

INSTRUMENT SERIAL NUMBER

706458



®

DANGER

It is not possible to screen all high voltages, so care should be taken not to touch high voltage tags. Also where possible the instrument should be unplugged AND switched off during servicing. A BLEEDER PATH FOR THE EHT IS NOT PROVIDED, so after switching off and before touching any internal parts, the EHT should be discharged by temporarily shorting the appropriate points to chassis, (for instance the CRT cathode pin and PDA connector where applicable).



FOR SERVICING AND SPARES ENQUIRIES
SEE THE INFORMATION AT START OF SECTION 5.

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OSCILLOSCOPE TYPE D67A

INSTRUCTION MANUAL

INTRODUCTION

The D67A is a 25 MHz, all solid state dual-trace oscilloscope. An 8 x 10 cm mesh 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 150 kHz rate. The delayed sweep feature permits close examination of any part of a complex waveform and allows for an accurate time measurement of the input waveform. The solid state design, using FET input circuitry, provides minimum drift and fast stabilization time.

The D67A is subject to continuous development and improvement and may therefore incorporate minor changes. These changes which usually affect the Components Lists and Circuit Diagrams are described on Amendment Lists issued at regular intervals and are located in the pocket inside the back cover.

In addition to the standard instrument, variations known as Options are available and are listed in Section 7 of this manual.

WARNING

DO NOT ALLOW A BRIGHT STATIONARY SPOT TO REMAIN DISPLAYED ON THE SCREEN FOR LONG PERIODS, FOR EXAMPLE, WHEN THERE IS NO SIGNAL IN THE TRIGGERED CONDITION, OTHERWISE THE CRT PHOSPHOR COULD BE DAMAGED.

NOTICE TO OWNER

If it is necessary to return this instrument to TEKTRONIX for servicing attention should be paid to the following points. To obviate the risk of damage during transit and to facilitate packaging, the owner is requested to remove the power supply cable and NOT to send the following items unless they are suspect.

Manual

Probes

Power Supply Lead

Plug Assemblies

SECTION 1

SPECIFICATION

Although the D67A is functional a few seconds after switching on, a period of approximately 20 minutes should be allowed before checking to full specification.

1.1 DISPLAY

1.1.1	CATHODE RAY TUBE (CRT)	Rectangular flat faced, single gun C.R.T. with mesh PDA
	Display area	10 x 8 divisions
	Phosphor	P31 (standard), P7 or P11
	Overall accelerating potential	10 kV approximately

1.1.2 EXTERNAL INTENSITY MODULATION

Coupling	AC to cathode
Amplitude, Peak to Peak	25 V maximum
Time constant	20µs

1.2 VERTICAL AMPLIFIER

1.2.1	DISPLAY MODE	Channel 1 Channel 2 (normal or inverted) Channels 1 and 2 Added Alternate Chopped at 150 kHz approx.
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1.2.2	BANDWIDTH (3db)	X1 GAIN	X10 GAIN
	DC Coupled	DC -- 25 MHZ	DC -- 15 MHZ
	AC Coupled	2 Hz -- 25 MHZ	2 Hz -- 15 MHZ
1.2.3	RISETIME	14 ns nominal	23 ns nominal

1.2.4 VERTICAL DEFLECTION

Calibrated -- accuracy ±3%	12 ranges (1-2-5 sequence)
X1	10 mV/div -- 50 V/div
X10	1 mV/div 5 V/div
Uncalibrated with variable	Complete cover between steps and to 125 V/div or greater
Signal delay	200 ns.

1.2.5	INPUT IMPEDANCE	1 MΩ shunted by 39 pF approximately
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1.2.6	MAXIMUM INPUT VOLTAGE	400 V peak
	DC, AC or sum of	

DISPLAY MODES There are four horizontal display modes selected by the row of four push buttons on the extreme right hand side of the instrument front panel. With **A ONLY** selected the A sweep is operative and the B sweep disabled. When **A INT** is selected that part of the A sweep covered by the B sweep is intensified. The intensified portion may be adjusted with the **B TIME/DIV**, **VARIABLE** and **DELAY** controls to show the portion of the display that will be expanded when the **B DEL** button is depressed. With the **B DEL** button in, the B sweep is displayed and it should always be selected to be faster than the A sweep. When **MIX** is selected a mixed sweep viewing mode is displayed. The first part of the trace is at the A sweep speed and the rest of the trace is at B sweep speed.

position. If a dual trace display is required on **EXT X**, the vertical display mode must be set to **CHOP**, the **ALT** and **ADD** modes will provide only one trace.

SAWTOOTH OUT

provides a positive-going ramp waveform when the A sweep is running. A recurrent sawtooth is produced when **VARIABLE A** is pulled out for the sweep generator to free-run. The resistance of an applied load should exceed 30 kΩ to avoid over-loading the sweep generator.

INPUT BNC

connectors are linked to the vertical channel attenuators via the **DC-GND-AC** switches; a capacitor is inserted in series in the **AC** position. When the switch is set to **GND**, the inner of the connector is open-circuited and the attenuator shorted to chassis.

2.3 INPUT AND OUTPUT CONNECTORS

Z MOD at the rear of the instrument, is connected via an isolating capacitor to the CRT cathode. A negative-going signal is thus necessary to intensity the trace while a positive-going signal will blank it.

EXT the BNC connectors in the sweep section of the front panel enable external triggering signals to be applied to the timebases when the lowest **TRIG MODE** buttons are out.

GATE OUT Provides fast-edged negative-going rectangular pulses lasting for the duration of the A or B sweeps. In the **A ONLY** mode, the pulse duration is that of the A sweep. In the **A INT** and **B DEL** mode, the duration is that of the B sweep.

PROBE ADJUST FACILITY The A sweep gate signal may be used as an alternative to a 1 kHz square-wave for compensating X10 probes. Connect the probe to the required channel **INPUT** socket, set **VOLTS/DIV** to 100 mV, **VARIABLE** fully clockwise, **INPUT** to **AC**, **TIME/DIV A** to 1 ms, **VARIABLE A** pulled out and display to **A ONLY**. Apply the probe tip to the **GATE OUT** socket. Adjust the probe trimmer for a square corner on the leading negative edge of the display.

The TP2 which is recommended for this instrument is a miniature passive probe where the probe trimmer is adjusted through a hole in the probe body.

If a 1 kHz squarewave is used, the amplitude should be about 500 mV and a few cycles of the waveform should be displayed.

CAL socket provides a waveform for checking the calibration of the vertical channels. The repetition rate is at supply frequency.

GND is connected to the chassis of the instrument.

EXT X is d.c. coupled to the horizontal amplifier in the **EXT X** position of the **TIME/DIV A** switch. A X5 amplification of the horizontal display is obtained by pulling out **FINE**

2.4 FIRST TIME OPERATION

2.4.1 SETTING THE CONTROLS

Set the controls as follows:

CRT CONTROLS

INTENSITY Fully anti-clockwise
POWER OFF

FOCUS Central
ASTIG (at rear) Central

TRACE ROTATION (at rear) As set
SCALE ILLUM. (at rear) As set

VERTICAL DISPLAY CH1 AND CH2 CONTROLS

OFF - ON ON
INT. TRIG 1
CHOP - ALT - ADD CHOP
POSITION Central
INVERT - NORMAL NORMAL
VOLTS/DIV 0.2 V/DIV
VARIABLE Fully clockwise (out)
DC-GND-AC GND

MAIN SWEEP A CONTROLS

TIME/DIV 5 ms
VARIABLE Fully clockwise and pulled out
TRIG (level) Fully anti-clockwise - AUTO
TRIG MODE AC, + and INT
SINGLE SHOT REP.

HORIZONTAL DISPLAY CONTROLS

POSITION Central
FINE Central and pushed in
DISPLAY A ONLY

DELAYED SWEEP B CONTROLS

TIME/DIV 0.5 ms/div
VARIABLE Fully clockwise and pulled out
TRIG (level) Fully anti-clockwise - AUTO
TRIG MODE + and INT
DELAY 5 - outer dial (in window)
0 - inner dial

2.4.2 SWITCH ON

1. The mains cable should be fitted to the instrument. See paragraph 2.1.4.
2. The voltage selector should be checked for correct setting and the mains fuse checked for correct rating. See paragraphs 2.1.2 and 2.1.3.
3. Plug the mains cable into the supply.
4. Switch on by turning the **INTENSITY** control clockwise.
5. Allow a short while for a trace to appear.

NOTE

Although at this stage the instrument is fully operational a period of 20 minutes should be allowed to elapse before

To obtain X10 again the VARIable control should be pushed in. A further push on this control releases the switch and the gain reverts to X1.

DC-GND-AC selects the input coupling. In the DC position the signal from the INPUT socket is connected directly to the attenuator, whilst a capacitor is connected in series in the AC position. In the GND position, the input signal is disconnected and the input to the attenuator is grounded. This enables a zero d.c. level to be obtained which can be used as a reference.

2.2.3 INT TRIG

Buttons select the source of trigger signal; from either or both channels. When alternately triggering from the two channels the INT TRIG buttons should be released to the out position. This facility should not be used in the chop mode. When operating this way the traces should be partially superimposed.

2.2.4 MAIN SWEEP A CONTROLS

TIME/DIV controls the speed of the main sweep. The sweep rates indicated are only valid if VARIable is fully clockwise and fine position is pushed in for x1 gain. If fine position is pulled out and VARIable is at CAL, the calibrations should be divided by a factor of 5 to ascertain the sweep speed. In all the intensified, mixed and delayed settings of the display buttons, the TIME/DIV A control should be set to a slower speed than TIME/DIV B.

VARIable enables speeds between that indicated by TIME/DIV and the next lower speed to be selected. The control also selects free-running or triggered operation of the main sweep. The free-running position is useful for trace location, irrespective of trigger control settings, and for providing a repetitive sawtooth from the SAWTOOTH OUT socket to drive other equipment.

TRIG (level) selects the point on the signal waveform at which the A sweep starts. In the AUTO position, the sweep runs recurrently at a low repetition rate in the absence of a triggering signal; when a suitable signal is applied, the sweep is automatically triggered at the mean level of the input waveform.

TRIG MODE INT and EXT enable the A sweep to be triggered either internally, from the vertical amplifier, or externally.

TRIG SLOPE + and - provide a triggering facility from the positive going or negative going slopes of a waveform.

H.F. REJECT With an attenuator setting of 1mV/division and/or operating in the Chop mode the HF REJ button should be depressed if the frequency of an input signal is 10 KHz or less.

TV TRIG When TV is selected the trigger circuit acts as a sync separator to give field sync for sweep ranges 2s/div to 0.1ms/div and line sync for sweep ranges 50 μs/div to 0.2 μs/div.

SINGLE SHOT assists in viewing or photographing a non-recurrent signal. If a recurrent signal is applied to the oscilloscope, in the single-shot condition, the sweep will run once each time RESET is pressed.

2.2.5 DELAYED SWEEP B CONTROLS

TIME/DIV controls the speed of the delayed sweep. The sweep speeds indicated are only valid if VARIable B is fully clockwise and fine position is pushed in for X1 horizontal gain. If fine position is pulled out and VARIable is at CAL, the calibration should be divided by 5 to give the effective sweep speed. In the A INT by B, MIX and B DEL display modes the delayed sweep should always be set faster than the main sweep.

VARIable enables speeds between that indicated by the TIME/DIV switch and the next lower speed to be selected. The control also selects gated or ungated operation of the delayed sweep. In gated operation, the B sweep will start only after receipt of a suitable triggering signal, whereas in the ungated mode, the B sweep will start at any point on the A sweep as selected by the DELAY control. For minimum delay jitter, the gated mode should be used in preference to the ungated. When ungated, the INT/EXT B trigger selector should be set EXT to reduce any possibility of fast trigger pulses trying to gate the sweep.

TRIG (level) is only operative in the gated condition of the delayed sweep; the control selects the point on the triggering signal at which the sweep will start. In the AUTO position, the sweep will start at the mean level of the triggering waveform.
TRIG MODE buttons are only operative in the gated condition of the B sweep.

the polarity button is used in conjunction with LEVEL to determine the starting point of the B sweep.

INT-EXT button enables internal triggering, from the vertical amplifier, or external triggering. Unless a suitable external signal is applied when the button is at EXT, no B sweep will occur in the B DEL or A INT display modes, in the gated condition.

DELAY varies the point on the A sweep at which the B sweep starts. The dial markings serve as a reference for the control setting but do not indicate any particular value of delay time. With ungated operation of the B sweep DELAY continuously varies the start of the delayed sweep with reference to the main sweep, while with gated operation the start of the delayed sweep moves in a succession of jumps to the same point on the adjacent cycle of a repetitive waveform.

2.2.6 HORIZONTAL DISPLAY CONTROLS

POSITION ← → varies the location of the trace(s) in the horizontal axis.

FINE acts as a more sensitive position control as well as the X5 horizontal gain switch. When pulled out in the X5 position, all sweep speed calibrations must be divided by 5.

1.3 HORIZONTAL DEFLECTION

1.3.1 SWEEP GENERATOR

Display modes	A A intensified by B A and B mixed B delayed by A Single shot
Sweep rates (A and B sweeps)	
Calibrated	22 ranges (1-2-5 sequence)
X1	2 s/div --- 200 ns/div ±3%
X5	400 ms/div --- 40 ns/div ±5%
Uncalibrated with variable	Complete cover between steps and to 5s/div or greater

1.3.2 EXTERNAL HORIZONTAL AMPLIFIER

Bandwidth (±3db)	DC --- 1 MHz
Risetime	350 ns nominal
Deflection factor	3 V/div approximately
With X5 expansion	600 mV/div approximately
Maximum input (peak)	400 V
Input impedance	1 mΩ shunted by 30 pF.

1.4 TRIGGER A

1.4.1 INTERNAL

Source	CH1, CH2 or alternate
AC automatic	50 Hz --- 25 MHz
AC level	10 Hz --- 25 MHz
TV	TV field for sweep ranges 2 s/div to 0.1 ms/div TV line for sweep ranges 50μs/div to 0.2μs/div TV field or line is selected automatically by the setting of the Time/div switch

1.4.2 HF REJECT

Auto	50 Hz --- 50 kHz
Level	10 Hz --- 50 kHz

1.4.3 SENSITIVITY

≤ 15 MHz	0.2 divisions (0.5 div on X10 Gain)
25 MHz	1 division

1.4.4 EXTERNAL

Coupling	AC
Amplitude	250 mV to ±15 V at above frequencies
Impedance	100 kΩ shunted by 30 pF

1.5 TRIGGER B**1.5.1 INTERNAL**

Source	CH1, CH2 or alternate
AC Automatic	50 Hz – 5 MHz approximately
AC Level	10 Hz – 5 MHz approximately

1.5.2 SENSITIVITY

0.5 divisions

1.5.3 EXTERNAL

Coupling	AC
Amplitude	250 mV to ± 15 V at above frequencies
Impedance	100 k Ω shunted by 30 pF

1.6 FRONT PANEL OUTPUTS**1.6.1 CALIBRATOR, Peak to Peak**

500 mV square wave at supply frequency

Accuracy 2%

1.6.2 A SWEEP SAWTOOTH

Coupling	DC
Amplitude, peak	36 V approximately
Minimum load	30 k Ω

1.6.3 GATE OUT

Duration of A or B sweep	Depending on horizontal mode selected
Coupling	DC
Amplitude, peak	5 V approximately

1.7 GENERAL**1.7.1 POWER REQUIREMENTS**

Voltage	100 – 125 V in 5 V steps 200 – 250 V in 10 V steps
Frequency	48 Hz – 400 Hz
Consumption	50 VA approximately

1.7.2 SIZE

Height	24 cm.
Width	21 cm.
Depth	44 cm.

1.7.3 WEIGHT

11.5 kgm

1.7.4 COOLING

Convection

1.7.5 TEMPERATURE RANGE (AMBIENT)

Operational	0°C to + 40°C
Storage	0°C to + 70°C

1.8 STANDARD ACCESSORIES SUPPLIED WITH THE INSTRUMENT

ACCESSORY	QUANTITY	PART NUMBER
Manual	1	070-1989-00
Power Cord (U.K.)	1	161-0085-02

1.9 ACCESSORIES AVAILABLE AS EXTRAS

ACCESSORY	PART NUMBER (for ordering)
Cover Front Protection	016-0341-00
Probe type TP1 (X1 attenuator)	010-0291-00
Probe type TP2 (X10 attenuator)	
Approx. 1.5 metres cable	010-0292-00
Approx. 1.8 metres cable	010-0292-02
Approx. 3.0 metres cable	010-0292-03
Probe type TP5 (X1-X10 attenuator)	010-0295-00
Approx. 1.2 metres cable	

IMPORTANT NOTICE

It is recommended that the specification limits of this instrument be checked periodically according to the Calibration Procedure, as temperature humidity, and long-term ageing could affect the measurement accuracy. This is particularly important before making critical measurements.

SECTION 2

OPERATING INSTRUCTIONS

2.1 PRE OPERATIONAL CHECK

2.1.1 GENERAL

Although this instrument is robust and is subjected to stringent checks before leaving our factory, it should be checked externally for possible damage. In the case of damage contact the carriers and your local Tektronix field office immediately.

Before switching the instrument on it is recommended that this section of the manual is read right through and that some time be spent in becoming familiar with the controls. Experienced oscilloscope users will find the instructions in paragraph 2.4.2 rather laborious and it is left to the individual user to decide what to omit reading.

The D67A relies on convection cooling and care should be taken to see that external air circulation is not restricted.

2.1.2 SUPPLY VOLTAGE ADJUSTMENT

Before operating the instrument it is necessary to adjust for the available a.c. mains supply by means of the voltage selector plug, on the rear panel. Provision is made for selecting 100V, 105V, 110V, 115V, 120V, 125V, 200V, 210V, 220V, 230V, 240V and 250V. The arrow on the selector plug points to the voltage selected.

2.1.3 MAINS FUSE

The fuse holder is situated on the rear panel and before operating the instrument a check should be made to see that the correct fuse is fitted. For operating voltages of 100V to 125V a 500mA fuse should be used and for 200V to 250V operation a 250mA fuse should be fitted.

2.1.4 MAINS CABLE (OR POWER CORD)

One of the two types of mains cable will be supplied with the instrument. For the American continent a lead with a moulded three pin plug will be supplied.

For the rest of the world the three core lead has short tails left for connecting to a plug top suitable for connection to the local supply system. The cores of this cable are colour coded as follows:

Line..... Brown
 Neutral..... Blue
 Earth 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.

Both types of mains cable have a moulded socket at one end which should be mated with the plug on the rear of the instrument and SECURED USING THE SCREWS AND NUTS PROVIDED.

2.2 OPERATION OF CONTROLS

2.2.1 CRT CONTROLS

INTENSITY varies the display intensity. An instrument ON/OFF switch is fitted to this control. In the A INT display mode, the portion of the display swept by B sweep is at the same intensity as in the A only condition, the remainder is slightly dimmed, reference Fig. 7.

FOCUS controls the display definition

ASTIG (on the rear panel) is used in conjunction with FOCUS for best overall definition.


TRACE ROT'N (on the rear panel) rotates the traces with respect to the horizontal axis of the CRT and is used to align the traces with the horizontal graticule divisions.

SCALE ILLUM (on the rear panel) varies the intensity of the graticule illumination.

2.2.2 VERTICAL (CH1 AND CH2)

ON-OFF with the button in the 'in' position the channel is switched on. With both channels switched off (both buttons out), a straight-line trace results which cannot be shifted by either POSITION control.

CHOP-ALT-ADD provides three display modes for the vertical channels. In the CHOPped mode, the channels are alternately switched on and off at a frequency of about 150 kHz. This mode is suitable at lower sweep speeds. With ALTERNate trace display selected, each channel is on alternately for the duration of a sweep. The alternate mode is preferable at higher sweep speeds. With both buttons released to the out position the ADD mode is selected and the signals on both channels are displayed additively. In this mode the CH1 POSITION control is used to shift the trace, the CH2 control being disabled. When in the ADD mode if the INVERT button is depressed the resultant display is the difference between the two input signals.

POSITION  is used to move the trace in the Y or vertical direction when the appropriate channel is ON. In the ADD mode only the CH1 POSITION control is operative.

INVERT-NORMAL the setting of this button determines whether the CH2 signal is displayed in the same polarity as the CH1 input signal or inverted. In the ADD mode the inverted setting is used to display the difference between two signals.

VOLTS/DIV switch provides twelve calibrated steps of attenuation, to the input signal provided that the VARIABLE control is in the fully clockwise (Cal) position.

VARIABLE enables attenuation settings between that selected by the VOLTS/DIV switch and the next lower setting to be achieved. When the control is in the fully clockwise position the sensitivity of the display is as per the setting of the VOLTS/DIV switch.

checking to full specification or making accurate measurements.

6. Adjust the INTENSITY control so that the traces are at a suitable viewing intensity.
7. Adjust the FOCUS control for the sharpest obtainable trace.
8. Centralize the trace using the X and Y POSITION controls.
9. Adjust TRACE ROTATION if necessary to make the traces horizontal.
10. Connect the 500 mV Calibration signal from the CAL socket to the input sockets. It will be necessary to construct a suitable lead using coax cable, BNC plugs for connecting to the input sockets and a 4 mm. plug for the CAL socket.
11. Switch the DC-GND-AC switches to DC.
12. Push in sweep A VARIABLE to lock the display.
13. If the instrument is used on a 50 Hz supply the resulting display should be 2.5 cycles of the calibrated waveform.
14. Re-adjust the INTENSITY, FOCUS and ASTIG if necessary to obtain a uniformly sharp display.
15. Observe that movement of the Y position controls move the traces up and down in a vertical direction and movement of the X position control moves the display in a horizontal direction.
16. Set the lower edge of one of the traces to one of the lower graticule lines using the Y position control.
17. Observe that the trace occupies 2.5 vertical graticule divisions.
18. Re-set the VOLTS/DIV switch of the channel being observed to 0.1 V/DIV.
19. Observe that the trace should now occupy 5 divisions.
20. Further clockwise movement of the VOLTS/DIV switch increases the display size whilst anti-clock-

wise movement reduces the display size. Re-set the control to 0.2 V/DIV

21. Set A TIME/DIV to 2 ms/DIV observe that the display is now of only one cycle duration. Set the controls back to 5 ms/div.

2.4.3 OPERATION OF THE ALTERNATIVE HORIZONTAL DISPLAY MODES

To illustrate the operation of the alternative horizontal display modes continue as follows:

1. Push in A INT.
2. Adjust INTENSITY to intensify 1 division of the trace(s) in relation to remainder.
3. Rotate DELAY for continuous movement of the intensified portion.
4. Push in MIX, observe that display consists of a portion of trace at the A sweep rate followed by the portion of the trace previously intensified, which is at the B sweep rate.
5. Push in B DEL and observe that the display consists of the portion intensified in (3) above.
6. Push in A INT.
7. Push in B Variable.
8. Rotate DELAY, observe that the intensified portion jumps to the same point on each half cycle.
9. Depress A ONLY.
10. Rotate LEVEL A for a stable trace.
11. Disconnect CAL from inputs 1 and 2.
12. Push in SINGLE SHOT.
13. Press RESET, observe adjacent neon comes on.
14. Connect CAL to input 1, observe that timebase runs once and neon extinguishes. This simulates a random phenomenon of a single shot display.

SECTION 3 CIRCUIT DESCRIPTION

3.1 GENERAL

This section will assist the reader to comprehend the circuitry of the D67A. By referring to the block diagram, Figure 1, the reader will see the interfaces of the various networks and signal paths, which will be dealt with in detail later.

The signal is fed via the attenuator to the vertical amplifier. The vertical amplifier description covers the function of the 'Y' input, channels 1 and 2, delay line driver and output amplifiers, and trigger pre-amplifier. A detailed description of the channel switching is given. The output is fed to the 'Y' plates of the CRT with a portion of it being fed to the trigger network.

The description of the trigger network covers both triggers 'A' and 'B', which provides pulses of suitable amplitude and polarity to trigger the timebase from internally or externally derived waveforms.

The timebase description deals with the ALT pulse and sweep generators, single shot and hold-off, sweep gating and delay bistables. This stage determines the start and finish of each sweep and generates a sawtooth waveform for the horizontal amplifier.

The horizontal amplifier covers the 'X' output, which amplifies the sawtooth waveform or an external 'X' signal and applies it in push-pull to the 'X' plates of the CRT.

The unblanking amplifier covers the chop blanking amplifier, and trace unblanking amplifier, the output being fed to the grid of the CRT.

The calibrator is included with the description of the power supplies, its function is to provide a calibrated peak to peak squarewave at power-line frequency for the purposes of checking the vertical amplifier and timebase calibration.

3.2 CH1 AND CH2 ATTENUATORS

The signals to be observed are fed to the instrument via BNC socket and switch S901, reference Figure 2, to two identical attenuators each comprising five frequency-compensated resistive dividers with ratios of 1000:1, 100:1, 10:1, 5:1, 2:1. These are switched, singly or in tandem, C902, C903, C904, C912 and C913 serve to standardize the input time constants, C905, C906, C907, C914 and C916 compensate the respective dividers.

3.3 VERTICAL AMPLIFIER

3.3.1 The circuits of channel 1 and channel 2 are identical; channel 1 is described below with reference to Figure 3.

The output from the attenuator is fed, via a protection circuit C601, C602, R602a, R602b, R601 and R603, to the gate of TR601. The protection circuit prevents excessive voltage damaging the input FET.

TR601 and TR602 form a paraphase amplifier with their sources long-tailed through TR628. R624 provides variable gain control.

Compensation is provided by R625 for trace movement caused by varying R624. Neutralization is effected by C604.

The output from the FET input stage is taken via emitter followers TR603 and TR604 to a gain stage, TR605 and TR606. In the emitter circuit R617 sets the X1 channel gain and R618 the X10. The collector outputs are connected to the switching stage, TR609 and TR611, via emitter followers, TR607 and TR608. These provide, in push-pull, the channel trigger signal. The Miller capacities of the above gain stage are neutralized by C603 and C609.

TR609 and TR611 form a long-tailed pair, with C606 and R614 providing H.F. compensation. Their output feeds a shunt feedback amplifier, TR612 and TR613.

3.3.2 The feedback resistors are split into pairs, R644, R650 and R658, R661; with the signal delay line compensation, at one end, being provided by C621, R656, C619, R655, C618, R654 and C617, R653 connected between junctions of the above pairs. The compensation at the other end, reference Figure 4 is provided by C751 and R751. The delay line is terminated at each end by R643, R659, R752 and R753.

The output from the delay line is fed to the emitter input of the output stage TR752 and TR753, and drives the 'Y' plates of the CRT Figure 13.

A portion of the output is taken via a balanced divider, R771, R773 and R772, R774 to switch, S751 which switches either the above portion of the signal or the channel signal from the emitter followers, TR607 and TR608, to a long-tailed pair, TR755, TR757, which drive the Trigger circuit.

3.4 CHANNEL SWITCHING

3.4.1 GENERAL

Channel switching is carried out by TR614 and TR615, which act as a bistable in the ALT mode and a free-running multivibrator in the CHOP mode, the current being provided via a long-tail TR616.

3.4.2 ALT

In the ALT mode a negative-going pulse coinciding with the start of the sweep flyback, is fed via D606 or D609, to the above bistable, causing it to switch. When TR614 is conducting, it passes current from the switching stage, TR609 and TR611, and allows the CH1 signal to pass to the shunt feedback amplifier, TR612 and TR613. At the same time TR615 is off, its collector rises to 16 V approx. taking the emitter of CH2 switching stage, TR626 and TR627 with it and so cutting off the current. Diodes D610 and D612 prevent the base-emitter junctions from breaking down in the reverse condition.

3.4.3 CHOP

In the CHOP mode, R648 and R664 are returned to H.T. via R696 forming an astable multivibrator. The frequency is mainly determined by R648, R664, C613, C622, R647, R663 and R696.

3.4.4 ADD

In the ADD mode, the current supplied via TR616 is switched off, so both TR614 and TR615 are non-conducting. Both switching stages TR609, TR611 and TR626, TR627 are required to be on, so extra current is bled from the 115 V line via R637 and R638. Current flows through the switching stages, via R646 and R662 through R673, to earth. Hence these signals are added at the bases of TR612 and TR613. CH2 signal can be inverted by switch, S604, to provide addition or subtraction of two signals.

3.4.5 The table overleaf shows the state of the switched components for all switch combinations followed by a résumé on the part of circuit activated.

Condition A denotes R637, R638 connected to +115 V.
 Condition B denotes TR616 conducting
 Condition C denotes R673 connected to junction R646/R662

CH1	CH2	ALternate			CHOP			ADD		
		A	B	C	A	B	C	A	B	C
On	Off	No	Yes	No	No	Yes	No	No	Yes	No
Off	On	No	Yes	No	No	Yes	No	No	Yes	No
On	On	No	Yes	No	No	Yes	No	Yes	No	Yes
Off	Off	No	Yes	No	No	Yes	No	No	Yes	No

3.4.6 CH1 ON, CH2 OFF

TR614, TR609 and TR611 are conducting, this feeds the output of TR609 and TR611 to the bases of TR612 and TR613; TR626 and TR627 being reversed biased by the potential at TR615 collector.

3.4.7 CH1 OFF, CH2 ON

TR615, TR626 and TR627 are conducting, so only the output of TR626 and TR627 may pass to the bases of TR612 and TR613; TR609 and TR611 being reversed biased by the potential at TR614 collector.

3.4.8 CH1 ON, CH2 ON. ALTERNATE

TR614 and TR615 are connected to form a bistable circuit. At the end of each sweep, a negative-going pulse appears at the junction of D606 and D609 which reverses the state of the bistable. Hence TR614 and TR615 conduct alternately and allow the output, of CH1 and CH2 alternately, to reach the bases of TR612 and TR613.

3.4.9 CH1, CH2 CHOPPED

R648 and R664 are returned to H.T. via R696 to form an astable multivibrator, which free runs at 150 kHz approximately. Thus the outputs of CH1 and CH2 are successively switched into TR614 and TR615 at 150 kHz. At each transition a pulse is fed from the emitters of TR612 and TR613 via C642 to the unblanking amplifier Figure 12 which blanks the CRT beam and thus provides automatic transient blanking in the chopped mode.

3.4.10 CH1, CH2 ADD

The tail of the multivibrator and R633 are disconnected; TR614 and TR615 are non-conducting; R673 is connected to ground providing a current path for both channels simultaneously; TR609, TR611, TR626 and TR627 are conducting; extra current being fed to their collectors, via R637 and R638 from the +115 V line, to maintain correct conditions. CH1 and CH2 may be used as a summing or differential (with INVERT pressed) amplifier.

3.4.11 CH1 OFF, CH2 OFF

TR614 and TR615 are non-conducting, preventing outputs from either CH1 or CH2 from reaching TR612 and TR613.

3.5 SWEEP TRIGGERS

It will be seen by referring to Figure 5 and 6, that the circuitry of the main Sweep Trigger 'A' and the delayed Sweep Trigger 'B' are substantially the same. The difference being, the TV and HF REJ modes are omitted in the latter and the trigger will not free-run in the absence of a trigger input.

The bases of Trigger 'A' input amplifiers, TR2 and TR3, are fed with internal or external trigger signals via switches, S1a and S1b. S1a selects the source: the collectors of TR755 and TR757 in the vertical amplifier or TR1 the external trigger amplifier. S1b selects the polarity of the trigger signal on which the triggering occurs.

When switched in by S2, R16, the LEVEL control, varies the base potentials of TR2 and TR3 in antiphase. This alters the quiescent voltage on the base of TR4 and

so the d.c. level of signal required to trip TR4 and TR5; these form a Schmitt trigger in the A.C. position of S3b.

When S2 is open in the AUTO position, feedback is applied from TR5 collector via R24 and R22 to TR3 base and from TR4 collector via R25 and R8 to TR2 base. This feedback causes TR2, TR3, TR4 and TR5 to oscillate in the absence of a trigger input at a low frequency, primarily determined by C7, R24 and R25. When signals are applied, TR2 and TR3 lock to their frequency. In the free-running condition, the amplitude of the output at the collector of TR3 is controlled by the trigger sensitivity preset R33; this adjusts the hysteresis of TR4 and TR5. R12 is set to provide symmetric operation of TR2 and TR3.

When S3b is in the AC position, TR4 and TR5 form a Schmitt trigger with coupling resistor R32 and speed-up capacitor C10. The constant amplitude rectangular-wave output at the collector of TR5 is differentiated by C13 and R36; the resulting bi-directional pulses to the series clipper D1 which provides the collector of TR104 in the sweep circuit with positive-going trigger pulses.

At frequencies of about 5 MHz and above, dividing down action occurs in the Schmitt and the repetition rate of the Schmitt output signal becomes a sub-multiple of the input frequency.

In the TV position of S3b, R27 is disconnected from the emitter of TR4; TR4 converts into a sync separator with C8 being switched across R29. TR5 changes into an inverter with decoupling capacitor C12 being switched across the emitter resistors R27, R33 and R34. In the TV frame position of S210 the differentiating time-constant of C13 and R36 is increased by the addition of R39.

With S3a in the HF REJ position, C15 is connected across the input of the Schmitt to decouple the high frequency component of the trigger signal.

When VARIABLE 'A' is pulled out for the sweep to free-run, the sweep is no longer triggered.

Trigger 'B' internally or externally, derived signals are applied to the bases of TR52 and TR53 via S51a and S51b. The setting of S51a determines whether the input is derived from TR754 and TR756 in the vertical amplifier or from an external input via TR51. S51b selects the polarity on which triggering occurs.

The output from the collector of TR53 is applied to the base of TR54; this with TR55 form a Schmitt circuit. The potential on the base of TR54 is either preset when S52 is open or adjustable by R66 when S52 is closed. R62 balances TR52 and TR53; R82 controls the hysteresis of TR54 and TR55.

The constant amplitude output at the collector of TR55 is differentiated by C64 and R85. D51 passes positive-going pulses to the collector of TR163 in the B sweep circuit.

When VARIABLE B is pulled out for ungated operation of the B sweep, the trigger B circuit has no effect on the display. The point on the A sweep at which the B sweep starts is determined solely by the setting of the DELAY control.

3.6 TIMEBASES

The waveforms, illustrated in Figure 7, are included to assist the reader when studying the circuits of timebases 'A' and 'B' shown in Figures 8 and 9 respectively. It must be noted that the instrument is set in the A INT - nongated mode to give the waveforms.

The sweep generator of timebase 'A' consists of a Miller run-up stage TR109, with TR110 as a source follower. TR102 and TR103 form the Single-Shot and Hold-off bistable intercoupled with TR104 and TR105 the sweep-gating bistable.

In the quiescent condition of the timebase, TR102 is on, TR103 off, TR104 off, and TR105 on. D105 and D106 are holding C_t, the timing capacitor selected by S210/2F (Figure 10), discharged. When a positive-going trigger pulse is applied to the base of TR105 via D1 (Figure 5), R126 and C104, the sweep-gating bistable changes states; TR104 turns on and TR105 off.

The positive potential at TR104 collector turns off D1, preventing further trigger pulses from entering the bistable.

The collector of TR105 goes negative until clamped by D104 slightly below chassis potential. D105 and D106 are then cut off and current flows into C_t through R_t the timing resistor selected by S210/1B and R134 to start the sweep. The gate of TR110 and hence the base of TR109 gradually fall causing TR109 collector to rise, providing a positive going sweep. The negative excursion of TR110 gate is limited by the large loop gain leaving virtually constant current flow into C_t .

As the collector of TR109 rises, D103 becomes forward biased and C_h the hold-off capacitor selected by S210/1F, charges. The rising voltage across C_h is fed to the base of TR102 until the point, determined by R109, is reached when TR102 turns off and TR103 turns on. The positive potential at TR103 collector turns off TR104 causing TR105 to turn on forward biasing D105. The sweep is thus terminated and the flyback begins.

C_t then discharges through D105 and TR105, causing the gate of TR110 and the base of TR109 to rise.

Although TR104 is off and TR105 on, the sweep-gating bistable is unaffected by incoming trigger pulses since TR104 base is clamped by TR103.

The collector of TR109 falls linearly, due to the Miller action and the flyback ends with the collector of TR109 clamped by D106 at the same level as at the start of the sweep. During the flyback D103 turns off allowing C_h to discharge, taking TR102 base negative. C_h continues to discharge beyond the flyback period until the point, determined by R113, is reached when TR102 turns on and TR103 off thus unclamping the base of TR104. The sweep-gating bistable is then ready to be switched by the next incoming trigger pulses.

In the Free-run condition, TR105 is biased off allowing the sweep to start immediately. The sweep cycle is the same as in the triggered condition until C_h has discharged sufficiently to allow TR102 to turn on, and TR103 off. As soon as the base of TR104 is unclamped, TR105 immediately turns off again due to the positive bias on its base and the sweep cycle recurs continuously.

When the Single-shot condition is selected a positive bias is applied to the base of TR102. The sweep cycle is as above until the point when C_h discharges.

When C_h has discharged, TR102 does not turn on again, due to the positive bias on its base, and a positive going reset pulse must be applied to the base of TR103 to switch the single-shot and hold-off bistable over and thus unclamp TR104 base. In the triggered condition the sweep will not begin until a trigger pulse initiates it. After a single sweep "lockout" occurs, TR104 base is clamped until the reset button is depressed to "arm" the sweep. The free-run condition allows the sweep to cycle once up to the point where TR104 base remains clamped. Pressing the reset button switches the sweep-gating bistable unclamping TR104 base and the positive bias on TR105 base turns it off causing a single sweep to occur immediately.

In the Delay Circuit TR111 and TR112 form a Schmitt trigger circuit with TR111 non-conducting and TR112 conducting in the quiescent condition of the timebase: The DELAY control, R139, determines the reverse bias at the base of TR111.

A portion of the positive going 'A' sweep is also fed to TR111 base via R142, driving is positive until the point, determined by the delay setting, is reached when TR111 turns on, and hence TR112 turns off, its collector going positive. This condition is maintained until the sweep ends and the negative going flyback allows TR111 to turn off and thus TR112 to turn on, its collector going negative.

A positive going step waveform coinciding with the start of the 'A' sweep is also fed to the base of TR111 from TR113 collector via R154, to rapidly overcome the bias when a small delay time is required.

The differentiated output from TR112 collector is fed to the base of TR162 in timebase 'B' the positive going edge resetting the delayed sweep, and the negative going edge terminating it, should its duration exceed the remaining 'A' sweep.

The sweep generator circuit of timebase 'B' is essentially the same as timebase 'A' with a Miller run-up stage TR165

driven by TR166 a source follower. The bistable formed by TR161 and TR162 is intercoupled with the sweep-gating bistable, TR163 and TR164. The sweep generator is permanently connected in the single-shot condition with TR161 returned to the 115 V h.t. supply except when the test link is removed for calibration, section 4.2.8.1 refers. Two operating modes are obtainable: B DEL non-gated and gated sweep.

In the non-gated mode, before the start of the 'A' sweep, TR161 is held off by the positive base bias via R161, causing TR162 to conduct. The resultant positive potential at TR162 collector clamps the base of TR163 positive, causing TR163 to cut off and TR164 to conduct. The positive collective potential of TR164 holds D163 and D164 on maintaining C_t discharged.

During the 'A' sweep, at a point determined by the DELAY control, the delay circuit bistable changes state, the resulting output providing a positive-going pulse at the base of TR162, turning it off and TR161 on. TR163 is now unclamped and the bias at the base of TR164, due to the position of S161, causes it immediately to turn off and TR163 on. TR164 collector goes negative until clamped by D162 turning on. D163 and D164 are thus cut-off and the current flows into C_t via R_t and R184 to start the sweep. The positive-going sweep turns on D161 and continues until TR161 turns off and TR162 on, its collector clamping TR163 off and TR164 on. The 'B' sweep is then terminated and flyback occurs, C_t discharging through D163 and TR164 until D164 conducts. The quiescent condition is now restored with D163 and D164 holding C_t discharged. The circuit remains in this condition until the next positive pulse from the delay circuit initiates another delayed sweep during the next 'A' sweep.

In the gated mode of the 'B' sweep, the positive pulse from the delayed circuit during the 'A' sweep, referred to above, turns TR162 off and TR161 on. Although TR163 base is now unclamped, the gate-sweeping bistable does not immediately change state, due to the position of S161, reducing the positive bias at TR164 base and remaining unswitched until the next incoming pulse, from the trigger 'B' circuit, appears at TR163 collector to switch over the bistable and start the sweep. The sweep gate then continues as above until the quiescent condition is restored.

Should the duration of the delayed sweep exceed that remaining of the 'A' sweep in either the gated or non-gated mode, it is terminated by the negative going pulse from the delay circuit coinciding with the end of the 'A' sweep.

In the MIXED sweep mode, the 'B' sweep ramp, normally fed back to the hold off bistable via D161, is connected instead of the collector of TR168. The circuit operates normally until the 'B' sweep reaches its full amplitude. It is then clamped by D168 via TR168 to approximately 36 V, and stays at this potential during the remainder of the 'A' sweep. The 'B' sweep is then caused to run down by the negative pulse at TR162 base as previously described at the end of the 'A' sweep.

3.7 HORIZONTAL AMPLIFIER

Figure 11 shows the external horizontal and sawtooth waveform from either timebase 'A' or 'B' coupled, via the display switch S275, to the base of TR276, an operational amplifier, where it is mixed with the D.C. potentials from the POSITION and FINE position controls. The gain switch S276, determines the feedback required to give X1 and X5 horizontal magnification. The output from the collector of TR276 is coupled to the base of TR277, which, with TR278 forms a push-pull output amplifier driving the CRT 'X' plates (Fig. 13). D282 prevents saturation of TR277 and R292 balances the amplifier with no voltage across the gain switch. The mean output potential of the amplifier is set by R297.

3.8 UNBLANKING AMPLIFIER

If reference is made to Figure 12, it will be seen that TR261 and TR262 form a feedback amplifier whose output collector is connected to g_1 , control grid, of the CRT, reference Figure 13.

TR253 and TR254 form a bistable triggered by the differentiated pulses from amplifier TR251 via C251. TR253 output collector current drives the feedback amplifier.

A second bistable, TR255 and TR256, also drives the feedback amplifier via emitter follower TR257, this bistable being triggered by the pulses from TR252 via C252.

TR258 and TR259 form a two stage pulse amplifier, TR258 driving the feedback amplifier in the chopped mode of the vertical amplifier.

In the quiescent condition of the horizontal deflection system, TR253 and TR257 are conducting; the current taken by them biases off the feedback amplifier causing a voltage to appear across TR261. This voltage is in series with that across the INTENSITY control, R805 (Figure 13), and results in the negative grid bias cutting off the CRT beam.

The two bistables are switched according to the display mode selected by S275. In the 'A' mode, the emitters of TR251 and TR252 are connected to TR113 in timebase 'A' (Figure 8).

At the start of the 'A' sweep, the negative-going potential at TR105 collector drives the base and hence the emitter of TR113 negative thereby allowing TR251 and TR252 to conduct, their collectors going negative. These negative-going pulses fed to TR254 and TR256 bases, switch both bistables over, TR254 on and TR253 off, also TR256 on and TR255 off and hence TR257 off. TR261 turns fully on, reducing the voltage across it to nearly zero; and the grid to cathode voltage of the CRT to that across the INTENSITY control, allowing the beam to appear on the CRT screen. This condition is maintained for the duration of the 'A' sweep. The positive excursion of TR105 collector which terminates the 'A' sweep, takes TR113 base and emitter positive which in turn drives the emitters of TR251 and TR252 positive. The positive potential at their emitters causes TR251 and TR252 to stop conducting and the resultant positive-going pulses at their collectors cause both bistables to change states again; restoring the quiescent condition with the CRT beam blanked.

In the 'A' INT mode, the emitter of TR251 is connected to TR113 in timebase 'A' (Figure 8) and TR252 emitter to TR167 in timebase 'B' (Figure 9). Both TR253 and TR257 are conducting before the start of the 'A' sweep, causing the amplifier TR261 and TR262 to blank the beam as above. At the start of the 'A' sweep TR251 turns on, its negative-going collector potential switching over the bistable TR253 and TR254. Since TR253 is non-conducting, the reduced bias on TR262 base allows TR261 to conduct more heavily, the voltage across it falls to a low value determined by the current taken by TR257 which is still conducting. The trace is then partially unblanked and visible on the CRT screen. This condition is maintained until the start of the 'B' sweep, when TR167 turns off and allows TR252 to turn on. The negative excursion of TR257 collector switches over the second bistable TR255 and TR256. Consequently TR257 turns off, allowing the feedback amplifier to turn fully on and the trace to reach its full brightness level determined by the intensity control. At the end of the 'B' sweep TR167 and TR252 switch back the bistable

TR255 and TR256. Thus TR257 conducts biasing the feedback amplifier off slightly and reducing the traces brightness to its original level.

The termination of the 'A' sweep causes bistable TR253 and TR254 to change states and the increased bias due to TR253 conducting turns off the feedback amplifier resulting in blanking of the trace.

In the 'B' DEL mode, both TR251 and TR252 emitters are connected to TR167 in timebase 'B' causing the trace to bright up for the duration of the 'B' sweep only.

In the CHOP mode of the vertical amplifier, positive-going pulses are fed to the base of TR159 via C642, (Fig.3). During the switching transition of the channel-switching multivibrator, TR259 conducts, the resultant negative pulses at its collector are passed to the base of TR258, via C257, causing it also to conduct. The pulses of current taken by TR258 bias off the feedback amplifier is thus suppressing switching transients.

When EXT.X mode is selected, relay RL275 is energised forward biasing D255 and D254, thus ensuring that TR254 and TR256 are conducting. The feedback amplifier is thus unaffected by the bistables and maximum trace brightness is obtained.

3.9 POWER SUPPLIES

The power supplies consist of a +12 V, -12 V, +115 V, +8.5 kV, (reference Figure 14) and a -1.55 kV supply, (reference Figure 13).

For the +12 V supply, TR404, TR412 and TR413 form a series voltage stabilizer, the output voltage being established by the ratio of R435, R436, R437 and the reference diode D423. Any fluctuation in the output voltage is cancelled out by the high-gain negative feedback loop. All control currents are obtained from the output side of the series element so that a short circuit on the output turns off TR404 without damage to components.

The -12 V supply operates in the same way as the +12 V supply with TR406, TR408 and TR411 forming a series stabilizer using the +12 V as the reference voltage.

TR402, TR403 and TR405 form the series stabilizer for the +115 V supply using the above -12 V as the reference voltage. D421 protects the series transistor in the event of a short circuit on the output and R403 provides short term current limitation.

For the -1.55 kV supply, the voltage across C405, C406, C407, C428, C429 and C408 is effectively in series with the regulator transistors TR401 and TR407, the collector of TR401 being positive with respect to ground and output being negative. The +115 V is used as a reference voltage and the reference potentiometer is formed by R404, R411, R301, R302, R303, R304 and D301. R404 sets the voltage at the base of TR409, an emitter follower which drives TR407. A.C. feedback is supplied by C417. Any change in output voltage is fed to the base of TR409, which drives the collector of TR401 in the opposite direction, maintaining the voltage between output and ground constant.

The +8.5 kV supply for the CRT PDA is obtained from the voltage multiplier C402, C403, C410, C411, D401, D402, D410 and D411.

The 500 mV peak to peak squarewave calibrator output is developed across R406 by using the 13.7 V A.C. output from the power transformer to switch D419 alternately on and off. D419 is in series with the divider chain R414, R409 and R406 between the -12 V and chassis. R414 is used to set the current through the chain and consequently the voltage developed across R406.

SECTION 4

MAINTENANCE AND RE-CALIBRATION

Care must be taken not to touch high voltage tags. The instrument **MUST BE UNPLUGGED** when removing the case, removing or replacing the tube, or other components and where possible during other servicing.

4.1 INTRODUCTION

4.1.1 GENERAL

The solid-state design of the instrument should render frequent readjustment of the internal preset controls unnecessary; however, to ensure the maintenance of full measurement accuracy, it is desirable to make an occasional check on the vertical amplifier sensitivity and the timebase sweep/speed. The internally generated 500 mV peak to peak calibration waveform may conveniently be used for these checks.

4.1.2 CHECK SWEEP SPEED

1. Push FINE position in.
2. Set TIME/DIV to 10 ms and VARIABLE fully clockwise.
3. Link INPUT and CAL.
4. Adjust other controls for a locked display.
50 Hz supply : Check for 1 cycle/ 2 divs.
50 Hz supply : Check for 3 cycle/5 divs.
400 Hz supply: Switch TIME/DIV to 1 ms and check for 2 cycles/5 divs.

NOTE: To maintain the measuring accuracy, it is advisable to refer to the Set Timing Procedure, as line frequency may vary.

4.1.3 CHECK GAIN

Vertical amplifier may be checked as follows:

1. Set CH1 and CH2 VOLTS/DIV to 0.1 V and turn VARIABLE fully clockwise
2. Set DC-GND-AC to DC.
3. Apply the 500 mV peak to peak CAL waveform to INPUT 1.
4. Adjust POSITION, TRIGGER and SWEEP controls for a convenient display.
5. Check Gain for 5 divs. amplitude.
6. Remove CAL from INPUT 1, apply to INPUT 2 and adjust controls as necessary for a display triggered by Channel 2.
7. Check Gain for 5 divs amplitude.

NOTE: The VARIABLE gain controls must remain fully clockwise.

Should it be necessary to adjust the gain, reference should be made to the appropriate procedure in the Calibration paragraph of this Section. It should be noted that TR601 with TR602 and TR617 with TR618 are matched pairs.

Before it is assumed that a fault condition exists, control settings should be verified with reference to the Pre-Operational Check, page 2/1.

4.1.4 TOOLS AND EQUIPMENT

The following tools and equipment will be required.

Screwdrivers Plain 4 mm blade.
Plain insulated handle.
Pozidrive.

Non Capacitive trimming tool.

Variable Transformer with voltmeter.

Test oscilloscope.

x10 probe (recommended type TP2, Part Number 010-0270-00).

Voltmeter with resistance of 20 k Ω /Volt or better suitable for measurement of voltages in the range 0 - 1.45 kV.
Squarewave generator with frequencies from 1 kHz to 1 MHz variable from 5 mV pp to 2.5 V pp \pm 1%.

Sinewave source with frequency greater than 100 kHz with amplitude greater than 50 mV.

It would also be useful to have the following items:

- 1 μ s and 100 μ s time mark pulses.
- Composite TV waveform.

4.2 MECHANICAL

4.2.1 LOCATION OF PRESET CONTROLS

Attenuator trimmers are accessible from the left-hand side, front, after the covers have been removed. The vertical amplifier on PC212 is also on this side. PC210 on the right-hand side carries the circuits for the time base and power supply. The boards are marked with a legend to facilitate component identification.

4.2.2 ACCESS TO INTERIOR

1. Disconnect the instrument from the mains supply.
2. To remove the cabinet sides, loosen the two handle-clamp securing screws, ease the top of each side outwards and unhook the bottom of each side from the locating slots in the chassis base.
3. The chassis base cover plate is secured by six fixing screws, one at each corner and one half-way along each of the longer sides.

4.2.3 C.R.T. REMOVAL

1. Disconnect the instrument from the mains supply.
2. Remove both cabinet sides as shown above.
3. Remove the rear cover which is secured by a screw at each corner.
4. Unplug the PDA cap and earth both the male connector on the lead and the socket on the side of the tube ensuring that the residual high voltage has been fully discharged.
5. Unplug the 12 pin base socket, and the five side pin connectors.
6. Unplug the trace rotation coil plug from the left-hand board.
7. Remove the three screws holding the mumetal screen and remove the C.R.T. and screen towards the rear of the instrument until the face of the tube is clear of the panel and chassis edge.
8. Move the front end of the C.R.T. to the left and carefully remove it from the instrument complete with its screen.
9. Remove the adhesive tape and the rear location moulding and remove the C.R.T. from the screen.
10. Remove the trace rotation coil and rubber packing strips from the C.R.T.

4.2.4 C.R.T. REPLACEMENT

Fit in the reverse order to that given in 4.2.3 above ensuring that the C.R.T. forward end is located in the rubber moulding behind the front panel. If the TRACE ROTATION control does not provide an adequate range of adjustment reverse the trace rotation plug.

4.3 CALIBRATION

4.3.1 GENERAL

The following procedure enables a full calibration of the instrument to be accomplished. If any step or steps are carried out in isolation, regard should be paid to the risk of interaction with other adjustments and also to control

settings and waveforms applied in earlier steps.

NOTE: It is important never to adjust the potentiometers controlling the voltages of the stabilised lines (R404, R421, R431 or R436) unless it is intended to carry out a complete calibration of the instrument.

4.3.2 PROBE COMPENSATION

1. Connect x10 probe to INPUT socket.
2. Apply tip to 0.5 V peak to peak squarewave source or GATE OUT.
3. If the squarewave is used, adjust controls to display a few cycles of the waveform. Set VOLTS/DIV to 10 mV and adjust probe trimmer for square corners. The compensation should be re-checked if the probe is transferred to the other channel.
4. When using the GATE OUT waveform a sweep speed of 1 ms/div is recommended: set VOLTS/DIV to 100 mV: the leading corner of the step waveform should be adjusted for optimum squareness, that is, for the starting point to be level with the rest of the trace.

NOTE: The TP2 probe trimmer has a screwdriver adjustment through a hole in the probe body.

4.3.3 PRELIMINARY

1. With the instrument disconnected from the supply, remove the cabinet sides by partially unscrewing the carrying-handle securing clamps and moving the tops of the sides outwards.
2. Set all internal presets to mid-position.
3. Measure the resistances of the four stabilised lines to chassis. Resistances should be approximately as follows:

Line	Test Point	Resistance
Volts		Ohms
+12	147	250 - 350
-12	148	350 - 500
+115	149	1.5 - 3 k
-1.45 k	CRT cathode pin 7	2 M or greater

4. Insert the voltage-selector plug in the rear panel with the arrow indicating the nominal voltage of the local AC supply or the nearest value to it.
5. Connect the oscilloscope's power cable to a metered variable transformer. The cores of the cable are colour coded as follows:

Line	Neutral	Earth (Ground)
Brown	Blue	Green/Yellow

6. Connect the transformer to the supply and switch on supply and oscilloscope.
7. Adjust the variable transformer to give the same voltage as that indicated by the voltage selector plug.

4.3.4 POWER SUPPLY

NOTE: All instructions in this section must be performed in numerical sequence.

4.3.4.1 SET +12 V LINE: R436.

Connect D.C. voltmeter with negative to chassis and positive to tag 147. Adjust R436 for a reading of 12 V.

4.3.4.1 SET -12 V LINE: R431

Connect voltmeter positive to chassis and negative to tag

148. Adjust R431 for a reading of 12 V.

4.3.4.3 SET +115 V LINE: R421

Connect voltmeter negative to chassis and positive to tag 149. Adjust R421 for a reading of 115 V.

4.3.4.4 SET CRT CATHODE VOLTS (-1.45 kV): R404

1. Connect voltmeter, negative to chassis and positive to the collector of TR401. Adjust R404 for a reading of 250V. Disconnect voltmeter set to a high range and reconnect positive to chassis and negative to CRT cathode (pin 7 on socket).
2. Switch off, disconnect meter, remove variable transformer, connect oscilloscope to supply and switch on.

4.3.5. INITIAL SETTINGS

4.3.5.1 SET INITIAL CONDITIONS

1. Set front-panel controls as follows:

POSITION (CH1 and CH2)	Central
OFF-ON (CH1 and CH2)	OFF
TIME/DIV A	1 ms
VARIABLE A	Pulled out
DISPLAY	A ONLY
POSITION (Horizontal)	Central
FINE	Central and pushed in
2. After advancing INTENSITY, adjust preset R125 to provide free-running trace.
3. Adjust FOCUS and ASTIG for best definition.
4. Depress CH1 OFF-ON button and adjust R635 to centre trace.

4.3.6 HORIZONTAL AMPLIFIER

4.3.6.1 SET MEAN X-PLATE POTENTIAL: R297

1. Switch TIME/DIV A to EXT X.
2. Connect a D.C. voltmeter between the collectors of TR277 and TR278, pins 171, 172.
3. Adjust horizontal POSITION and FINE for a reading of 0 V.
4. Connect voltmeter with negative to chassis and positive to the collector of TR278, pin 172. Adjust R297 for a reading of 52.5 V.
5. Repeat 3 and 4 until correct conditions are obtained.

4.3.6.2 SET HORIZONTAL D.C. BALANCE: R292

1. Pull out FINE for x5 gain and centre the spot on the graticule with POSITION and FINE.
2. Push in FINE and re-centre the spot with R292.
3. Repeat 4.3.6.1 and 4.3.6.2 (Ops 1 and 2) until there is no spot movement when switching between x1 and x5 gain and the conditions in 4.3.6.1 above are met.

4.3.6.3 SET EXTERNAL HORIZONTAL D.C. BALANCE: R137.

1. Pull out FINE for x5 gain.
2. Adjust R137 for no spot movement when the EXT X and GND sockets are intermittently shorted together.

4.3.6.4 SET EXTERNAL HORIZONTAL INPUT COMPENSATION: C113 ON TIME/DIV SWITCH.

1. With x5 horizontal gain, apply a 2.5 V peak to peak 10 kHz squarewave between EXT X and GND sockets.
2. Adjust C113 for minimum width of intensified areas at the ends of the trace.
3. Push in FINE and remove squarewave.

4.3.7 CATHODE RAY TUBE

4.3.7.1 SET TRACE ALIGNMENT: TRACE ROTATION (AT REAR)

Set TIME/DIV A to 1 ms and adjust TRACE ROTATION to align trace with centre graticule line. If the trace

cannot be aligned, reverse the 2 - pin plug at bottom rear of the left-hand etched circuit board then adjust TRACE ROTATION.

4.3.7.2 SET GEOMETRY: R309

1. Apply a 100 kHz or higher frequency sinewave to CH1.
2. Adjust VOLTS/DIV and the sinewave amplitude to provide a raster whose top and bottom edges are just within the display area.
3. Adjust R309 for minimum curvature at the edges of the raster.
4. Disconnect the sinewave generator.

4.3.8 SWEEP TRIGGER A

4.3.8.1 SET AUTOMATIC A AND TRIGGER SENSITIVITY A; R12 AND R33.

1. Set TIME/DIV A to EXT X, TIME/DIV B to OFF, TRIG MODE A to EXT, AC, +, all other buttons out and LEVEL A and B to AUTO.
2. Set CH1 and CH2 INPUT switches to GND, VOLTS/DIV to 10mV, gain to X1, CH1 on, CH2 off and INT TRIG to 1.
3. Connect the test oscilloscope set to 0.1 V/div and 20ms/div to the collector of TR3 (tag 124).
4. Turn R33 fully clockwise and adjust R12 to the centre of the range over which a continuous oscillation, at about 1 MHz, is observed on the test oscilloscope.
5. Turn R33 slightly anti-clockwise and reset R12 to the centre of the range of oscillation.
6. Repeat 5 until the oscillation is replaced by a low frequency triangular waveform.
7. Adjust R12 and R33 to give a symmetrical waveform of 70 to 80 mV peak to peak checking that the period is greater than 30 ms. Disconnect test oscilloscope.

4.3.9 SWEEP GENERATOR A

4.3.9.1 SWEEP LENGTH A:

1. With DISPLAY set A ONLY switch TIME/DIV A to 0.5 ms and ensure VARIABLE A is pulled out.
2. Adjust R109 for 10.2 divs trace length.

4.3.9.2 SET SWEEP HOLD-OFF TIME A: R113

1. Apply test oscilloscope to SAWTOOTH OUT socket and adjust R113 to make the duration of hold-off equal to the duration of flyback. That is, for horizontal portion of the display to be equal in time to the negative-going portion.
2. Disconnect the test oscilloscope.

4.3.9.3 SET 0.2 ms TIMING A: R143

1. Push in VARIABLE A and set the control fully clockwise.
2. Set TIME/DIV A to 0.2 ms and ensure that FINE is pushed in.
3. Set CH1 INPUT to AC.
4. Apply 100 μ s time markers or a 10 kHz squarewave to CH1.
5. Depress CH1 INT TRIG button; If necessary reset R125 for a locked display. The LEVEL A control may then be used to lock the display.
6. Set R143 for 2 markers per division.
7. Reset R109 if necessary for 10.2 divs trace length.

4.3.9.4 SET x5 GAIN: R285

Pull out FINE then adjust R285 for 2 markers or 2 cycles of squarewave over 5 divs. Push in FINE.

4.3.9.5 SET 0.2 μ s TIMING A: C219A ON TIME/DIV. SWITCH

1. Ensure that VARIABLE A is pushed in and fully clockwise.

2. Switch TIME/DIV A to 0.2 μ s.
3. Apply 1 μ s time markers or a 1 MHz squarewave to CH1.
4. Using a non-capacitive trimming tool, adjust C219A, on a TIME/DIV switch, for 1 marker or 1 cycle of squarewave over 5 division.

4.3.9.6 SET 0.2 μ s SWEEP LENGTH A: C114

1. Adjust C114 for the same 10.2 div. trace length as set by R109, reference 4.3.9.1 operation 2.
2. Remove markers or squarewave.

4.3.9.7 SET STABILITY A: R125

NOTE: This adjustment is best made using a composite sync or video television waveform. If this is available perform operations 1 to 6, if not, carry out the alternative procedure in operations 7 to 12.

1. Switch TIME/DIV A to 0.5 ms, LEVEL A to AUTO and TRIG MODE A to TV.
2. Apply the sync or video waveform to CH1 and adjust the amplitude to about 1 division.
3. Set R125 fully anti-clockwise then turn it gradually clockwise until display just locks.
4. Pull out VARIABLE A and check that trace free-runs.
5. Depress SINGLE-SHOT then RESET, check that sweep fires each time RESET is depressed.
6. Push in VARIABLE A and depress RESET, check that a triggered sweep is obtained each time RESET is depressed.

NOTE: If all these conditions are not met, repeat operations 3 to 6 with R125 very slightly more clockwise. Remove television waveform and return TRIG A to AC and SINGLE-SHOT TO NORMAL. Since a television waveform has been used, do not perform operations 7 to 12 but proceed to 4.3.10.

If a television waveform is not available, proceed as follows:

7. Set TIME/DIV A to 0.5 ms, LEVEL A to AUTO, TRIG MODE A to AC, +, INT.
8. Apply 1 kHz squarewave to CH1 and adjust the amplitude of display to 1 div.
9. With VARIABLE A pushed in, set R125 fully anti-clockwise then turn R125 gradually clockwise until a locked trace just appears.
10. Pull out VARIABLE A and check that sweep free-runs.
11. Depress SINGLE-SHOT then RESET. Check that a triggered sweep results each time RESET is pressed.

NOTE: If all these conditions are not obtained, repeat operations 10 to 12 with R125 very slightly more clockwise. Remove 1 kHz squarewave and release SINGLE-SHOT.

4.3.10 SWEEP TRIGGER B

4.3.10.1 SET TRIGGER BALANCE B AND TRIGGER SENSITIVITY B: R62 and R82.

1. Switch off oscilloscope and unplug link from tag 153; the link is replaced in 4.3.11.6.
2. Switch instrument on.
3. Set controls as in 4.3.8.1 apart from CH1, AC-DC-GND which is set to DC.
4. Apply 1 kHz squarewave to CH1 and adjust for a 0.5 division display.
5. Apply test oscilloscope to tag 125 at the collector of TR55 and adjust R62 and R82 to give a squarewave display on the test oscilloscope about 4V in amplitude.
6. Set R62 to centre of range over which squarewave appears.
7. Set R82 as far clockwise as possible while still retaining the squarewave display.
8. Using VAR reduce the display to 0.3 div and adjust R82 until display just fails to lock.
9. Check that without any further adjustment of R82 that the display locks on all amplitudes above 0.3 div.

4.3.11 SWEEP GENERATOR B**4.3.11.1 SET HORIZONTAL BALANCE B: R187**

1. With TIME/DIV B at OFF, set DISPLAY to B DEL and pull out FINE.
2. Adjust R187 for no movement of the spot when the feed-through on the TIME/CM switch bracket (with 1 M Ω resistor attached) is intermittently shorted to the chassis.
3. Remove 1 kHz squarewave.

4.3.11.2 SET SWEEP LENGTH B: R165

1. With TIME/DIV A at EXT X, push in FINE.
2. Set TIME/DIV B to 0.5 ms and pull out VARIABLE B.
3. Adjust R165 for 10.2 divs. length of trace. If necessary adjust R179 to obtain trace.

4.3.11.3 SET SWEEP HOLD-OFF TIME B: R168

1. Apply test oscilloscope to the collector of TR165 and adjust R168 to make the duration of hold-off equal to the duration of flyback.
2. Remove test oscilloscope.

4.3.11.4 SET 0.2 ms TIMING B: R186

1. Check that DISPLAY is at B DEL, FINE is pushed in and TRIG MODE B is at +, INT.
2. Push in VARIABLE B and set fully clockwise.
3. Switch TIME/DIV B to 0.2 ms.
4. Apply 100 μ s markers to 10 kHz squarewave to CH1. If necessary adjust R179 for a locked display.
5. Adjust R186 for 2 markers or 2 cycles of squarewave per division LEVEL B may be used to ensure best triggering on markers.
6. Reset R165 if necessary for 10.2 divs. trace length.

4.3.11.5 SET 0.2 μ s TIMING B: C219B MOUNTED ON THE TIME/DIV SWITCH

1. Ensure VARIABLE B is fully clockwise.
2. Switch TIME/DIV B to 0.2 μ s and apply 1 μ s markers or a 1 MHz squarewave to CH1.
3. Using a non-capacitive trimming tool, adjust C219B for 1 marker or 1 cycle of squarewave over 5 divs.

4.3.11.6 SET STABILITY B: R179

1. With LEVEL B at AUTO, TRIG MODE B at +, INT and VARIABLE B pushed in, switch TIME/DIV B to 0.5 ms.
2. Apply 1 kHz squarewave to CH1 and adjust the amplitude of display to 1 division.
3. Turn R179 fully clockwise, then anti-clockwise till the display disappears; turn back to a midway position.
4. Pull out VARIABLE B and check that sweep free-runs.
5. Switch off oscilloscope and replace link removed in 4.3.10.1
6. Switch on, push in VARIABLE A and B, set DISPLAY to A INT, DELAY to 5.00, TIME/DIV B to 20 μ s, TIME/DIV A to 1 ms, LEVEL A to AUTO and TRIG MODE A to A.C. +, INT.
7. Short EXT B trigger connector to GND and check that with rotation of DELAY the intensified portion of the trace moves across the trace in a series of jumps; if not re-adjust R179.
8. Release INT-EXT B TRIG MODE button and check that the intensified portion disappears, if not, reset R179 and re-check operations 6, 7 and 8.
9. Pull out VARIABLE B. Check that the intensified portion of the display can be moved steadily across the screen with DELAY control; if not, reset R179 and re-check operations 6 to 9.
10. Remove squarewave and the connection to GND from the EXT B trigger connector.

4.3.12 VERTICAL AMPLIFIER**4.3.12.1 TO SET CH1 BALANCE, CH1 ON, CH2 OFF**

1. Set VOLTS/DIV to 10 mV.

2. Set POSITION to centre of range.
3. Set DC-GND-AC to AC.
4. Connect 1 kHz squarewave of 5 mV/peak to peak amplitude to input 1.
5. Push VARIABLE for x10 gain.
6. Adjust R642 until trace appears.
7. Set R618 for 5 div deflection.
8. Increase signal amplitude to 25 mV.
9. Turn VARIABLE fully anti-clockwise.
10. Adjust R622 to equalise POSITION range about screen centre.
11. Release VARIABLE for x1 gain.

4.3.12.2 TO SET CH2 BALANCE CH2 ON, CH1 OFF

1. Set VOLTS/DIV to 10 mV.
2. set POSITION to centre of range.
3. Set DC-GND-AC to AC.
4. Connect 1 kHz squarewave of 5 mV peak to peak amplitude to input 2.
5. Push VARIABLE for x10 gain.
6. Adjust R669 until trace appears.
7. Set R693 for 5 div deflection.
8. Increase signal amplitude to 25 mV.
9. Turn VARIABLE fully anti-clockwise.
10. Adjust R697 to equalise POSITION range about screen centre.
11. Release VARIABLE for x1 gain.

4.3.13 VERTICAL AMPLIFIER (D.C. and L.F. SETTING)**4.3.13.1 TO SET CH1 VARIABLE AND POSITION BALANCE: R625 and R642.**

1. Check CH1 on, CH2 off.
2. Set VARIABLE for x10 gain.
3. Set VOLTS/DIV to 10 mV.
4. Set DC-GND-AC to GND.
5. Adjust POSITION to align trace with graticule centre line.
6. Push VARIABLE for x10 gain.
7. Adjust R642 to centralise trace.
8. Release VARIABLE for x1 gain.
9. Repeat operations 5 through 8 until no trace movement occurs when operating VARIABLE.
10. Push VARIABLE for x10 gain.
11. Turn VARIABLE fully anti-clockwise.
12. Adjust R625 to centralise trace.
13. Turn VARIABLE fully clockwise.
14. Repeat operations 5 through 13 until there is no movement when VARIABLE is turned through its range.

4.3.13.2 TO SET CH2 POSITION BALANCE: R669

1. Switch CH2 on.
2. Push both VARIABLES for x10 gain.
3. Set both DC-GND-AC to GND.
4. Turn both VARIABLES fully clockwise.
5. Set CHOP-ADD-ALT to ALT.
6. Centralise both traces.
7. Set CHOP-ADD-ALT to ADD.
8. Adjust R669 to centralise trace.
9. Repeat operations 5 through 8 until no trace movement occurs.

4.3.13.3 TO SET CH2 VARIABLE BALANCE: R701.

1. CH1 off. Check CH2 is on.
2. Set VARIABLE fully clockwise.
3. Set VOLTS/DIV to 10 mV.
4. Set DC-GND-AC to GND.
5. Adjust POSITION to align trace with graticule centre line.
6. Push VARIABLE for x10 gain.
7. Turn VARIABLE fully anti-clockwise.
8. Adjust R701 to centralise trace.
9. Repeat operations 6 through 8 until there is no movement when VARIABLE is turned through its range.

4.3.13.4 TO SET CH1 x1 GAIN: R617.

1. Switch CH1 on, CH2 off.
2. Set VOLTS/DIV to 10 mV.
3. Release VARIable for x1 gain.
4. Press INT TRIG 1.
5. Set TIME/DIV to 1 ms.
6. Set DC-GND-AC to DC.
7. Connect 1 kHz squarewave of 50 mV peak to peak amplitude to input 1.
8. Adjust R617 to give 5 div amplitude.

4.3.13.5 TO SET CH1 x10 GAIN: R618.

1. Set input signal to 5 mV peak to peak.
2. Push VARIable for x10 gain.
3. Adjust R618 to give 5 div amplitude.

4.3.13.6 TO SET CH2 x1 GAIN: R691.

NOTE: Operations 4.3.13.6 and 4.3.13.7 assume that CH1 gain, operations 4.3.13.4 to 4.3.13.5 have been accurately set.

1. Switch CH1 off, CH2 on.
2. Set both VOLTS/DIV to 10 mV.
3. Turn VARIable fully clockwise.
4. Set DC-GND-AC to DC.
5. Release VARIable for x1 gain.
6. Press INT TRIG 2.
7. Set CHOP-ADD-ALT to ALT.
8. Adjust POSITION to centralise traces.
9. Connect 1 kHz squarewave of 50 mV peak to peak amplitude to INPUT 2.
10. Adjust R691 for 5 div amplitude.
11. Switch CH1 on.
12. Connect 1 kHz squarewave of 50 mV peak to peak amplitude to INPUT 1 and 2.
13. Check channels for identical traces.

4.3.13.7 TO SET CH2 x10 GAIN: R693

1. Set input signal to 5 mV peak to peak.
2. Push both VARIables for x10 gain.
3. Adjust R693 for 5 div amplitude.
4. Check channels for identical traces.

4.3.13.8 TO SET CH1 INPUT AND NEUTRALIZING CAPACITORS: C601 and C604.

1. Connect 1 kHz squarewave of 50 mV peak to peak amplitude to INPUT 1.
1. Switch CH1 on, CH2 off.
3. Press INT TRIG 1.
4. Turn VARIable fully clockwise.
5. Set VOLTS/DIV to 10 mV.
6. Release VARIable for x1 gain.
7. Set DC-GND-AC to DC.
8. Adjust C604 for square corner with a non-capacitive trimming tool.
9. Turn VARIable fully anti-clockwise.
10. Adjust C601 for square corner (increase signal amplitude if required).
11. Turn VARIable fully clockwise.
12. Repeat operations 9 and 10 until a square corner is maintained at the extreme positions of the VARIable control.

4.3.13.9 TO SET CH2 INPUT AND NEUTRALISING CAPACITORS: C634 and C636.

1. Connect 1 kHz squarewave of 50 mV peak to peak amplitude to INPUT 2.
2. Switch CH2 on, CH1 off.
3. Press INT TRIG 2.
4. Turn VARIable fully clockwise.
5. Set VOLTS/DIV to 10 mV.
6. Release VARIable for x1 gain.
7. Set DC-GND-AC to DC.
8. Adjust C636 for square corner with a non-capacitive trimming tool.
9. Turn the VARIable fully anti-clockwise.
10. Adjust C634 for square corner (increase signal amplitude if required).

11. Turn VARIable fully clockwise.

12. Repeat operations 9 and 10 until a square corner is maintained at the extreme positions of the VARIable control.

4.3.14 ATTENUATOR (adjustment).

4.3.14.1 TO SET CH1 ATTENUATOR COMPENSATION

1. Switch CH1 on.
2. Transfer the input signal to INPUT 1.
3. Press INT TRIG 1.
4. DC-GND-AC. Set CH1 to DC, CH2 to GND.
5. Turn VARIable fully clockwise.
6. Set VOLTS/DIV to Col. 1 below.
7. Set Calibrator to Col. 2.
8. Adjust trimmer, Col. 3 for square corner.
9. Repeat operations 6, 7 and 8 until trimmers in Col. 3 have been adjusted.

VOLTS/DIV 1	Squarewave 1 kHz 2	Adjust 3
Volt	Volt	
20 m	0.1	C914
50 m	0.25	C916
0.1	0.5	C907
0.2	1	C913
0.5	2.5	C912
1	5	C906
10	50	C905

10. Connect a compensated x10 probe between Calibrator and INPUT 1.
11. Repeat operations 6, 7 and 8 with reference to table below.

VOLTS/DIV 1	Squarewave 1 kHz 2	Adjust 3
Volt	Volt	
0.1	5	C904 (0.1 V probe)
1	50	C903 (1.0 V probe)
10	100	C902

12. Disconnect input signal and probe.

4.3.14.2 TO SET CH2 ATTENUATOR COMPENSATION

1. Connect the input signal to INPUT 2.
2. Check CH2 is on.
3. Press INT TRIG 2.
4. DC-GND-AC. Set CH1 to GND, CH2 to DC.
5. Carry out operation 5 through 12 in 4.3.14.1 above, using the respective CH2 controls.

4.3.15 VERTICAL AMPLIFIER (PULSE RESPONSE)

4.3.15.1 TO SET CH1 NEUTRALIZATION C605 and C608.

1. Connect 1 MHz squarewave to 50Ω Terminator.
 2. Connect Terminator to INPUT 1.
 3. Switch CH1 on, CH2 on.
 4. Press INT TRIG 1.
 5. DC-GND-AC. Set CH1 to DC, CH2 to GND.
 6. Set VOLTS/DIV to 10 mV.
 7. Set TIME/DIV to 0.2 μs.
 8. Adjust CH1 squarewave amplitude for a 5 div trace.
 9. Adjust C605 and C608 to minimize interaction of CH1 trace on CH2.
- NOTE: The physical settings of C605 and C608 should be approximately equal; this is determined by the relative positions of the rotor stator vanes.

4.3.15.2 TO SET CH2 NEUTRALIZATION: C625 and C631.

1. Connect 1 MHz squarewave to 50 Ω Terminator.
2. Connect Terminator to INPUT 2.
3. Press INT TRIG 2.
4. DC-GND-AC. Set CH1 to GND, CH2 to DC.
5. Set VOLTS/DIV to 10 mV.
6. Set TIME/DIV to 0.2 μ s.
7. Adjust CH2 squarewave amplitude for a 5 div trace.
8. Adjust C625 and C631 to minimize interaction of CH2 trace on CH1.

NOTE: The physical settings of C625 and C631 should be approximately equal; This is determined by the relative positions of the rotor and stator vanes.

4.3.15.3. SET H.F. FREQUENCY RESPONSE: C606, C619, C621 C632, R614, R681, R656, L752 and L753

NOTE: The resultant settings of this procedure are extremely critical. Inaccuracies will have an adverse effect on bandwidth and pulse.

1. Connect 100 kHz squarewave signal to INPUT 1 via Terminator.
2. Set TIME/DIV to 5 μ s.
3. Turn R614 fully clockwise.
4. Turn C606 until stator and rotating vanes are visible.
5. Screw out cores of L752 and L753.
6. Set the input signal to give 3 div amplitude approximately.
7. Press INT TRIG 1.
8. Set DC-GND-AC to DC.
9. Adjust TRIG for a locked display.
10. Adjust C619 for corners without overshoot.
11. Reset input signal to 1 MHz squarewave.
12. Set TIME/DIV to 0.2 μ s.
13. Adjust R656 and C621 alternatively for optimum squarewave.

NOTE: Turn R656 clockwise until a point is reached

immediately prior to the squarewave deterioration.

14. Set TIME/DIV to 5 μ s.
15. Check for flatness of wave top.
16. Repeat operations 12 through 15 until a squarewave is displayed.
17. Set TIME/DIV to 0.2 μ s.
18. Adjust C606 for maximum overshoot.
19. Turn R614 slightly anti-clockwise to eliminate H.F. oscillation on the trailing edge of the first overshoot.
20. Adjust C606 to eliminate overshoot.
21. Gradually screw in the cores of L752 and L753 alternately until the leading edge of the squarewave is vertical without overshoot.
22. Connect the signal to INPUT 2.
23. Press INT TRIG 2.
24. Adjust TRIG for a locked display.
25. Turn R681 fully clockwise.
26. Adjust C632 for maximum overshoot.
27. Turn R681 slightly anti-clockwise to eliminate H.F. oscillation on the trailing edge of the first overshoot.
28. Adjust C632 to eliminate overshoot.
29. Check CH1 and CH2 for similar pulse responses.
30. Check that the 3 db bandwidths of both channels are better than 25 MHz.

4.3.15.4 SET INTERNAL 500 mV CALIBRATOR: R414.

1. Set CH1 VOLTS/DIV to 0.1 and ensure CH1 VARIABLE is fully clockwise. Depress CH1 INT TRIG button and set CH1 DC-GND-AC to DC.
2. Apply accurate 500 mV peak to peak squarewave to CH1 and note precisely the amplitude of display; This should be 5 divisions if 4.3.13.4 above, has been correctly carried out.
3. Remove squarewave and apply signal from CAL 500 mV peak to peak socket.
4. Adjust R414 for exactly the same amplitude as found in operation 2.

SECTION 5 COMPONENT LIST

Values of resistors are stated in ohms or multiples of ohms; ratings at 70°C are in watts or sub-multiples of watts. Values of capacitors are stated in sub-multiples of farads; ratings at 70°C are in volts or kilovolts.

Whenever possible, exact replacements for components should be used, although locally available alternative may be satisfactory for standard components.

Any order for replacement parts should include:

- | | |
|--------------------------------|--------------------------|
| 1. Instrument type | 4. Component part number |
| 2. Instrument serial number | 5. Component value |
| 3. Component circuit reference | |

CIRCUIT REFERENCE BLOCKS

The table below gives the blocks of circuit references, so that the reader can relate the items listed in this section and their location in the circuitry and printed circuit boards in Section 6.

Circuit Reference		Circuit	Fig.	P.C. Board No.
From	To			
1	50	Trigger 'A'	5	210
51	100	Trigger 'B'	6	210
101	160	Timebase 'A' and delay circuit	8	210
161	200	Timebase 'B'	9	210
201	240	Time/Div switch	10	No Board
241	280	Unblanking Amplifier	12	210
281	300	X Amplifier	11	210
301	400	C.R.T.	13	210
401	599	Power Supplies	14	210
600	700	Y Amplifier Input & Channel switching	3	212
701	900	Y Amplifier Output & Trigger preamplifier	4	212
901	1000	Attenuator	2	146

ABBREVIATIONS

BM Button mica	CV Carbon variable	PC Polycarbonate
C Carbon	E Electrolytic	PE Polyester
CER Ceramic	MG Metal Glazed	PP Polypropylene
CM Cermet thick film	MF Metal Film	PS Polystyrene
CP Carbon preset	MO Metal Oxide	SM Silver mica
CT Ceramic trimmer	PPT Polypropylene trimmer	WWV Wire-wound variable
† Tolerance of -20% + 80%	PEP Polyester paper	

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All requests for repairs or replacement parts should be directed to the Tektronix Field Office or representative in your area. This procedure will assure you the fastest possible service. In the UK enquiries should be made to Harpenden.

CIR REF	PART NUMBER	VALUE	DESCRIPTION			CIR REF	PART NUMBER	VALUE	DESCRIPTION			
			TYPE	TOL %	RATING Volts				Eff. Ser.No.	TYPE	TOL %	RATING Volts
C1	285-1078-00	1.5 μ	PE	20	63	*C214	285-0869-00	47 p	PS	2 pF	350	
C2	285-1078-00	1.5 μ	PE	20	63	*C215	285-0762-00	450 p	PS	1	125	
C3	285-0773-00	100 n	PE	20	400	*C216	285-0770-00	4.7 n	PS	1	125	
C4	285-0779-00	470 n	PE	20	100	*C217	285-0926-00	47 n	PE	1	63	
C5	281-0678-00	3.0 p	CER	0.1 p	500	*C218	285-0927-00	470 n	PC	1	63	
C6	281-0678-00	3.0 p	CER	0.1 p	500	*C219	281-0732-00	3 - 12 p	CT		350	
C7	285-1078-00	1.5 μ	ELEC		25	643451	*C220	285-0928-00	4.7 μ	PC	1	63
C8	290-0499-00	15 μ	ELEC		16	*C221	285-0884-00	29 p	PS	1 pF	350	
C9	285-0850-00	1.0 μ	PS	5	125	*C222	285-0769-00	10 n	PE	20	400	
C10	285-0920-00	56 p	PS	2	350	*C223	285-0866-00	10 p	PS	1	350	
C11	285-0779-00	470 n	PE	20	100	*C224	283-0653-00	5.0 p	SM	10	350	
C12	290-0497-00	100 μ	ELEC		16							
C13	285-0854-00	100 p	PS	2	350							
C14	285-1078-00	1.5 μ	PE	20	63							
C15	281-0710-00	10 n	CER	†	250							
						C251	281-0754-00	100 p	CER	20	4 k	
						C252	281-0754-00	100 p	CER	20	4 k	
						C253	285-0867-00	20 p	PS	1 p	350	
						C254	285-0867-00	20 p	PS	1 p	350	
C51	285-1078-00	1.5 μ	PE	20	63	C255	285-0850-00	1.0 n	PS	5	125	
C52	285-1078-00	1.5 μ	PE	20	63	C256	285-0867-00	20 p	PS	1 p	350	
C53	285-0773-00	100 n	PE	20	400	C257	281-0677-00	10 n	CER	†	1.5 k	
C54	285-0779-00	470 n	PE	20	100	C258	281-0705-00	1.0 p	CER	0.1 p	500	
C55	281-0723-00	1.8 p	CER	0.1 p	500	C259	290-0623-00	4.7 μ	ELEC		25	
C56	281-0723-00	1.8 p	CER	0.1 p	500	C260	285-0873-00	200 p	PS	5	350	
C57	285-0779-00	470 n	PE	20	100	C261	285-0867-00	20 p	PS	1 p	350	
						C262	281-0710-00	10 n	CER	†	250	
C59	285-0850-00	1 n	PS	5	125							
C61	285-0920-00	56 p	PS	2	350	C277	285-0850-00	1.0 n	PS	5	125	
C62	285-0779-00	470 n	PE	20	100	C278	285-0873-00	200 p	PS	5	350	
						C279	285-0795-00	220 n	PE	20	250	
C64	285-0854-00	100 p	PS	2	350	C280	281-0710-00	10 n	CER	†	250	
						C281	281-0710-00	10 n	CER	†	250	
C101	285-0850-00	1 n	PS	5	125							
C102	285-0776-00	27 p	PS	1 p	350	C301	285-0853-00	470 n	PE	20	400	
C103	285-0854-00	100 p	PS	2	350	C302	285-0772-00	100 n	PE	10	400	
C104	285-0873-00	200 p	PS	5	350	C303	285-0796-00	100 n	PE	20	250	
C105	285-0874-00	470 p	PS	5	125	C304	281-0682-00	20 n	CER		2 k	
C106	285-0867-00	20 p	PS	1 p	350	C305	285-0796-00	100 n	PE	20	250	
C107	285-0870-00	120 p	PS	2	350							
C109	285-0873-00	200 p	PS	5	350							
C110	285-0866-00	10 p	PS	1	350	C401	290-0500-00	470 μF	ELEC		100	
C111	285-0854-00	100 p	PS	2	350	C402	285-0992-00	22 nF	PEP	10	5 k	
C112	285-0769-00	10 n	PE	20	400	C403	285-0992-00	22 nF	PEP	10	5 k	
C113	281-0732-00	3 - 12 p	CT		350	C404	290-0500-00	470 μF	ELEC		100	
C114	281-0154-00	2 - 12 p	PP		100	C405	290-0489-00	15 μF	ELEC	†	350	
C115	285-0843-00	30 p	PS	2 p	350	C406	290-0489-00	15 μF	ELEC	†	350	
C116	285-0769-00	10 n	PE	20	400	C407	290-0489-00	15 μF	ELEC	†	350	
C117	285-0994-00	470 n	PE	20	100	C408	290-0489-00	15 μF	ELEC	†	350	
						C409	285-1032-00	47 n	PE	20	160	
						C410	285-0992-00	22 nF	PEP	10	5 k	
C161	285-0854-00	100 p	PS	2 p	350	C411	285-0992-00	22 nF	PEP	10	5 k	
C162	285-0873-00	200 p	PS	5	350	C412	290-0498-00	1 mF	ELEC	†	25	
C163	285-0867-00	20 p	PS	1 p	350	C413	290-0498-00	1 mF	ELEC	†	25	
C164	285-0769-00	10 n	PE	20	400	C414	285-0874-00	470 pF	PS	5	125	
C165	285-0843-00	30 p	PS	2 p	350	C415	285-0790-00	10 nF	PE	20	125	
C166	283-0653-00	5 p	SM	10	350	C416	290-0498-00	1 mF	ELEC	†	25	
						C417	281-0677-00	10 nF	CER	†	2 k	
C168	281-0710-00	10 n	CER	†	250	C418	290-0495-00	47 μF	ELEC		40	
						C419	285-0795-00	220 nF	PE	20	250	
						C420	285-0874-00	470 pF	PS	5	125	
						C421	285-0796-00	100 nF	PE	20	250	
						C422	290-0496-00	33 μF	ELEC		160	
						C423	285-0796-00	100 nF	PE	20	250	
						C424	290-0623-00	4.7 μF	ELEC		25	
*C210	285-0874-00	470 p	PS	5	125	C425	290-0495-00	47 μF	ELEC	†	40	
*C211	285-0792-00	4.7 n	PE	20	125	C426	290-0623-00	4.7 μF	ELEC		25	
*C212	285-1032-00	47 n	PE	20	160	C427	290-0490-00	100 μF	ELEC		25	
*C213	285-0791-00	470 n	PE	10	125							

CIR REF	PART NUMBER	VALUE	DESCRIPTION			RATING	Eff. Ser.No.	CIR REF	PART NUMBER	VALUE	DESCRIPTION			RATING	Eff. Ser.No.
			TYPE	TOL %	Volts						TYPE	TOL %	Volts		
C428	290-0489-00	15 μF	ELEC		350		C632	281-0157-00	5.5p-65.5p	T		500			
C429	290-0489-00	15 μF	ELEC		350		C633	281-0723-00	1.8p	CER	0.1 p	500			
C430	281-0682-00	20 nF	CER	†	2 k		C634	281-0156-00	1.4p-6.4p	T		500			
C431	290-0491-00	100 μF	ELEC		63		C635	285-0845-00	68 p	PS	2 p	350			
C432	285-0915-00	100 nF	PE	20	100		C636	281-0157-00	5.5-65 pF	T		500			
C433	285-0923-00	220 nF	PE	10	160		C637	281-0710-00	10 n	CER	†	250			
C435	285-0779-00	470 nF	PE	20	100		C638	290-0493-00	22 μ	ELEC		16			
C600	285-0796-00	100 n	PE	20	250		C639	281-0710-00	10 n	CER	†	250			
C601	281-0157-00	5.5p-65.5p	T		500		C641	285-0994-00	470 n	PE	†	100			
C602	285-0845-00	68 p	PS	2 p	350		C642	281-0734-00	100 n	CER	†	30			
C603	281-0723-00	1.8 p	CER	0.1 p	500		C643	285-0915-00	100 n	PE	20	100			
C604	281-0156-00	1.4p-6.4p	T		500		C644	281-0710-00	10 n	CER	†	250			
C605	281-0156-00	1.4p-6.4p	T		500		C751	281-0678-00	3 p	CER	0.1 p	500			
C606	281-0157-00	5.5p-65.5p	T		500		C752	285-0795-00	220 n	PE	20	250			
C607	281-0734-00	100 n	CER	†	30		C753	281-0710-00	10 n	CER	†	250			
C608	281-0156-00	1.4p-6.4p	T		500		C754	281-0710-00	10 n	CER		250			
C609	281-0723-00	1.8 p	CER	0.1 p	500		C755	281-0713-00	10 p	CER	0.25 p	750			
C611	290-0623-00	4.7 μ	ELEC		25		C756	281-0713-00	10 p	CER	0.25 p	750			
C612	285-0788-00	100 n	PE	10	125		C757	285-0869-00	47 p	PS	2 p	350			
C613	285-0854-00	100 p	PS	2 p	350		C901	285-0772-00	100 n	PE	10	400			
C614	281-0710-00	10 n	CER	†	250		*C902	281-0155-00	2-22 p	PP		500			
C616	281-0710-00	10 n	CER	†	250		*C903	281-0155-00	2-22p	PP		500			
C617	281-0676-00	2.2 p	CER	0.1 p	500		*C904	281-0155-00	2-22 p	PP		500			
C618	281-0713-00	10 p	CER	0.25 p	750		*C905	281-0156-00	1.4p-6.4p	PP		500			
C619	281-0155-00	2-22 p	T		500		*C906	281-0156-00	1.4p-6.4p	PP		500			
C620	281-0734-00	100 n	CER	†	30		*C907	281-0154-00	2-12 p	PP		500			
C621	281-0155-00	2-22 p	T		500		*C908	283-0607-00	2.0 n	BM	10	500			
C622	285-0854-00	100 p	PS	2 p	350		*C909	283-0719-00	470 p	BM	10	500			
C623	281-0734-00	100 n	CER	†	30		*C911	285-0844-00	39 p	PS	2 p	350			
C624	290-0494-00	47 μ	ELEC		25		*C912	281-0155-00	2-22p	PPT		500	643851		
C625	281-0156-00	1.4p-6.4p	T		500		*C913	281-0154-00	2-12p	PPT		500	643851		
C626	281-0734-00	100 n	CER	†	30		*C914	281-0155-00	2-22p	PPT		500			
C627	281-0723-00	1.8 p	CER	0.1 p	500		*C915	283-0662-00	7.5 p	SM	0.5	350			
C628	290-0623-00	4.7 μ	ELEC		25		*C916	281-0154-00	2-12p	PPT		500			
C629	285-0788-00	100 n	PE	10	125		*C917	285-0842-00	15 p	PS	1 p	350			
C630	285-1046-00	100 n	PE	20	160										
C631	281-0156-00	1.4p-6.4p	T		500										

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING	Eff. Ser. No.
D1	152-0370-00		AAV 30	GE		50 V	
D2	152-0370-00		AAV 30	GE		50 V	
D3	152-0062-00		IN 914	Si			
D51	152-0370-00		AAV 30	GE		50 V	
D52	152-0370-00		AAV 30	GE		50 V	
D53	152-0062-01		IN 914	Si		75 mA	
D101	152-0062-01		IN 914	Si		75 mA	
D102	152-0062-01		IN 914	Si		75 mA	
D103	152-0062-01		IN 914	Si		75 mA	
D104	152-0062-01		IN 914	Si		75 mA	
D105	152-0343-00		IN 914T	Si			
D106	152-0370-00		AAV 30	GE		50 V	
D107	152-0062-01		IN 914	Si		75 mA	
D108	152-0062-01		IN 914	Si		75 mA	

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING	Eff. Ser.No.
D109	152-0346-00	11V	Zener	Si	5	33 W	
D161	152-0062-01		1N 914	Si		75 mA	
D162	152-0062-01		1N 914	Si		75 mA	
D163	152-0343-00		1N 914 T	Si			
D164	152-0370-00		AA Y 30	GE		50 V	
D165	152-0343-00		1N 914 T	Si			
D166	152-0343-00		1N 914 T	Si			
D168	152-0644-00	36 V	Zener	Si		700 mW	
D251	152-0370-00		AA Y 30	Si		50 V	
D252	152-0062-01		1N 914	Si		75 mA	
D253	152-0062-01		1N 914	Si		75 mA	
D254	152-0062-01		1N 914	Si		75 mA	
D255	152-0062-01		1N 914	Si		75 mA	
D256	152-0062-01		1N 914	Si		75 mA	
D281	152-0062-01		1N 914	Si		75 mA	
D282	152-0062-01		1N 914	Si		75 mA	
D301	152-0344-00	100 V	Zener				
D401	152-0515-00	6000 V	SMC60	Si			
D402	152-0515-00	6000 V	SMC60	Si		330 mW	
D403	152-0344-00	100 V	Zener	Si		330 mW	
D404	152-0344-00	100 V	Zener	Si		700 mW	
D405	152-0388-00	130 V	Zener	Si			
D406	152-0515-00	6000 V	SCM60	Si			
D407	152-0515-00	6000 V	SCM60	Si		0.5 A	
D408	152-0341-00	450 V	ZS 75	Si		0.5 A	
D409	152-0341-00	450 V	ZS 75	Si			
D410	152-0515-00	6000 V	SCM60	Si			
D411	152-0515-00	6000 V	SCM60	Si		75 mA	
D412	152-0062-01		1N 914	Si		0.5 A	
D413	152-0341-00	450V	Rectifier			0.5 A	
D414	152-0339-00	50 V	ZS 70	Si		0.5 A	
D415	152-0339-00	50 V	ZS 70	Si		0.5 A	
D416	152-0062-01		1N 914	Si		75 mA	
D417	152-0062-01		1N 914	Si		75 mA	
D418	152-0339-00	50 V	ZS 70	Si		0.5 A	
D419	152-0062-01		1N 914	Si		75 mA	
D421	152-0487-00	47V	Zener BZY93/C47			20 W	
D422	152-0339-00	50 V		Si		0.5 A	
D423	152-0348-00	6.2 V	Zener	Si	5	330 mW	
D424	152-0062-01		1N 914	Si		75 mA	
D425	152-0062-01		1N 914	Si		75 mA	
D426	152-0339-00	50 V		Si		500 mA	
D427	152-0341-00	450 V		Si		500 mA	
D428	152-0062-01		1N 914	Si		75 mA	
D429	152-0344-00	100 V	Zener	Si		330 mW	
D431	152-0354-00	12 V	Zener	Si	5	330 mW	
D432	152-0484-00	39 V	Zener BZX61/C39	Si	5	700 mW	

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING	Eff. Ser.No.
D601	152-0554-00		BAY 74	Si			
D603	152-0554-00		BAY 74	Si			
D604	152-0348-00	6.2 V	Zener	Si	5	330 mW	
D606	152-0062-01		1N 914			75 mA	
D607	152-0062-01		1N 914			75 mA	
D608	152-0062-01		1N 914			75 mA	
D609	152-0062-01		1N 914			75 mA	
D610	152-0554-00		BAY 74	Si			
D611	152-0348-00	6.2 V	Zener	Si	5	330 mW	
D612	152-0554-00		BAY 74	Si			
D751	152-0062-01		1N914/1N4148				643781
D752	152-0543-00	5.1V	Zener	Si	5	400 mW	643781
CIR REF	PART NUMBER	VALUE	DESCRIPTION				
DL751		636-0006-00	200 ns	Delay Line Assy.			
FB101		276-0597-00		Ferrite Bead Mullard FX1115			
FB102		267-0597-00		Ferrite Bead Mullard FX1115			
FB161- FB162		276-0597-00 276-0597-00		Ferrite Bead Mullard FX1115 Ferrite Bead Mullard FX1115			
FS401		159-0079-00	500 mA	Fuse Link 1.25" lg slow for 100-125 V			
FS401		159-0077-00	250 mA	Fuse Link 1.25" lg slow for 200-250 V			
CIR REF	PART NUMBER	VALUE	DESCRIPTION			RATING	Eff. Ser.No.
ILP401	150-0095-00		Lamp 14 V L.E.S.			750 mW	
ILP402	150-0110-00		Lamp 12 V Capless			960 mW	
ILP403	150-0110-00		Lamp 12 V Capless			960 mW	
L1	108-0665-00	4.7 μH	Inductor Fixed				
L2	108-0665-00	4.7 μH	Inductor Fixed				
L275	119-0283-00	12 V	Solenoid Type 1S12				
L402	108-0483-00	16 μH	Inductor Fixed 5%				
L601	108-0482-00	160 μH	Inductor Fixed				
L602	108-0482-00	160 μH	Inductor Fixed				
L603	108-0665-00	4.7 μH	Inductor Fixed				
L751	108-0504-00		Trace Rotation Coil				
L752	114-0301-00	4.7 μH	Inductor Fixed				
L753	114-0301-00	4.7 μH	Inductor Fixed				

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.	CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
R1	317-0180-00	18	C	5	125 m		R85	317-0222-01	2.2 k	C	5	125 m	
R3	317-0104-01	100 k	C	5	125 m		R86	317-0103-01	10 k	C	5	125 m	
R4	317-0104-01	100 k	C	5	125 m		R87	317-0180-01	18	C	5	125 m	
R5	317-0271-01	270	C	5	125 m								
R6	317-0362-01	3.6 k	C	5	125 m		R101	317-0393-01	39 k	C	5	125 m	
R7	317-0102-01	1.0 k	C	5	125 m		R102	317-0103-01	10 k	C	5	125 m	
R8	317-0182-01	1.8 k	C	5	125 m		R103	317-0333-01	33 k	C	5	125 m	
R9	317-0222-01	2.2 k	C	5	125 m		R104	317-0225-01	2.2 M	C	10	250 m	
							R105	317-0105-01	1 M	C	5	125 m	
R11	317-0332-01	3.3 k	C	5	125 m		R106	317-0224-01	220 k	C	5	125 m	
R12	311-0719-00	470	CP	20	250 m		R107	317-0333-01	33 k	C	5	125 m	
R13	317-0821-01	820	C	5	125 m		R108	317-0222-01	2.2 k	C	5	125 m	
R14	317-0222-01	2.2 k	C	5	125 m		R109	311-0735-00	10 k	CP	20	250 m	
R15	317-0821-01	820	C	5	125 m		R110	315-0335-02	3.3 M	CF	5	250 m	
R16	311-1050-00	2.2 k	CV	20	250 m		R111	317-0472-01	4.7 k	C	5	125 m	
R17	317-0821-01	820	C	5	125 m		R112	317-0223-01	22 k	C	5	125 m	
R18	317-0222-01	2.2 k	C	5	125 m		R113	311-0735-00	10 k	CP	20	250 m	
R19	317-0332-01	3.3 k	C	5	125 m		R114	317-0472-01	4.7 k	C	5	125 m	
R20	315-0181-01	180	C	5	250 m		R115	317-0183-01	18 k	C	5	125 m	
R21	317-0102-01	1.0 k	C	5	125 m		R116	317-0182-01	1.8 k	C	5	125 m	
R22	317-0182-01	1.8 k	C	5	125 m		R117	317-0331-01	330	C	5	125 m	
R23	317-0222-01	2.2 k	C	5	125 m		R118	303-0153-01	15 k	C	5	125 m	
R24	317-0233-01	22 k	C	5	125 m	643451	R119	317-0152-01	1.5 k	C	5	125 m	
R25	317-0103-01	10 k	C	5	125 m	643451	R120	301-0685-02	6.8 M	C	5	500 m	643751
R26	317-0393-01	39 k	C	5	125 m		R121	317-0123-01	12 k	C	5	125 m	
R27	317-0122-01	1.2 k	C	5	125 m		R122	317-0392-01	3.9 k	C	5	125 m	
							R123	317-0682-01	6.8 k	C	5	125 m	
R29	317-0223-01	22 k	C	5	125 m		R124	317-0223-01	22 k	C	5	125 m	
R30	317-0180-01	18	C	5	125 m		R125	311-0850-00	15 k	CP	20	250 m	
R31	317-0221-01	220	C	5	125 m		R126	317-0122-01	1.2 k	C	5	125 m	
R32	317-0222-01	2.2 k	C	5	125 m		R127	317-0472-01	4.7 k	C	5	125 m	
R33	311-0717-00	220	CP	20	250 m		R128	317-0680-01	68	C	5	125 m	
R34	317-0332-01	3.3 k	C	5	125 m		R129	317-0102-01	1 k	C	5	125 m	
R35	317-0471-01	470	C	5	125 m								
R36	317-0222-01	2.2 k	C	5	125 m		R131	317-0472-01	4.7 k	C	5	125 m	
R37	316-0335-02	3.3 M	C	10	250 m		R132	317 0101-01	100	C	5	125 m	
R38	317-0103-01	10 k	C	5	125 m		R133	315-0823-02	82 k	C	5	250 m	
R39	317-0224-01	220 k	C	5	125 m		R134	311-1048-00	50 k	CV	20	250 m	
R40	317-0180-01	18	C	5	125 m		R135	317-0100-01	10	C	5	125 m	
R41	317-0822-01	8.2 k	C	5	125 m	643451	R136	317-0103-01	10 k	C	5	125 m	
R42	317-0183 01	18 k	C	5	125 m	643451	R137	311-0719-00	470	CP	20	250 m	
							R138	317-0272-01	2.7 k	C	5	125 m	
R51	317-0180-01	18	C	5	125 m		R139	311-1052-00	2 k	WW	5	875 m	
							R140	317-0471-01	470	C	5	125 m	
R53	317-0104-01	100 k	C	5	125 m		R141	321-0279-48	7.87 k	MF	1	125 m	
R54	317-0104-01	100 k	C	5	125 m		R142	321-0850-48	27 k	MF	1	125 m	
R55	317-0271-01	270	C	5	125 m		R143	311-0735-00	10 k	CP	20	250 m	
R56	317-0362-01	3.6 k	C	5	125 m		R144	317-0221-01	220	C	5	125 m	
R57	317-0152-01	1.5 k	C	5	125 m		R145	317-0153 01	15 k	C	5	125 m	
R58	317-0182-01	1.8 k	C	5	125 m		R146	317-0221-01	220	C	5	125 m	
R59	317-0562-01	5.6 k	C	5	125 m		R147	317-0222-01	2.2 k	C	5	125 m	
							R148	317 0222-01	2.2 k	C	5	125 m	
R61	317-0332-01	3.3 k	C	5	125 m		R149	317-0333-01	33 k	C	5	125 m	
R62	311-0851-00	1.0 k	CP	20	250 m								
R63	317-0821-01	820	C	5	125 m		R151	317-0562-01	5.6 k	C	5	125 m	
R64	317-0682-01	6.8 k	C	5	125 m		R152	315-0331-02	330	C	5	250 m	
R65	317-0821-01	820	C	5	125 m		R153	317-0332-01	3.3 k	C	5	125 m	
R66	311-1053-00	10 k	CV	20	250 m		R154	321-0419-48	226 k	MF	1	125 m	
R67	317-0821-01	820	C	5	125 m		R155	317-0101-01	100	C	5	125 m	
R68	317-0682-01	6.8 k	C	5	125 m		R156	315 0684-01	680 k	C	10	250 m	
R69	317-0332-01	3.3 k	C	5	125 m		R157	316-0105-01	1 M	C	10	250 m	
							R158	316-0125-01	1.2 M	C	10	250 m	
R71	317-0152-01	1.5 k	C	5	125 m		R159	317-0222 01	2.2 k	C	5	125 m	
R72	317-0182-01	1.8 k	C	5	125 m								
R73	317-0562-01	5.6 k	C	5	125 m		R161	317 0105-01	1.0 M	C	5	125 m	
							R162	317-0224-01	220 k	C	5	125 m	
R76	317- 0393-01	39 k	C	5	125 m		R163	317-0333 01	2.2 k	C	5	125 m	
							R164	317-0222-01	2.2 k	C	5	125 m	
R78	317-0122-01	1.2 k	C	5	125 m		R165	311-0735 00	10 k	CP	20	250 m	
R79	317-0221-01	220	C	5	125 m		R166	317-0472 01	4.7 k	C	5	125 m	
							R167	317-0223-01	22 k	C	5	125 m	
R81	317-0222-01	2.2 k	C	5	125 m		R168	311-0735-00	10 k	CP	20	250 m	
R82	311-0717-00	220	CP	20	250 m		R169	317-0472-01	4.7 k	C	5	125 m	
R83	317-0332-01	3.3 k	C	5	125 m								
R84	317-0471-01	470	C	5	125 m		R171	317-0183-01	18 k	C	5	125 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.	CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
R172	317-0182-01	1.8 k	C	5	125 m		R281	317-0392-01	3.9 k	C	5	125 m	
R173	317-0331-01	330	C	5	125 m		R282	317-0223-01	22 k	C	5	125 m	
R174	303-0153-01	15 k	C	5	1		R283	311-1082-00	5 k	CV	20	250 m	
R175	317-0152-01	1.5 k	C	5	125 m		R284	317-0333-01	33 k	C	5	125 m	
R176	317-0123-01	12 k	C	5	125 m		R285	311-0798-00	2.2 k	CP	20	250 m	
R177	317-0822-01	8.2 k	C	5	125 m		R286	311-1047-01	5 k	CV	20	250 m	
R178	317-0392-01	3.9 k	C	5	125 m		R287	317-0562-01	5.6 k	C	5	125 m	
R179	311-0850-00	15 k	CP	20	250 m		R288	317-0123-01	12 k	C	5	125 m	
R181	317-0122-01	1.2 k	C	5	125 m		R289	317-0122-01	1.2 k	C	5	125 m	
R182	317-0101-01	100	C	5	125 m		R290	317-0391-01	390	C	5	125 m	
R183	315-0823-02	82 k	C	5	250 m		R291	317-0472-01	4.7 k	C	5	125 m	
R184	311-1048-00	50 k	CV	20	250 m		R292	311-0719-00	470	CP	20	250 m	
R185	317-0100-01	10	C	5	125 m		R293	317-0911-01	910	C	5	125 m	
R186	311-0735-00	10 k	CP	20	250 m		R294	317-0751-01	750	C	5	125 m	
R187	311-0719-00	470	CP	20	250 m		R295	317-0121-01	120	C	5	125 m	
R188	317-0272-01	2.7 k	C	5	125 m		R296	315-0331-01	330	C	5	250 m	
R189	317-0153-01	15 k	C	5	125 m		R297	311-0717-00	220	CP	20	250 m	
R190	317-0471-01	470	C	5	125 m		R298	307-0255-00	4.7 k	MO	5	3.25	
R191	316-0125-01	1.2 M	C	10	250 m		R299	307-0255-00	4.7 k	MO	5	3.25	
R192	315-0684-01	680 k	C	10	250 m		R301	307-0418-00	750 k	MF	2	1	
R193	317-0222-01	2.2 k	C	55	125 m		R302	307-0418-00	750 k	MF	2	1	
R194	317-0393-01	39 k	C	5	125 m		R303	311-1810-00	220 k	C	20		
R195	317-0470-01	47	C	5	125 m		R304	307-0418-00	750 k	MF	2	1	
R196	316-0105-01	1.0 M	C	10	250 m		R305	311-1398-00	1 M	CV	20	2	
R197	317-0153-00	15 k	C	5	125 m		R306	315-0684-01	680 k	C	5	250 m	
*R210	321-0469-48	750 k	MF	1	125 m		R307	311-1809-01	100 k	CV	20	250 m	
*R211	321-0440-48	374 k	MF	1	125 m		R308	315-0102-01	1 k	C	5	250 m	
*R212	321-0419-48	226 k	MF	1	125 m		R309	311-0809-00	1 M	CP	20	250 m	
*R213	321-0373-48	75 k	MF	1	125 m		R311	317-0473-01	47 k	C	5	125 m	
*R214	321-0344-48	37.4 k	MF	1	125 m		R312	317-0273-01	27 k	C	5	125 m	
*R215	321-1325-48	24 k	MF	1	125 m		R313	317-0104-01	100 k	C	5	125 m	
*R216	321-0277-48	7.5 k	MF	1	125 m		R314	317-0104-01	100 k	C	5	125 m	
*R217	321-0844-48	2.2 k	MF	1	125 m		R315	316-0106-01	10 M	C	10	250 m	
*R218	321-0193-48	1.0 k	MF	1	125 m		R400	302-0333-01	33 k	C	10	500 m	
*R219	321-0852-48	36 k	MF	1	125 m		R401	311-1760-00	100	CV	20	1	
*R220	321-0344-48	37.4 k	MF	1	125 m		R402	317-0472-01	4.7 k	C	5	125 m	
R248	315-0125-01	1.2 M	CF	5	250 m		R403	307-0256-00	27	MO	5	1.5	
R249	317-0222-01	2.2 k	C	5	125 m		R404	311-0756-00	47 k	CP	20	250 m	
R250	317-0222-01	2.2 k	C	5	125 m		R405	317-0824-01	820 k	C	5	125 m	
R251	303-0123-01	12 k	C	5	1		R406	317-0222-01	2.2 k	C	5	125 m	
R252	303-0682-01	6.8 k	C	5	1		R407	315-0223-01	22 k	C	5	250 m	
R253	317-0152-01	1.5 k	C	5	125 m		R408	317-0392-01	3.9 k	C	5	125 m	
R254	303-0123-01	12 k	C	5	1		R409	317-0393-01	39 k	C	5	125 m	
R255	303-0822-01	8.2 k	C	5	1		R410	315-0100-03	10	C	5	250 m	
R256	317-0123-01	12 k	C	5	125 m		R411	321-0407-48	169 k	MF	1	125 m	
R257	317-0272-01	2.7 k	C	5	125 m		R412	317-0824-01	820 k	C	5	125 m	
R258	317-0242-01	2.4 k	C	5	125 m		R413	317-0684-01	680 k	C	5	125 m	643701
R259	317-0272-01	2.7 k	C	5	125 m		R414	311-0850-00	15 k	CP	20	250 m	
R260	317-0100-01	10	C	5	125 m		R415	317-0103-01	10 k	C	5	125 m	
R261	317-0332-01	3.3 k	C	5	125 m		R416	303-0560-01	56	C	5	1	
R262	317-0332-01	3.3 k	C	5	125 m		R417	317-0105-01	1.0 M	C	5	125 m	
R263	317-0682-01	6.8 k	C	5	125 m		R418	317-0103-01	10 k	C	5	125 m	
R264	317-0123-01	12 k	C	5	125 m		R419	303-0223-01	22 k	C	5	1	
R265	317-0681-01	680	C	5	125 m		R420	317-0101-01	100	C	5	125 m	
R266	317-0272-01	2.7 k	C	5	125 m		R421	311-0913-00	1.5 k	CP	20	250 m	
R267	317-0242-01	2.4 k	C	5	125 m		R422	317-0222-01	2.2 k	C	5	125 m	
R268	317-0272-01	2.7 k	C	5	125 m		R423	317-0102-01	1 k	C	5	125 m	
R269	317-0332-01	3.3 k	C	5	125 m		R424	317-0474-01	470 k	CF	5	125 m	643701
R270	317-0100-01	10	C	5	125 m		R426	317-0562-01	5.6 k	C	5	125 m	
R271	317-0332-01	3.3 k	C	5	125 m		R427	317-0102-01	1 k	C	5	125 m	
R272	317-0392-01	3.9 k	C	5	125 m		R430	307-0317-00	390	MO	5	5.25	
R273	317-0222-01	2.2 k	C	5	125 m		R431	311-0913-00	1.5 k	CP	20	250 m	
R274	317-0393-01	39 k	C	5	125 m		R432	317-0472-01	4.7 k	C	5	125 m	
R275	303-0202-01	2k	C	5	1		R434	317-0102-01	1 k	C	5	125 m	
R276	315-0912-03	9.1 k	C	5	250 m		R435	317-0392-01	3.9 k	C	5	125 m	
R277	317-0152-01	1.5 k	C	5	125 m		R436	311-0798-00	2.2 k	CP	20	250 m	
R278	317-0332-01	3.3 k	C	5	125 m		R437	317-0562-01	5.6 k	C	5	125 m	
R279	317-0152-01	1.5 k	C	5	125 m		R438	317-0102-01	1 k	C	5	125 m	
R280	315-0103-01	10 k	C	5	250 m		R439	317-0102-01	1 k	C	5	125 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.	CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
R768	307-0257-00	940	MO	5	1.5		*R901	321-0481-42	1.0 M	MF	0.5	125 m	
R769	317-0103-01	10 k	C	5	125 m		*R902	325-0124-00	990 k	MF	0.5	125 m	
R771	317-0683-01	68 k	C	5	125 m		*R903	325-0125-00	900 k	MF	0.5	125 m	
R772	317-0683-01	68 k	C	5	125 m		*R904	317-0470-01	47	C	5	125 m	
R773	317-0333-01	33 k	C	5	125 m		*R905	321-0193-42	1.0 k	MF	0.5	125 m	
R774	317-0333-01	33 k	C	5	125 m		*R906	321-1289-42	10.1 k	MF	0.5	125 m	
R775	317-0471-01	470	C	5	125 m		*R907	321-1389-42	111 k	MF	0.5	125 m	
R776	317-0332-01	3.3 k	C	5	125 m		*R908	317-0470-01	47	C	5	125 m	
R777	317-0471-01	470	C	5	125 m								
R778	317-0332-01	3.3 k	C	5	125 m								
R779	303-0273-01	27 k	C	5	1								
R781	303-0273-01	27 k	C	5	1		*R911	317-0470-01	47	C	5	125 m	
R782	317-0471-01	470	C	5	125 m		*R912A)	(500 k)					
R783	317-0332-01	3.3 k	C	5	125 m		*R912B)	(800 k)					
R784	317-0471-01	470	C	5	125 m		*R912C)	310 0680 00	(250 k)	CM	1	250 m	
R785	317-0332-01	3.3 k	C	5	125 m		*R912D)	(1.0 M)					

CIR REF	PART NUMBER	DESCRIPTION	Eff. Ser.No.	CIR REF	PART NUMBER	DESCRIPTION	Eff. Ser.No.
RL275	148-0073-00	Reed Relay		S276	With R286	X1 - X5 X Gain	
S1	260-1783-00	Trigger Polarity A					
S2	With R16	Auto					
S3	260-1784-00	AC - TV		S401	With R305	Power ON - Off	
S51	260-1783-00	Trigger Polarity B					
S52	With R66	Auto		S601)	260 1299-00	Channel Select	
S101	260-1145-00	Single Shot		S602)	260-1204-00	Sum/Chop/Alt.	
S102	With R134	Free Run		S603	260-1298-00	Norm/Invert	
				S604	260-1298-00	X1 - X10 Gain	
				S605)			
				S606)			
S161	With R184	Pull Non Gated		S751	260 1089-00	Internal Trig.	
*S210	260-1786-00	Time/Div.		*S901	260-1136-00	DC GND AC	
				*S902	260-1446-00	Volts/Div.	
S275	260-1785-00	Display		T401	120-0594-01	Mains Transformer	

CIR REF	PART NUMBER	DESCRIPTION	TYPE	RATING @ 25° C	Eff. Ser.No.	CIR REF	PART NUMBER	DESCRIPTION	TYPE	RATING @ 25° C	Eff. Ser.No.
TR1	151-0320-01	MPS6518	Si	PNP	300 mW	TR51	151-0320-01	MPS6518	Si	300 mW	
TR2	151-0320-01	MPS6518	Si	PNP	300 mW	TR52	151-0320-01	MPS6518	Si	300 mW	
TR3	151-0320-01	MPS6518	Si	PNP	300 mW	TR53	151-0320-01	MPS6518	Si	300 mW	
TR4	151-0320-01	MPS6518	Si	PNP	300 mW	TR54	151-0320-01	MPS6518	Si	300 mW	
TR5	151-0320-01	MPS6518	Si	PNP	300 mW	TR55	151-0320-01	MPS6518	Si	300 mW	

CIR REF	PART NUMBER	DESCRIPTION	TYPE	RATING Eff. @ 25° C	Ser.No.	CIR REF	PART NUMBER	DESCRIPTION	TYPE	RATING Eff. @ 25° C	Ser.No.
TR101	151-0257-00	2N1990U	Si	NPN	600 mW	TR409	151-0320-00	MPS6518	Si	PNP	300 mW
TR102	151-0320-00	MPS6518	Si	PNP	300 mW	TR411	151-0320-00	MPS6518	Si	PNP	300 mW
TR103	151-0320-00	MPS6518	Si	PNP	300 mW	TR412	151-0127-02	2N2369	Si	NPN	360 mW
TR104	151-0320-01	MPS6518	Si	PNP	300 mW	TR413	151-0127-02	2N2369	Si	NPN	360 mW
TR105	151-0320-01	MPS6518	Si	PNP	300 mW						
TR106	151-0127-02	2N2369	Si	NPN	360 mW	TR601)					
TR107	151-0320-00	MPS6518	Si	PNP	300 mW	TR602)	151-1036-00	Dual FET		N Channel	
TR108	151-0127-02	2N2369	Si	NPN	300 mW	TR603	151-0127-02	2N2369	Si	NPN	300 mW
TR109	151-0242-00	2N3904	Si	NPN	300 mW	TR604	151-0127-02	2N2369	Si	NPN	300 mW
TR110	151-1052-00	FET BFW0265		N Channel	250 mW	TR605	151-0242-00	2N3904	Si	NPN	300 mW
TR111	151-0127-02	2N2369	Si	NPN	360 mW	TR606	151-0242-00	2N3904	Si	NPN	300 mW
TR112	151-0127-02	2N2369	Si	NPN	360 mW	TR607	151-0127-02	2N2369	Si	NPN	360 mW
TR113	151-0127-02	2N2369	Si	NPN	360 mW	TR608	151-0127-02	2N2369	Si	NPN	360 mW
						TR609	151-0127-02	2N2369	Si	NPN	360 mW
TR161	151-0320-00	MPS6518	Si	PNP	300 mW	TR611	151-0127-02	2N2369	Si	NPN	360 mW
TR162	151-0320-00	MPS6518	Si	PNP	300 mW	TR612	151-0127-03	BSX20	Si	NPN	360 mW
TR163	151-0320-00	MPS6518	Si	PNP	300 mW	TR613	151-0127-03	BSX20	Si	NPN	360 mW
TR164	151-0320-00	MPS6518	Si	PNP	300 mW	TR614	151-0242-00	2N3904	Si	NPN	300 mW
TR165	151-0242-00	2N3904	Si	NPN	300 mW	TR615	151-0242-00	2N3904	Si	NPN	300 mW
TR166	151-1052-00	FET BFW0265		N Channel	250 mW	TR616	151-0490-00	FRB750	Si	NPN	1W
TR167	151-0127-02	2N2369	Si	NPN	360 mW	TR617)					
TR168	151-0326-00	BC107	Si	NPN	300 mW	TR618)	151-1036-00	Dual FET		N Channel	
						TR619	151-0127-02	2N2369	Si	NPN	360 mW
TR251	151-0242-00	2N3904	Si	NPN	300 mW	TR621	151-0127-02	2N2369	Si	NPN	360 mW
TR252	151-0242-00	2N3904	Si	NPN	300 mW	TR622	151-0242-00	2N3904	Si	NPN	300 mW
TR253	151-0320-00	MPS6518	Si	PNP	300 mW	TR623	151-0242-00	2N3904	Si	NPN	300 mW
TR254	151-0320-00	MPS6518	Si	PNP	300 mW	TR624	151-0127-02	2N2369	Si	NPN	360 mW
TR255	151-0320-00	MPS6518	Si	PNP	300 mW	TR625	151-0127-02	2N2369	Si	NPN	360 mW
TR256	151-0320-00	MPS6518	Si	PNP	300 mW	TR626	151-0127-02	2N2369	Si	NPN	360 mW
TR257	151-0242-00	2N3904	Si	NPN	300 mW	TR627	151-0127-02	2N2369	Si	NPN	360 mW
TR258	151-0445-00	ZTX214C	Si	PNP		TR628	151-0127-02	2N2369	Si	NPN	360 mW
TR259	151-0127-02	2N2369	Si	NPN	360 mW	TR629	151-0127-02	2N2369	Si	NPN	360 mW
TR261	151-0320-01	MPS6518	Si	PNP	300 mW						
TR262	151-0320-01	MPS6518	Si	PNP	300 mW	TR751	151-0127-02	2N2369	Si	NPN	360 mW
						TR752	151-0310-00	E1530	Si	NPN	800 mW
TR276	151-0317-00	BC109C	Si	NPN	300 mW	TR753	151-0310-00	E1530	Si	NPN	800 mW
TR277	151-0257-03	FRB749	Si	NPN	625 mW	TR754	151-0320-01	MPS6518	Si	PNP	300 mW
TR278	151-0257-03	FRB749	Si	NPN	625 mW	TR755	151-0320-01	MPS6518	Si	PNP	300 mW
						TR756	151-0320-01	MPS6518	Si	PNP	300 mW
TR401	151-0343-00	BF259	Si	NPN	800 mW	TR757	151-0320-01	MPS6518	Si	PNP	300 mW
TR402	151-0332-00	2N4899	Si	PNP							
TR403	151-0257-01	BF305	Si	NPN	800 mW	V101	151-0069-00	Neon Type 3L			
TR404	151-0244-00	2N3702	Si	PNP	300 mW						
TR405	151-0326-01	BC107	Si	NPN	300 mW	V301	154-0626-01	C.R.T. 95447			
TR406	151-0310-00	E1530	Si	NPN	800 mW						
TR407	151-0343-00	BF259	Si	NPN	800 mW						
TR408	151-0320-00	MPS6518	Si	PNP	300 mW						

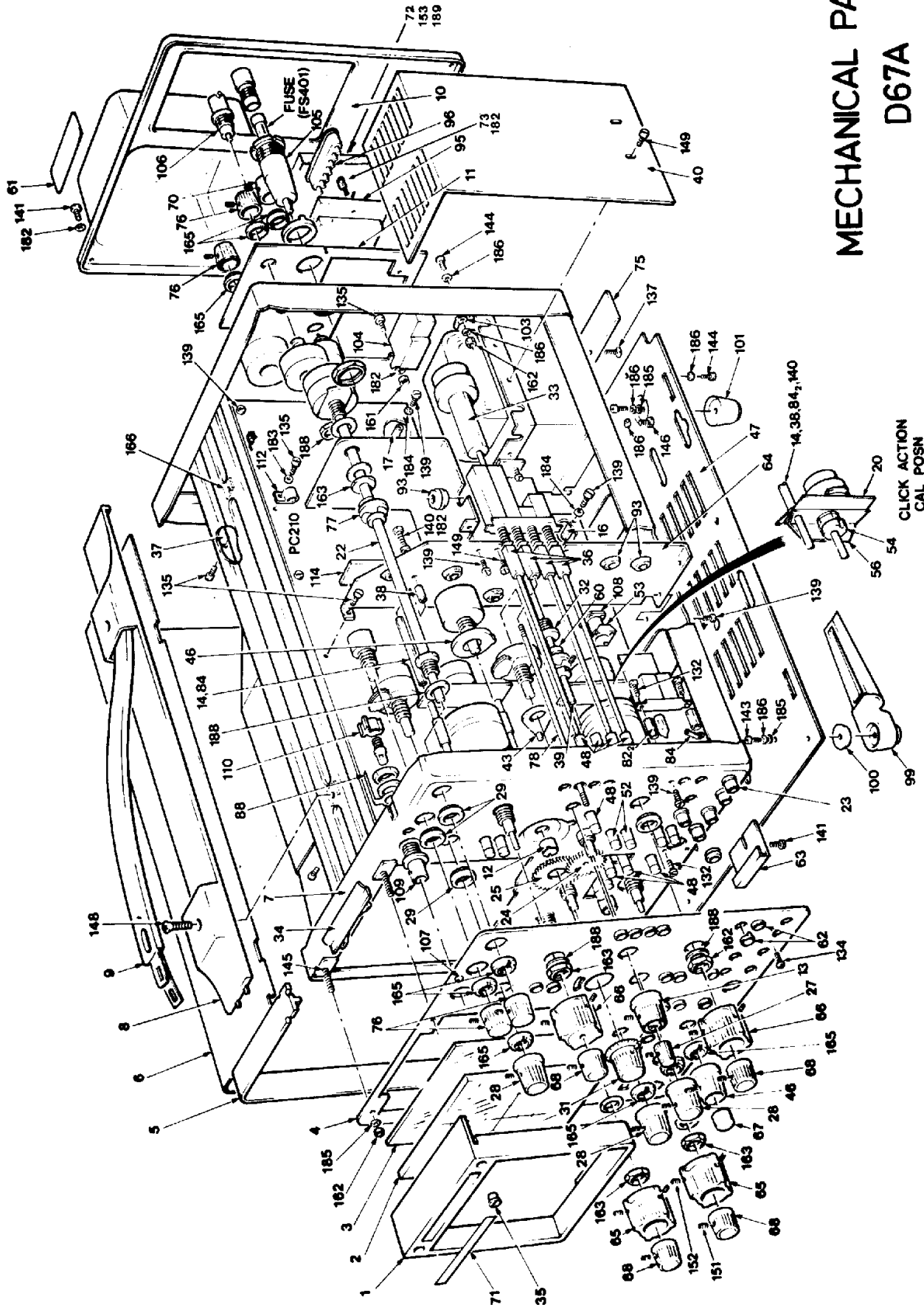
CIR REF	PART NUMBER	VALUE	TOL %	RATING Watts	Eff. Ser.No.
TH101	307-0258-00	130 Ω	20	500 mW at 25° C	
TH161	307-0258-00	130 Ω	20	500 mW at 25° C	
TH601	307-0258-00	130 Ω	20	500 mW at 25° C	
TH602	307-0258-00	130 Ω	20	500 mW at 25° C	

ASSEMBLIES

DESCRIPTION	PC BOARD	PART NUMBER
Sum Alt Chop	PC 118 wired assembly	670-4160-00
Graticule Lamps	PC 103 wired assembly	670-0997-00
Reed Relay	PC 108	644-0028-00
X10 Gain Invert	PC 117 assembly	388-2129-00
Switch Volts/Div		262-0989-00
Switch Time/Div		262-0991-00
Single Shot	PC 122 assembly	388-2084-02
'Y' Amp	PC 212 wired assembly	670-4159-00
EHT	PC 144 wired assembly	670-1978-00
Main Board	PC 210 wired assembly	670-4081-01
Attenuator	PC 146 wired assembly	670-2343-00
Channel Select	PC 211 wired assembly	670-4158-00
Display Switch	PC 209 wired assembly	670-4157-00

D67A MECHANICAL PARTS LIST
(Item numbers refer to Views 1 and 2)

Item	Part No.	Description	Eff. from Ser. No.	Item	Part No.	Description	Eff. from Ser. No.
1	200-1884-01	Bezel light hood		79	361-0537-02	Spacer round 10mm long	
2	331-0289-02	Graticule		80	407-1147-00	Bracket, pot mounting	
3	378-0605-05	Filter grey (standard)		81	384-1400-00	Rod bearing 13/16" long	
4	333-2084-01	Panel, front marking		82	385-0208-02	Spacer 6BA/8BA, 11mm long	
5	124-0317-01	Trim, front		83	385-0196-00	Spacer 6BA hex 11/16" long	
6	390-0448-04	Cabinet side (LH)		84	210-0297-00	Solder lug 6BA	
	390-0448-05	Cabinet side (RH)		85	337-1708-01	Trimmer screen, processed	
7	441-1298-00	Chassis, spotwelded assembly		86	337-1707-00	Screen, outer	
8	352-0434-01	Holder, handle		87	401-0144-01	Sleeve bearing 25.4mm long	
9	367-0101-01	Handle, black		88	210-0275-00	Solder lug 3/8" ID	
10	200-1766-01	Cover, rear		89	401-0145-00	Bearing, moulding	
11	333-2085-02	Panel, rear, marking		90	376-0177-00	Coupling 1/4" to 1/8" diameter	
12	220-0592-00	Nut, bearing		91	384-1142-06	Extension shaft, 124mm long	
13	366-1254-02	Knob assembly (coarse horiz pos)		92	214-1626-00	Spring, compression	
14	385-0214-00	Spacer 6BA hex 46mm		93	348-0160-00	Grommet 3/8" ID	
15	361-0202-00	Spacer 6BA hex 1" long		94	644-0028-00	Reed relay assembly	
16	385-0201-00	Spacer 6BA hex 25/32" long		95	136-0315-00	Socket, voltage selector	
17	385-0202-00	Spacer 6BA hex 27/32" long		96	134-0102-00	Plug, voltage selector, 7 pin	
18	407-0599-01	Bracket, mounting		97	200-2106-00	CAP EHT type BRS18	
19	337-1130-00	Mu-metal screen		98	134-0157-00	PDA connector button type H	
20	386-1756-00	Plate, timebase switch		99	348-0463-00	Foot, raising member, front	
21	361-0283-00	Spacer mounting 6BA hex		100	210-1075-01	Washer, packing foot glass loaded nylon	
22	384-1089-01	Rod, extension 7/8" long		101	348-0462-00	Foot fixed, rear, black	
23	136-0381-02	Socket 4mm assembly		102	124-0212-00	Tag strip 3 way, centre earth	
24	214-1358-01	Double gear, black		103	210-0297-00	Solder lug 4BA	
25	214-1359-01	Gear, 60 teeth (indicating)		104	134-0135-00	Plug, Belling & Lee, R4091/1	
26	361-0323-00	Bush, spacer		105	352-0499-00	Fuse holder, Belling & Lee, L1348C	
27	366-1635-00	Knob assembly, marking fine		106	131-0650-01	Socket BNC, GE35027	
28	366-1636-00	Knob assembly, medium skirted		107	378-0597-00	Filter lens, green	
29	361-0324-00	Bush, spacer		108	131-0651-00	Socket BNC, GE35007	
30	337-1310-01	Screen, pot mounting		109	131-0650-00	Socket BNC, GE35008	
31	366-1237-01	Knob assembly (delay)		110	136-0311-00	Lampholder Q3526	
32	358-0425-00	Bush		112	343-0207-00	Plasclip insuloid NX1 3/16" ID	
33	385-0207-00	Spacer, hex 40mm long		113	253-0111-00	Insulator elec	
34	670-0997-00	Graticule lamp assembly		114	252-0650-00	Insulator elec	
35	220-0607-01	Nut, special, black					
36	376-0132-00	Coupling, switch extension grey		131	213-0461-00	Screw 8BA 3/4" ch slot cadmium	
37	381-0326-00	Bar, securing		132	213-0458-00	Screw 8BA 3/16" ch slot cadmium	
38	361-0374-01	Spacer, hex 3/8" long					
39	384-1046-00	Extension shaft 1/8" diameter		134	213-0719-00	Screw 8BA 3/8" rd slot chrome	
40	200-1230-00	Cover, voltage warning		135	213-0393-00	Screw 6BA 1/4" poz pan cadmium	
41	354-0404-00	CRT rear location moulding					
42	354-0407-00	Ring, CRT shockmount		137	213-0391-00	Screw 6BA 1/4" csk poz cadmium	
43	401-0125-00	Bearing pin assembly		138	213-0653-00	Screw 6BA 3/8" poz pan chrome	
44	407-0965-01	Bracket mounting		139	213-0392-00	Screw 6BA 3/16" poz pan cadmium	
45	384-1103-00	Extension rod		140	213-0433-00	Screw 6BA 5/8" poz pan cadmium	
46	366-1365-01	Knob assembly (CH2 pos)		141	213-0449-00	Screw 6BA 1/2" poz pan chrome	
47	200-1235-02	Baseplate cover		142	213-0474-00	Screw 4BA 3/16" poz pan cadmium	
48	366-1414-15	Knob assembly, pushbutton 13mm		143	213-0398-00	Screw 4BA 3/8" poz pan cadmium	
49	202-0193-02	EHT-box, tapped		144	213-0388-00	Screw 4BA 1/4" poz pan cadmium	
50	670-1978-00	PC144 wired assembly		145	213-0472-00	Screw 4BA 3/4" csk poz cadmium	
51	670-1979-00	EHT unit assembly		146	213-0470-00	Screw 4BA 1/4" hex slot cadmium	
52	366-1414-16	Knob assembly, pushbutton 36mm					
53	210-0293-00	Lug, earth		148	213-0772-00	Screw 2BA 11/16" poz inst chrome	
54	401-0193-00	Cam (with set screws)		149	213-0366-00	Screw 4PK/AB x 1/4" poz pan cadmium	
55	376-0136-00	Coupling		150	213-0724-00	Screw 4PK/AB x 5/8" poz pan cadmium	
56	214-1817-00	Spring clip		151	213-0248-00	Set screws (knobs) M3 x 3	
57	361-0537-01	Spacer round, 11mm long		152	213-0249-00	Set screws (knobs) M3 x 5	
58	358-0345-00	Bush		153	213-0802-00	Screw M2 x 4mm	715001
59	636-0006-00	Delay line assembly					
60	376-0126-00	Coupling, Jackson 1/4" to 1/8"		160	220-0718-00	Nut 8BA full hex cadmium	
61	334-2968-00	Marker, ident warning		161	220-0716-00	Nut 6BA full hex cadmium	
62	200-1885-00	Bezel, pushbutton		162	220-0714-00	Nut 4BA full hex cadmium	
63	343-0591-00	Retainer trim		163	220-0750-00	Nut 32TP1 1/2" AF 3/8" ID brass	
64	386-3412-00	Plate, display switch					
65	366-1642-00	Knob assembly, Series 5 - recessed		165	220-0527-00	Nut, slotted ring chrome	
66	366-1640-00	Knob assembly, Series 5 - special		166	220-0801-00	Nut captive	
67	366-1634-00	Knob, push					
68	366-1641-00	Knob, assembly "VAR"		180	210-1214-00	Washer 8BA shakeproof int	
69	334-2752-00	Mod record label		181	210-1213-00	Washer 8BA small plain cadmium	
70	366-1637-00	Knob assembly med 1/8" ID		182	210-1210-00	Washer 6BA shakeproof int	
71	334-2611-00	Plate identification		183	210-1207-00	Washer 6BA large plain cadmium	
72	200-2208-00	Cover, Elec. moulded	715001	184	210-1205-00	Washer 6BA locking	
73	129-0706-00	Spacer mntg 6BA	715001	185	210-1204-00	Washer 4BA large plain cadmium	
				186	210-1215-00	Washer 4BA shakeproof int	
75	381-0367-00	Bar chassis		187	210-1203-00	Washer 2BA shakeproof int	
76	366-1637-01	Knob assembly, med, 1/4" ID		188	210-3051-00	Washer 3/8" ID 5/8" OD plain cadmium	715001
77	376-0131-00	Coupling, Jackson 1/4" to 1/4"		189	210-1290-00	Washer plain M2	
78	384-1022-01	Extension rod, 112.5mm long					



MECHANICAL PARTS
D67A
(VIEW 1)

SECTION 6

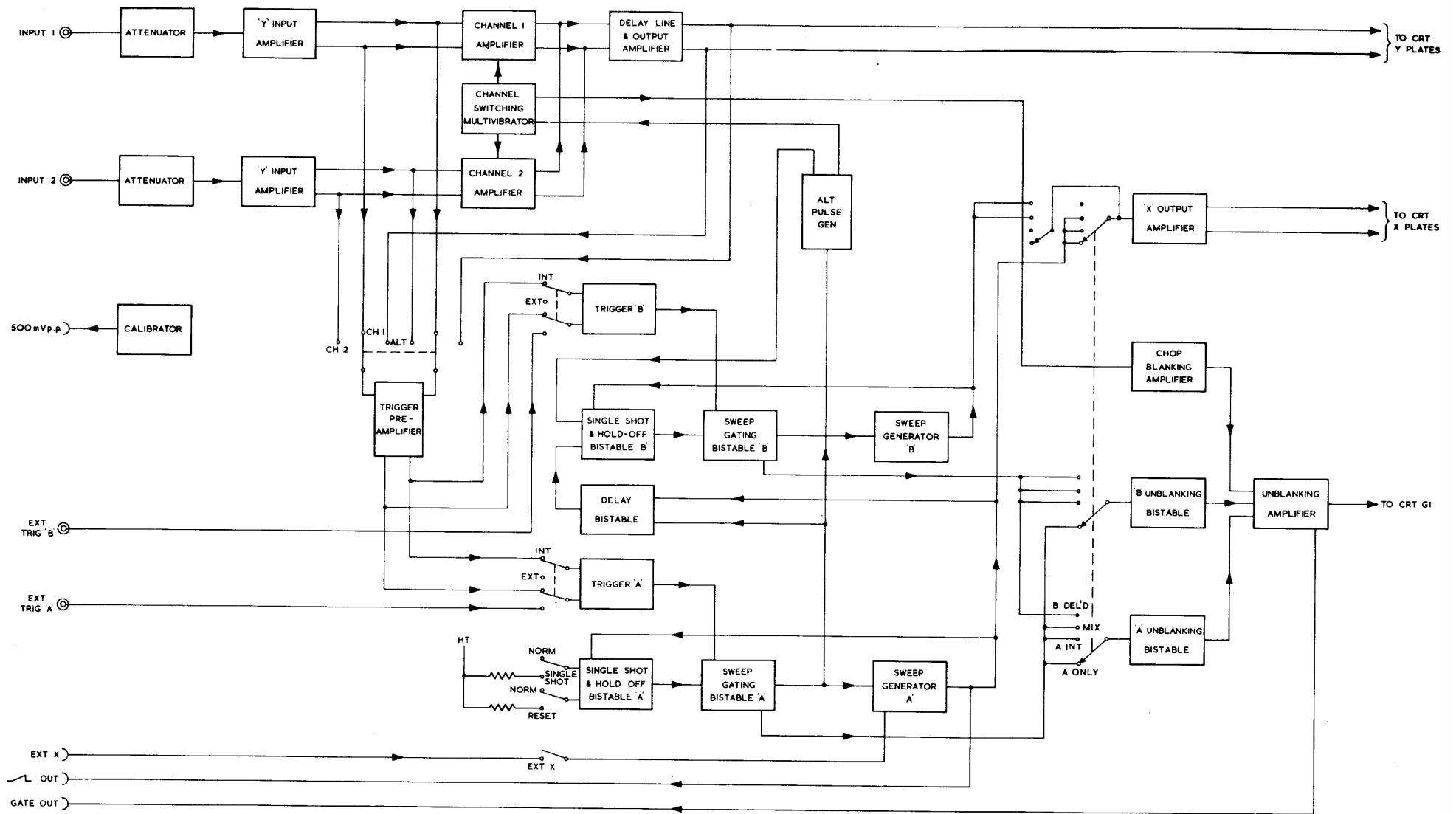
CIRCUIT DIAGRAMS

To minimize the risk of misinterpretation of component values on circuit diagrams, the decimal point has been replaced by the multiplier or sub-multiplier of the basic unit. For instance, 2.2 megohms is shown as 2M2 and 1.8 picofarads is shown as 1p8.

To aid the reader further, in addition to the block Circuit Reference Table in Section 5.1, to locate a component in the circuit diagram, a table is provided at the top of each circuit diagram, in which the circuit reference will appear, where practicable, directly above the component being sought.

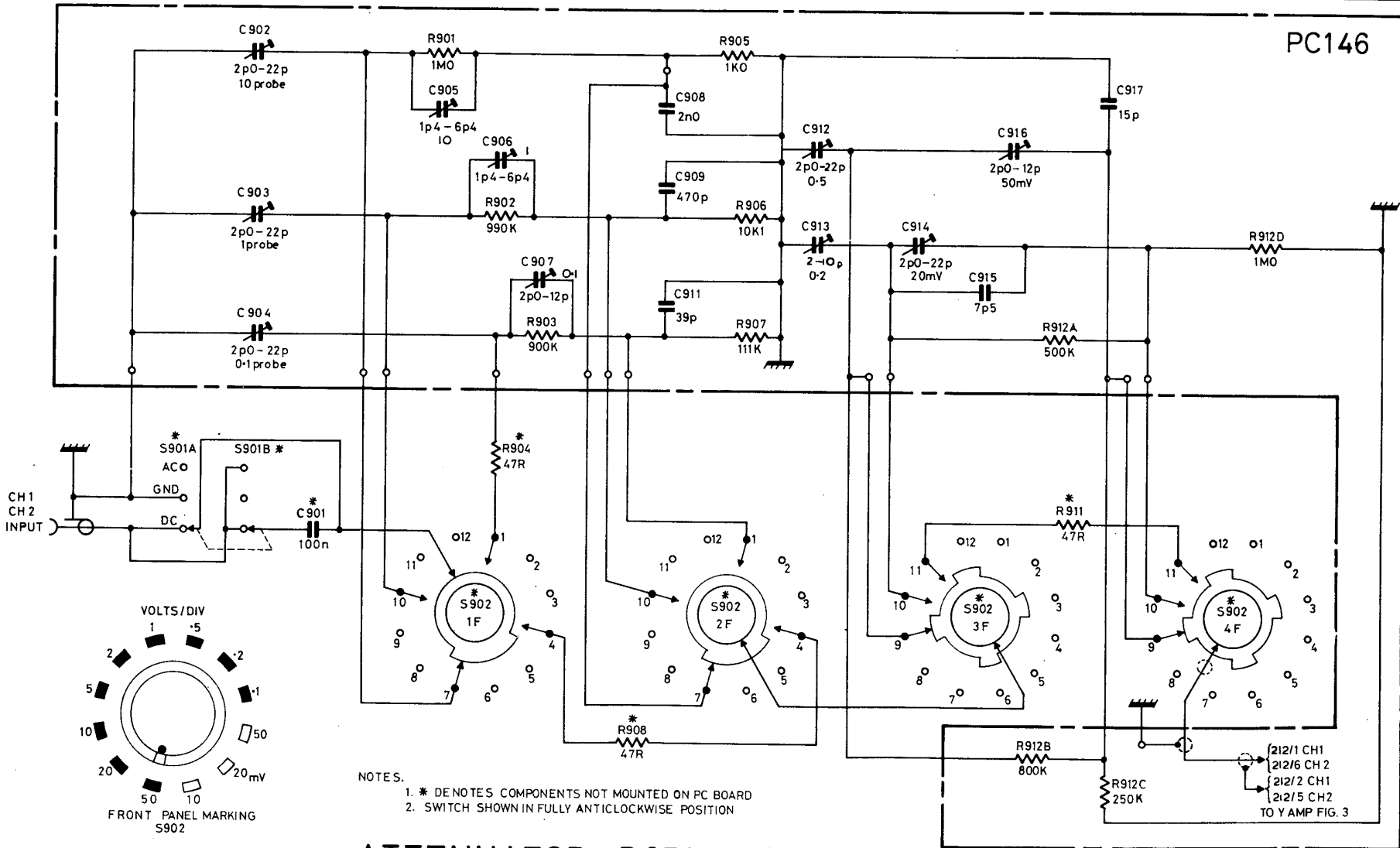
PRINTED CIRCUITS

Blue shows the rear track as seen through the board. Red, the component side track.



BLOCK DIAGRAM D67A
FIG. 1

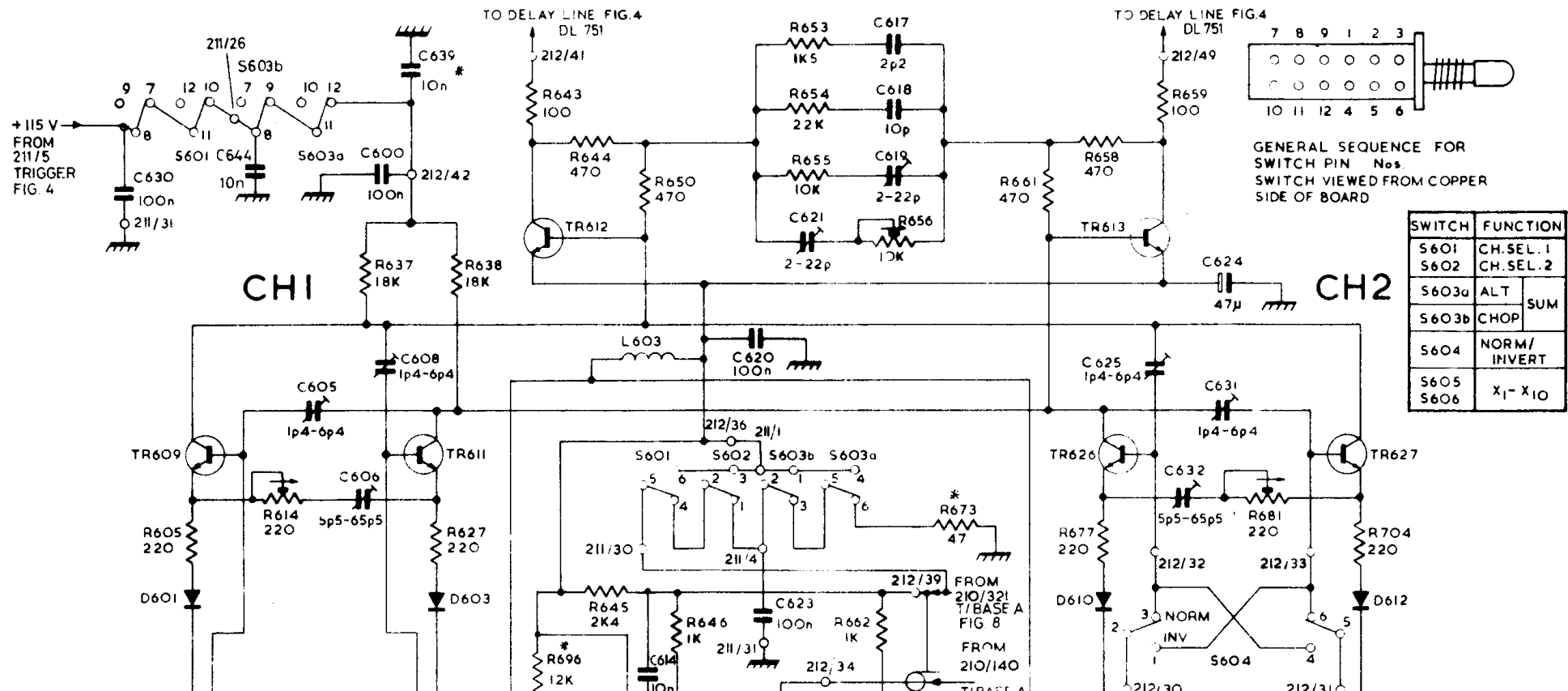
RESISTORS			901	902 904	903		908	905 906 907		912A 912B	911	912C		912D
CAPACITORS	902 903 904	901		905	906	907	908 909 911		912 913	914	915 916	917		
MISC	S901A	S901B		S902 1F			S902 2F			S902 3F			S902 4F	

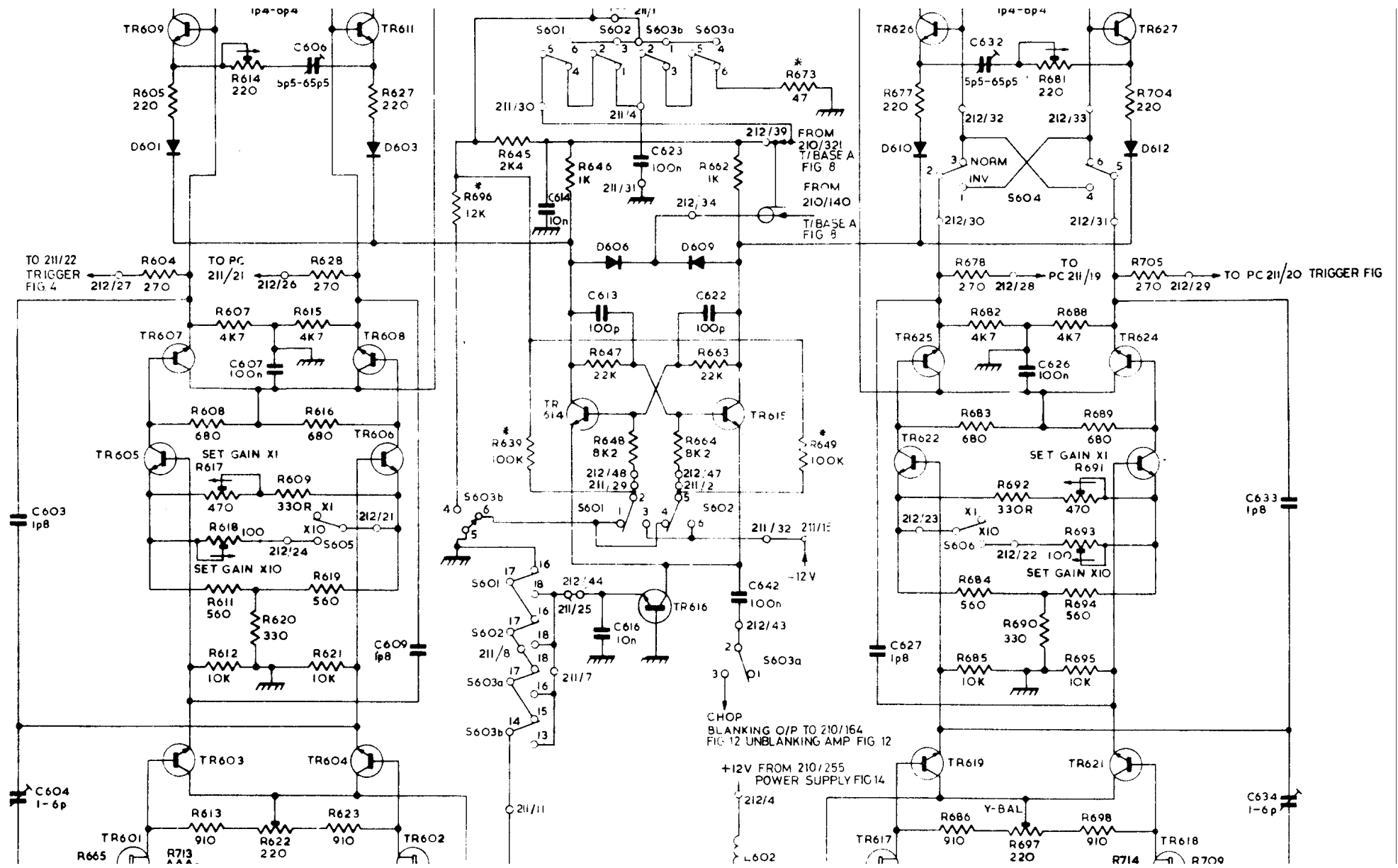


- NOTES.
- * DE NOTES COMPONENTS NOT MOUNTED ON PC BOARD
 - SWITCH SHOWN IN FULLY ANTICLOCKWISE POSITION

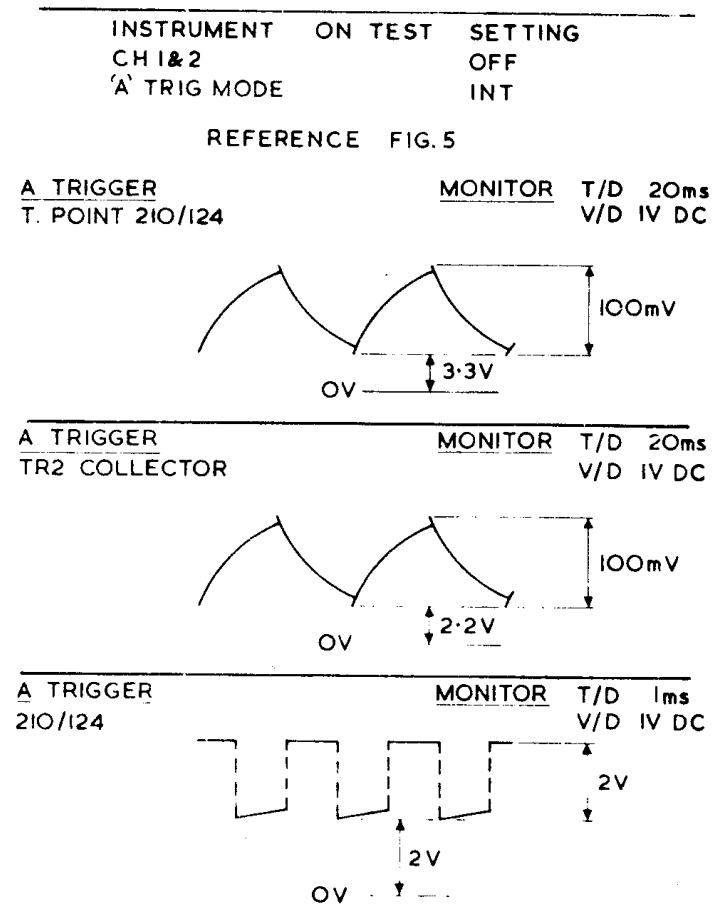
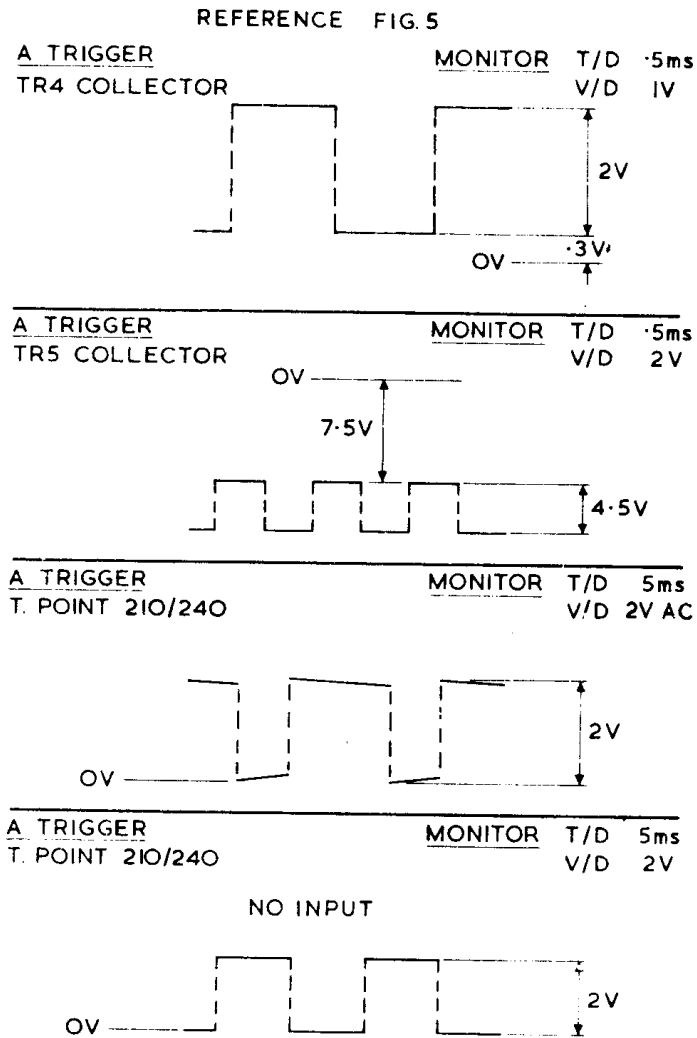
ATTENUATOR D67A FIG.2

603	605	608	607	614	615	637	638	643	644	650	646	648	653	663	662	673	661	658	686	659	692	681	689	704	706
601	604	613	617	620	616	628	627	633	645	631	647	654	654	666	666	679	668	677	687	678	690	688	698	705	708
665	602A	606	618	622	609	614				635	642	652	655	656	670	669	676	674	682	697	691	702	707A	707B	
	713		611	624	623	621	629		641		610		664		667	672		675	683	699	693	707B	714	712	
			612	625	626	632	630	696	634		660		657			671			684	701	694				
			602B	626				680	636				651				700		685	703	695			709	
RESISTORS																									
603	602		644	605	606	608	609	611	614	613	621	622	617	628	627	625	632	624	626				635	633	
604	630			607	600					637	623		618					631	629				634	636	
601				638		639	612			620		642	619												
CAPACITORS																									
S66	S602	S601	S603b	S603a	TR611	TR602	TR612	S601	L603	S602	S603b	S603a	TR615	TR617	TR626	TR613	S604	TR627							
	D601	TR609	TR607	TR605	D603	TR608	L601	S602	S601	D606	TR616	D609	D611	S606	D610	S606	TR629	D612							
		TR605	TR603	TR601	TR606	TR604		S603a	D605		S66	D607	D608	S601	TR625	S603a		TR624							
		TR601	TH601		D604			S603b	TR614					TR619	S603b	S602		TR623							
MISC									S605			L602						TR621							
																		TR618							
																		TH602							

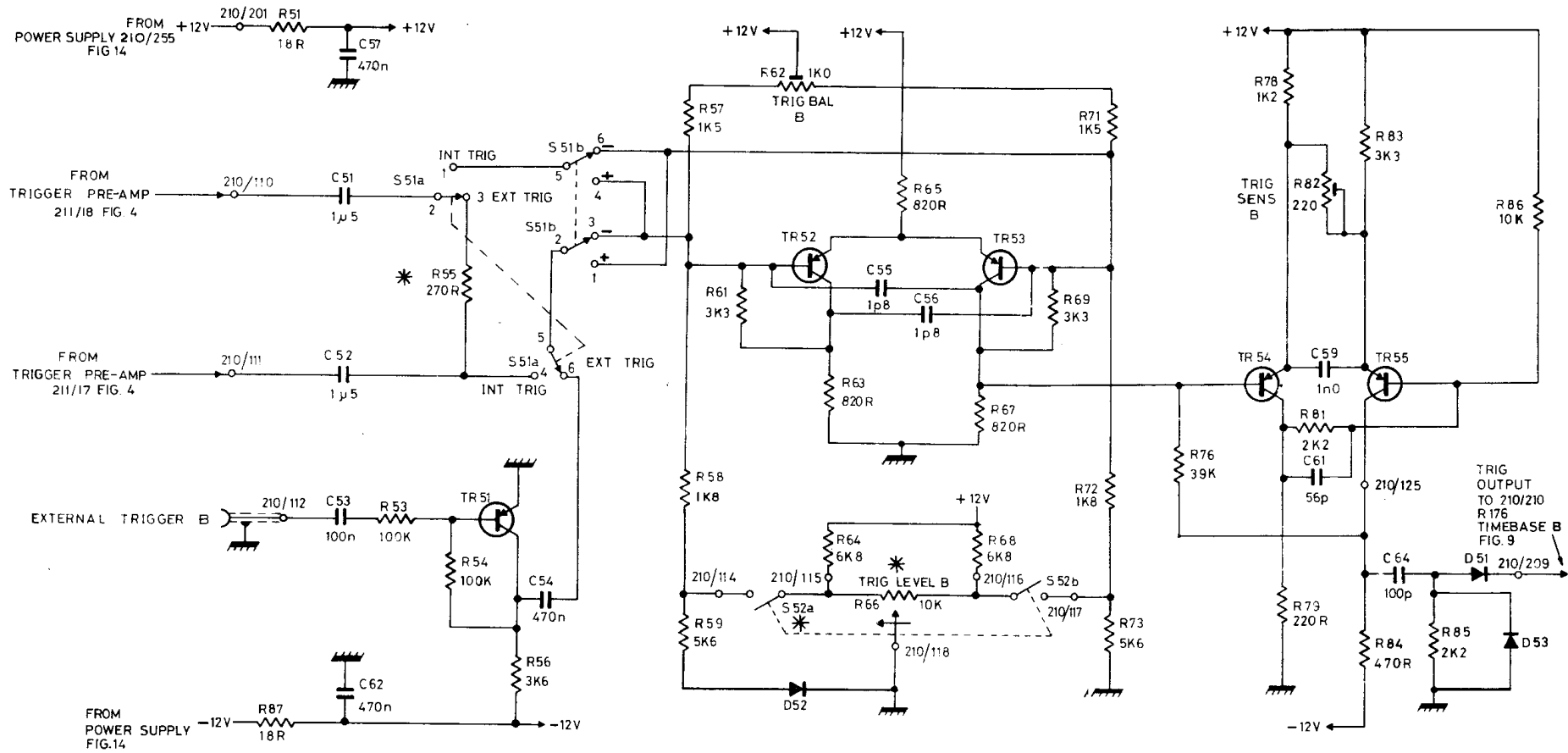




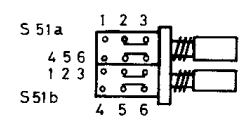
INSTRUMENT	ON TEST	SETTING
CH.1 INPUT		1kHz 5mV
VOLT/DIV		0.2V
TIME/DIV		1ms



RESISTORS	51 87	53	54 55	56	57 58 59	61	62	63 64	65 66	67 68	69	71 72 73	76	78 79	81 82	83 84	85	86
CAPACITORS		57 51 52	53 62	54					55 56						59 61		64	
MISC				S51a TR51	S51b	S52a	TR52 D52			TR53	S52b			TR54		TR55	D51	D53



TRIG MODE
 IN OUT
 INT ○ EXT
 + ○ -



PUSH BUTTON
 SWITCH VIEWED
 FROM COPPER
 SIDE OF BOARD

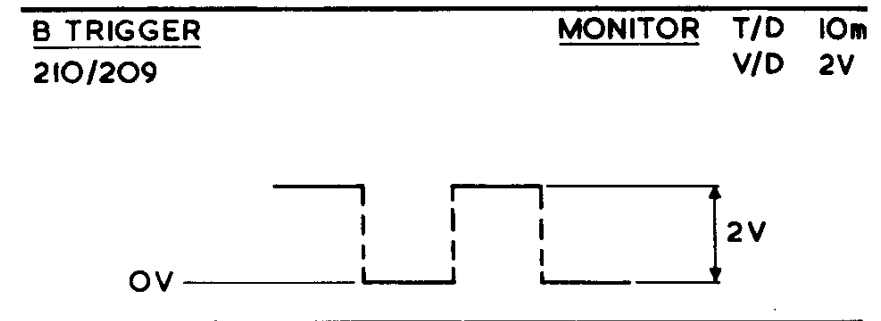
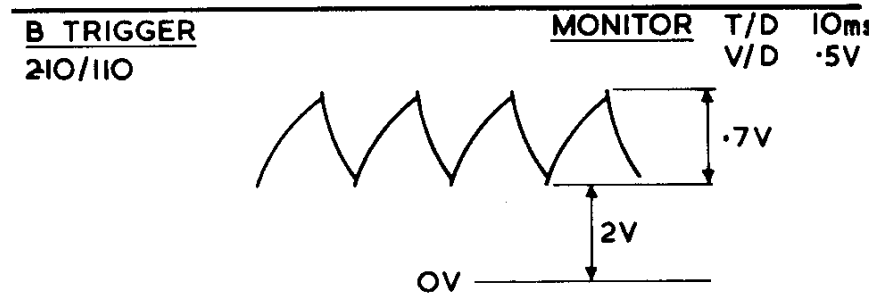
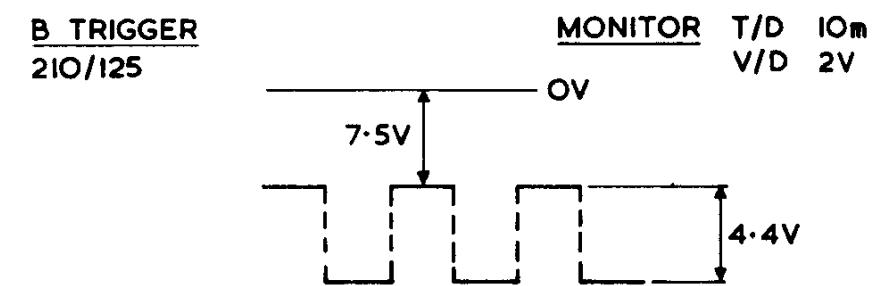
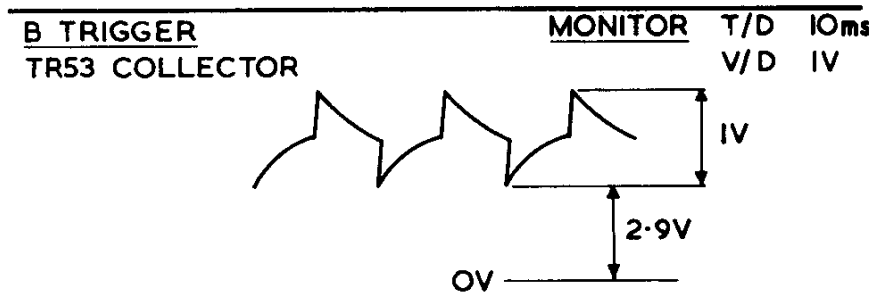
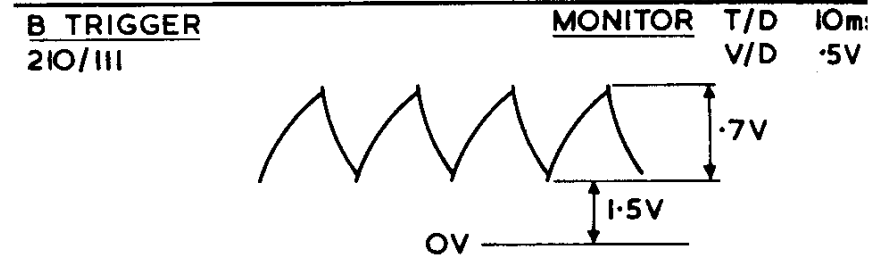
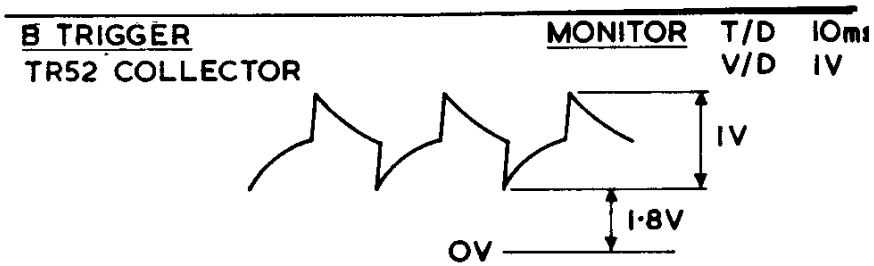
NOTES.

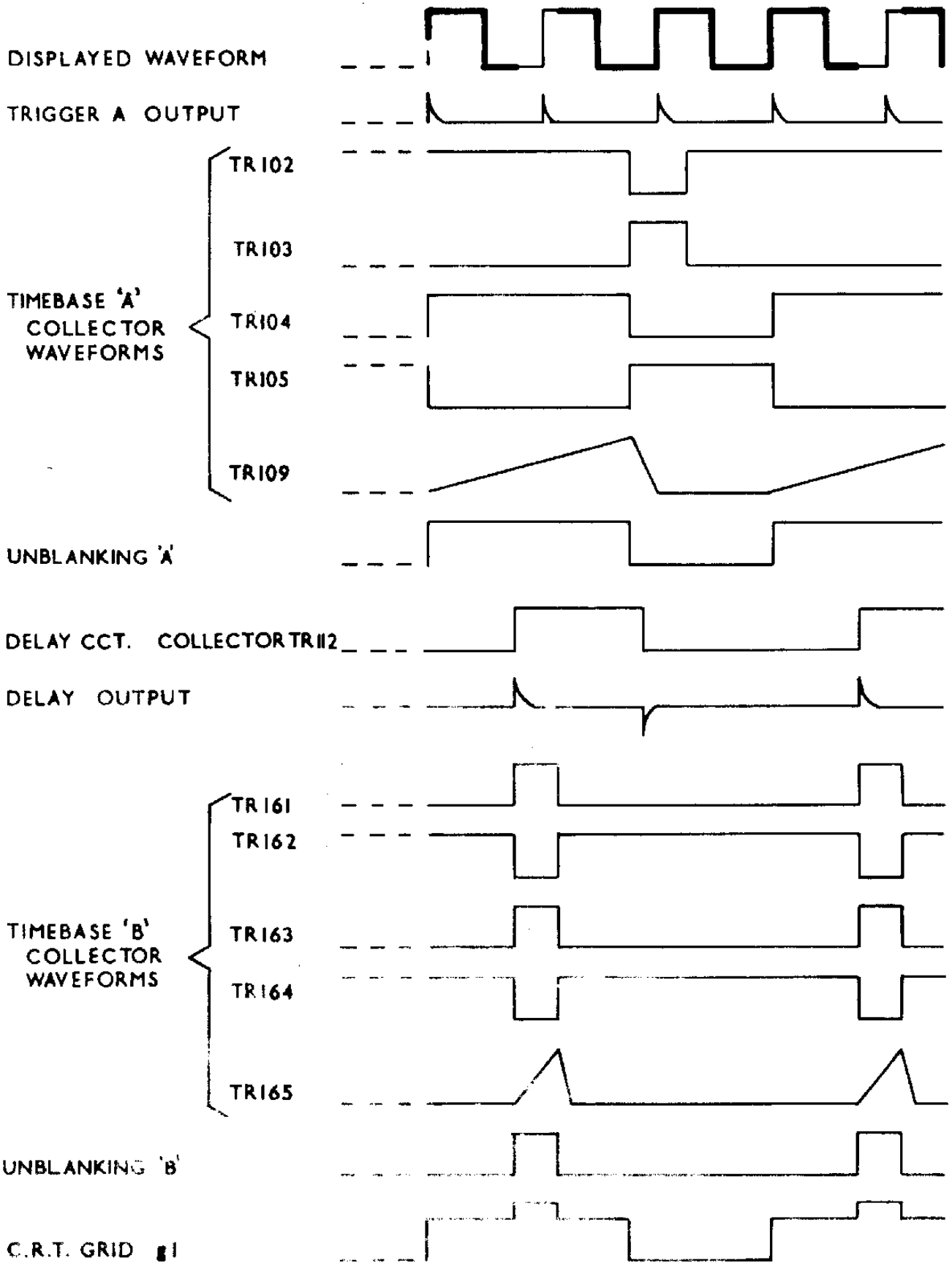
1. 210/114 DENOTES PC BOARD EYELET OR TERMINAL No. CONNECTION.
2. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD.
3. S51 SHOWN IN THE OUT POSITION.

TRIGGER CIRCUIT B
 FIG. 6 (PC 210)
 D67A

INSTRUMENT ON TEST SETTING
 CH 1 INPUT 1V 50Hz
 VOLT/DIV 1V
 VERT MODE ALT
 TIME/DIV 1ms FREE RUN

REFERENCE FIG. 6

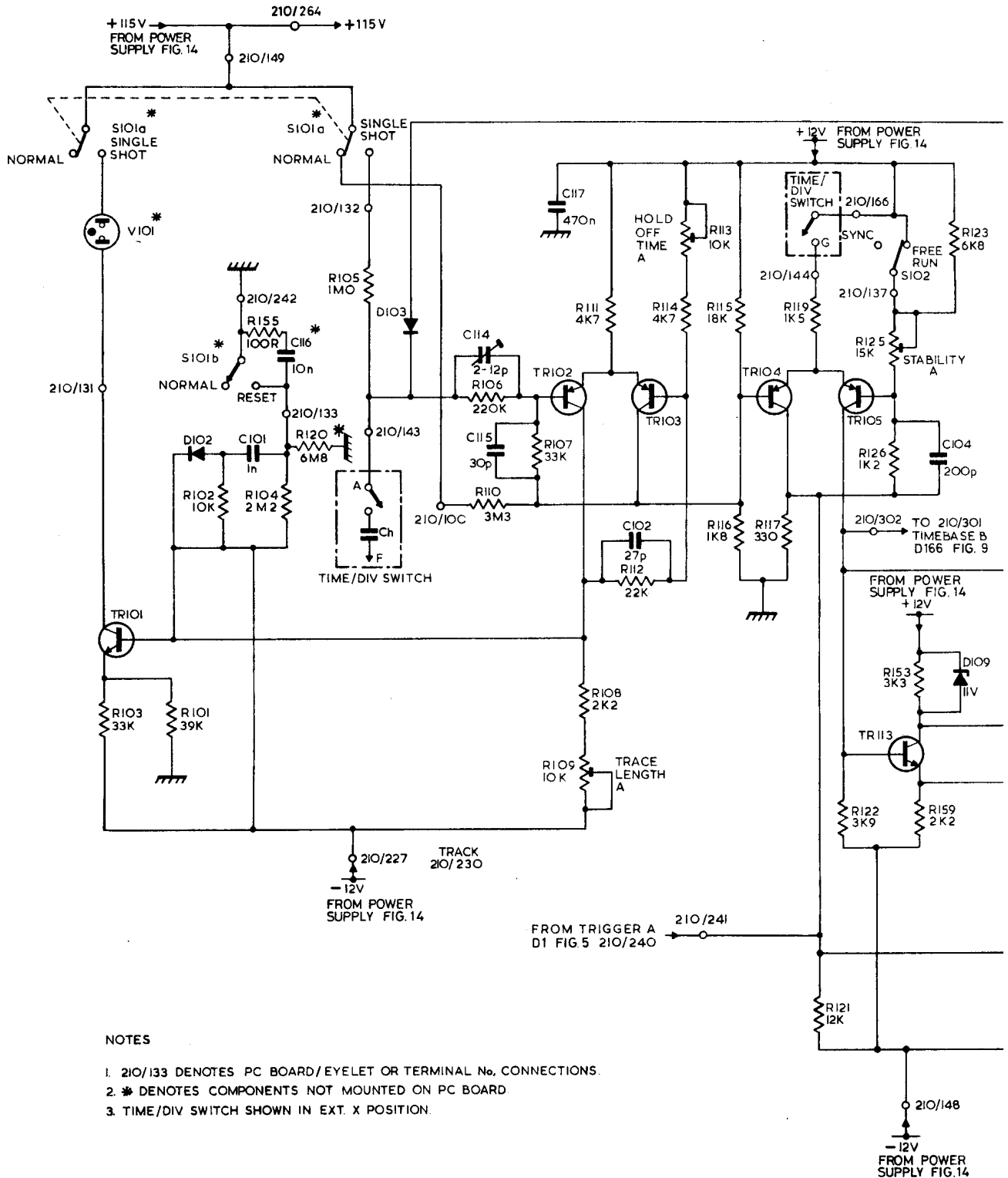




Waveforms for "A INTEN'S by B, none gated" delay mode.

FIG. 7.

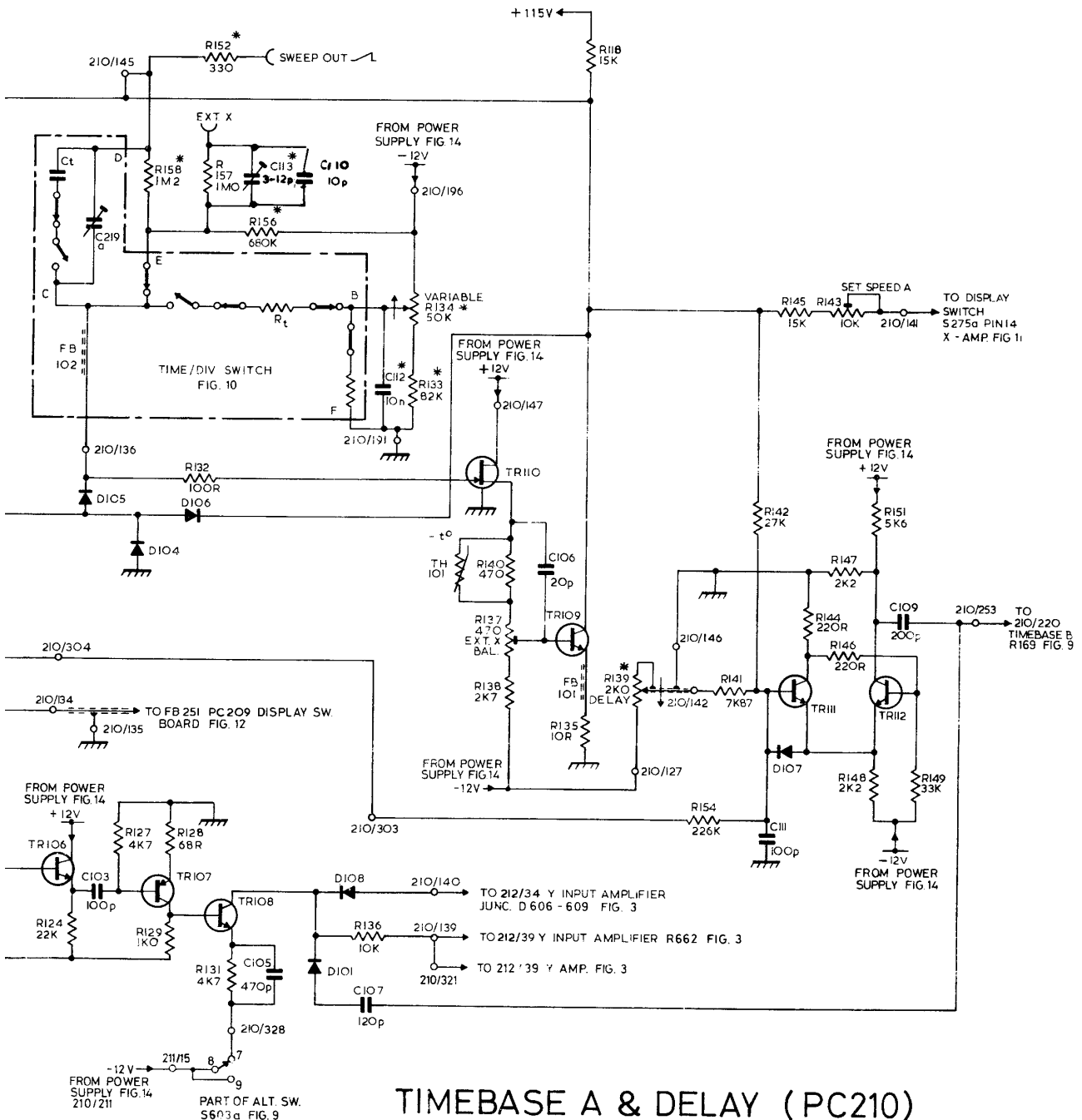
RESISTORS	IO1	IO2	IO4	IO5	IO6	IO7	IO8	II2	II3	II5	II7	II9	I22	I25	I53	I23
	IO3	I55	I20		II0	IO9	III	II4	II6		I21		I26	I59		
CAPACITORS	IO1	II6			II4	II7	IO2									IO4
					II5											
MISC.	VIO1	DIO2		DIO3		TRIO2	TRIO3		TRIO4	TRIO5						DIO9
	TRIO1															TRII3



NOTES

1. 210/133 DENOTES PC BOARD/EYELET OR TERMINAL No. CONNECTIONS.
2. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD.
3. TIME/DIV SWITCH SHOWN IN EXT. X POSITION.

124	127	128	157	131		136	134	140	118	139	154	142	145	143	151
	158	129	132	156			133	137	135			141	144	147	149
IO3					113	110	IO7		IO6			111			IO9
					105										
TRIO6	DIO4	DIO6	TRIO8		DIO1		DIO8	TRIO9							TRIO9
DIO5		TRIO7												TRIO7	TRIO12

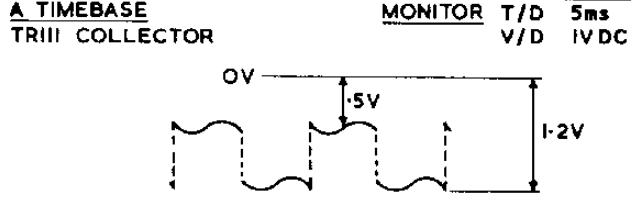
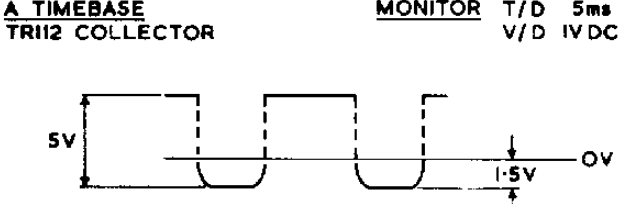
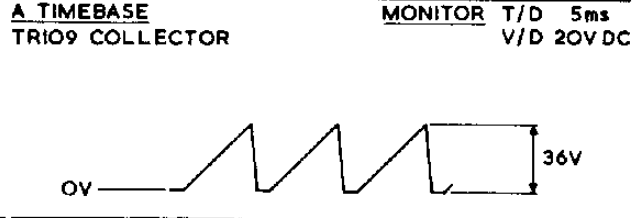
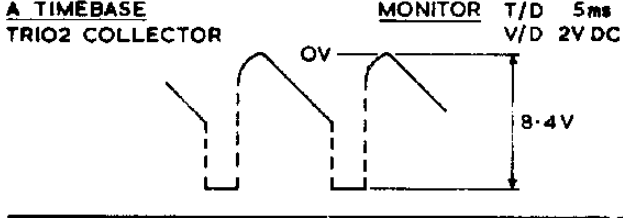
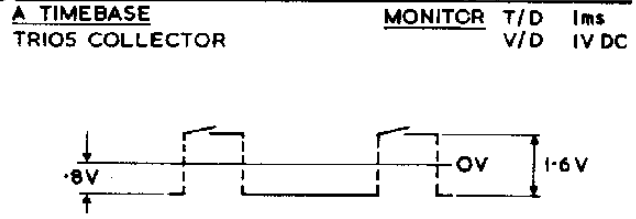
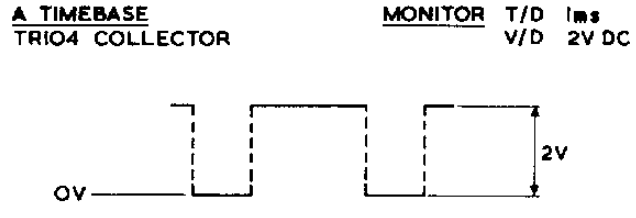
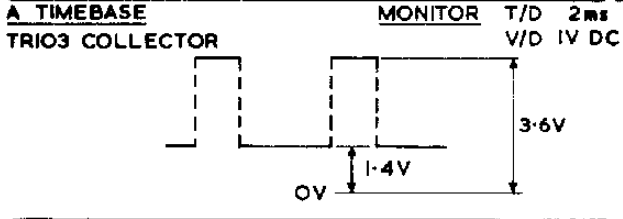
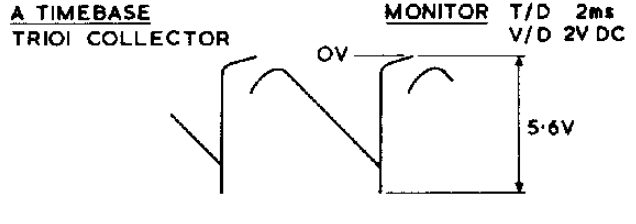
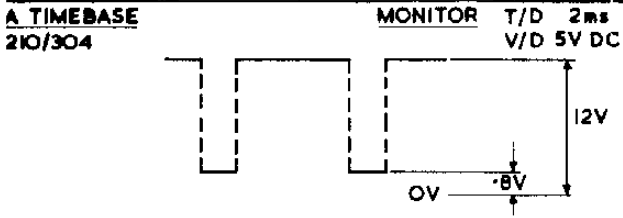


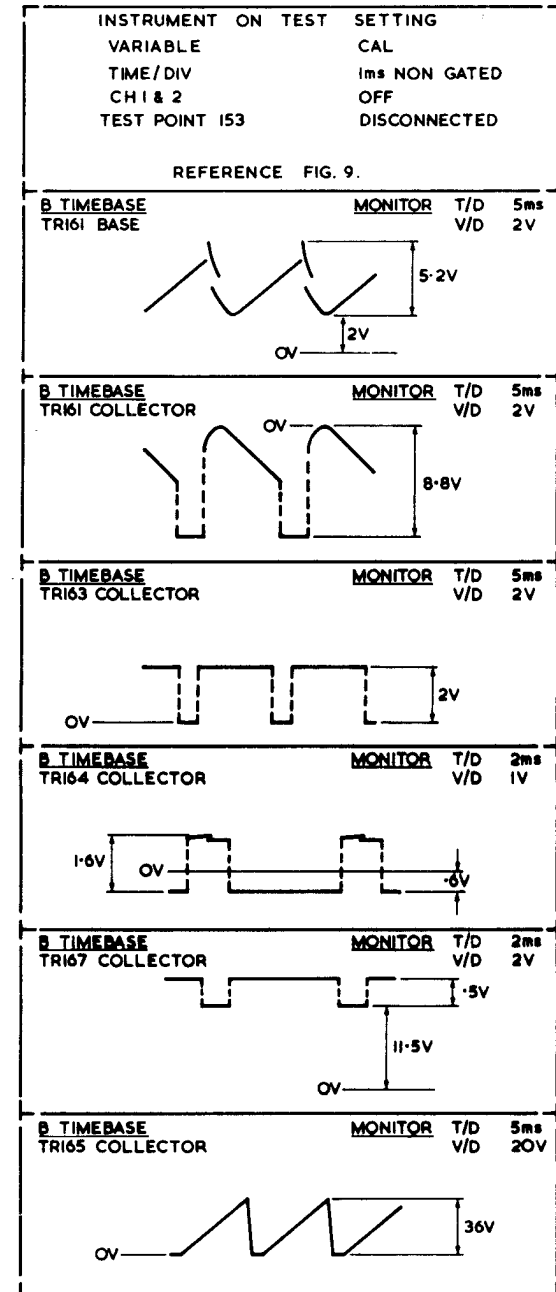
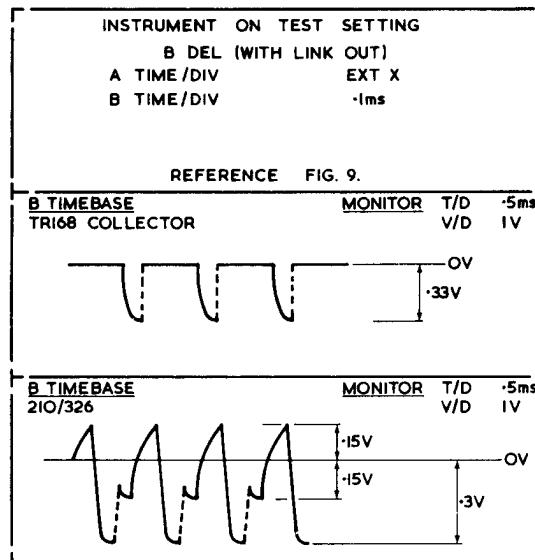
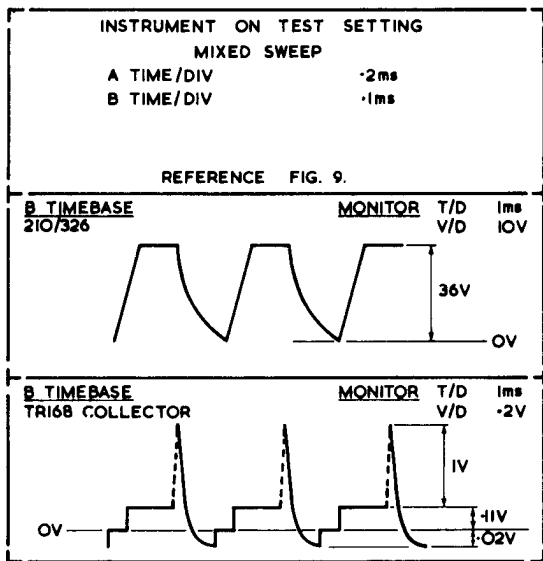
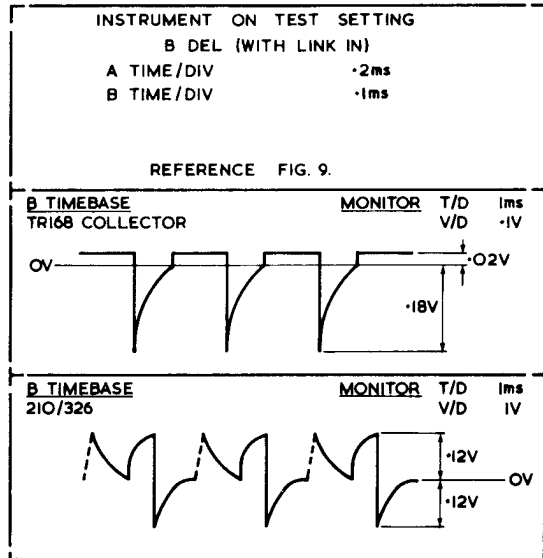
TIMEBASE A & DELAY (PC210)
D67A FIG. 8

INSTRUMENT	ON TEST	SETTING
TIME/DIV	1ms	FREE RUN
VARIABLE (T/D)		CAL
DELAY		5

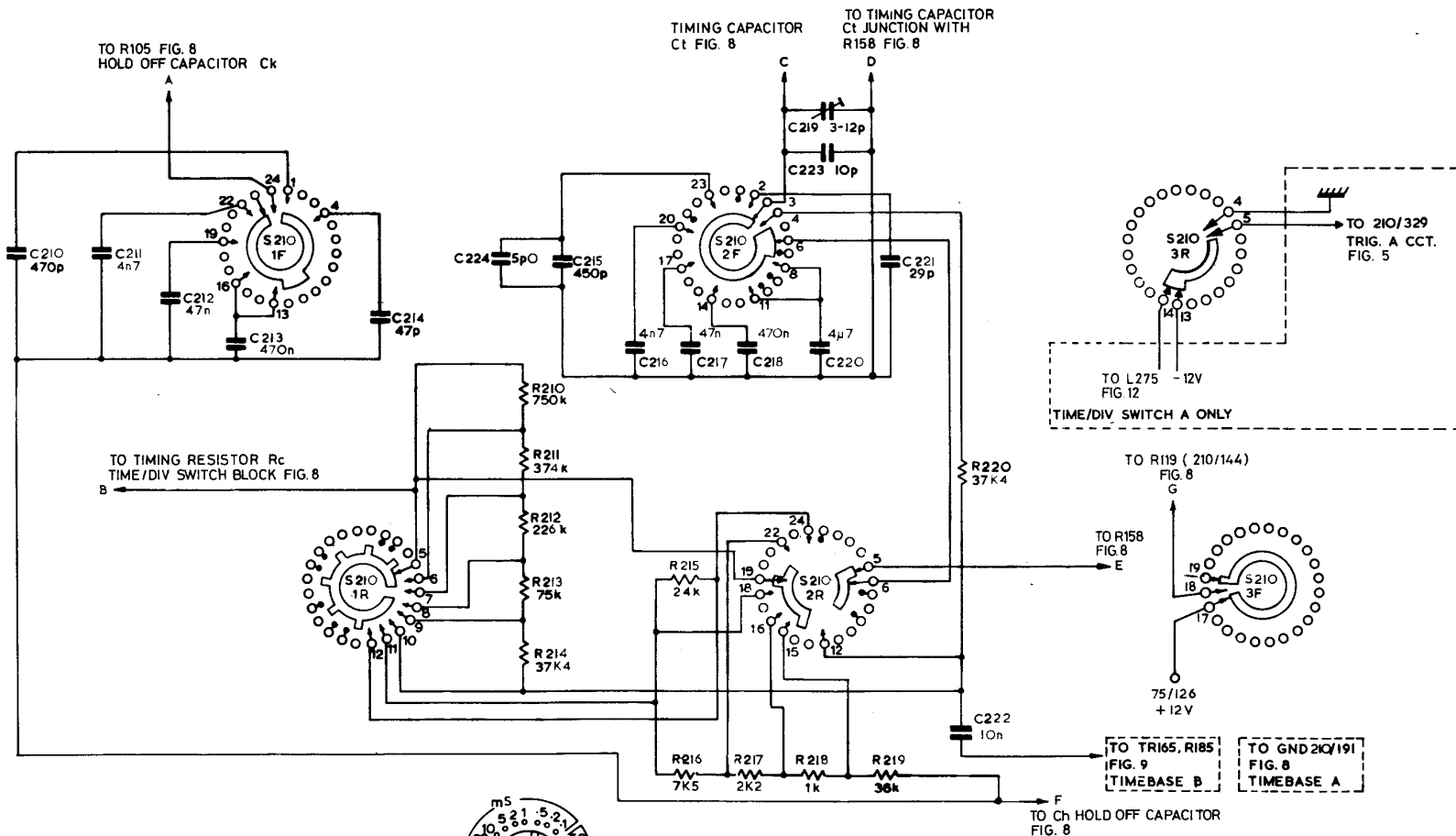
NOTE DOTTED LINE INDICATES FAST RISE

REFERENCE FIG.8

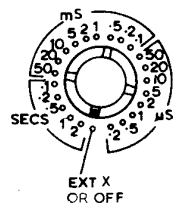




MISC	S 210 1F S210 1R					S210 2F S210 2R					S 210 3R	S210 3F		
	210	211	212	213	214	224	215	216	217	218	219	221	222	
C												22C	223	222
R						210 211 212 213 214		215 216	217	218	219		220	



- NOTES:-
1. 210/126 DENOTES PC 210/TERMINAL No.
 2. S 210 SHOWN IN FULLY ANTI-CLOCKWISE POSITION WAFERS VIEWED FROM FRONT.

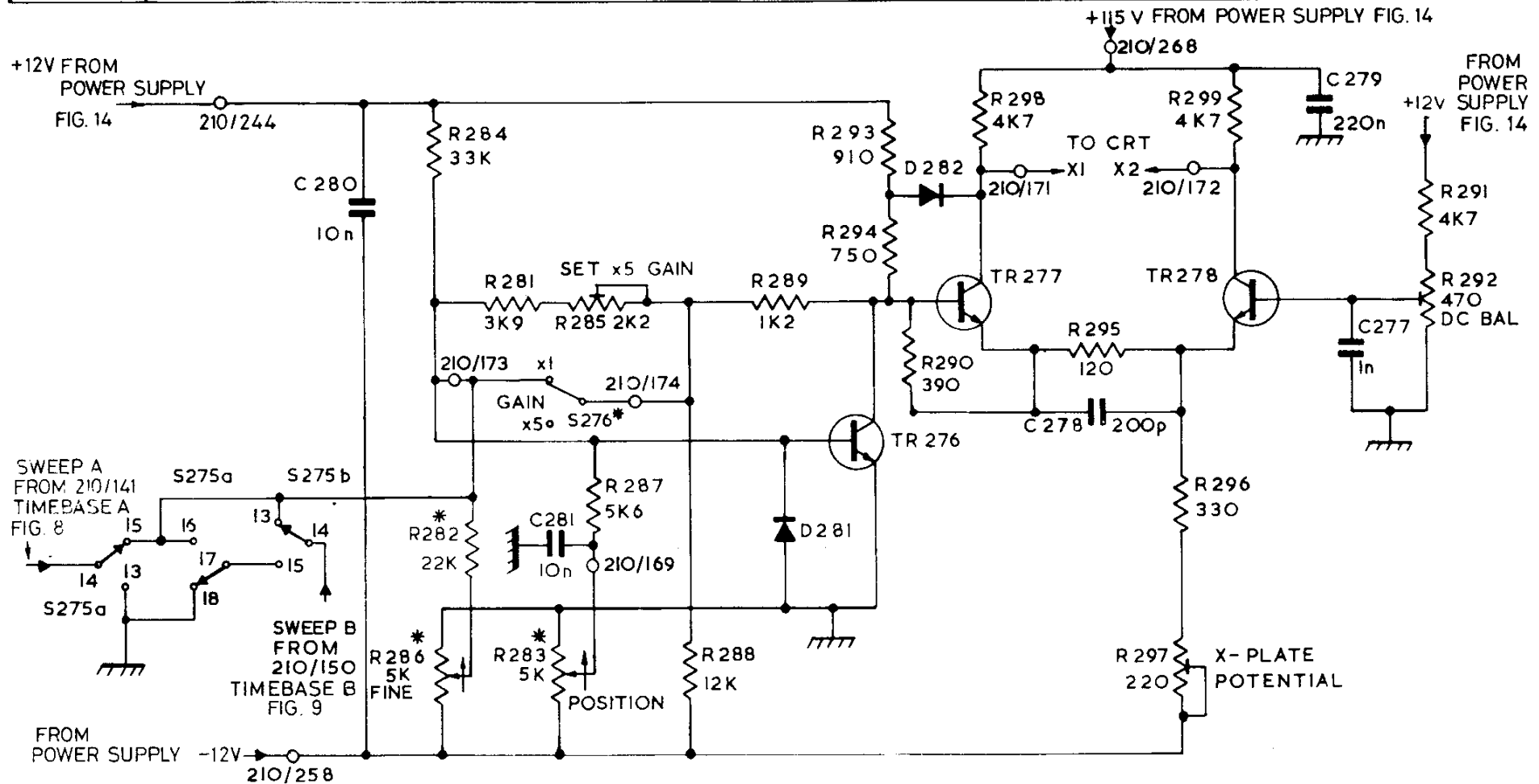


TIME / DIV SWITCH POSITIONS

TIME / DIV SWITCH
D67A (A & B)

FIG. 10

RESISTORS	284 282	281 283	285 287	288	289	293 294 290	298	295	296 297	299	291 292
CAPACITORS	280	281						278		279	277
MISC.	S275a S275b	S276			D 281 TR276 D282 TR277					TR278	

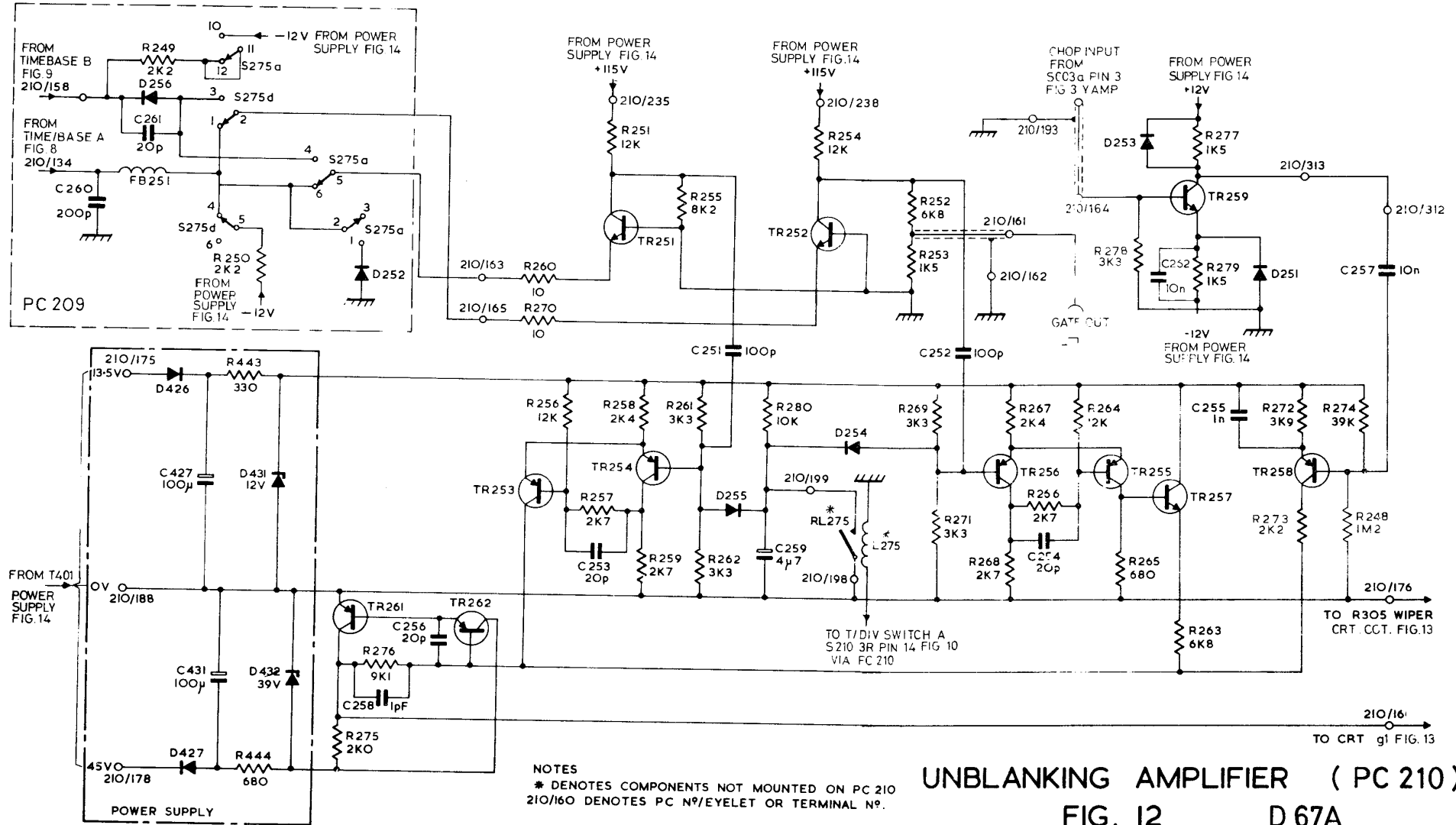


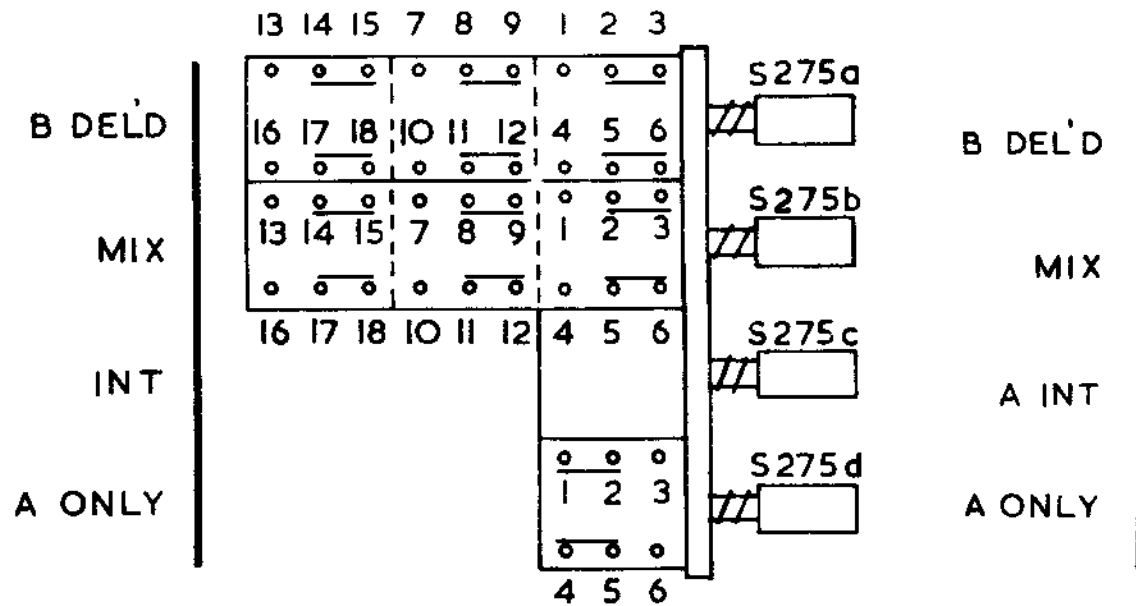
- NOTES: 1. * DENOTES COMPONENT NOT MOUNTED ON PC 210
 2. 210/244 DENOTES PC BOARD No/EYELET OR TERMINAL No.

X-AMPLIFIER (PC210)

FIG. II D 67A

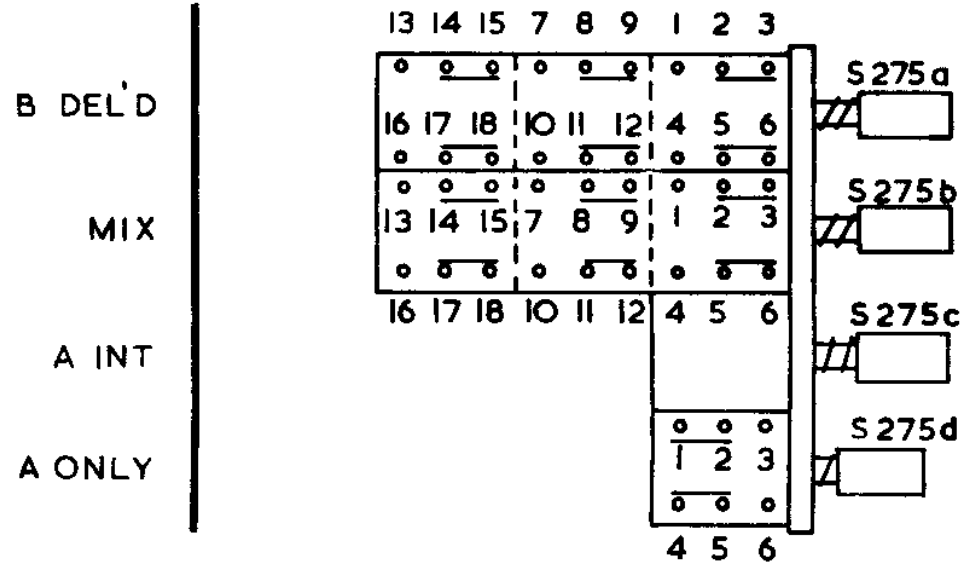
RESISTORS	249	443 444 250	275	276	260 270	251 257	258 259	261 255	262	280	254	252 269 253 271	267 268	264	265 278	263 277 279	272 273	274 248
CAPACITORS	261 260	427 431	260	258	256	253	251	259	252	254	C262	255						
MISCELLANEOUS	D 256 FB 251	D 426 D 427 S 275	D 431 D 432	TR 261 D 252	TR 262	TR 253	TR 251 TR 254	D 255	TR 252 D 254 L 275 RL 275	TR 256	TR 255	TR 257 TR 259 D 253	D 251	TR 258				





PUSH BUTTON SWITCHES
VIEWED FROM TRACK SIDE
OF BOARD.

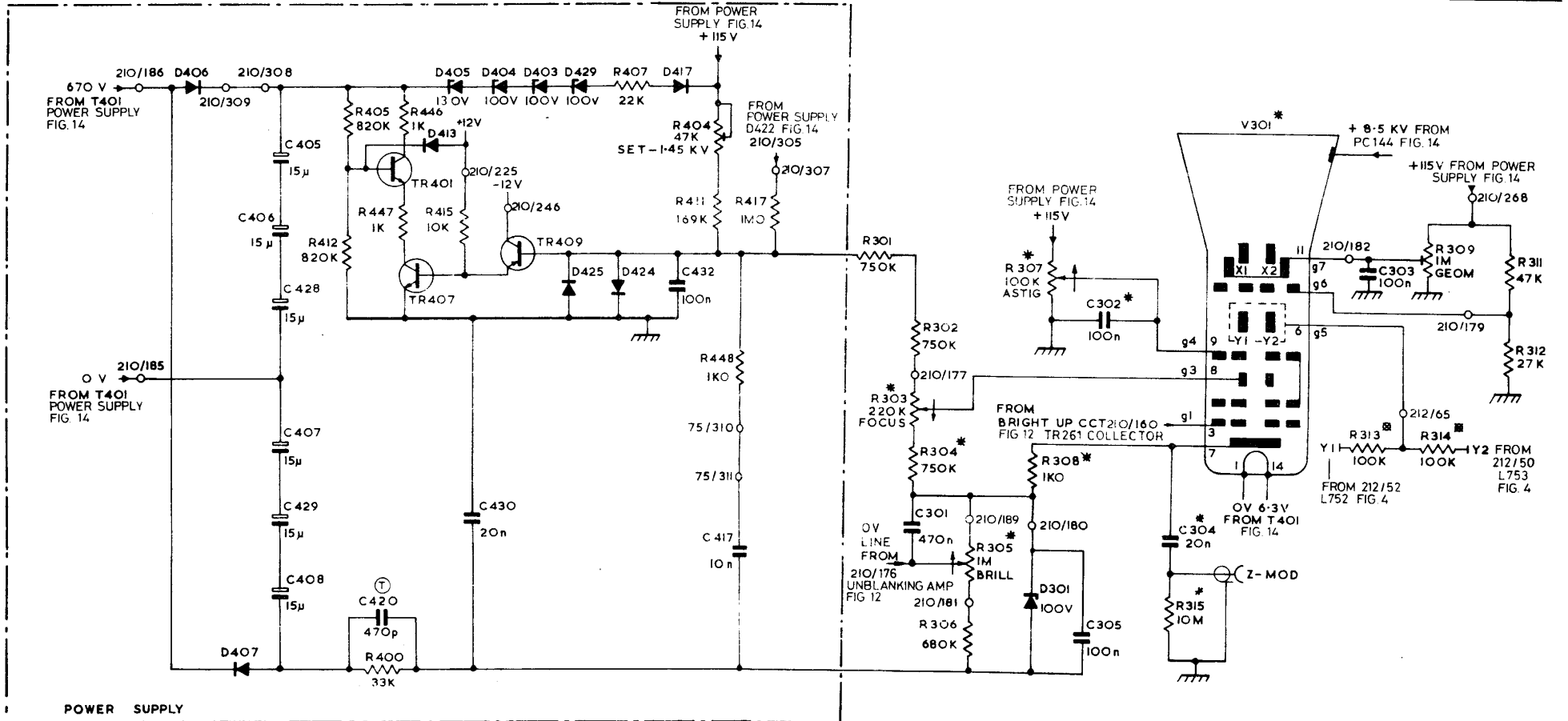
'X' Amplifier Switch



PUSH BUTTON SWITCHES VIEWED
FROM COPPER SIDE OF BOARD.

Unblanking Amplifier Switch

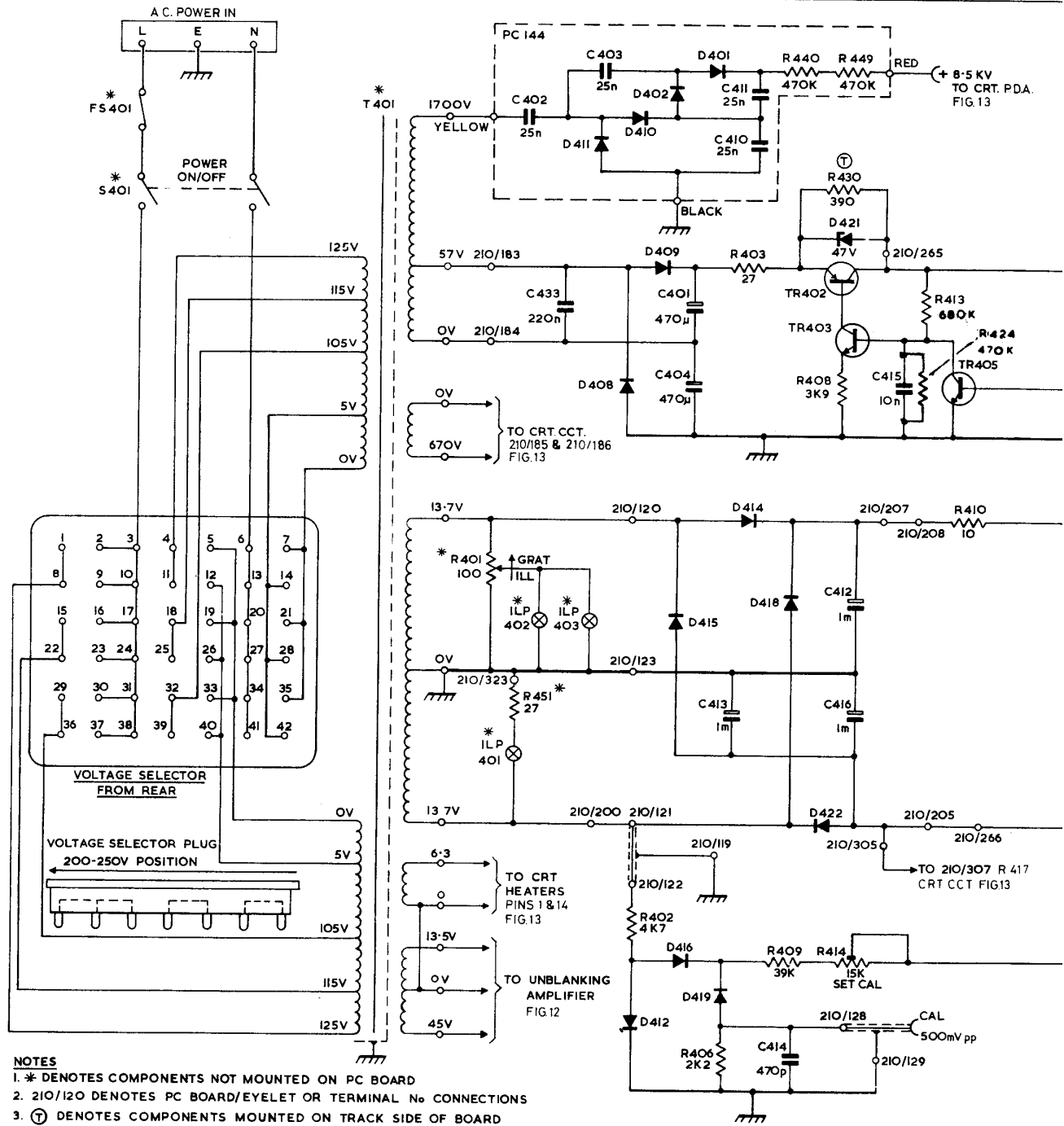
RESISTORS	405 412	446 447	400 415	407	404 411	448 417	301 303	302 304	305 306	307 308	315	313	309 314	311 312
CAPACITORS	406,405 407,428 408,429	420	430	432	417		301			305 302	304		303	
MISCELLANEOUS	D406 D407		TR401 TR407 D413	D405 D404 D413	D403 D429 TR409	D425 D424 D417				D301			V301	



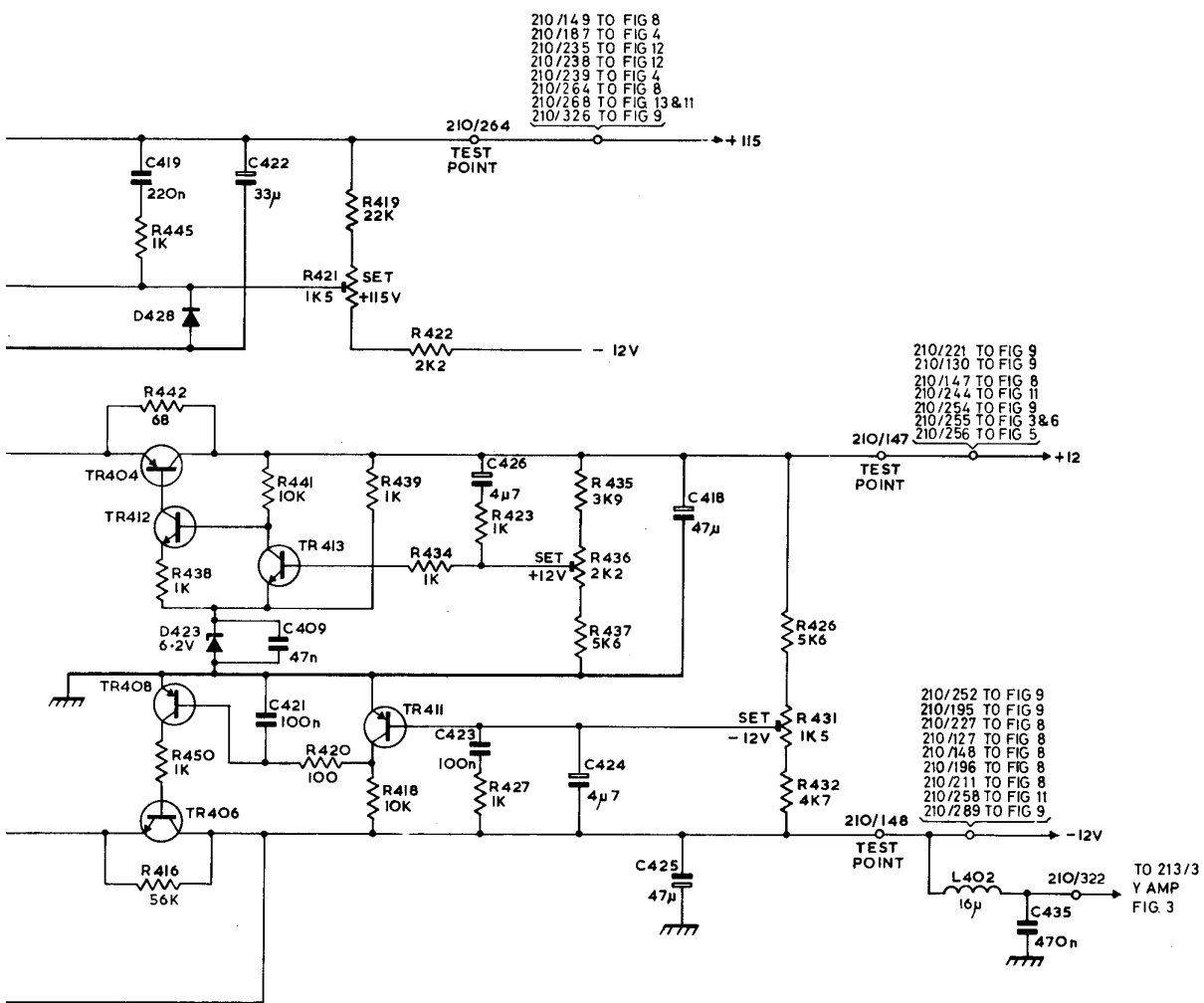
- NOTES
- 1 ■ DENOTES COMPONENTS MOUNTED ON PC212
 - 2 * DENOTES COMPONENTS NOT MOUNTED ON PC 210 OR PC212
 - 3 210/177 DENOTES PC BOARD No/EYELET OR TERMINAL No.
 - 4 ⊕ DENOTES COMPONENTS MOUNTED ON TRACK SIDE OF BOARD

C.R.T. CIRCUIT (PC 210) D67A
FIG. 13

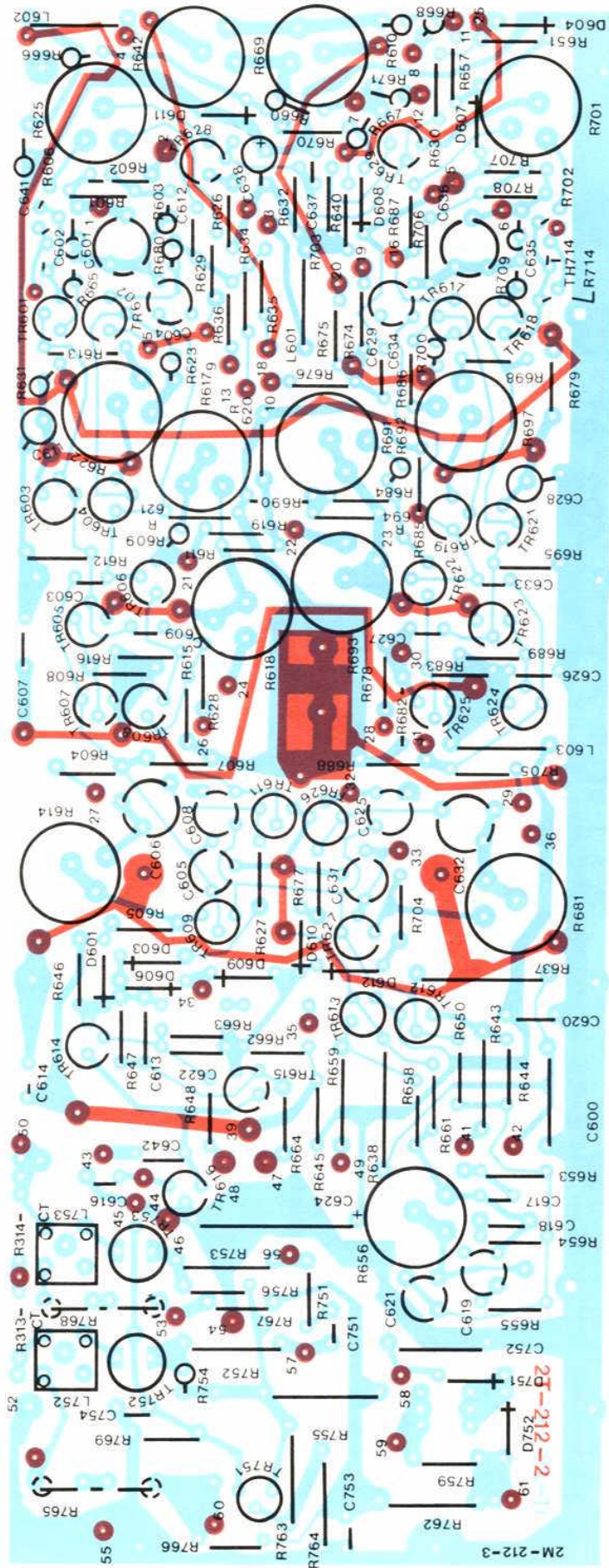
RESIS ORS		401			403	440	449			
		451	403	402	406	408	413	424	410	
CAPACITORS		402	403	401	411	430	409	414		
		433		404	410	416	412			
					413	414	416			
MISC	FS401	T401	ILP402	D411	D402	D401	TR402	D421	TR405	
	S401		ILP401	D408	D410	D414	TR403	D422		
				ILP403	D409	D416				



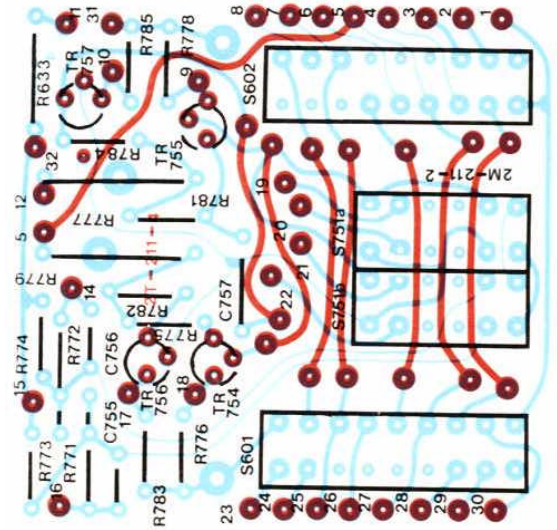
445		419	422	423	435	426
442		421	434	427	436	431
438		439	418		437	432
416	450	441	420			
419		422	409	426	424	418
		421		423	424	435
					425	
TR404		D428		TR411		L402
TR412	D423	TR413				
TR408		TR406				



POWER SUPPLY (PC 210)
 D67A FIG. 14

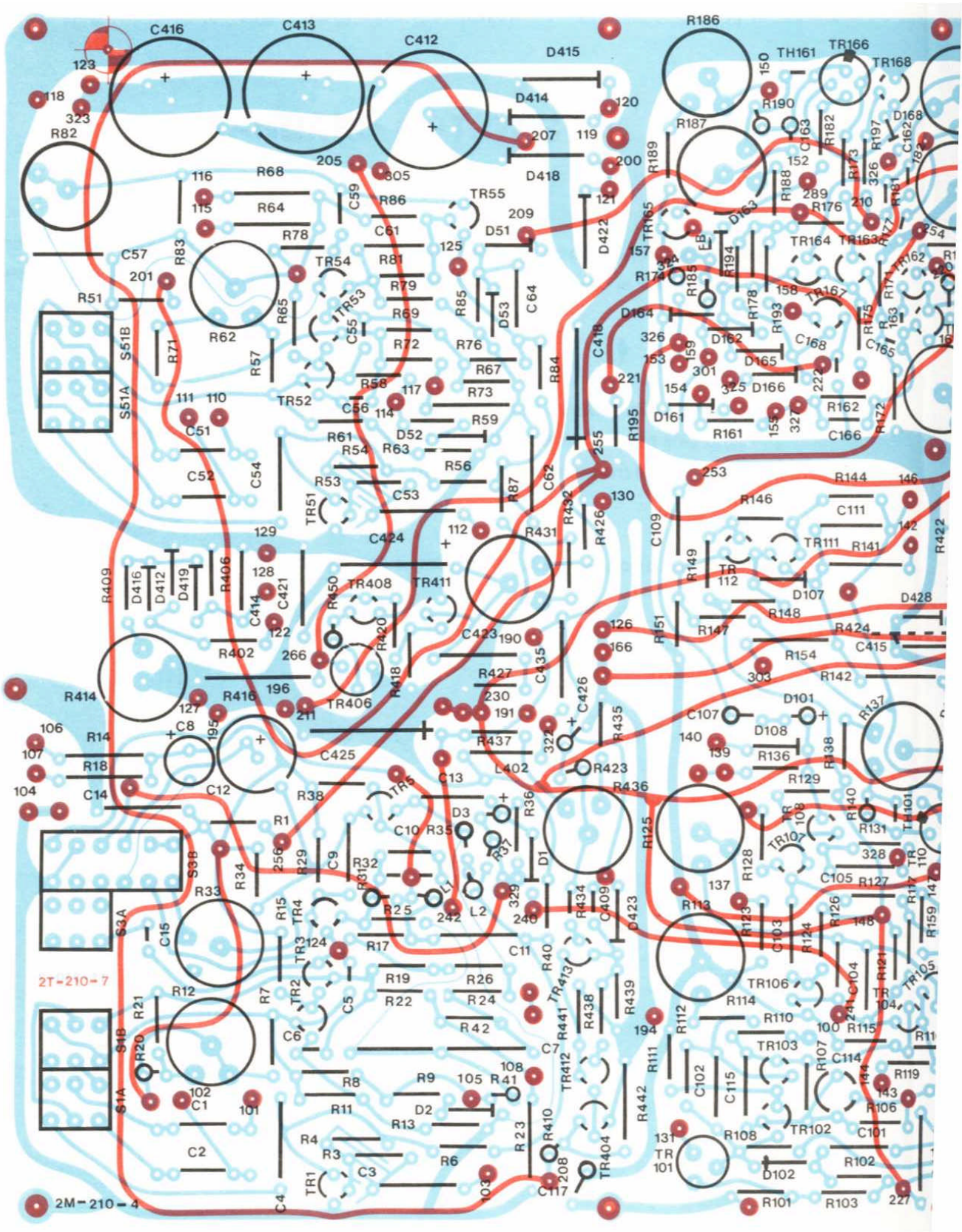


PC212



PC211

FIG. 15



PC210

FIG. 16

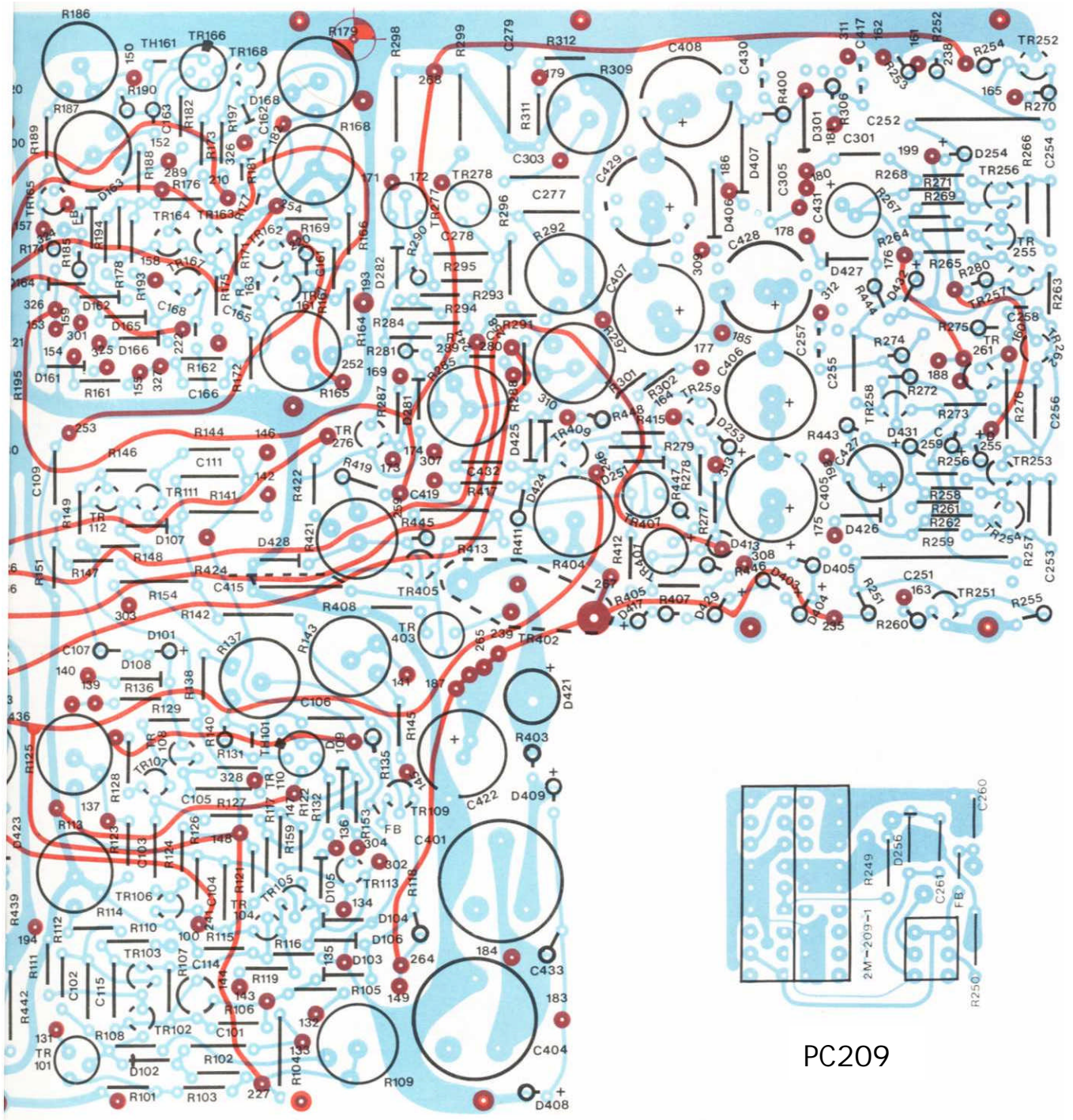


FIG. 16 (Cont.)