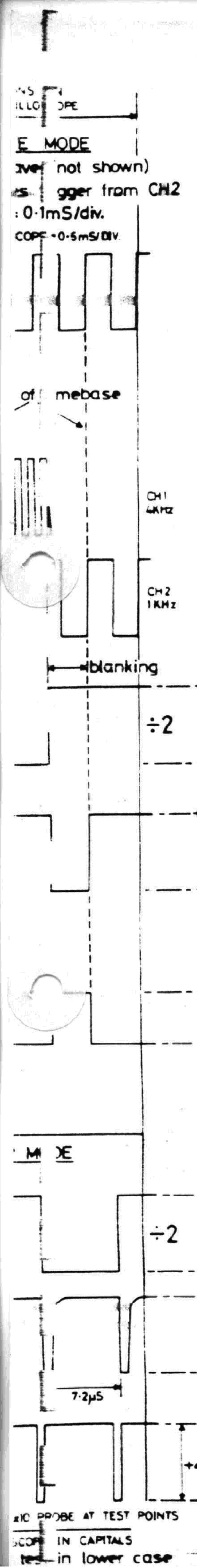
V401 Should Read PN: 154-0854-00 CRT Mullard 56819GY/93
(Internal Grat)

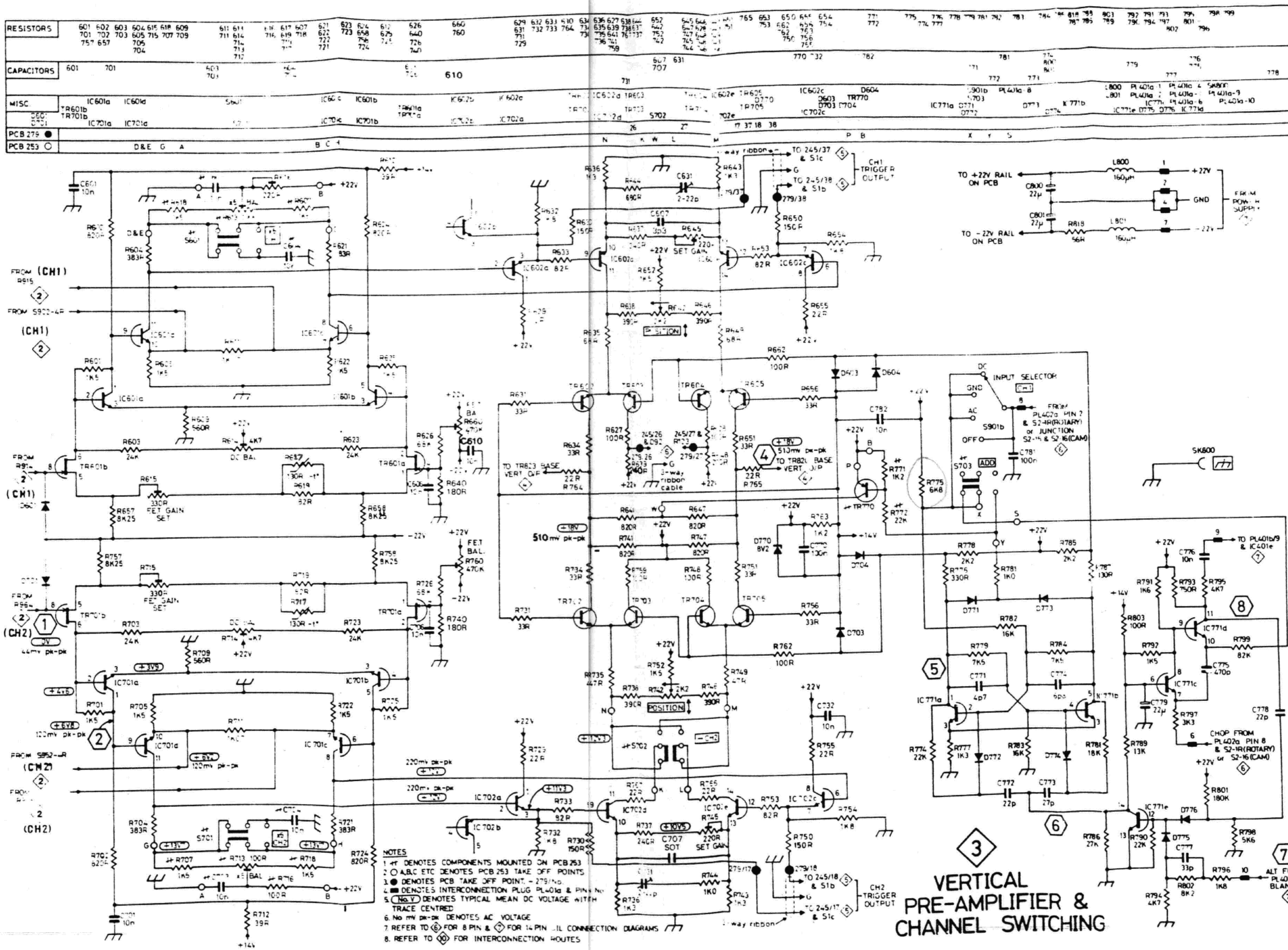
TEKTRONIX UK LTD., TELEQUIPMENT DIV., 313 CHASE ROAD, SOUTHGATE, LONDON, N14 6JJ



10 INTERCONNECTION DIAGRAM

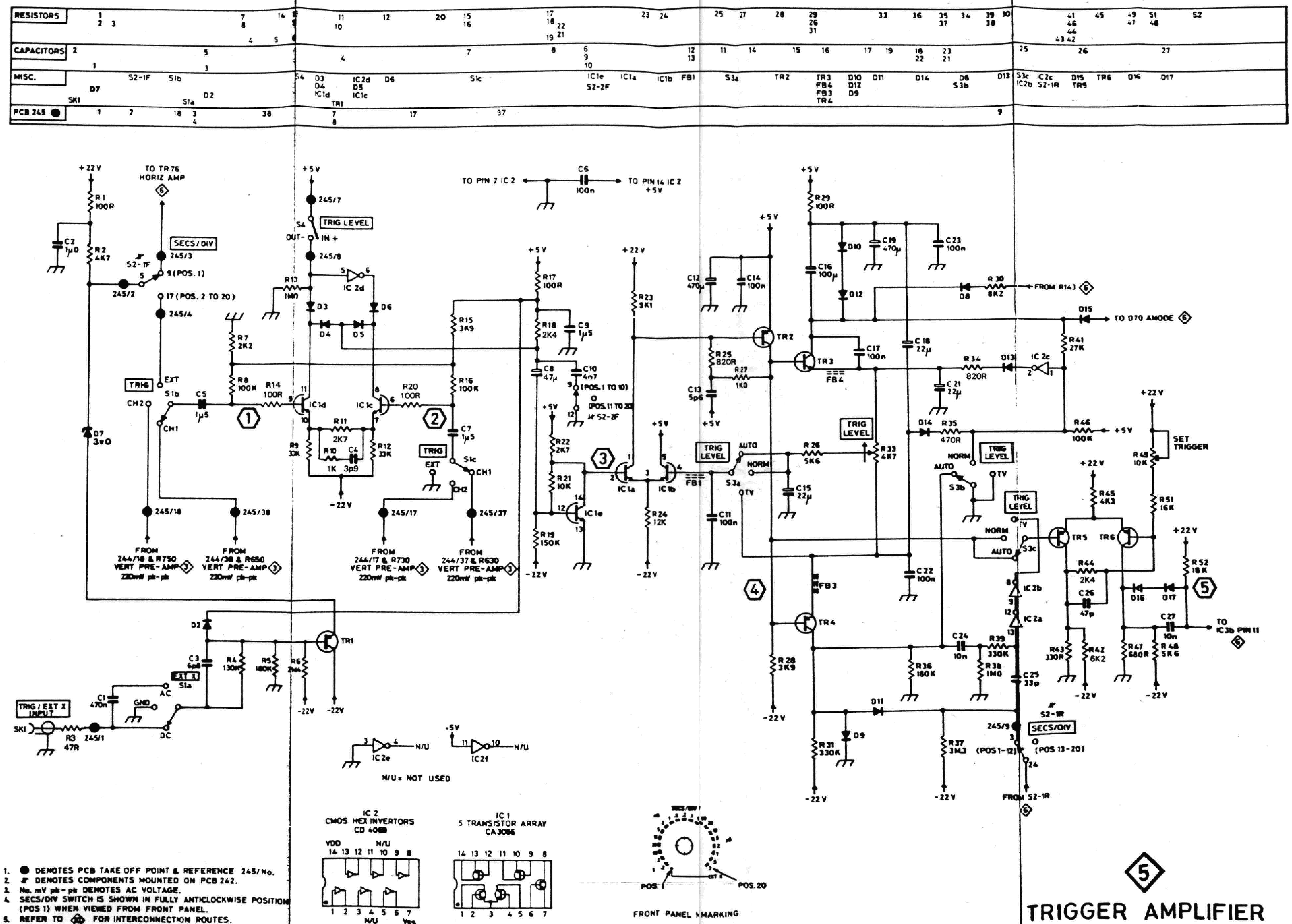
NOTES
1. N/U - NOT USED
2. N/C - NOT CONNECTED





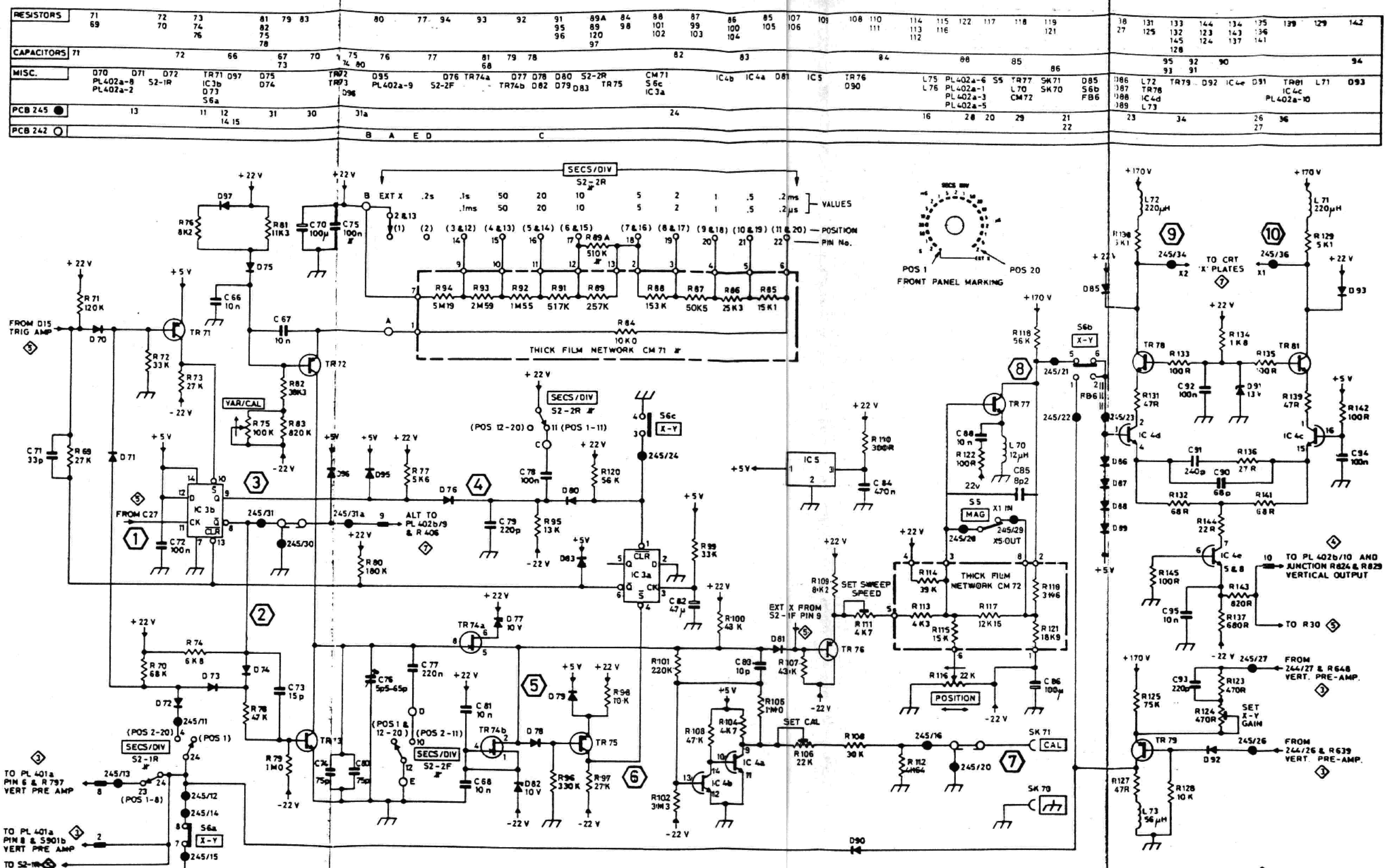
NOTES
1. ≠ DENOTES COMPONENTS MOUNTED ON PCB 253
2. O A,B,C ETC DENOTES PCB 253 TAKE OFF POINTS
3. ● DENOTES PCB TAKE OFF POINT - 279/No
4. ■ DENOTES INTERCONNECTION PLUG PL401a & PIN No
5. (No V) DENOTES TYPICAL MEAN DC VOLTAGE WITH TRACE CENTRED
6. No mV pk-pk DENOTES AC VOLTAGE
7. REFER TO (6) FOR 8 PIN & (7) FOR 14 PIN IC CONNECTION DIAGRAMS
8. REFER TO ◇ FOR INTERCONNECTION ROUTES

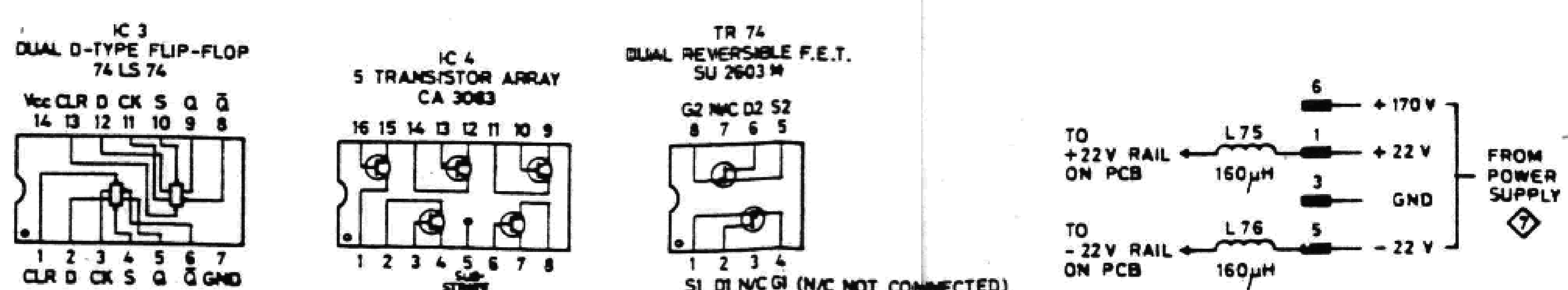
(3)
VERTICAL PRE-AMPLIFIER & CHANNEL SWITCHING



1. ● DENOTES PCB TAKE OFF POINT & REFERENCE 245/No.
2. ⫨ DENOTES COMPONENTS MOUNTED ON PCB 242.
3. No. mV pk-pk DENOTES AC VOLTAGE.
4. SECS/DIV SWITCH IS SHOWN IN FULLY ANTICLOCKWISE POSITION (POS 1) WHEN VIEWED FROM FRONT PANEL.
5. REFER TO ⑥ FOR INTERCONNECTION ROUTES.

⑤ TRIGGER AMPLIFIER



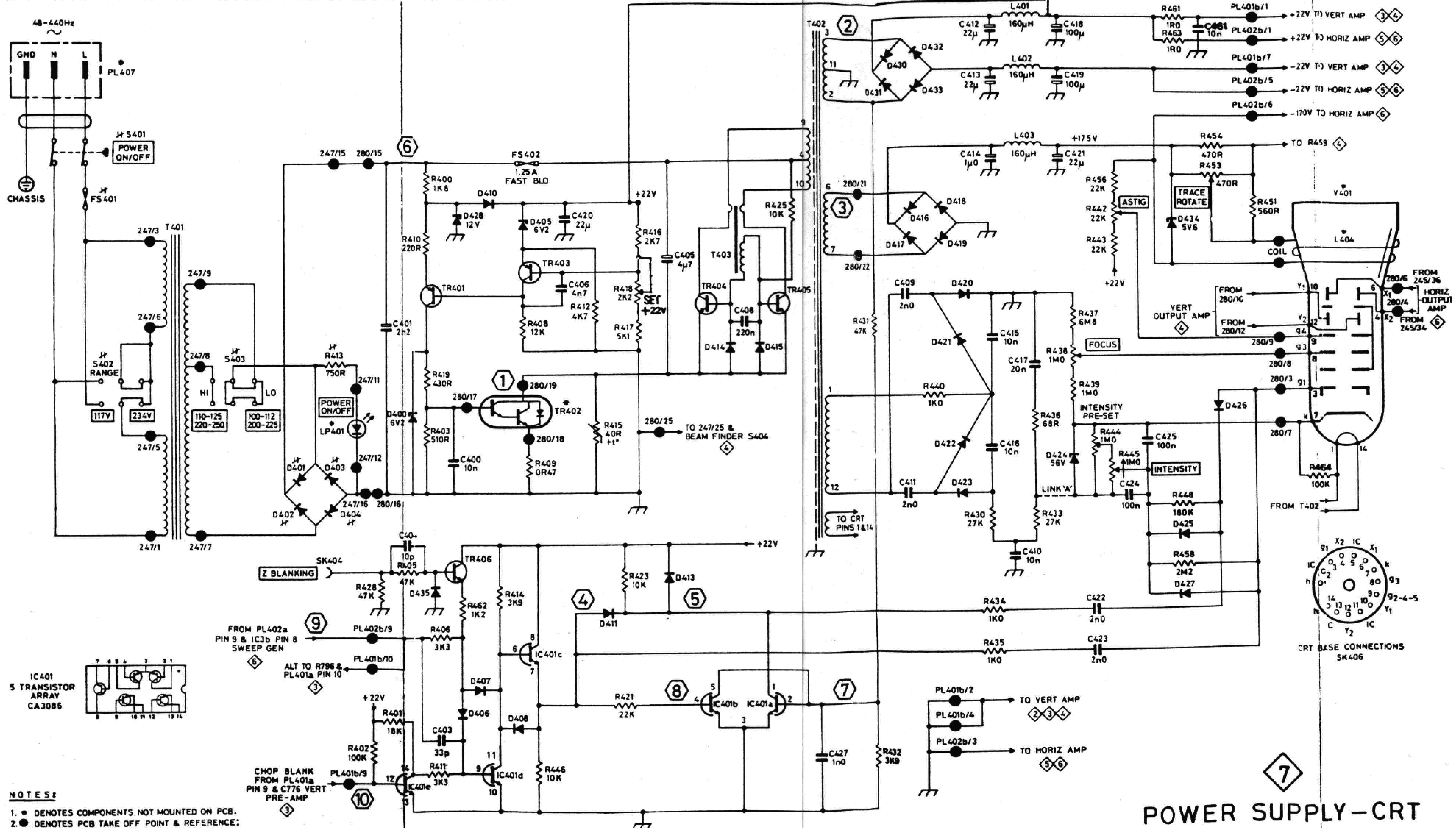


NOTES:

1. ● DENOTES PCB245 TAKE OFF POINTS & REFERENCE (245/No.).
2. ○ DENOTES PCB 242 TAKE OFF POINTS (A, B, C etc.).
3. ▬ DENOTES INTERCONNECTION SYSTEM (PLUG PL402a WITH PIN No.).
4. ⫽ DENOTES COMPONENTS MOUNTED ON PCB 242.
5. SECS/DIV SWITCH IS SHOWN IN FULLY ANTICLOCKWISE POSITION (POS 1) WHEN VIEWED FROM FRONT PANEL.
6. REFER TO ◈ FOR INTERCONNECTION ROUTES.

6 SWEEP GENERATOR HORIZONTAL AMP CALIBRATOR

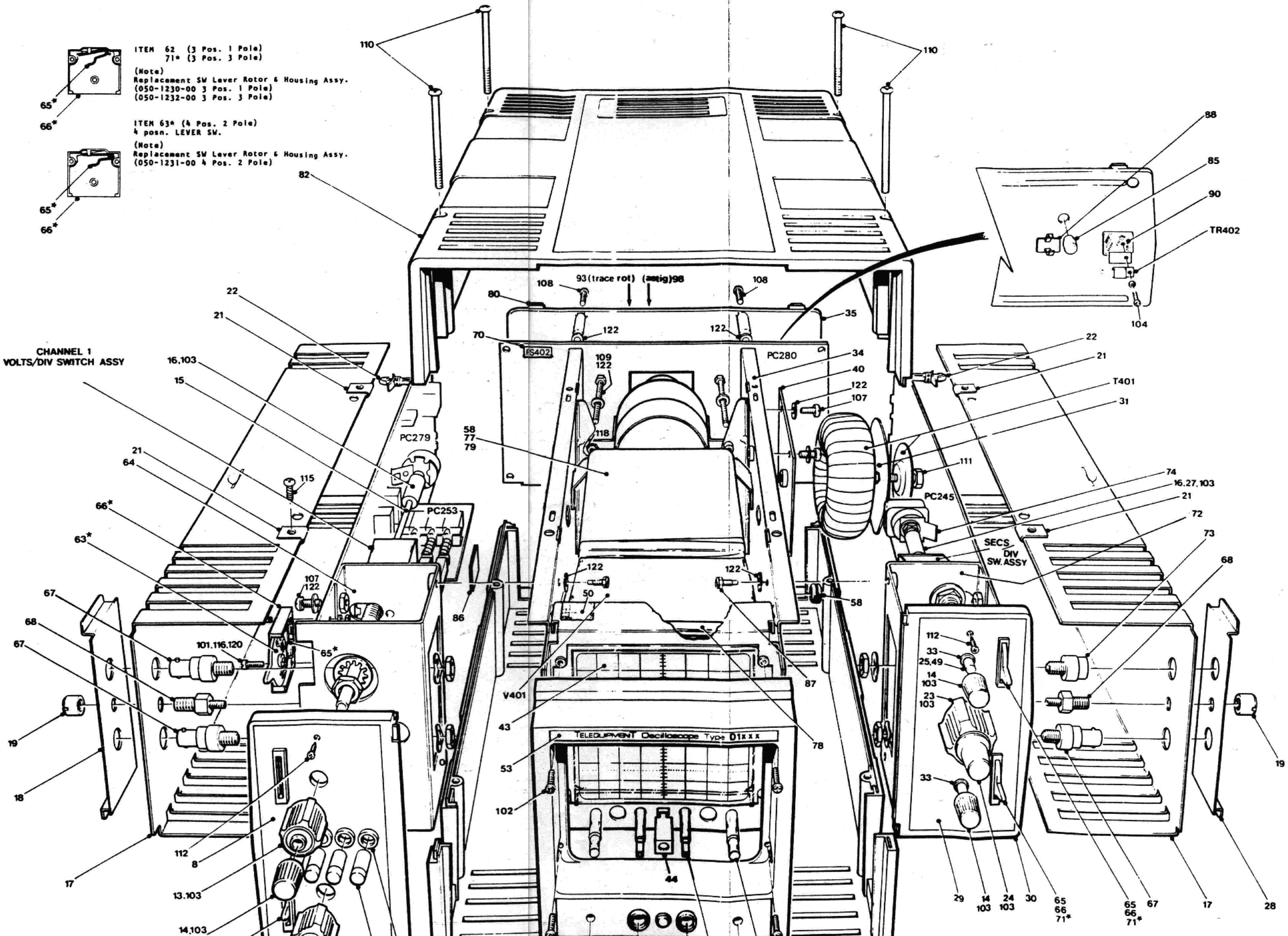
RESISTORS	413, 428 402, 401, 410 405, 400 419 403 406 411, 462, 414, 408 409 446, 412, 415, 418 417 423 421, 416, 425, 431, 432, 440, 430 434 435, 438 436 433, 437 439, 456 442 443 444, 445, 461 463 448 458, 454 453, 451, 464
CAPACITORS	401 404, 403, 400, 420 406, 405, 408, 427, 409 411, 412 413 414, 415 416, 417 410, 418 419 421, 422 423, 424, 425, 461
MISC.	FS401 S402, PL407 S401, T401, S403, D401 D402, LP401 D403 SK404 D404, D400 IC401e, D435, TR401 TR406, D428 D407 D406, D410 D408 IC401d, FS402 D405 TR403, TR402 IC401c, D411, D413, IC401b, TR403 TR404 D414, D415 IC401a, TR405, T402, D431, D430 D416 D417, D432 D433 D418, D419 D420 D421, D422 D423, L401 L402 L403, D424, D434 D425 D427, D426, V401 V404 SK406
PCB 280 ●	PL401b/9, PL402b/9 PL401b/10, 15 16, 17, 19 18, 25, 21 22, PL401b/2 PL401b/4, PL402b/3, PL401b/1 PL402b/1, PL401b/7 PL402b/5, PL402b/6, 1 4 COIL, 3 7, 6 4
PCB 247 ●	3 6 5 1, 9 8 7, 15, 11 12 16



NOTES:

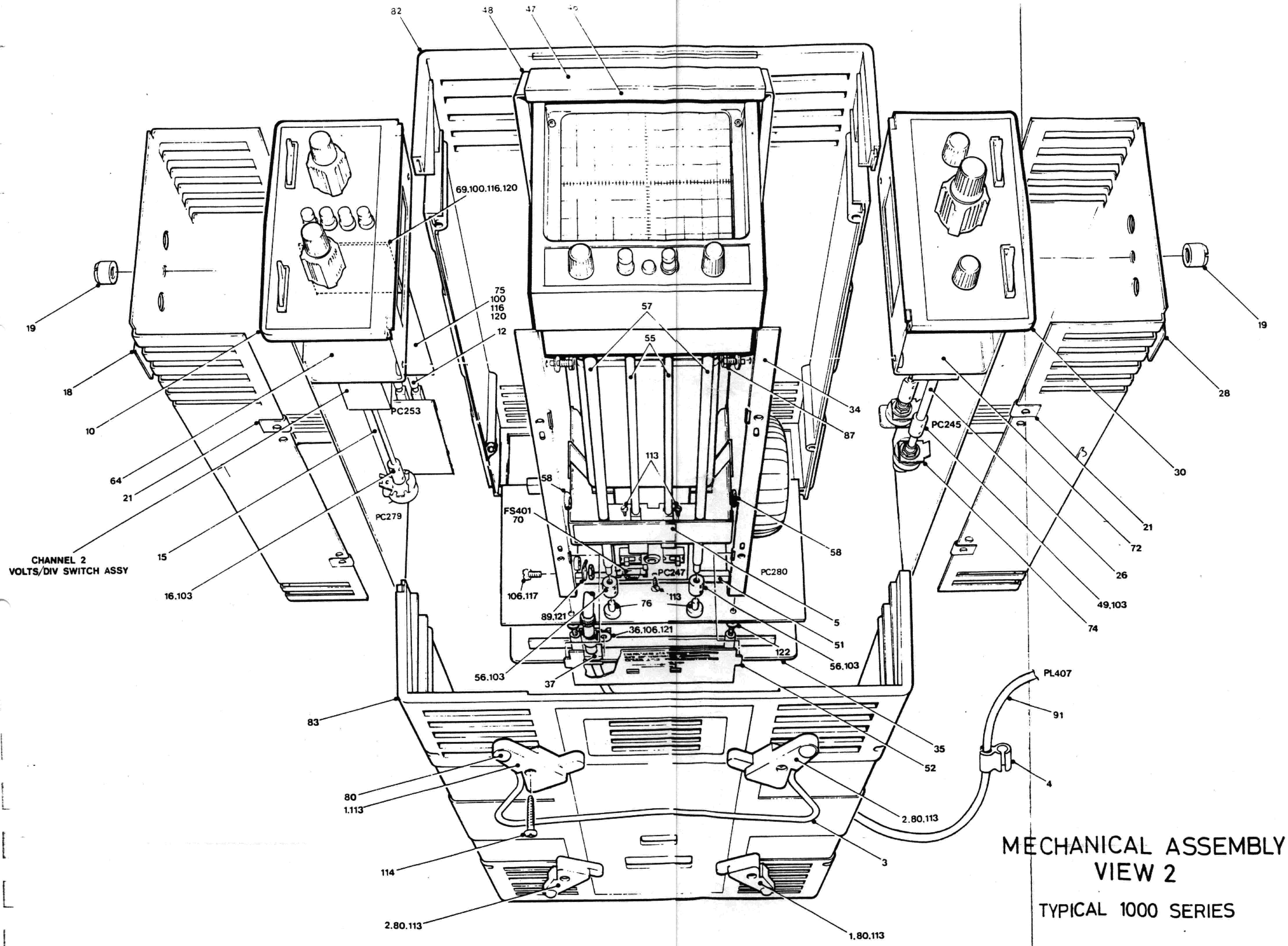
1. ● DENOTES COMPONENTS NOT MOUNTED ON PCB.
2. ● DENOTES PCB TAKE OFF POINT & REFERENCE: 280/No., 247/No., PL401b/No., PL402b/No.
3. ✱ DENOTES COMPONENTS MOUNTED ON PCB 247.
4. REFER TO ⑩ FOR INTERCONNECTION ROUTES.

⑦ POWER SUPPLY—CRT & BLANKING



MECHANICAL ASSEMBLY
VIEW 1
TYPICAL 1000 SERIES

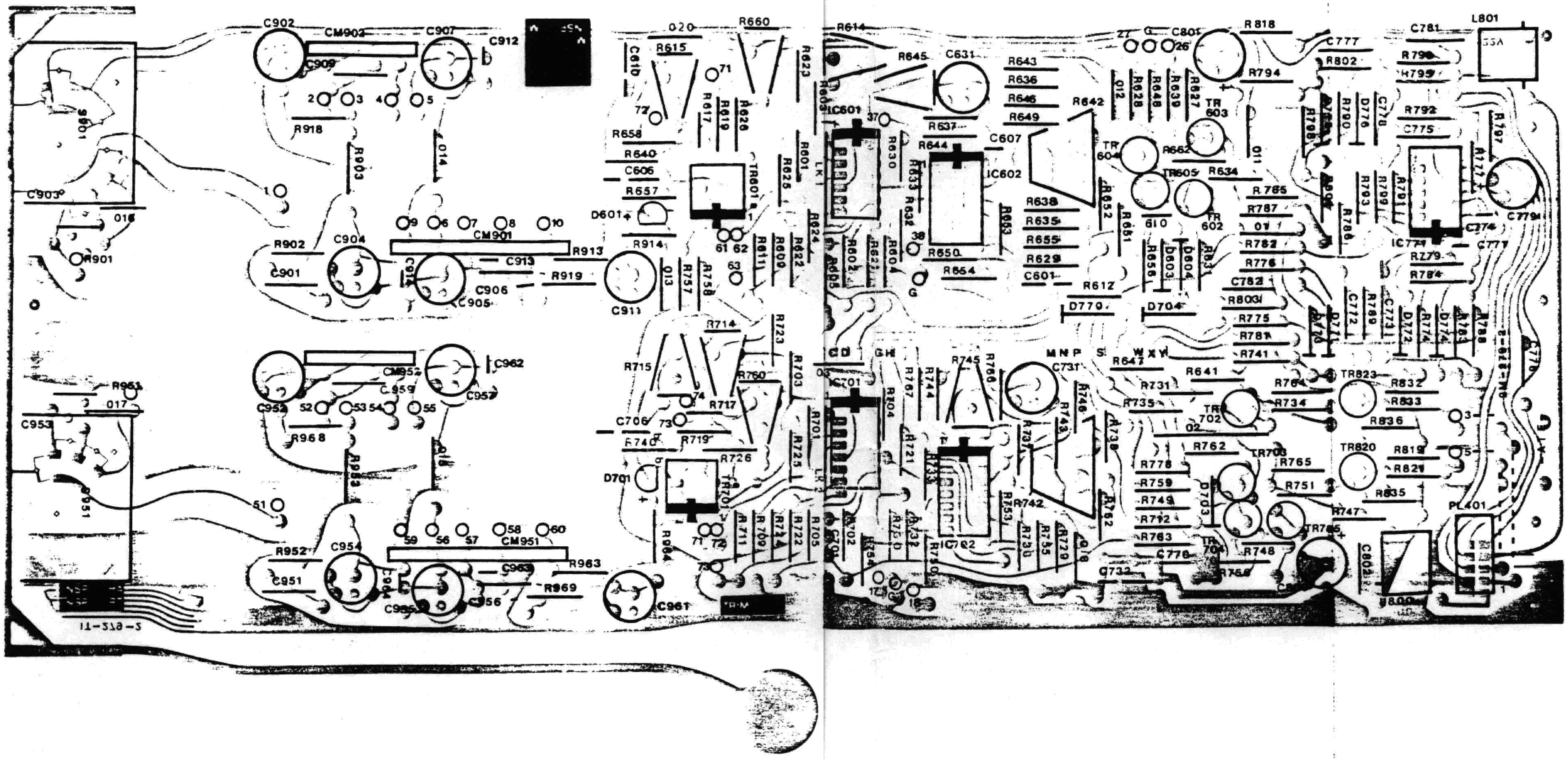
REV Cm



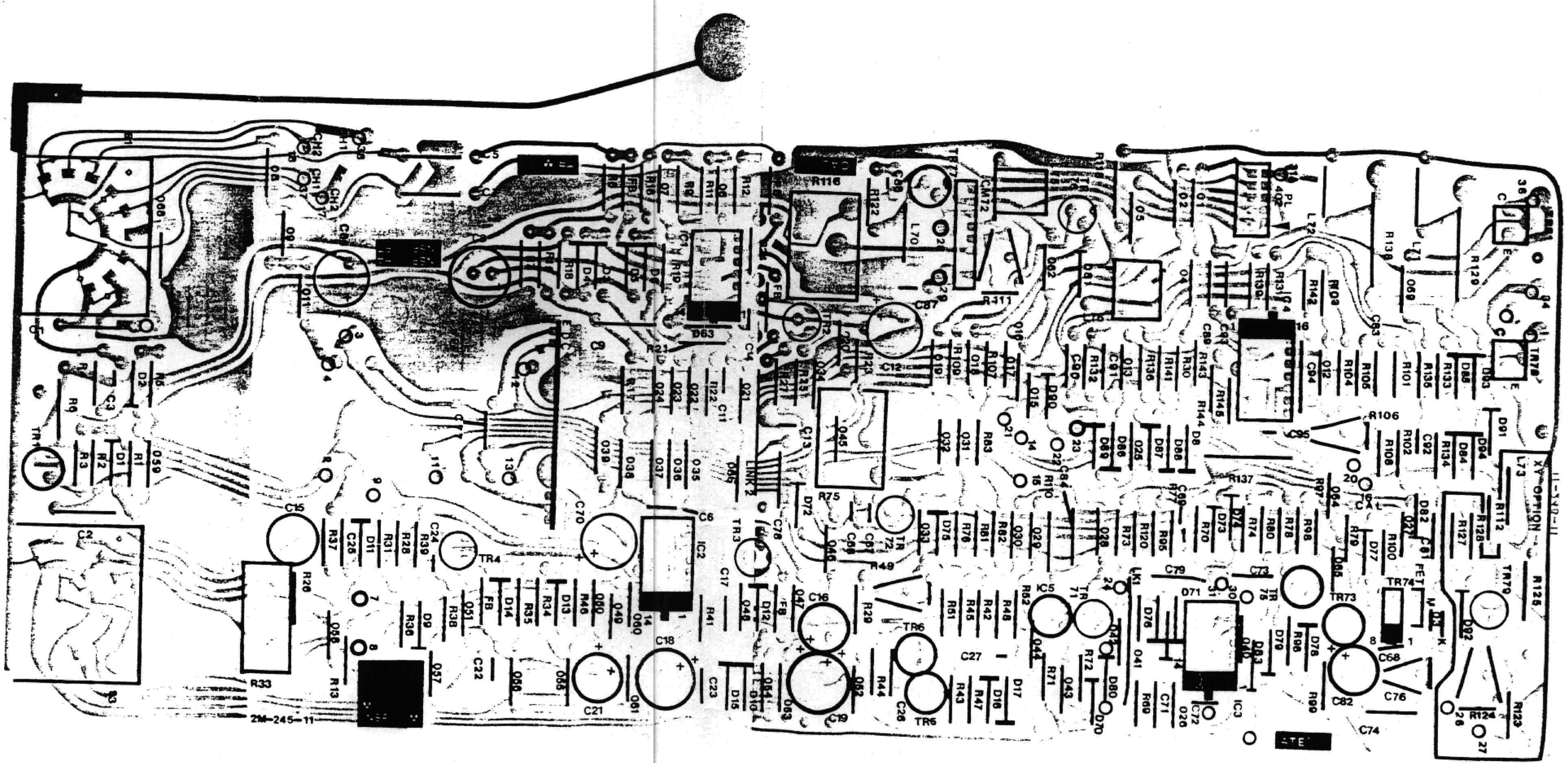
MECHANICAL ASSEMBLY
VIEW 2

TYPICAL 1000 SERIES

REV Cm



PC 279


2M-245-11
X-Y OPTION
LINK 2
R116
R33
C15
TR4
C18
C21
C19
TR6
TR5
C16
IC5
IC3
IC2
TR73
TR74
TR70
C82
C76
C74
R124
R123
R106
R137
C27
D63

PC 245