INSTRUMENT SERIAL NUMBER 0000001

TELEQUIPMENT ®

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

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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.

		X1 GAIN	X10 GAIN
1.2.2	**BANDWIDTH (3db)**		
	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
1.2.6	**MAXIMUM INPUT VOLTAGE**	
	DC, AC or sum of	400 V peak

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.

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 squarewave 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 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.

2.4 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

	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 kΩ 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 kΩ
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) Approx. 1.2 metres cable	010-0295-00

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 100 V, 105 V, 110 V, 115 V, 120 V, 125 V, 200 V, 210 V, 220 V, 230 V, 240 V and 250 V. 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 100 V to 125 V a 500 mA fuse should be used and for 200 V to 250 V operation a 250 mA 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-clockwise 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

		ALTernate			CHOP			ADD		
CH1	CH2	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 R161 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 regative 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 kΩ/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 ±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 μs and 100 μs 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 μs 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 μs 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 μs.
3. Apply 1 μs 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 μs 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 MΩ 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 μs 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 μs TIMING B: C219B MOUNTED ON THE TIME/DIV SWITCH

1. Ensure VARiable B is fully clockwise.
2. Switch TIME/DIV B to 0.2 μs and apply 1 μs 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 μs, 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.

4.13.2 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 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 μs.
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 μs.
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 μs.
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 μs.
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 μs.
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. Chech 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 satisfa- tory for standard components.

Any order for replacement parts should include:

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

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 TYPE	TOL %	RATING Volts	Eff. Ser.No.
C1	285-1078-00	1.5 µ	PE	20	63	
C2	285-1078-00	1.5 µ	PE	20	63	
C3	285-0773-00	100 n	PE	20	400	
C4	285-0779-00	470 n	PE	20	100	
C5	281-0678-00	3.0 p	CER	0.1 p	500	
C6	281-0678-00	3.0 p	CER	0.1 p	500	
C7	285-1078-00	1.5µ	ELEC		25	643451
C8	290-0499-00	15 µ	ELEC		16	
C9	285-0850-00	1.0 µ	PS	5	125	
C10	285-0920-00	56 p	PS	2	350	
C11	285-0779-00	470 n	PE	20	100	
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	
C51	285-1078-00	1.5 µ	PE	20	63	
C52	285-1078-00	1.5 µ	PE	20	63	
C53	285-0773-00	100 n	PE	20	400	
C54	285-0779-00	470 n	PE	20	100	
C55	281-0723-00	1.8 p	CER	0.1 p	500	
C56	281-0723-00	1.8 p	CER	0.1 p	500	
C57	285-0779-00	470 n	PE	20	100	
C59	285-0850-00	1 n	PS	5	125	
C61	285-0920-00	56 p	PS	2	350	
C62	285-0779-00	470 n	PE	20	100	
C64	285-0854-00	100 p	PS	2	350	
C101	285-0850-00	1 n	PS	5	125	
C102	285-0776-00	27 p	PS	1 p	350	
C103	285-0854-00	100 p	PS	2	350	
C104	285-0873-00	200 p	PS	5	350	
C105	285-0874-00	470 p	PS	5	125	
C106	285-0867-00	20 p	PS	1 p	350	
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	
C111	285-0854-00	100 p	PS	2	350	
C112	285-0769-00	10 n	PE	20	400	
C113	281-0732-00	3 - 12 p	CT		350	
C114	281-0154-00	2 - 12 p	PP		100	
C115	285-0843-00	30 p	PS	2 p	350	
C116	285-0769-00	10 n	PE	20	400	
C117	285-0994-00	470 n	PE	20	100	
C161	285-0854-00	100 p	PS	2 p	350	
C162	285-0873-00	200 p	PS	5	350	
C163	285-0867-00	20 p	PS	1 p	350	
C164	285-0769-00	10 n	PE	20	400	
C165	285-0843-00	30 p	PS	2 p	350	
C166	283-0653-00	5 p	SM	10	350	
C168	281-0710-00	10 n	CER	†	250	
*C210	285-0874-00	470 p	PS	5	125	
*C211	285-0792-00	4.7 n	PE	20	125	
*C212	285-1032-00	47 n	PE	20	160	
*C213	285-0791-00	470 n	PE	10	125	

CIR REF	PART NUMBER	VALUE	DESCRIPTION TYPE	TOL %	RATING Volts	Eff. Ser.No.
*C214	285-0869-00	47 p	PS	2 pF	350	
*C215	285-0762-00	450 p	PS	1	125	
*C216	285-0770-00	4.7 n	PS	1	125	
*C217	285-0926-00	47 n	PE	1	63	
*C218	285-0927-00	470 n	PC	1	63	
*C219	281-0732-00	3 - 12 p	CT		350	
*C220	285-0928-00	4.7 µ	PC	1	63	
*C221	285-0884-00	29 p	PS	1 pF	350	
*C222	285-0769-00	10 n	PE	20	400	
*C223	285-0866-00	10 p	PS	1	350	
*C224	283-0653-00	5.0 p	SM	10	350	
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	
C255	285-0850-00	1.0 n	PS	5	125	
C256	285-0867-00	20 p	PS	1 p	350	
C257	281-0677-00	10 n	CER	†	1.5 k	
C258	281-0705-00	1.0 p	CER	0.1 p	500	
C259	290-0623-00	4.7 µ	ELEC		25	
C260	285-0873-00	200 p	PS	5	350	
C261	285-0867-00	20 p	PS	1 p	350	
C262	281-0710-00	10 n	CER	†	250	
C277	285-0850-00	1.0 n	PS	5	125	
C278	285-0873-00	200 p	PS	5	350	
C279	285-0795-00	220 n	PE	20	250	
C280	281-0710-00	10 n	CER	†	250	
C281	281-0710-00	10 n	CER	†	250	
C301	285-0853-00	470 n	PE	20	400	
C302	285-0772-00	100 n	PE	10	400	
C303	285-0796-00	100 n	PE	20	250	
C304	281-0682-00	20 n	CER		2 k	
C305	285-0796-00	100 n	PE	20	250	
C401	290-0500-00	470 µF	ELEC		100	
C402	285-0992-00	22 nF	PEP	10	5 k	722631
C403	285-0992-00	22 nF	PEP	10	5 k	722631
C404	290-0500-00	470 µF	ELEC		100	
C405	290-0489-00	15 µF	ELEC	†	350	
C406	290-0489-00	15 µF	ELEC	†	350	
C407	290-0489-00	15 µF	ELEC	†	350	
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	722631
C411	285-0992-00	22 nF	PEP	10	5 k	722631
C412	290-0498-00	1 mF	ELEC	†	25	
C413	290-0498-00	1 mF	ELEC	†	25	
C414	285-0874-00	470 pF	PS	5	125	
C415	285-0790-00	10 nF	PE	20	125	
C416	290-0498-00	1 mF	ELEC	†	25	
C417	281-0677-00	10 nF	CER	†	2 k	
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	
C425	290-0495-00	47 µF	ELEC	†	40	
C426	290-0623-00	4.7 µF	ELEC		25	
C427	290-0490-00	100 µF	ELEC		25	

CIR REF	PART NUMBER	VALUE	DESCRIPTION TYPE	TOL %	RATING Volts	Eff. Ser.No.
C428	290-0489-00	15 µF	ELEC		350	
C429	290-0489-00	15 µF	ELEC		350	
C430	281-0682-00	20 nF	CER	†	2 k	
C431	290-0491-00	100 µF	ELEC		63	
C432	285-0915-00	100 nF	PE	20	100	
C433	285-0923-00	220 nF	PE	10	160	
C435	285-0779-00	470 nF	PE	20	100	
C600	285-0796-00	100 n	PE	20	250	
C601	281-0157-00	5.5p-65.5p	T		500	
C602	285-0845-00	68 p	PS	2 p	350	
C603	281-0723-00	1.8 p	CER	0.1 p	500	
C604	281-0156-00	1.4p-6.4p	T		500	
C605	281-0156-00	1.4p-6.4p	T		500	
C606	281-0157-00	5.5p-65 5p	T		500	
C607	281-0734-00	100 n	CER	†	30	
C608	281 0156-00	1.4p-6.4p	T		500	
C609	281-0723-00	1.8 p	CER	0.1 p	500	
C611	290-0623-00	4.7 µ	ELEC		25	
C612	285-0788-00	100 n	PE	10	125	
C613	285-0854-00	100 p	PS	2 p	350	
C614	281-0710-00	10 n	CER	†	250	
C616	281-0710-00	10 n	CER	†	250	
C617	281-0676-00	2.2 p	CER	0.1 p	500	
C618	281-0713-00	10 p	CER	0.25 p	750	
C619	281-0155-00	2-22 p	T		500	
C620	281-0734-00	100 n	CER	†	30	
C621	281-0155-00	2-22 p	T		500	
C622	285-0854-00	100 p	PS	2 p	350	
C623	281 0734-00	100 n	CER	†	30	
C624	290-0494 00	47 µ	ELEC		25	
C625	281-0156 00	1.4p-6.4p	T		500	
C626	281-0734-00	100 n	CER	†	30	
C627	281-0723-00	1.8 p	CER	0.1 p	500	
C628	290-0623-00	4.7 µ	ELEC		25	
C629	285-0788-00	100 n	PE	10	125	
C630	285-1046 00	100 n	PE	20	160	
C631	281 0156-00	1.4p-6.4p	T		500	
C632	281-0157-00	5.5p-65.5p	T		500	
C633	281-0723-00	1.8p	CER	0.1 p	500	
C634	281-0156-00	1.4p-6 4p	T		500	
C635	285-0845-00	68 p	PS	2 p	350	
C636	281-0157-00	5.5-65 pF	T		500	
C637	281-0710 00	10 n	CER	†	250	
C638	290-0493-00	22 µ	ELEC		16	
C639	281-0710 00	10 n	CER	†	250	
C641	285-0994-00	470 n	PE	†	100	
C642	281 0734 00	100 n	CER	†	30	
C643	285-0915-00	100 n	PE	20	100	
C644	281-0710-00	10 n	CER	†	250	
C751	281-0678-00	3 p	CER	0 1 p	500	
C752	285-0795-00	220 n	PE	20	250	
C753	281 0710-00	10 n	CER	†	250	
C754	281-0710-00	10 n	CER		250	
C755	281-0713-00	10 p	CER	0 25 p	750	
C756	281-0713-00	10 p	CER	0.25 p	750	
C757	285-0869-00	47 p	PS	2 p	350	
C901	285-0772 00	100 n	PE	10	400	
*C902	281-0155 00	2-22 p	PP		500	
*C903	281-0155-00	2-22p	PP		500	
*C904	281-0155-00	2-22 p	PP		500	
*C905	281-0156-00	1.4p 6.4p	PP		500	
*C906	281-0156-00	1.4p-6.4p	PP		500	
*C907	281-0154-00	2-12 p	PP		500	
*C908	283-0607-00	2.0 n	BM	10	500	
*C909	283-0719-00	470 p	BM	10		
*C911	285-0844-00	39 p	PS	2 p	350	
*C912	281-0155-00	2-22p	PPT		500	643851
*C913	281-0154-00	2-12p	PPT		500	643851
*C914	281-0155-00	2-22p	PPT		500	
*C915	283-0662-00	7.5 p	SM	0.5	350	
*C916	281-0154-00	2-12p	PPT		500	
*C917	285-0842-00	15 p	PS	1 p	350	

CIR REF	PART NUMBER	VALUE	DESCRIPTION	TYPE	TOL %	RATING	Eff. Ser. No.
D1	152-0370-00		AAY 30	GE		50 V	
D2	152 0370-00		AAY 30	GE		50 V	
D3	152-0062-00		IN 914	Si			
D51	152-0370-00		AAY 30	GE		50 V	
D52	152-0370-00		AAY 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		AAY 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		AAY 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		AAY 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			
D403	152-0344-00	100 V	Zener	Si		330 mW	
D404	152-0344-00	100 V	Zener	Si		330 mW	
D405	152-0388-00	130 V	Zener	Si		700 mW	
D406	152-0515-00	6000 V	SCM60	Si			
D407	152-0515-00	6000 V	SCM60	Si			
D408	152-0341-00	450 V	ZS 75	Si		0.5 A	
D409	152-0341-00	450 V	ZS 75	Si		0.5 A	
D410	152-0515-00	6000 V	SCM60	Si			
D411	152-0515-00	6000 V	SCM60	Si			
D412	152-0062-01		1N 914	Si		75 mA	
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	
D147	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.
R1	317-0180-00	18	C	5	125 m	
R3	317-0104-01	100 k	C	5	125 m	
R4	317-0104-01	100 k	C	5	125 m	
R5	317-0271-01	270	C	5	125 m	
R6	317-0362-01	3.6 k	C	5	125 m	
R7	317-0102-01	1.0 k	C	5	125 m	
R8	317-0182-01	1.8 k	C	5	125m	
R9	317-0222-01	2.2 k	C	5	125 m	
R11	317-0332-01	3.3 k	C	5	125 m	
R12	311-0719-00	470	CP	20	250 m	
R13	317-0821-01	820	C	5	125 m	
R14	317-0222-01	2.2 k	C	5	125 m	
R15	317-0821-01	820	C	5	125 m	
R16	311-1050-00	2.2 k	CV	20	250 m	
R17	317-0821-01	820	C	5	125 m	
R18	317-0222-01	2.2 k	C	5	125 m	
R19	317-0332-01	3.3 k	C	5	125 m	
R20	315-0181-01	180	C	5	250 m	
R21	317-0102-01	1.0 k	C	5	125 m	
R22	317-0182-01	1.8 k	C	5	125 m	
R23	317-0222-01	2.2 k	C	5	125 m	
R24	317-0233-01	22 k	C	5	125 m	643451
R25	317-0103-01	10 k	C	5	125 m	643451
R26	317-0393-01	39 k	C	5	125 m	
R27	317-0122-01	1.2 k	C	5	125 m	
R29	317-0223-01	22 k	C	5	125 m	
R30	317-0180-01	18	C	5	125 m	
R31	317-0221-01	220	C	5	125 m	
R32	317-0222-01	2.2 k	C	5	125 m	
R33	311-0717-00	220	CP	20	250 m	
R34	317-0332-01	3.3 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	
R37	316-0335-02	3.3 M	C	10	250 m	
R38	317-0103-01	10 k	C	5	125 m	
R39	317-0224-01	220 k	C	5	125 m	
R40	317-0180-01	18	C	5	125 m	
R41	317-0822-01	8.2 k		5	125 m	643451
R42	317-0183 01	18 k		5	125 m	643451
R51	317-0180-01	18	C	5	125 m	
R53	317-0104-01	100 k	C	5	125 m	
R54	317-0104-01	100 k	C	5	125 m	
R55	317-0271-01	270	C	5	125 m	
R56	317-0362-01	3.6 k	C	5	125 m	
R57	317-0152-01	1.5 k	C	5	125 m	
R58	317-0182-01	1.8 k	C	5	125 m	
R59	317-0562-01	5.6 k	C	5	125 m	
R61	317-0332-01	3.3 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	
R64	317-0682-01	6.8 k	C	5	125 m	
R65	317-0821-01	820	C	5	125 m	
R66	311-1053-00	10 k	CV	20	250 m	
R67	317-0821-01	820	C	5	125 m	
R68	317-0682-01	6.8 k	C	5	125 m	
R69	317-0332-01	3.3 k	C	5	125 m	
R71	317-0152-01	1.5 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	
R76	317- 0393-01	39 k	C	5	125 m	
R78	317-0122-01	1.2 k	C	5	125 m	
R79	317-0221-01	220	C	5	125 m	
R81	317-0222-01	2.2 k	C	5	125 m	
R82	311-0717-00	220	CP	20	250 m	
R83	317-0332-01	3.3 k	C	5	125 m	
R84	317-0471-01	470	C	5	125 m	
R85	317-0222-01	2.2 k	C	5	125 m	
R86	317-0103-01	10 k	C	5	125 m	
R87	317-0180-01	18	C	5	125 m	
R101	317-0393-01	39 k	C	5	125 m	
R102	317-0103-01	10 k	C	5	125 m	
R103	317-0333-01	33 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	
R106	317-0224-01	220 k	C	5	125 m	
R107	317-0333-01	33 k	C	5	125 m	
R108	317-0222-01	2.2 k	C	5	125 m	
R109	311-0735-00	10 k	CP	20	250 m	
R110	315-0335-02	3.3 M	CF	5	250 m	
R111	317-0472-01	4.7 k	C	5	125 m	
R112	317-0223-01	22 k	C	5	125 m	
R113	311-0735-00	10 k	CP	20	250 m	
R114	317-0472-01	4.7 k	C	5	125 m	
R115	317-0183-01	18 k	C	5	125 m	
R116	317-0182-01	1.8 k	C	5	125 m	
R117	317-0331-01	330	C	5	125 m	
R118	303-0153-01	15 k	C	5	1	
R119	317-0152-01	1.5 k	C	5	125 m	
R120	301-0685-02	6.8 M	C	5	500 m	643751
R121	317-0123-01	12 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	
R124	317-0223-01	22 k	C	5	125 m	
R125	311-0850-00	15 k	CP	20	250 m	
R126	317-0122-01	1.2 k	C	5	125 m	
R127	317-0472-01	4.7 k	C	5	125 m	
R128	317-0680-01	68	C	5	125 m	
R129	317-0102-01	1 k	C	5	125 m	
R131	317-0472-01	4.7 k	C	5	125 m	
R132	317 0101-01	100	C	5	125m	
R133	315-0823-02	82 k	C	5	250 m	
R134	311-1048-00	50 k	CV	20	250 m	
R135	317-0100-01	10	C	5	125 m	
R136	317-0103-01	10 k	C	5	125 m	
R137	311-0719-00	470	CP	20	250 m	
R138	317-0272-01	2.7 k	C	5	125 m	
R139	311-1052-00	2 k	WW	5	875 m	
R140	317-0471-01	470	C	5	125 m	
R141	321-0279-48	7.87 k	MF	1	125 m	
R142	321-0850-48	27 k	MF	1	125 m	
R143	311-0735-00	10 k	CP	20	250 m	
R144	317-0221-01	220	C	5	125 m	
R145	317-0153 01	15 k	C	5	125 m	
R146	317-0221-01	220	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	
R149	317-0333-01	33 k	C	5	125 m	
R151	317-0562-01	5.6 k	C	5	125 m	
R152	315-0331-02	330	C	5	250 m	
R153	317-0332-01	3.3 k	C	5	125 m	
R154	321-0419-48	226 k	MF	1	125 m	
R155	317-0101-01	100	C	5	125 m	
R156	315-0684-01	680 k	C	10	250 m	
R157	316-0105-01	1 M	C	10	250 m	
R158	316-0125-01	1.2 M	C	10	250 m	
R159	317-0222-01	2.2 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	
R163	317-0333-01	2.2 k	C	5	125 m	
R164	317-0222-01	2.2 k	C	5	125 m	
R165	311-0735-00	10 k	CP	20	250 m	
R166	317-0472-01	4.7 k	C	5	125 m	
R167	317-0223-01	22 k	C	5	125 m	
R168	311-0735-00	10 k	CP	20	250 m	
R169	317-0472-01	4.7 k	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.
R172	317-0182-01	1.8 k	C	5	125 m	
R173	317-0331-01	330	C	5	125 m	
R174	303-0153-01	15 k	C	5	1	
R175	317-0152-01	1.5 k	C	5	125 m	
R176	317-0123-01	12 k	C	5	125 m	
R177	317-0822-01	8.2 k	C	5	125 m	
R178	317-0392-01	3.9 k	C	5	125 m	
R179	311-0850-00	15 k	CP	20	250m	
R181	317-0122-01	1.2 k	C	5	125 m	
R182	317-0101-01	100	C	5	125 m	
R183	315-0823-02	82 k	C	5	250 m	
R184	311-1048-00	50 k	CV	20	250 m	
R185	317-0100-01	10	C	5	125 m	
R186	311-0735-00	10 k	CP	20	250 m	
R187	311-0719-00	470	CP	20	250 m	
R188	317-0272-01	2.7 k	C	5	125 m	
R189	317-0153-01	15 k	C	5	125 m	
R190	317-0471-01	470	C	5	125 m	
R191	316-0125-01	1.2 M	C	10	250 m	
R192	315-0684-01	680 k	C	10	250 m	
R193	317-0222-01	2.2 k	C	55	125 m	
R194	317-0393-01	39 k	C	5	125 m	
R195	317-0470-01	47	C	5	125 m	
R196	316-0105-01	1.0 M	C	10	250 m	
R197	317-0153-00	15 k	C	5	125 m	
*R210	321-0469-48	750 k	MF	1	125 m	
*R211	321-0440-48	374 k	MF	1	125 m	
*R212	321-0419-48	226 k	MF	1	125m	
*R213	321-0373-48	75 k	MF	1	125 m	
*R214	321-0344-48	37.4 k	MF	1	125 m	
*R215	321-1325-48	24 k	MF	1	125 m	
*R216	321-0277-48	7.5 k	MF	1	125 m	
*R217	321-0844-48	2.2 k	MF	1	125 m	
*R218	321-0193-48	1.0 k	MF	1	125 m	
*R219	321-0852-48	36 k	MF	1	125 m	
*R220	321-0344-48	37.4 k	MF	1	125 m	
R248	315-0125-01	1.2 M	CF	5	250 m	
R249	317-0222-01	2.2 k	C	5	125 m	
R250	317-0222-01	2.2 k	C	5	125 m	
R251	303-0123-01	12 k	C	5	1	
R252	303-0682-01	6.8 k	C	5	1	
R253	317-0152-01	1.5 k	C	5	125 m	
R254	303-0123-01	12 k	C	5	1	
R255	303-0822-01	8.2 k	C	5	1	
R256	317-0123-01	12 k	C	5	125 m	
R257	317-0272-01	2.7 k	C	5	125 m	
R258	317-0242-01	2.4 k	C	5	125 m	
R259	317-0272-01	2.7 k	C	5	125 m	
R260	317-0100-01	10	C	5	125 m	
R261	317-0332-01	3.3 k	C	5	125 m	
R262	317-0332-01	3.3 k	C	5	125 m	
R263	317-0682-01	6.8 k	C	5	125 m	
R264	317-0123-01	12 k	C	5	125 m	
R265	317-0681-01	680	C	5	125 m	
R266	317-0272-01	2.7 k	C	5	125 m	
R267	317-0242-01	2.4 k	C	5	125 m	
R268	317-0272-01	2.7 k	C	5	125 m	
R269	317-0332-01	3.3 k	C	5	125 m	
R270	317-0100-01	10	C	5	125 m	
R271	317-0332-01	3.3 k	C	5	125 m	
R272	317-0392-01	3.9 k	C	5	125 m	
R273	317-0222-01	2.2 k	C	5	125 m	
R274	317-0393-01	39 k	C	5	125 m	
R275	303-0202-01	2k	C	5	1	
R276	315-0912-03	9.1 k	C	5	250 m	
R277	317-0152-01	1.5 k	C	5	125 m	
R278	317-0332-01	3.3 k	C	5	125 m	
R279	317-0152-01	1.5 k	C	5	125 m	
R280	315-0103-01	10 k	C	5	250 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No
R281	317-0392-01	3.9 k	C	5	125 m	
R282	317-0223-01	22 k	C	5	125 m	
R283	311-1082-00	5 k	CV	20	250 m	
R284	317-0333-01	33 k	C	5	125m	
R285	311-0798-00	2.2 k	CP	20	250 m	
R286	311-1047-01	5 k	CV	20	250 m	
R287	317-0562-01	5.6 k	C	5	125 m	
R288	317-0123-01	12 k	C	5	125 m	
R289	317-0122-01	1.2 k	C	5	125 m	
R290	317-0391-01	390	C	5	125 m	
R291	317-0472-01	4.7 k	C	5	125 m	
R292	311-0719-00	470	CP	20	250 m	
R293	317-0911-01	910	C	5	125 m	
R294	317-0751-01	750	C	5	125 m	
R295	317-0121-01	120	C	5	125 m	
R296	315-0331-01	330	C	5	250 m	
R297	311-0717-00	220	CP	20	250 m	
R298	307-0255-00	4.7 k	MO	5	3.25	
R299	307-0255-00	4.7 k	MO	5	3.25	
R301	307-0418-00	750 k	MF	2	1	
R302	307-0418-00	750 k	MF	2	1	
R303	311-1810-00	220 k	C	20		
R304	307-0418-00	750 k	MF	2	1	
R305	311-1398-00	1 M	CV	20	2	
R306	315-0684-01	680 k	C	5	250 m	
R307	311-1809-01	100 k	CV	20	250 m	
R308	315-0102-01	1 k	C	5	250 m	
R309	311-0809-00	1 M	CP	20	250 m	
R311	317-0473-01	47 k	C	5	125 m	
R312	317-0273-01	27 k	C	5	125 m	
R313	317-0104-01	100 k	C	5	125 m	
R314	317-0104-01	100 k	C	5	125 m	
R315	316-0106-01	10 M	C	10	250 m	
R400	302-0333-01	33 k	C	10	500 m	
R401	311-1760-00	100	CV	20	1	
R402	317-0472-01	4.7 k	C	5	125 m	
R403	307-0256-00	27	MO	5	1.5	
R404	311-0756-00	47 k	CP	20	250 m	
R405	317-0824-01	820 k	C	5	125 m	
R406	317-0222-01	2.2 k	C	5	125 m	
R407	315-0223-01	22 k	C	5	250 m	
R408	317-0392-01	3.9 k	C	5	125 m	
R409	317-0393-01	39 k	C	5	125 m	
R410	315-0100-03	10	C	5	250 m	
R411	321-0407-48	169 k	MF	1	125 m	
R412	317-0824-01	820 k	C	5	125 m	
R413	317-0684-01	680 k	C	5	125 m	643701
R414	311-0850-00	15 k	CP	20	250 m	
R415	317-0103-01	10 k	C	5	125 m	
R416	303-0560-01	56	C	5	1	
R417	317-0105-01	1.0 M	C	5	125 m	
R418	317-0103-01	10 k	C	5	125 m	
R419	303-0223-01	22 k	C	5	1	
R420	317-0101-01	100	C	5	125 m	
R421	311-0913-00	1.5 k	CP	20	250 m	
R422	317-0222-01	2.2 k	C	5	125 m	
R423	317-0102-01	1 k	C	5	125 m	
R424	317-0474-01	470 k	CF	5	125 m	643701
R426	317-0562-01	5.6 k	C	5	125 m	
R427	317-0102-01	1 k	C	5	125 m	
R430	307-0317-00	390	MO	5	5.25	
R431	311-0913-00	1.5 k	CP	20	250 m	
R432	317-0472-01	4.7 k	C	5	125 m	
R434	317-0102-01	1 k	C	5	125 m	
R435	317-0392-01	3.9 k	C	5	125 m	
R436	311-0798-00	2.2 k	CP	20	250 m	
R437	317-0562-01	5.6 k	C	5	125 m	
R438	317-0102-01	1 k	C	5	125 m	
R439	317-0102-01	1 k	C	5	125 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
R440	315-0474-01	470 k	C	5	250 m	
R441	317-0103-01	10 k	C	5	125 m	
R442	315-0680-01	68	C	5	250 m	
R443	315-0331-01	330	C	5	250 m	
R444	303-0681-01	680	C	5	1	
R445	315-0102-01	1 k	C	5	250 m	
R446	315-0102-01	1 k	C	5	250 m	
R447	315-0102-01	1 k	C	5	250 m	
R448	315-0102-01	1 k	C	5	250 m	
R449	315-0474-01	470 k	C	5	250 m	
R450	315-0102-01	1 k	C	5	250 m	
R451	315-0270-01	27	C	5	250 m	
R601	317-0105-01	1 M	C	5	125 m	
R602	310-0679-00	111k + 900k	CM	1	250 m	
R603	317-0154-01	150 k	C	5	125 m	
R604	317-0271-01	270	C	5	125 m	
R605	317-0221-01	220	C	5	125 m	
R606	317-0751-01	750	C	5	125 m	
R607	317-0472-01	4.7 k	C	5	125 m	
R608	317-0681-01	680	C	5	125 m	
R609	317-0331-01	330	C	5	125 m	
R610	317-0221-01	220	C	5	125 m	
R611	317-0561-01	560	C	5	125 m	
R612	317-0103-01	10 k	C	5	125 m	
R613	317-0911-01	910	C	5	125 m	
R614	311-0717-00	220	CPRE	20	250 m	
R615	317-0472-01	4.7 k	C	5	125 m	
R616	317-0681-01	680	C	5	125 m	
R617	311-0719-00	470	CPRE	20	250 m	
R618	311-0712-00	100	CPRE	20	250 m	
R619	317-0561-00	560	C	5	125 m	
R620	317-0331-01	330	C	5	125 m	
R621	317-0103-01	10 k	C	5	125 m	
R622	311-0717-00	220	CPRE	20	250 m	
R623	317-0911-00	910	C	5	125 m	
R624	311-1829-00	1 k	CV	20	250 m	
R625	311-0712-00	100	CPRE	20	250 m	
R626	317-0271-01	270	C	5	125 m	
R627	317-0221-01	220	C	5	125 m	
R628	317-0271-01	270	C	5	125 m	
R629	317-0751-01	750	C	5	125 m	
R630	317-0681-00	680	C	5	125 m	
R631	317-0820-01	82	C	5	125 m	
R632	317-0391-01	390	C	5	125 m	
R633	315-0621-02	620	C	5	250 m	
R634	317-0473-01	47 k	C	5	125 m	
R635	317-0684-01	680 k	C	5	125 m	
R636	317-0105-01	1 M	C	5	125 m	
R637	303-0183-01	18 k	C	5	1	
R638	303-0183-01	18 k	C	5	1	
R639	317-0104-01	100 k	C	5	125 m	
R640	317-0392-01	3.9 k	C	5	125 m	
R642	311-0717-00	220	CPRE	20	250 m	
R643	321-0097-48	100	MF	11	125 m	
R644	317-0471-01	470	C	5	125 m	
R645	317-0242-01	2.4 k	C	5	125 m	
R646	317-0102-01	1 k	C	5	125 m	
R647	317-0223-01	22 k	C	5	125 m	
R648	317-0822-01	8.2 k	C	5	125 m	
R649	317-0104-01	100 k	C	5	125 m	
R650	317-0471-01	470	C	5	125 m	
R651	317-0122-01	1.2 k	C	5	125 m	
R652	311-1028-00	100 k	C	20	250 m	
R653	317-0152-01	1.5 k	C	5	125 m	
R654	317-0223-01	22 k	C	5	125 m	
R655	317-0103-01	10 k	C	5	125 m	
R656	311-0735-00	10 k	CPRE	20	250 m	
R657	317-0221-01	220	C	5	125 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
R658	317-0471-01	470	C	5	125 m	
R659	321-0097-48	100	MF	1	125 m	
R660	317-0221-01	220	C	5	125 m	
R661	317-0471-01	470	C	5	125 m	
R662	317-0102-01	1 k	C	5	125 m	
R663	317-0223-01	22 k	C	5	125 m	
R664	317-0822-01	8.2 k	C	5	125 m	
R665	317-0180-01	18	C	5	125 m	
R666	317-0821-01	820	C	5	125 m	
R667	317-0221-01	220	C	5	125 m	
R668	317-0393-01	39 k	C	5	125 m	
R669	311-0717-00	220	CPRE	20	250 m	
R670	317-0122-01	1.2 k	C	5	125 m	
R671	317-0393-01	39 k	C	5	125 m	
R672	311-1306-01	100 k	C	20	250 m	
R673	315-0470-01	47	C	5	250 m	
R674	317-0433-01	43 k	C	5	125 m	
R675	317-0105-01	1 M	C	5	125 m	
R676	317-0564-01	560 k	C	5	125 m	
R677	317-0221-01	220	C	5	125 m	
R678	317-0271-01	270	C	5	125 m	
R679	317-0820-01	82	C	5	125 m	
R680	317-0101-01	100	C	5	125 m	
R681	311-0717-00	220	CPRE	20	250 m	
R682	317-0472-01	4.7 k	C	5	125 m	
R683	317-0681-01	680	C	5	125 m	
R684	317-0561-01	560	C	5	125 m	
R685	317-0103-01	10 k	C	5	125 m	
R686	317-0911-01	910	C	5	125 m	
R687	317-0751-01	750	C	5	125 m	
R688	317-0472-01	4.7 k	C	5	125 m	
R689	317-0681-01	680	C	5	125 m	
R690	317-0331-01	330	C	5	125 m	
R691	311-0719-00	470	CPRE	20	250 m	
R692	317-0331-01	330	C	5	125 m	
R693	311-0712-00	100	CPRE	20	250 m	
R694	317-0561-01	560	C	5	125 m	
R695	317-0103-01	10 k	C	5	125 m	
R696	317-0123-01	12 k	C	5	125 m	
R697	311-0717-00	220	CPRE	20	250 m	
R698	317-0911-01	910	C	5	125 m	
R699	311-1829-00	1 k	CV	20	250 m	
R700	317-0101-01	100	C	5	125 m	
R701	311-0712-00	100	CPRE	20	250 m	
R702	317-0751-00	750	C	5	125 m	
R703	317-0271-01	270	C	5	125 m	
R704	317-0221-01	220	C	5	125 m	
R705	317-0271-01	270	C	5	125 m	
R706	317-0154-01	150 k	C	5	125 m	
R707	310-0679-00	111k + 900k	CM	1	250 m	
R708	317-0105-00	1M	C	5	125 m	
R709	317-0180-01	18	C	5	125 m	
R712	307-0394-00	3.9	C	5	125 m	
R713	317-0470-01	47	C	5	125 m	
R714	317-0470-01	47	C	5	125 m	
R751	317-0471-01	470	C	5	125 m	
R752	321-0100-48	107	MF	11	125 m	
R753	321-0100-48	107	MF	1	125 m	
R754	315-0122-01	1.2 k	C	5	250 m	
R755	307-0326-00	1.2 k	MO	5	1.5	
R756	317-0122-01	1.2 k	C	5	250 m	
R757						643781
R758						643781
R759	317-0471-01	470	C	5	125 m	
R761	311-1761-00	250		20	1	
R762	307-1052-00	620	MO	5	3.5	
R763	321-1296-48	12 k	MF	1	125 m	
R764	321-0874-48	39 k	MF	1	125 m	
R765	307-0257-00	940	MO	5	1.5	
R766	317-0470-01	47	C	5	125 m	
R767	317-0470-01	47	C	5	125 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
R768	307-0257-00	940	MO	5	1.5	
R769	317-0103-01	10 k	C	5	125 m	
R771	317-0683-01	68 k	C	5	125 m	
R772	317-0683-01	68 k	C	5	125 m	
R773	317-0333-01	33 k	C	5	125 m	
R774	317-0333-01	33 k	C	5	125 m	
R775	317-0471-01	470	C	5	125 m	
R776	317-0332-01	3.3 k	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	
R782	317-0471-01	470	C	5	125 m	
R783	317-0332-01	3.3 k	C	5	125 m	
R784	317-0471-01	470	C	5	125 m	
R785	317-0332-01	3.3 k	C	5	125 m	

CIR REF	PART NUMBER	VALUE Ohms	TYPE	TOL %	RATING Watts	Eff. Ser.No.
*R901	321-0481-42	1.0 M	MF	0.5	125 m	
*R902	325-0124-00	990 k	MF	0.5	125 m	
*R903	325-0125-00	900 k	MF	0.5	125 m	
*R904	317-0470-01	47	C	5	125 m	
*R905	321-0193-42	1.0 k	MF	0.5	125 m	
*R906	321-1289-42	10.1 k	MF	0.5	125 m	
*R907	321-1389-42	111 k	MF	0.5	125 m	
*R908	317-0470-01	47	C	5	125 m	
*R911	317-0470-01	47	C	5	125 m	
*R912A)		(500 k)				
*R912B)		(800 k)				
*R912C)	310 0680 00	(250 k)	CM	1	250 m	
*R912D)		(1.0 M)				

CIR REF	PART NUMBER	DESCRIPTION	Eff. Ser.No.
RL275	148-0073-00	Reed Relay	
S1	260-1783-00	Trigger Polarity A	
S2	With R16	Auto	
S3	260-1784-00	AC – TV	
S51	260-1783-00	Trigger Polarity B	
S52	With R66	Auto	
S101	260-1145-00	Single Shot	
S102	With R134	Free Run	
S161	With R184	Pull Non Gated	
*S210	260-1786-00	Time/Div.	
S275	260-1785-00	Display	

CIR REF	PART NUMBER	DESCRIPTION	Eff. Ser.No.
S276	With R286	X1 – X5 X Gain	
S401	With R305	Power ON – Off	
S601) S602)	260-1299-00	Channel Select	
S603	260-1204-00	Sum/Chop/Alt.	
S604	260-1298-00	Norm/Invert	
S605) S606)	260-1298-00	X1 – X10 Gain	
S751	260-1089-00	Internal Trig.	
*S901	260-1136-00	DC GND AC	
*S902	260-1446-00	Volts/Div.	
T401	120-0594-01	Mains Transformer	

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

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

CIR REF	PART NUMBER	DESCRIPTION		TYPE	RATING @ 25° C	Eff. Ser.No.
TR101	151-0257-00	2N1990U	Si	NPN	600 mW	
TR102	151-0320-00	MPS6518	Si	PNP	300 mW	
TR103	151-0320-00	MPS6518	Si	PNP	300 mW	
TR104	151-0320-01	MPS6518	Si	PNP	300 mW	
TR105	151-0320-01	MPS6518	Si	PNP	300 mW	
TR106	151-0127-02	2N2369	Si	NPN	360 mW	
TR107	151-0320-00	MPS6518	Si	PNP	300 mW	
TR108	151-0127-02	2N2369	Si	NPN	300 mW	
TR109	151-0242-00	2N3904	Si	NPN	300 mW	
TR110	151-1052-00	FET BFW0265		N Channel	250 mW	
TR111	151-0127-02	2N2369	Si	NPN	360 mW	
TR112	151-0127-02	2N2369	Si	NPN	360 mW	
TR113	151-0127-02	2N2369	Si	NPN	360 mW	
TR161	151-0320-00	MPS6518	Si	PNP	300 mW	
TR162	151-0320-00	MPS6518	Si	PNP	300 mW	
TR163	151-0320-00	MPS6518	Si	PNP	300 mW	
TR164	151-0320-00	MPS6518	Si	PNP	300 mW	
TR165	151-0242-00	2N3904	Si	NPN	300 mW	
TR166	151-1052-00	FET BFW0265		N Channel	250 mW	
TR167	151-0127-02	2N2369	Si	NPN	360 mW	
TR168	151-0326-00	BC107	Si	NPN	300 mW	
TR251	151-0242-00	2N3904	Si	NPN	300 mW	
TR252	151-0242-00	2N3904	Si	NPN	300 mW	
TR253	151-0320-00	MPS6518	Si	PNP	300 mW	
TR254	151-0320-00	MPS6518	Si	PNP	300 mW	
TR255	151-0320-00	MPS6518	Si	PNP	300 mW	
TR256	151-0320-00	MPS6518	Si	PNP	300 mW	
TR257	151-0242-00	2N3904	Si	NPN	300 mW	
TR258	151-0445-00	ZTX214C	Si	PNP		
TR259	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	
TR276	151-0317-00	BC109C	Si	NPN	300 mW	
TR277	151-0257-03	FRB749	Si	NPN	625 mW	
TR278	151-0257-03	FRB749	Si	NPN	625 mW	
TR401	151-0343-00	BF259	Si	NPN	800 mW	
TR402	151-0332-00	2N4899	Si	PNP		
TR403	151-0257-01	BF305	Si	NPN	800 mW	
TR404	151-0244-00	2N3702	Si	PNP	300 mW	
TR405	151-0326-01	BC107	Si	NPN	300 mW	643701
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	DESCRIPTION		TYPE	RATING @ 25° C	Eff. Ser.No.
TR409	151-0320-00	MPS6518	Si	PNP	300 mW	
TR411	151-0320-00	MPS6518	Si	PNP	300 mW	
TR412	151-0127-02	2N2369	Si	NPN	360 mW	
TR413	151-0127-02	2N2369	Si	NPN	360 mW	
TR601) TR602)	151-1036-00	Dual FET		N Channel		
TR603	151-0127-02	2N2369	Si	NPN	300 mW	
TR604	151-0127-02	2N2369	Si	NPN	300 mW	
TR605	151-0242-00	2N3904	Si	NPN	300 mW	
TR606	151-0242-00	2N3904	Si	NPN	300 mW	
TR607	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	
TR611	151-0127-02	2N2369	Si	NPN	360 mW	
TR612	151-0127-03	BSX20	Si	NPN	360 mW	
TR613	151-0127-03	BSX20	Si	NPN	360 mW	
TR614	151-0242-00	2N3904	Si	NPN	300 mW	
TR615	151-0242-00	2N3904	Si	NPN	300 mW	
TR616	151-0490-00	FRB750	Si	NPN	1W	
TR617) TR618)	151-1036-00	Dual FET		N Channel		
TR619	151-0127-02	2N2369	Si	NPN	360 mW	
TR621	151-0127-02	2N2369	Si	NPN	360 mW	
TR622	151-0242-00	2N3904	Si	NPN	300 mW	
TR623	151-0242-00	2N3904	Si	NPN	300 mW	
TR624	151-0127-02	2N2369	Si	NPN	360 mW	
TR625	151-0127-02	2N2369	Si	NPN	360 mW	
TR626	151-0127-02	2N2369	Si	NPN	360 mW	
TR627	151-0127-02	2N2369	Si	NPN	360 mW	
TR628	151-0127-02	2N2369	Si2	NPN	360 mW	
TR629	151-0127-02	2N2369	Si	NPN	360 mW	
TR751	151-0127-02	2N2369	Si	NPN	360 mW	
TR752	151-0310-00	E1530	Si	NPN	800 mW	
TR753	151-0310-00	E1530	Si	NPN	800 mW	
TR754	151-0320-01	MPS6518	Si	PNP	300 mW	
TR755	151-0320-01	MPS6518	Si	PNP	300 mW	
TR756	151-0320-01	MPS6518	Si	PNP	300 mW	
TR757	151-0320-01	MPS6518	Si	PNP	300 mW	
V101	151-0069-00	Neon Type 3L				
V301	154-0626-01	C.R.T. 95447				

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	

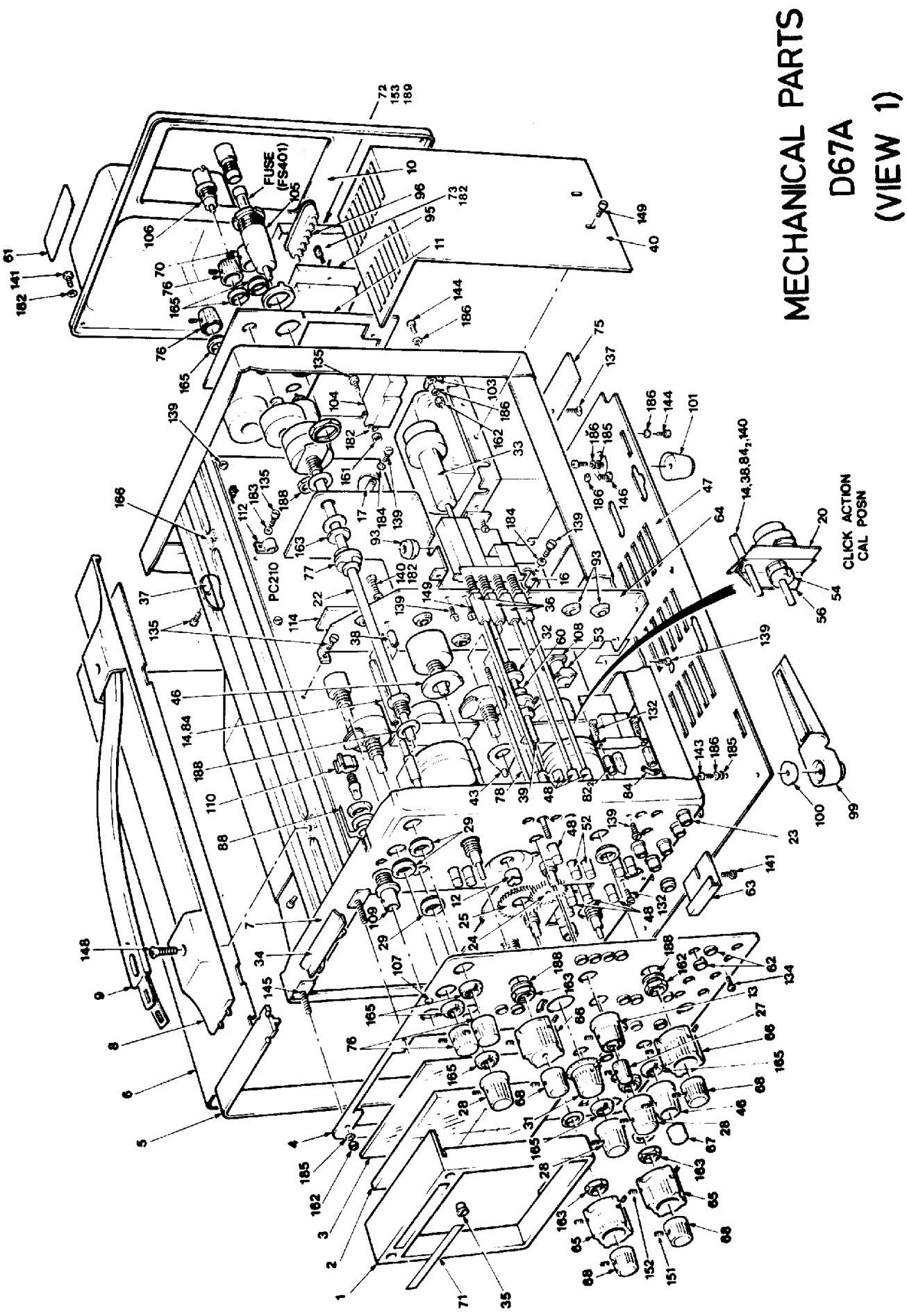
ASSEMBLIES

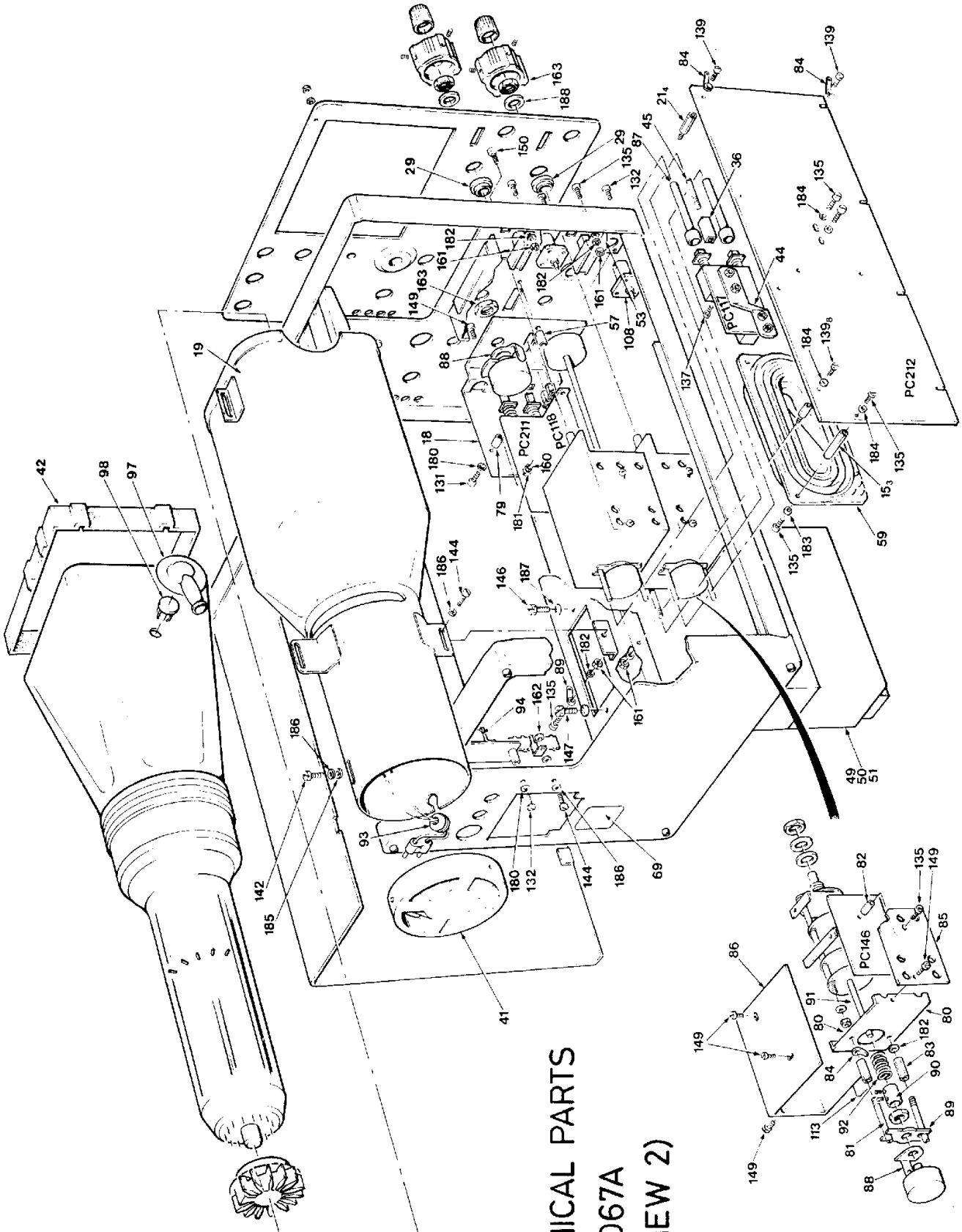
DESCRIPTION	PC BOARD	PART NUMBER
Sum Alt Chop	PC 118 wired assembly	670-4160-00
Graticule Lamps	PC 103 wired assembly	670-0997-00
Reed Relay	PC 108	644-0028-00
X10 Gain Invert	PC 117 assembly	388-2129-00
Switch Volts/Div		262-0989-00
Switch Time/Div		262-0991-00
Single Shot	PC 122 assembly	388-2084-02
'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.
1	200-1884-01	Bezel light hood	
2	331-0289-02	Graticule	
3	378-0605-05	Filter grey (standard)	
4	333-2084-01	Panel, front marking	
5	124-0317-01	Trim, front	
6	390-0448-04	Cabinet side (LH)	
	390-0448-05	Cabinet side (RH)	
7	441-1298-00	Chassis, spotwelded assembly	
8	352-0434-01	Holder, handle	
9	367-0101-01	Handle, black	
10	200-1766-01	Cover, rear	
11	333-2085-02	Panel, rear, marking	
12	220-0592-00	Nut, bearing	
13	366-1254-02	Knob assembly (coarse horiz pos)	
14	385-0214-00	Spacer 6BA hex 46mm	
15	361-0202-00	Spacer 6BA hex 1" long	
16	385-0201-00	Spacer 6BA hex 25/32" long	
17	385-0202-00	Spacer 6BA hex 27/32" long	
18	407-0599-01	Bracket, mounting	
19	337-1130-00	Mu-metal screen	
20	386-1756-00	Plate, timebase switch	
21	361-0283-00	Spacer mounting 6BA hex	
22	384-1089-01	Rod, extension 7¼" long	
23	136-0381-02	Socket 4mm assembly	
24	214-1358-01	Double gear, black	
25	214-1359-01	Gear, 60 teeth (indicating)	
26	361-0323-00	Bush, spacer	
27	366-1635-00	Knob assembly, marking fine	
28	366-1636-00	Knob assembly, medium skirted	
29	361-0324-00	Bush, spacer	
30	337-1310-01	Screen, pot mounting	
31	366-1237-01	Knob assembly (delay)	
32	358-0425-00	Bush	
33	385-0207-00	Spacer, hex 40mm long	
34	670-0997-00	Graticule lamp assembly	
35	220-0607-01	Nut, special, black	
36	376-0132-00	Coupling, switch extension grey	
37	381-0326-00	Bar, securing	
38	361-0374-01	Spacer, hex 3/8" long	
39	384-1046-00	Extension shaft 1/8" diameter	
40	200-1230-00	Cover, voltage warning	
41	354-0404-00	CRT rear location moulding	
42	354-0407-00	Ring, CRT shockmount	
43	401-0125-00	Bearing pin assembly	
44	407-0965-01	Bracket mounting	
45	384-1103-00	Extension rod	
46	366-1365-01	Knob assembly (CH2 pos)	
47	200-1235-02	Baseplate cover	
48	366-1414-15	Knob assembly, pushbutton 13mm	
49	202-0193-02	EHT-box, tapped	
50	670-1978-00	PC144 wired assembly	
51	670-1979-00	EHT unit assembly	
52	366-1414-16	Knob assembly, pushbutton 36mm	
53	210-0293-00	Lug, earth	
54	401-0193-00	Cam (with set screws)	
55	376-0136-00	Coupling	
56	214-1817-00	Spring clip	
57	361-0537-01	Spacer round, 11mm long	
58	358-0345-00	Bush	
59	636-0006-00	Delay line assembly	
60	376-0126-00	Coupling, Jackson 1/4" to 1/8"	
61	334-2968-00	Marker, ident warning	
62	200-1885-00	Bezel, pushbutton	
63	343-0591-00	Retainer trim	
64	386-3412-00	Plate, display switch	
65	366-1642-00	Knob assembly, Series 5 — recessed	
66	366-1640-00	Knob assembly, Series 5 — special	
67	366-1634-00	Knob, push	
68	366-1641-00	Knob, assembly "VAR"	
69	334-2752-00	Mod record label	
70	366-1637-00	Knob assembly med 1/8" ID	
71	334-2611-00	Plate identification	
72	200-2208-00	Cover, Elec. moulded	715001
73	129-0706-00	Spacer mtg 6BA	715001
75	381-0367-00	Bar chassis	
76	366-1637-01	Knob assembly, med, 1/4" ID	
77	376-0131-00	Coupling, Jackson 1/4" to 1/4"	
78	384-1022-01	Extension rod, 112.5mm long	
79	361-0537-02	Spacer round 10mm long	
80	407-1147-00	Bracket, pot mounting	
81	384-1400-00	Rod bearing 13/16" long	
82	385-0206-02	Spacer 6BA/8BA, 11mm long	
83	385-0196-00	Spacer 6BA hex 11/16" long	
84	210-0297-00	Solder lug 6BA	
85	337-1708-01	Trimmer screen, processed	
86	337-1707-00	Screen, outer	
87	401-0144-01	Sleeve bearing 25.4mm long	
88	210-0275-00	Solder lug 3/8" ID	
89	401-0145-00	Bearing, moulding	
90	376-0177-00	Coupling 1/4" to 1/8" diameter	
91	384-1142-06	Extension shaft, 124mm long	
92	214-1626-00	Spring, compression	
93	348-0160-00	Grommet 3/8" ID	
94	644-0028-00	Reed relay assembly	
95	136-0315-00	Socket, voltage selector	
96	134-0102-00	Plug, voltage selector, 7 pin	
97	200-2106-00	CAP EHT type BRS18	
98	134-0157-00	PDA connector button type H	
99	348-0463-00	Foot, raising member, front	
100	210-1075-01	Washer, packing foot glass loaded nylon	
101	348-0462-00	Foot fixed, rear, black	
102	124-0212-00	Tag strip 3 way, centre earth	
103	210-0297-00	Solder lug 4BA	
104	134-0135-00	Plug, Belling & Lee, R4091/1	
105	352-0499-00	Fuse holder, Belling & Lee, L1348C	
106	131-0650-01	Socket BNC, GE35027	
107	378-0597-00	Filter lens, green	
108	131-0651-00	Socket BNC, GE35007	
109	131-0650-00	Socket BNC, GE35008	
110	136-0311-00	Lampholder Q3526	
112	343-0207-00	Plasclip insuloid NX1 3/16" ID	
113	253-0111-00	Insulator elec	
114	252-0650-00	Insulator elec	
131	213-0461-00	Screw 8BA 3/4" ch slot cadmium	
132	213-0458-00	Screw 8BA 3/16" ch slot cadmium	
134	213-0719-00	Screw 8BA 3/8" rd slot chrome	
135	213-0393-00	Screw 6BA 1/4" poz pan cadmium	
137	213-0391-00	Screw 6BA 1/4" csk poz cadmium	
138	213-0653-00	Screw 6BA 3/8" poz pan chrome	
139	213-0392-00	Screw 6BA 3/16" poz pan cadmium	
140	213-0433-00	Screw 6BA 5/8" poz pan cadmium	
141	213-0449-00	Screw 6BA 1/2" poz pan chrome	
142	213-0474-00	Screw 4BA 3/16" poz pan cadmium	
143	213-0398-00	Screw 4BA 3/8" poz pan cadmium	
144	213-0388-00	Screw 4BA 1/4" poz pan cadmium	
145	213-0472-00	Screw 4BA 3/4" csk poz cadmium	
146	213-0470-00	Screw 4BA 1/4" hex slot cadmium	
148	213-0772-00	Screw 2BA 11/16" poz inst chrome	
149	213-0366-00	Screw 4PK/AB x 1/4" poz pan cadmium	
150	213-0724-00	Screw 4PK/AB x 5/8" poz pan cadmium	
151	213-0248-00	Set screws (knobs) M3 x 3	
152	213-0249-00	Set screws (knobs) M3 x 5	
153	213-0802-00	Screw M2 x 4mm	715001
160	220-0718-00	Nut 8BA full hex cadmium	
161	220-0716-00	Nut 6BA full hex cadmium	
162	220-0714-00	Nut 4BA full hex cadmium	
163	220-0750-00	Nut 32TP1 1/2" AF 3/8" ID brass	
165	220-0527-00	Nut, slotted ring chrome	
166	220-0801-00	Nut captive	
180	210-1214-00	Washer 8BA shakeproof int	
181	210-1213-00	Washer 8BA small plain cadmium	
182	210-1210-00	Washer 6BA shakeproof int	
183	210-1207-00	Washer 6BA large plain cadmium	
184	210-1205-00	Washer 6BA locking	
185	210-1204-00	Washer 4BA large plain cadmium	
186	210-1215-00	Washer 4BA shakeproof int	
187	210-1203-00	Washer 2BA shakeproof int	
188	210-3051-00	Washer 3/8" ID 5/8" OD plain cadmium	
189	210-1290-00	Washer plain M2	715001


MECHANICAL PARTS
D67A
(VIEW 1)
FUSE (FS401)
PC210
CLICK ACTION CAL POSN


MECHANICAL PARTS
D67A
(VIEW 2)

SECTION 6

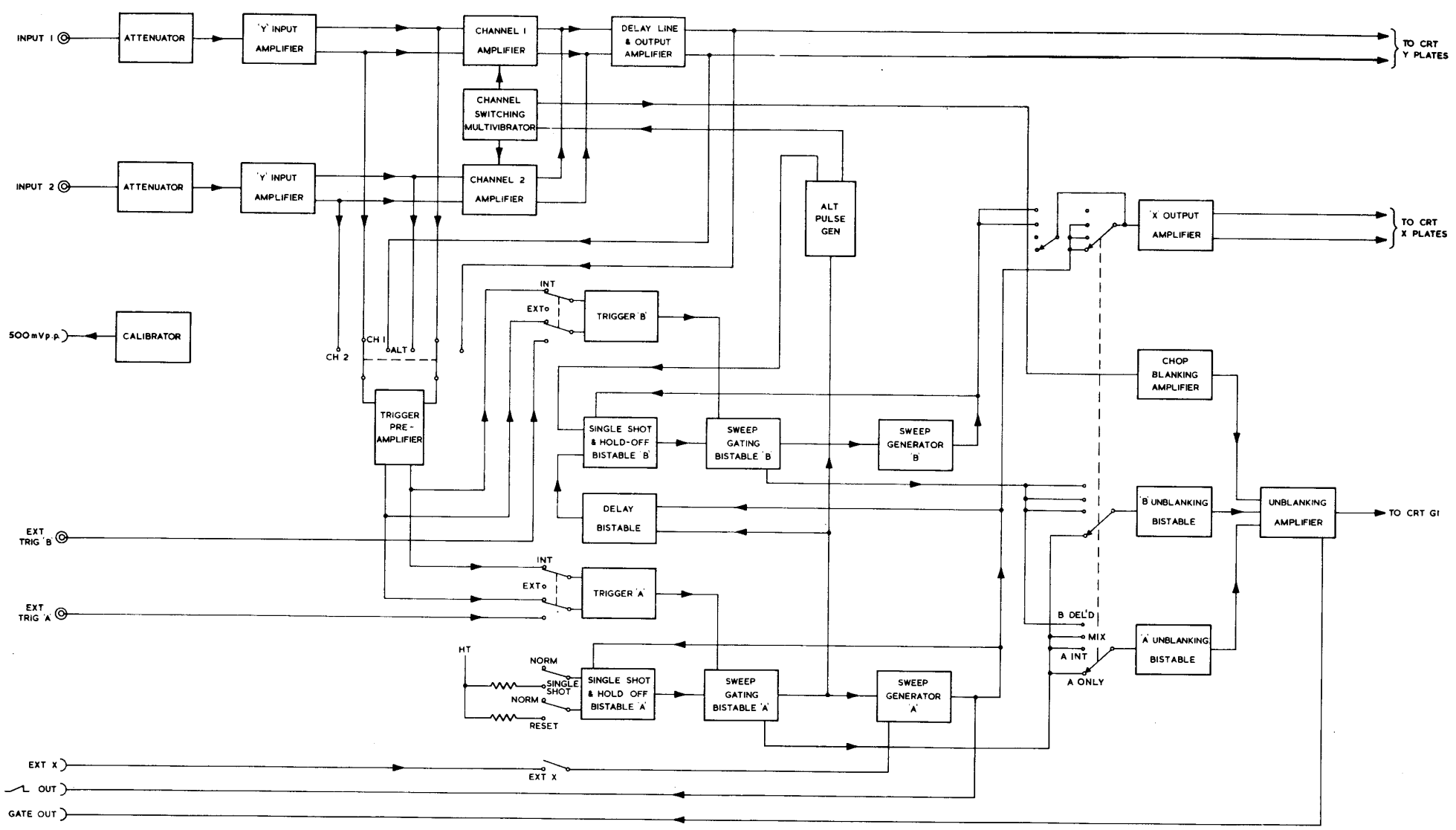
CIRCUIT DIAGRAMS

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.

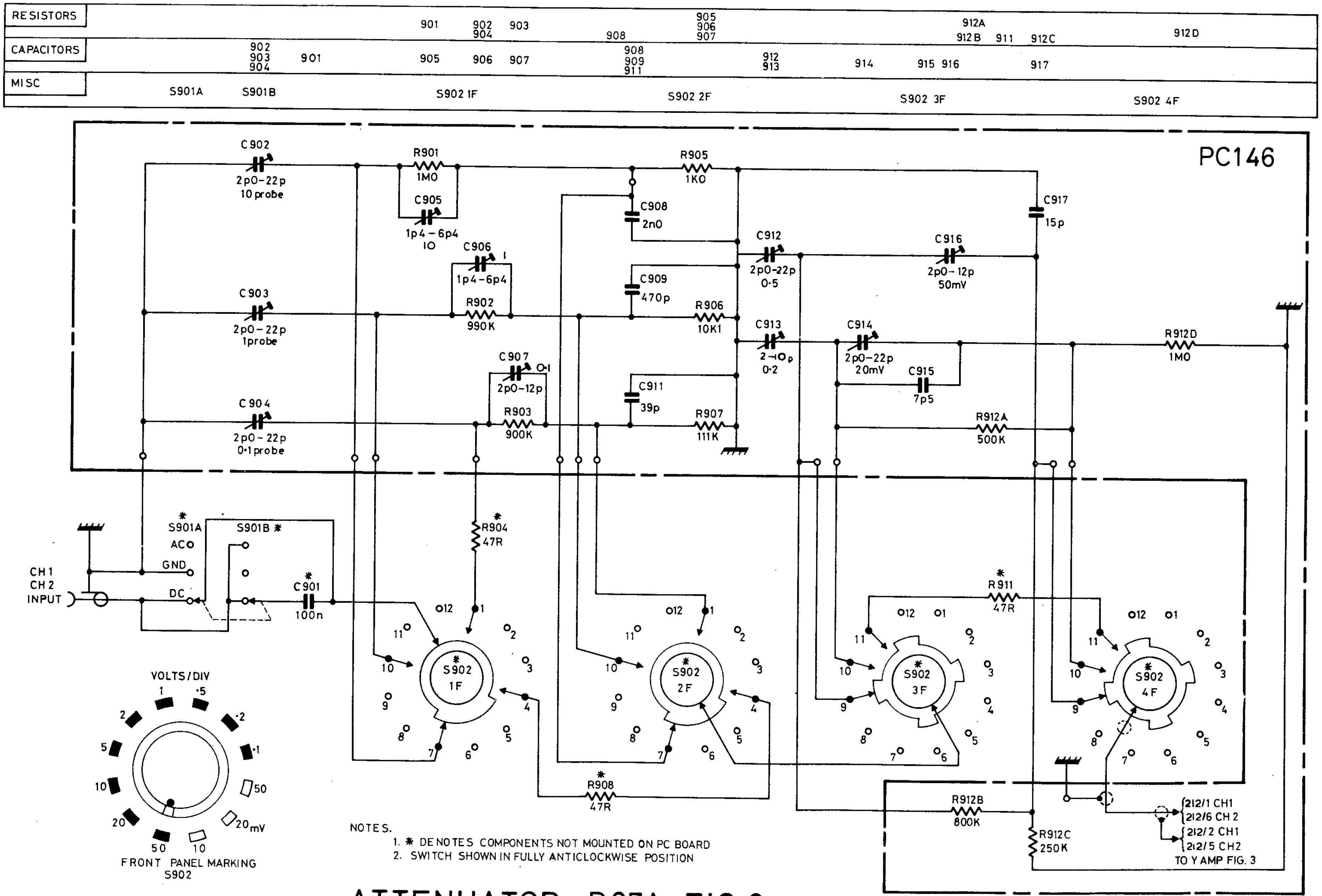
To aid the reader further, in addition to the block Circuit Reference Table in Section 5.1, to locate a component in the circuit diagram, a table is provided at the top of each circuit diagram, in which the circuit reference will appear, where practicable, directly above the component being sought.

PRINTED CIRCUITS

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



BLOCK DIAGRAM D67A
FIG. 1

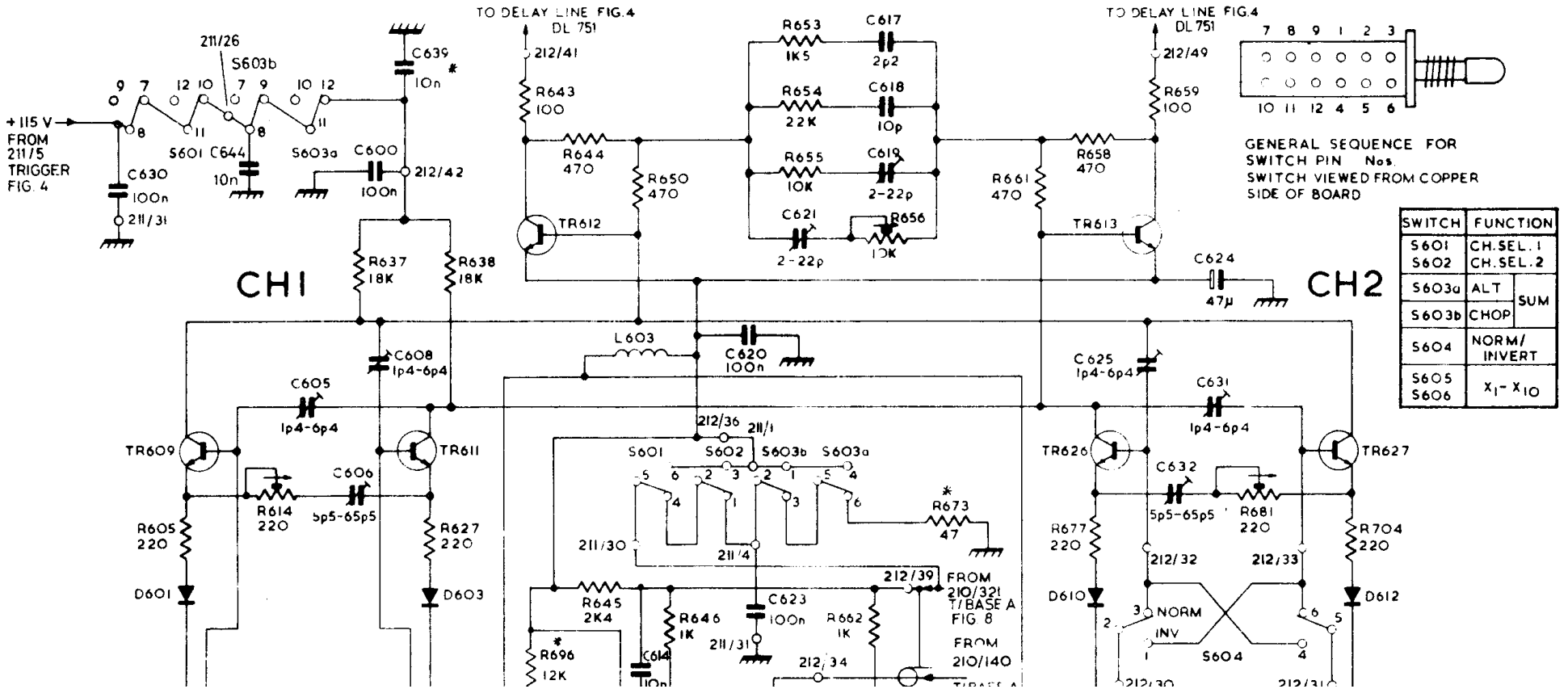


NOTES.

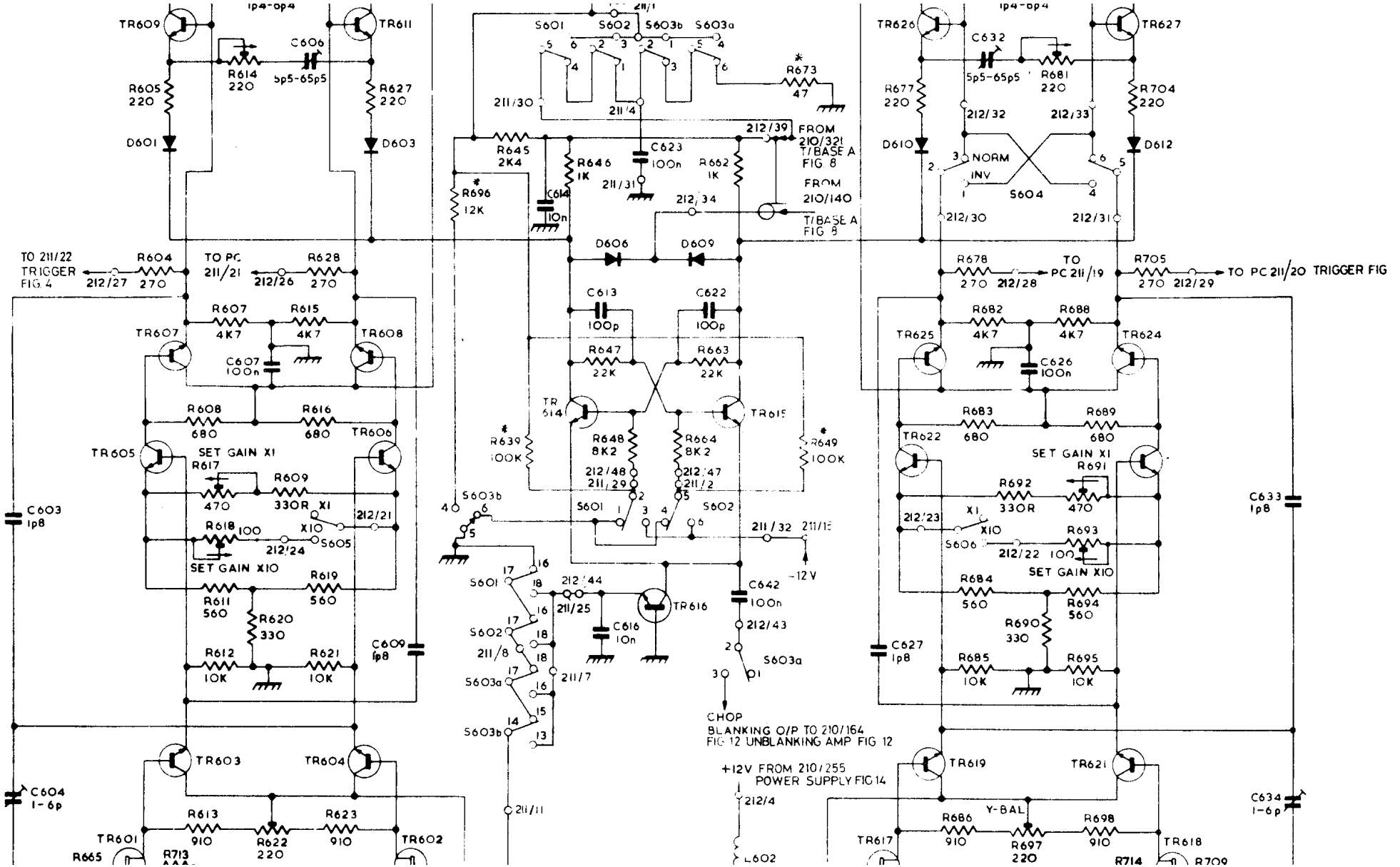
1. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD
2. SWITCH SHOWN IN FULLY ANTICLOCKWISE POSITION

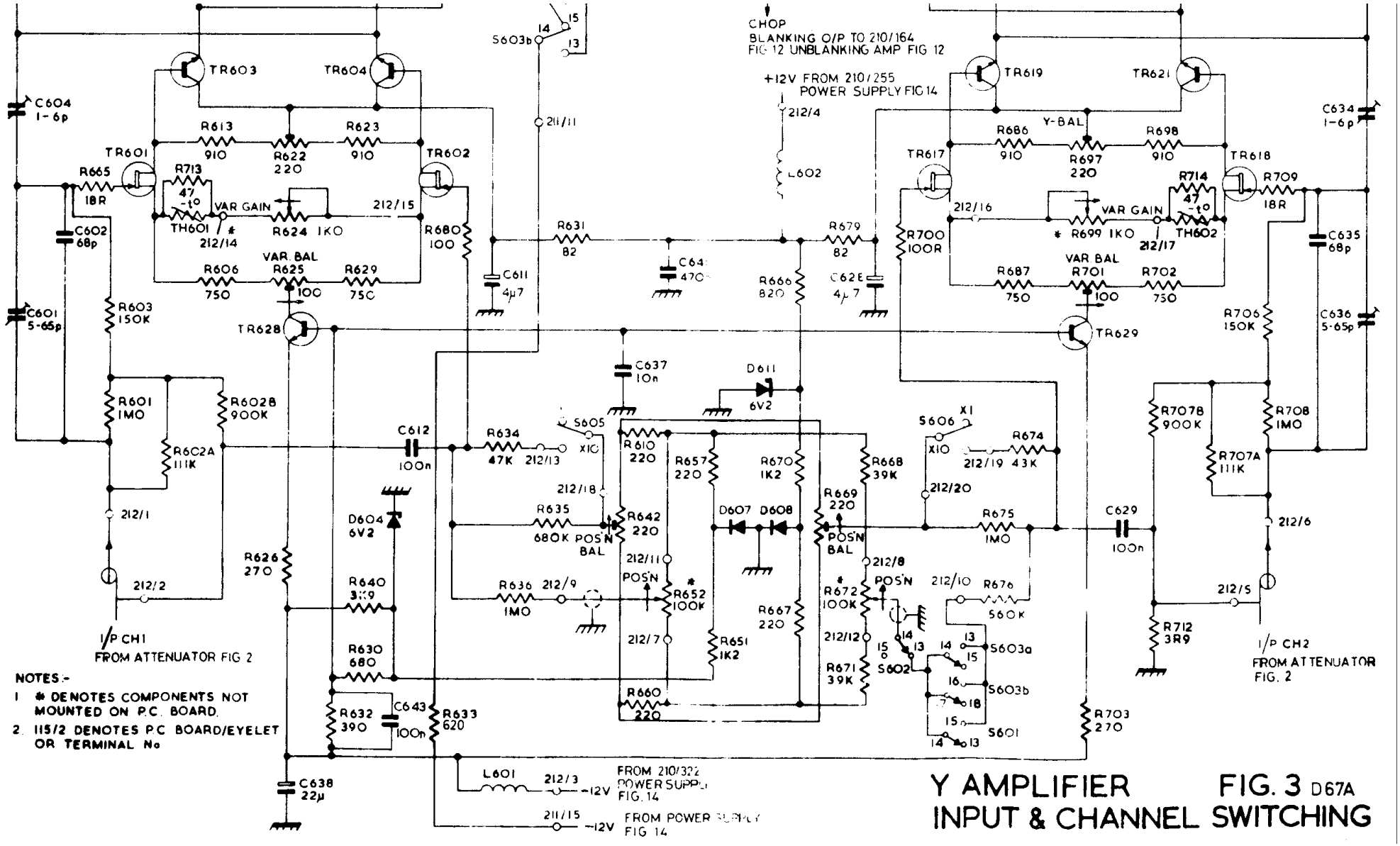
ATTENUATOR D67A FIG. 2

RESISTORS	603 601 665 605 604 602A 713 608 613 606 607 617 618 611 612 602B 614 620 622 624 625 626 615 616 609 623 637 628 619 621 632 638 627 629 630 643 633 696 680 644 645 641 634 636 639 650 631 635 646 647 642 610 660 652 648 653 654 655 664 657 651 663 656 662 666 670 667 673 679 669 672 671 661 668 700 649 658 677 676 686 687 674 675 659 678 682 683 684 685 692 690 697 699 701 703 681 688 691 693 694 695 689 698 702 707B 704 705 707A 714 712 709 706 708
CAPACITORS	603 604 601 602 630 644 605 607 638 606 600 608 639 643 612 609 611 614 616 613 637 620 641 621 623 622 642 617 618 619 628 627 625 632 624 631 626 629 635 633 634 636
MISC	S66 S602 D601 S601 TR609 TR607 TR605 TR603 TR601 TH601 S603b S603a TR628 TR611 D603 TR608 TR606 TR604 D604 TR602 TR612 L601 S601 S602 S603a S603b S605 L603 S601 D605 TR614 S602 D606 S603b TR616 S66 S603a D609 D607 L602 TR615 D611 D608 TR617 S606 S601 TR626 D610 TR625 TR622 TR619 S603b S602 TR613 S606 S603a S604 TR629 TR627 D612 TR624 TR623 TR621 TR618 TH602



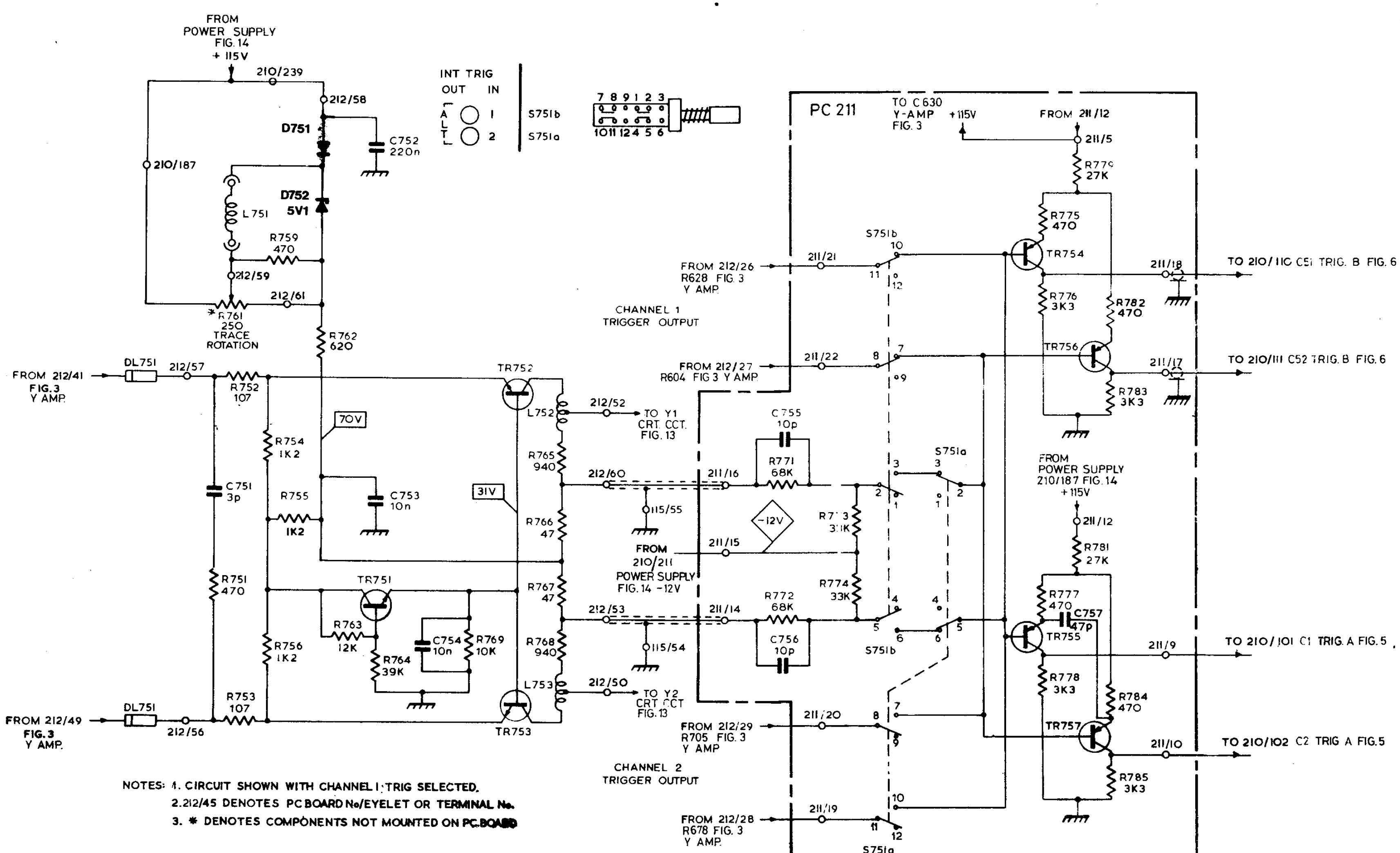
SWITCH	FUNCTION	
S601	CH.SEL.1	
S602	CH.SEL.2	
S603a	ALT	SUM
S603b	CHOP	SUM
S604	NORM/INVERT	
S605 S606	$X_1 - X_{10}$	


TR609
TR611
C606
R614 220
5p5-65p5
R605 220
R627 220
D601
D603
S601
S602
S603b
S603a
R673 47
211/30
211/4
212/39
FROM 210/321 T/BASE A FIG 8
R645 2K4
R646 1K
C623 100n
R662 1K
211/31
R696 12K
C614 10n
212/34
FROM 210/140 T/BASE A FIG 8
TO 211/22 TRIGGER FIG 4
R604 212/27 270
TO PC 211/21
R628 212/26 270
D606
D609
C613 100p
C622 100p
R607 4K7
R615 4K7
TR607
TR608
C607 100n
R647 22K
R663 22K
TR614
TR615
R608 680
R616 680
TR606
TR605
SET GAIN X1
R617 470
R609 330R
R639 100K
R648 8K2
R664 8K2
R649 100K
212/48
211/29
212/47
211/2
S603b
S601
S602
211/32
211/1E
X1
X10
212/21
S605
R618 100
212/24
SET GAIN X10
R619 560
-12V
C642 100n
212/44
211/25
TR616
C616 10n
212/43
S603a
R611 560
R620 330
R612 10K
R621 10K
C609 1p8
211/8
211/7
CHOP BLANKING O/P TO 210/164 FIG 12 UNBLANKING AMP FIG 12
+12V FROM 210/255 POWER SUPPLY FIG 14
212/4
L602
211/11
C603 1p8
C604 1-6p
TR603
TR604
TR601
TR602
R613 910
R622 220
R623 910
R665
R713
TR626
TR627
C632 5p5-65p5
R681 220
R677 220
R704 220
212/32
212/33
D610
D612
NORM
INV
S604
212/30
212/31
R678 270 212/28
TO PC 211/19
R705 270 212/29
TO PC 211/20 TRIGGER FIG
R682 4K7
R688 4K7
TR625
TR624
C626 100n
R683 680
R689 680
TR622
SET GAIN X1
R691
R692 330R
R693
212/23
212/22 100
SET GAIN X10
R684 560
R694 560
R690 330
R685 10K
R695 10K
C627 1p8
C633 1p8
TR619
TR621
C634 1-6p
Y-BAL
R686 910
R697 220
R698 910
TR617
TR618
R714
R709



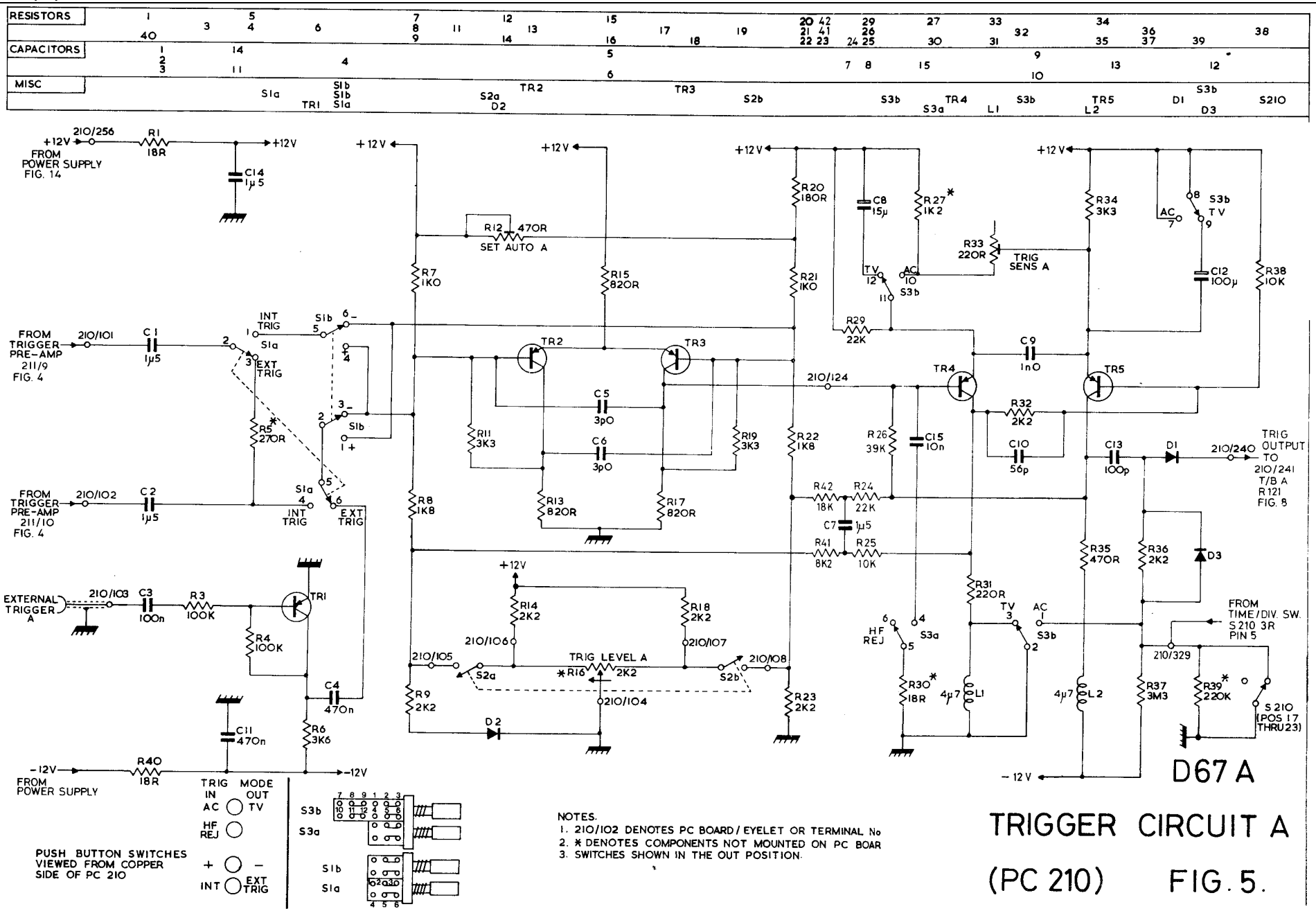
Y AMPLIFIER INPUT & CHANNEL SWITCHING FIG. 3 D67A

RESISTORS		761 752 751 753	759 754 755 756	762	763 764		769	765 766 767 768	771 772	773 774			775 776 777 778	779 781	782 783 784 785
CAPACITORS		751			752 753	754			755 756					757	
MISCELLANEOUS	DL751	L751		D751 D752	TR751		TR752 TR753	L752 L753			S751b	S751a	TR754 TR755		TR756 TR757



NOTES: 1. CIRCUIT SHOWN WITH CHANNEL 1 TRIG SELECTED.
2. 212/45 DENOTES PC BOARD No/EYELET OR TERMINAL No.
3. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD

Y-AMPLIFIER OUTPUT & TRIGGER PRE-AMPLIFIER CIRCUIT D67A FIG. 4

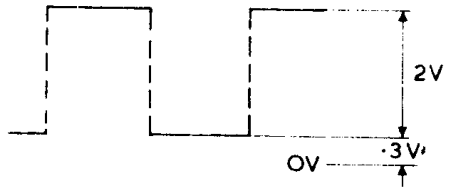

RESISTORS
CAPACITORS
MISC
+12V
-12V
FROM POWER SUPPLY FIG. 14
FROM TRIGGER PRE-AMP 211/9 FIG. 4
FROM TRIGGER PRE-AMP 211/10 FIG. 4
EXTERNAL TRIGGER A
INT TRIG
EXT TRIG
TRIG LEVEL A
TRIG OUTPUT TO 210/241 T/B A R121 FIG. 8
FROM TIME/DIV. SW. S210 3R PIN 5
S210 (POS 17 THRU 23)
TRIG IN AC
MODE OUT TV
HF REJ
PUSH BUTTON SWITCHES VIEWED FROM COPPER SIDE OF PC 210
NOTES.
1. 210/102 DENOTES PC BOARD / EYELET OR TERMINAL No
2. * DENOTES COMPONENTS NOT MOUNTED ON PC BOAR
3. SWITCHES SHOWN IN THE OUT POSITION.
D67 A
TRIGGER CIRCUIT A
(PC 210) FIG. 5.

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

REFERENCE FIG. 5

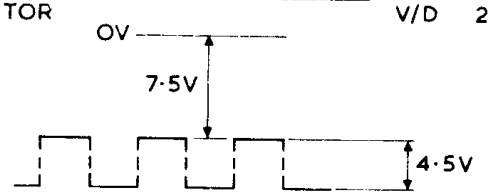
A TRIGGER
TR4 COLLECTOR

MONITOR T/D ·5ms
V/D 1V



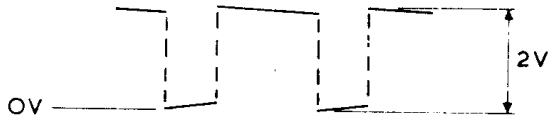
A TRIGGER
TR5 COLLECTOR

MONITOR T/D ·5ms
V/D 2V



A TRIGGER
T. POINT 210/240

MONITOR T/D 5ms
V/D 2V AC



A TRIGGER
T. POINT 210/240

MONITOR T/D 5ms
V/D 2V

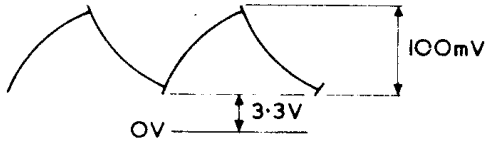
NO INPUT

INSTRUMENT	ON TEST	SETTING
CH 1&2		OFF
'A' TRIG MODE		INT

REFERENCE FIG. 5

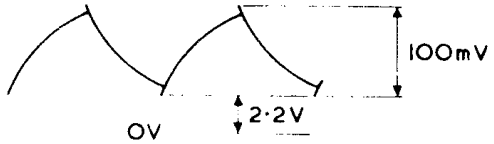
A TRIGGER
T. POINT 210/124

MONITOR T/D 20ms
V/D 1V DC



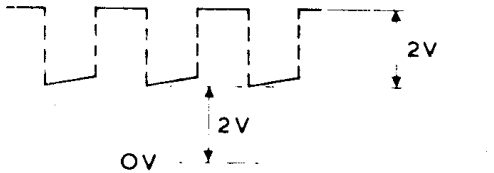
A TRIGGER
TR2 COLLECTOR

MONITOR T/D 20ms
V/D 1V DC

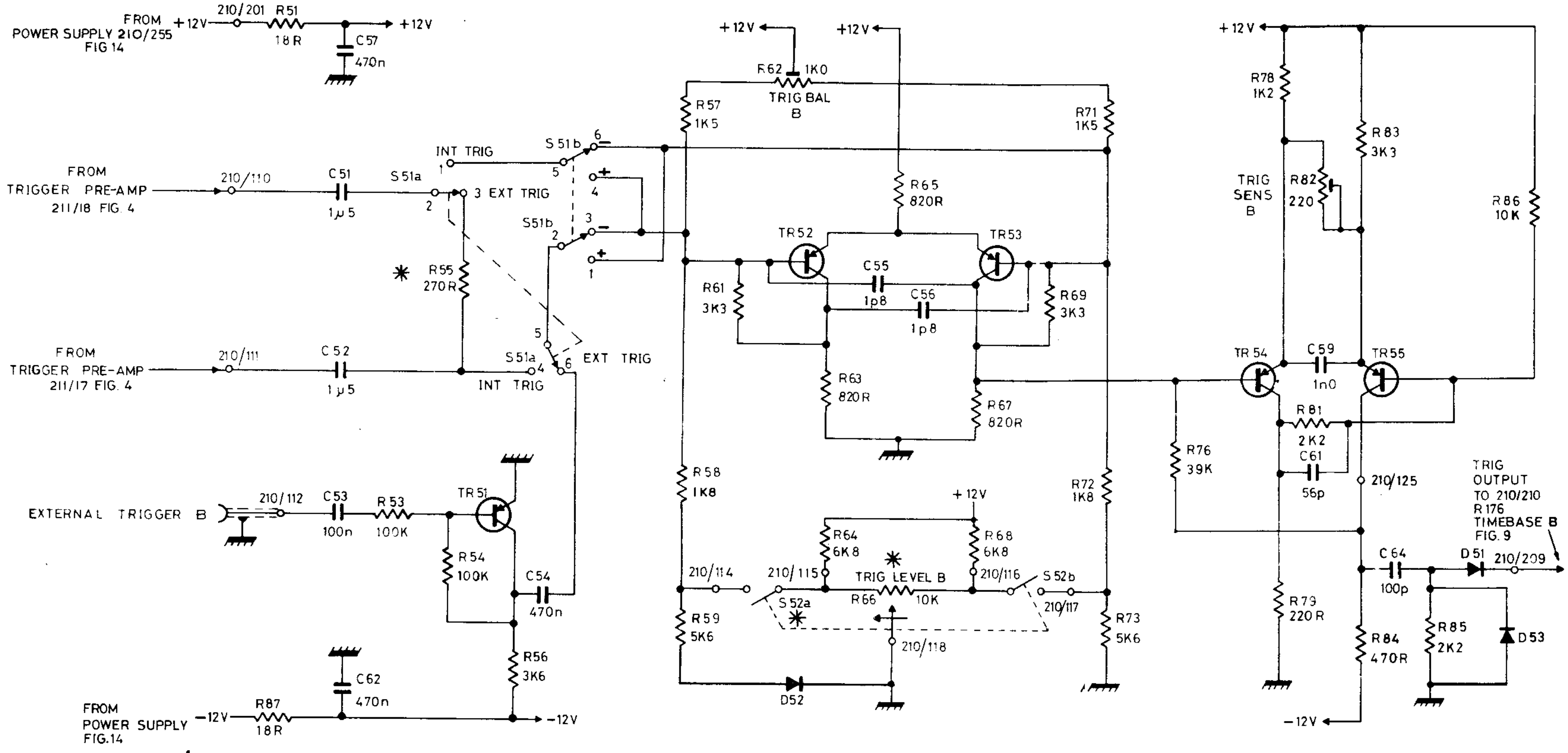


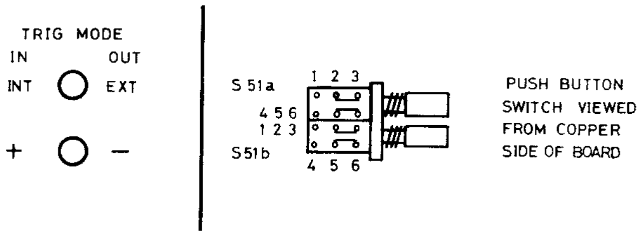
A TRIGGER
210/124

MONITOR T/D 1ms
V/D 1V DC



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	S51a S51b	S52a	TR52 D52			TR53	S52b			TR54		TR55	D51	D53





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)

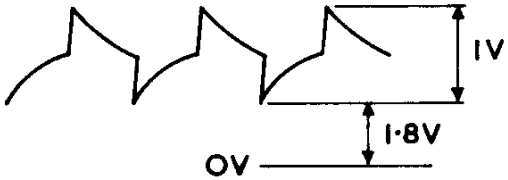
D 67A

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

REFERENCE FIG. 6

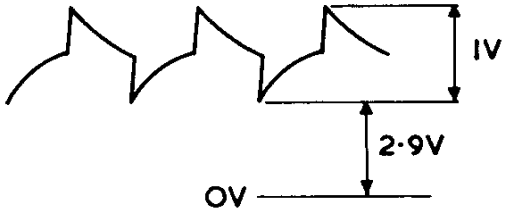
B TRIGGER
TR52 COLLECTOR

MONITOR T/D 10ms
V/D 1V



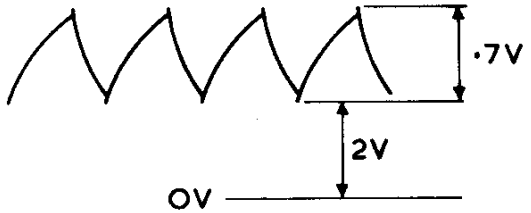
B TRIGGER
TR53 COLLECTOR

MONITOR T/D 10ms
V/D 1V



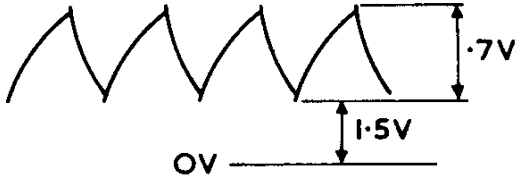
B TRIGGER
210/110

MONITOR T/D 10ms
V/D ·5V



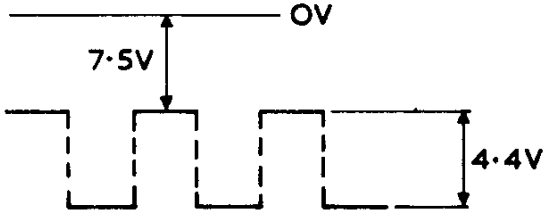
B TRIGGER
210/111

MONITOR T/D 10ms
V/D ·5V



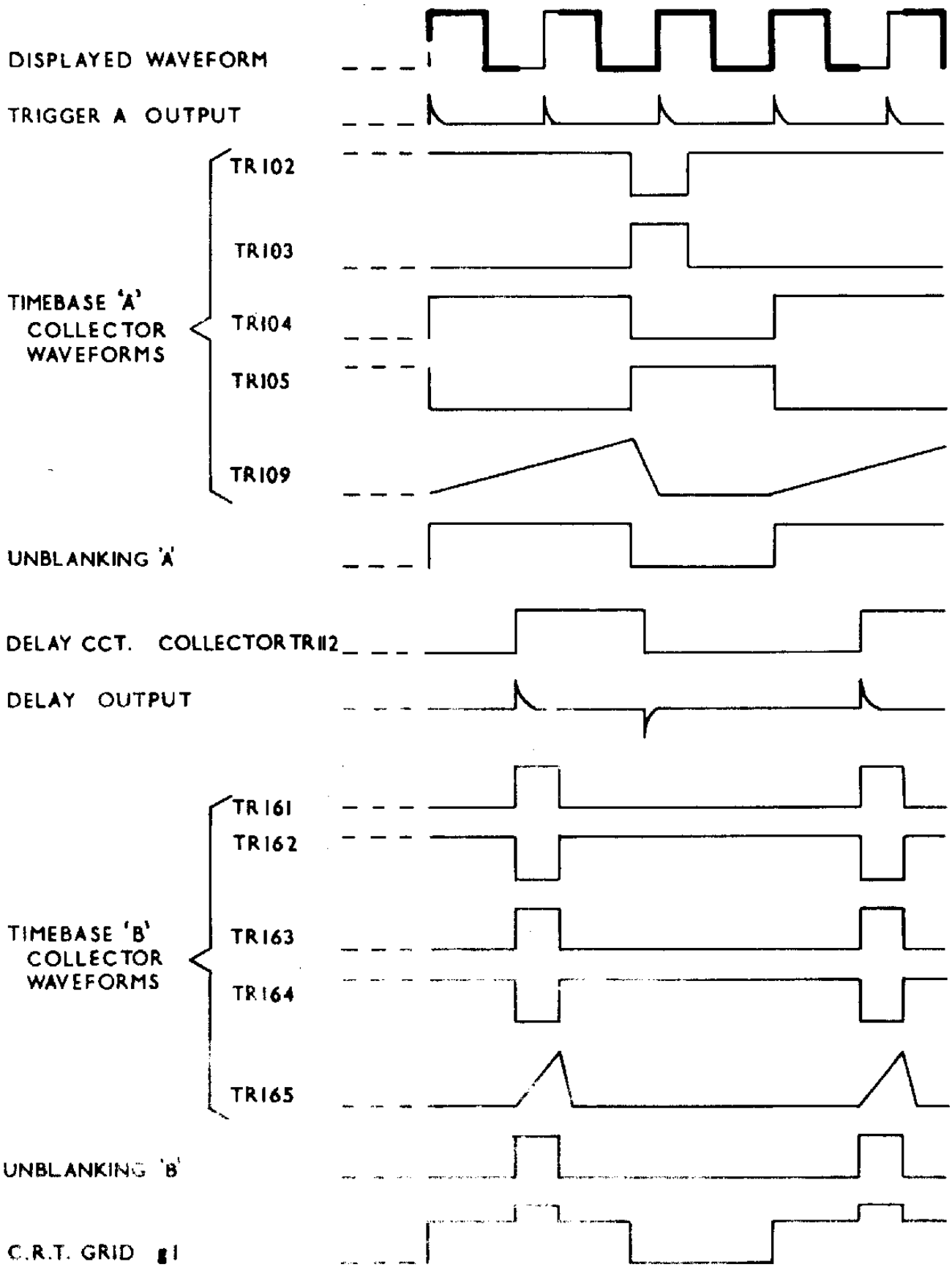
B TRIGGER
210/125

MONITOR T/D 10m
V/D 2V



B TRIGGER
210/209

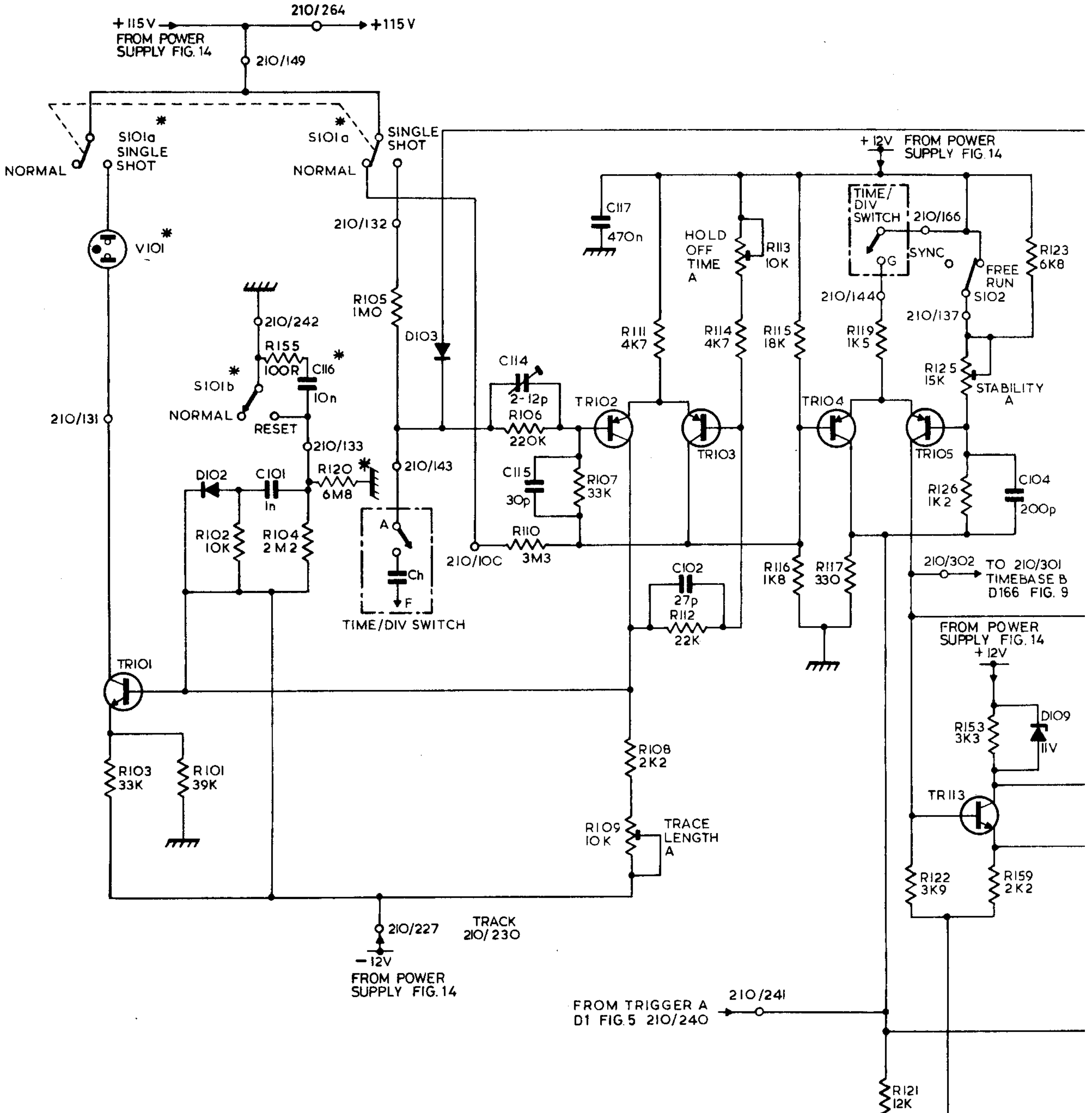
MONITOR T/D 10m
V/D 2V



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

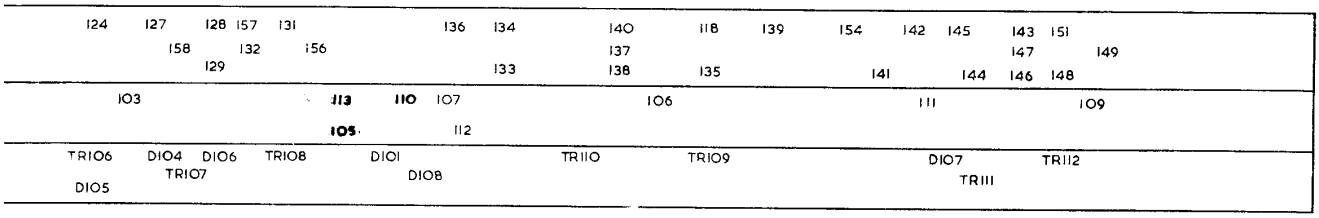
FIG. 7.

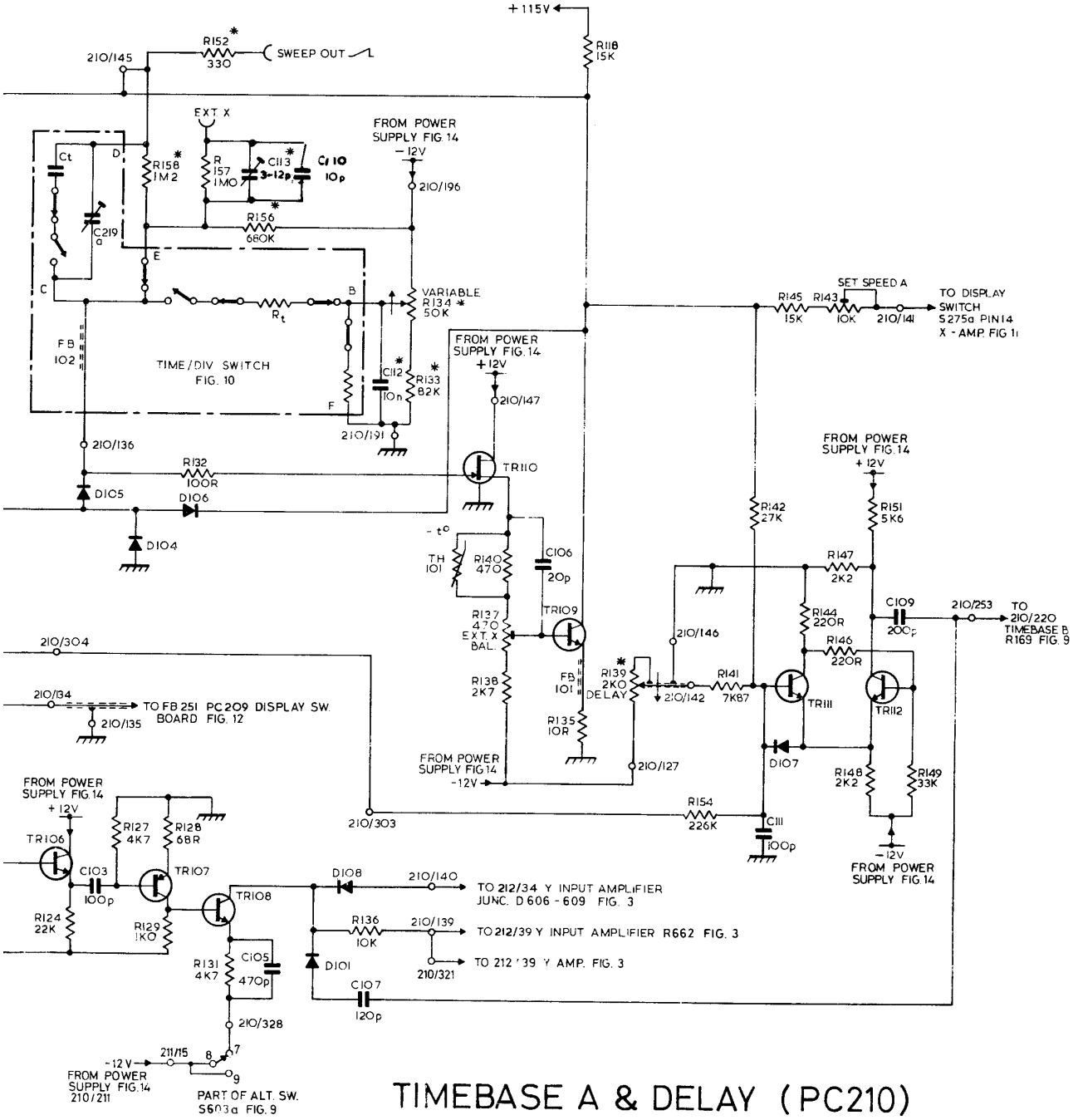
RESISTORS		101	102		104		105	106	107	108		112	113	115	117		122	125	153	123			
										111						119							
	103			155		120		110		109			114	116		121		126	159				
CAPACITORS				101	116			114	117		102									104			
								115															
MISC.	V101	D102					D103		TR102		TR103				TR104		TR105			D109			
	TR101																	TR113					



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.





TIMEBASE A & DELAY (PC210)
D67A FIG. 8

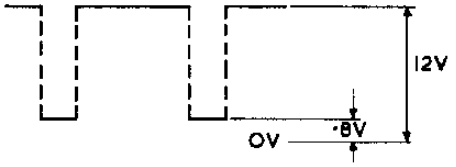
9/77

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

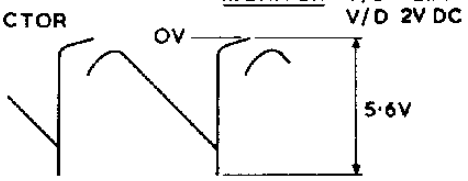
NOTE DOTTED LINE INDICATES FAST RISE

REFERENCE FIG. 8

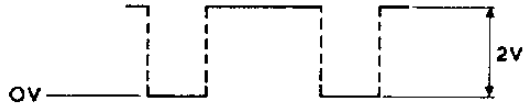
A TIMEBASE 210/304 — **MONITOR** T/D 2ms V/D 5V DC



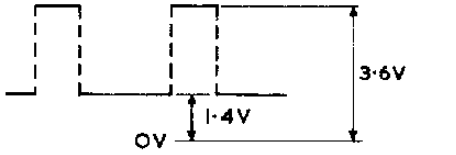
A TIMEBASE TRIO1 COLLECTOR — **MONITOR** T/D 2ms V/D 2V DC



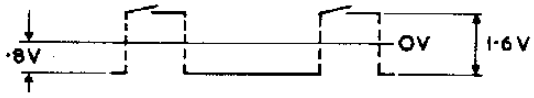
A TIMEBASE TRIO4 COLLECTOR — **MONITOR** T/D 1ms V/D 2V DC



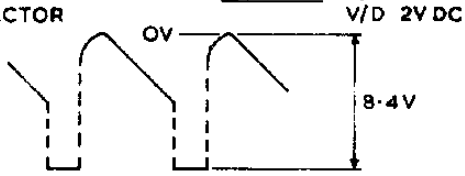
A TIMEBASE TRIO3 COLLECTOR — **MONITOR** T/D 2ms V/D 1V DC



A TIMEBASE TRIO5 COLLECTOR — **MONITOR** T/D 1ms V/D 1V DC

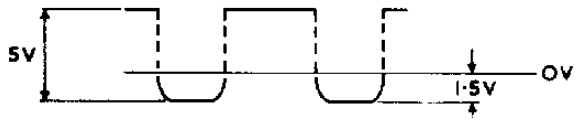


A TIMEBASE TRIO2 COLLECTOR — **MONITOR** T/D 5ms V/D 2V DC

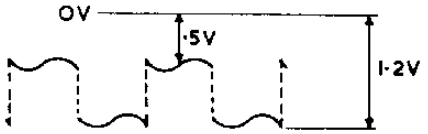


A TIMEBASE TRIO9 COLLECTOR — **MONITOR** T/D 5ms V/D 20V DC

A TIMEBASE TRII2 COLLECTOR — **MONITOR** T/D 5ms V/D 1V DC



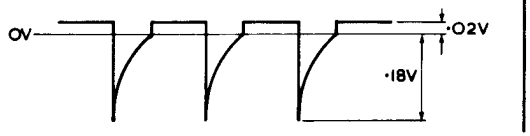
A TIMEBASE TRIII COLLECTOR — **MONITOR** T/D 5ms V/D 1V DC



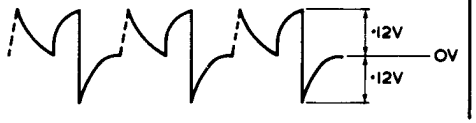
INSTRUMENT ON TEST SETTING
B DEL (WITH LINK IN)
A TIME/DIV ·2ms
B TIME/DIV ·1ms

REFERENCE FIG. 9.

B TIMEBASE — MONITOR — T/D 1ms
TRI68 COLLECTOR — V/D ·1V



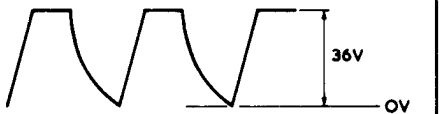
B TIMEBASE — MONITOR — T/D 1ms
210/326 — V/D 1V



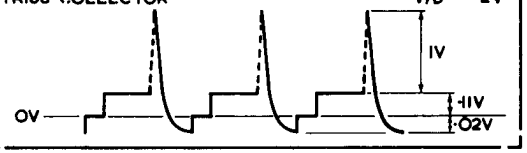
INSTRUMENT ON TEST SETTING
MIXED SWEEP
A TIME/DIV ·2ms
B TIME/DIV ·1ms

REFERENCE FIG. 9.

B TIMEBASE — MONITOR — T/D 1ms
210/326 — V/D 10V



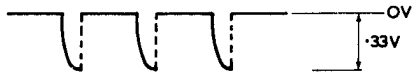
B TIMEBASE — MONITOR — T/D 1ms
TRI68 COLLECTOR — V/D ·2V



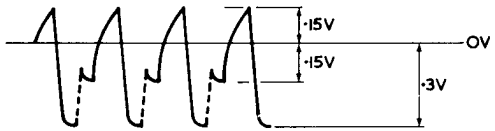
INSTRUMENT ON TEST SETTING
B DEL (WITH LINK OUT)
A TIME/DIV EXT X
B TIME/DIV ·1ms

REFERENCE FIG. 9.

B TIMEBASE — MONITOR — T/D ·5ms
TRI68 COLLECTOR — V/D 1V



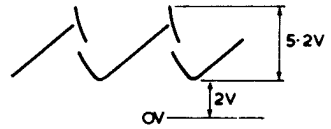
B TIMEBASE — MONITOR — T/D ·5ms
210/326 — V/D 1V



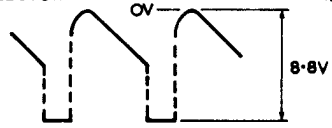
INSTRUMENT ON TEST SETTING
VARIABLE CAL
TIME/DIV 1ms NON GATED
CH 1 & 2 OFF
TEST POINT 153 DISCONNECTED

REFERENCE FIG. 9.

B TIMEBASE — MONITOR — T/D 5ms
TRI61 BASE — V/D 2V

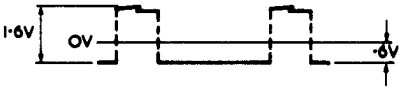


B TIMEBASE — MONITOR — T/D 5ms
TRI61 COLLECTOR — V/D 2V

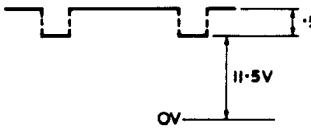


B TIMEBASE — MONITOR — T/D 5ms
TRI63 COLLECTOR — V/D 2V

B TIMEBASE — MONITOR — T/D 2ms
TRI64 COLLECTOR — V/D 1V

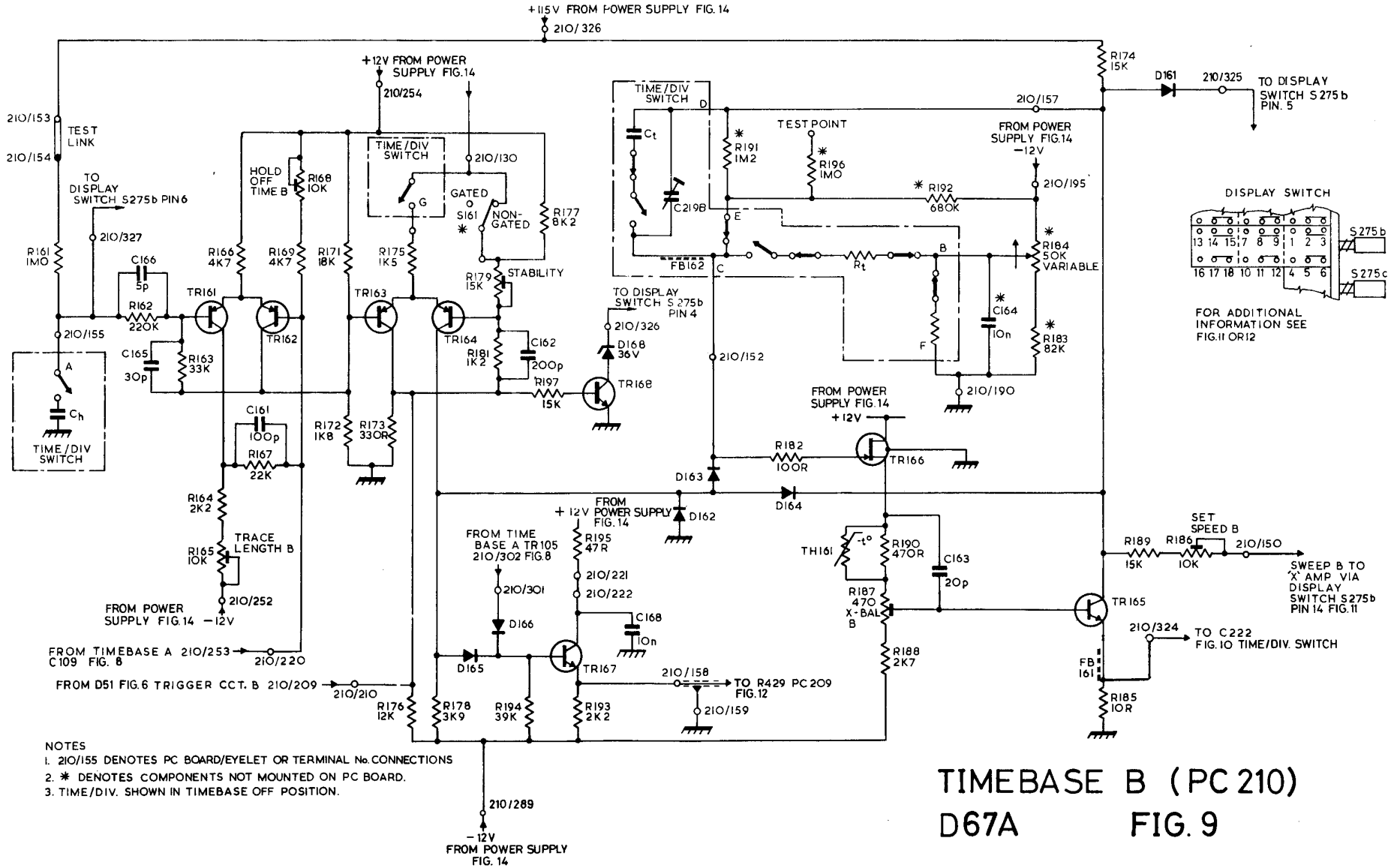


B TIMEBASE — MONITOR — T/D 2ms
TRI67 COLLECTOR — V/D 2V



B TIMEBASE — MONITOR — T/D 5ms
TRI65 COLLECTOR — V/D 20V

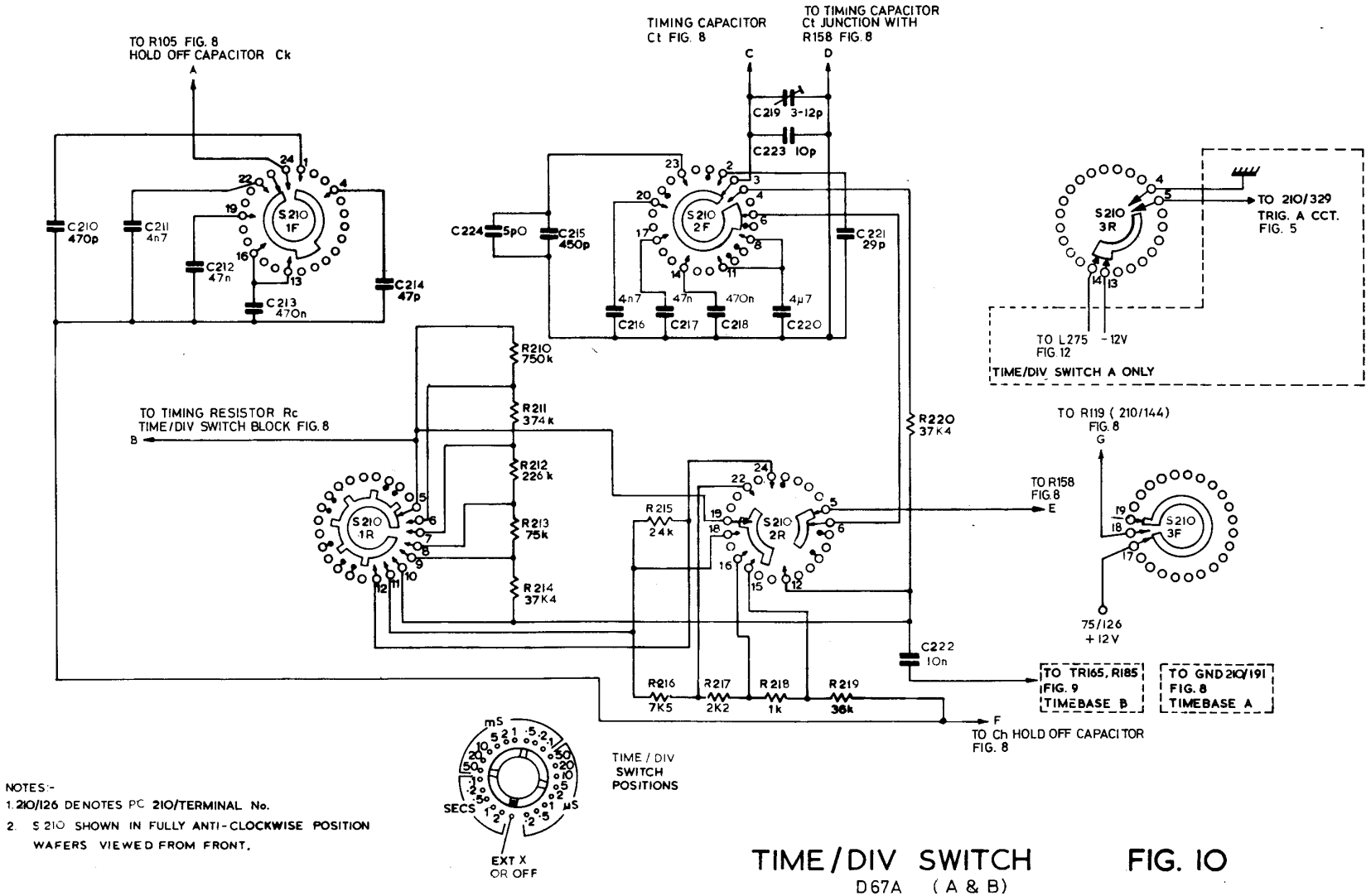
RESISTORS	R162 R163 R164 R166 R166 R171 R173 R175 R179 R194 R177 R195 R182 R190 R92 R184 R174 R189 R186
	R161 R165 R167 R169 R172 R176 R178 R181 R197 R193 R191 R196 R187 R188 R183 R185
CAPACITORS	C166 C161 C162 C168 C219 C163 C164
	C165
MISC.	TR161 TR162 TR163 TR164 S161 TR167 TR168 FB162 TR166 TR165
	D165 D166 D68 D162 D163 D164 TH161 D161 FB161



NOTES
1. 210/155 DENOTES PC BOARD/EYELET OR TERMINAL No. CONNECTIONS
2. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD.
3. TIME/DIV. SHOWN IN TIMEBASE OFF POSITION.

TIMEBASE B (PC 210)
D67A FIG. 9

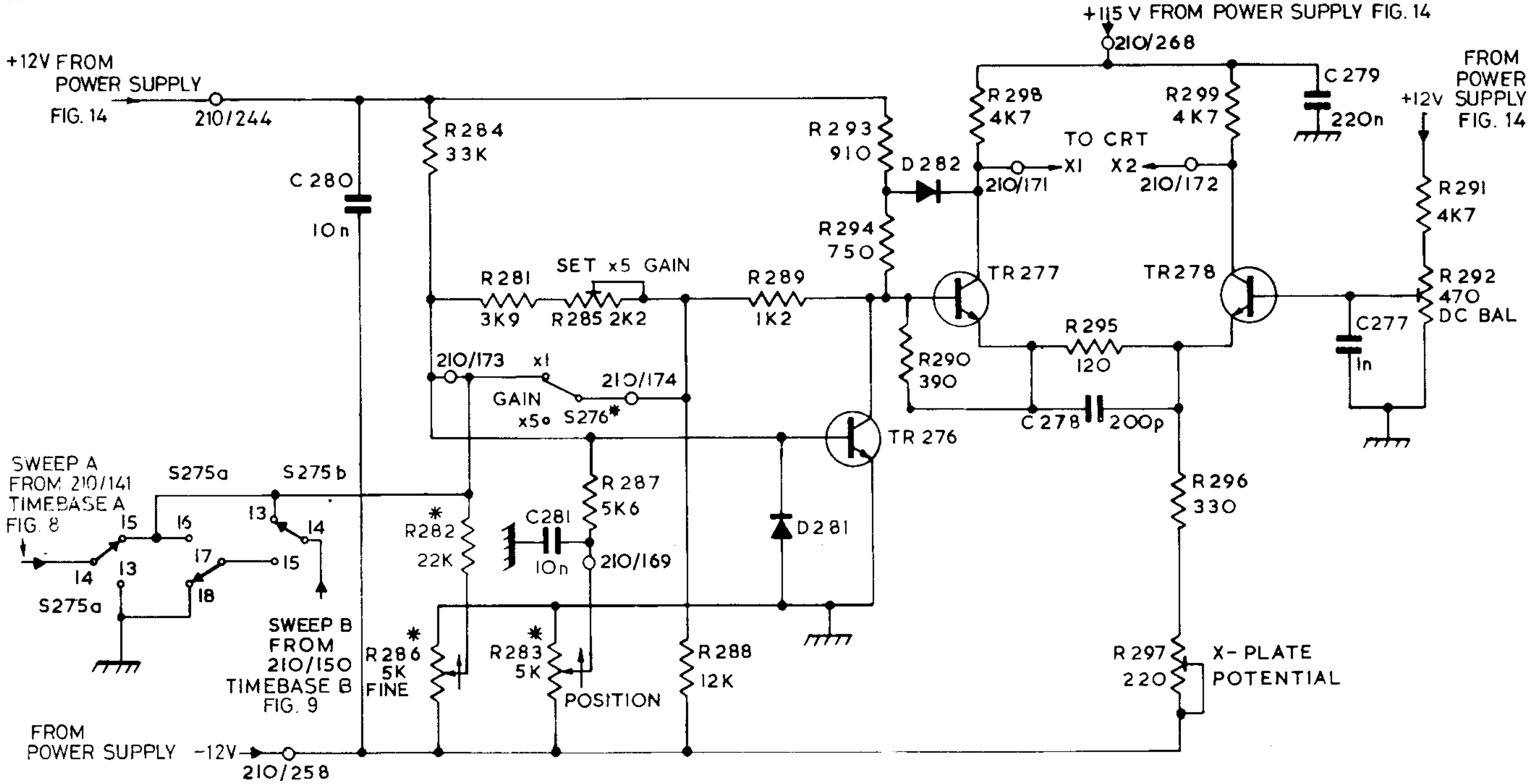
MISC	S 210 1F	S210 1R	S2102F	S2102R	S210 3R	S210 3F
C	210 211 212 213 214	224 215 216 217 218	219 220 221 222 223			
R	210 211 212 213 214	215 216 217 218 219	220			



TIME/DIV SWITCH FIG. 10

D67A (A & B)

RESISTORS	284 282 286 281 285 283 287 288 289 293 294 290 298 295 299 296 297 291 292
CAPACITORS	280 281 278 279 277
MISC.	S275a S275b S276 D281 TR276 D282 TR277 TR278



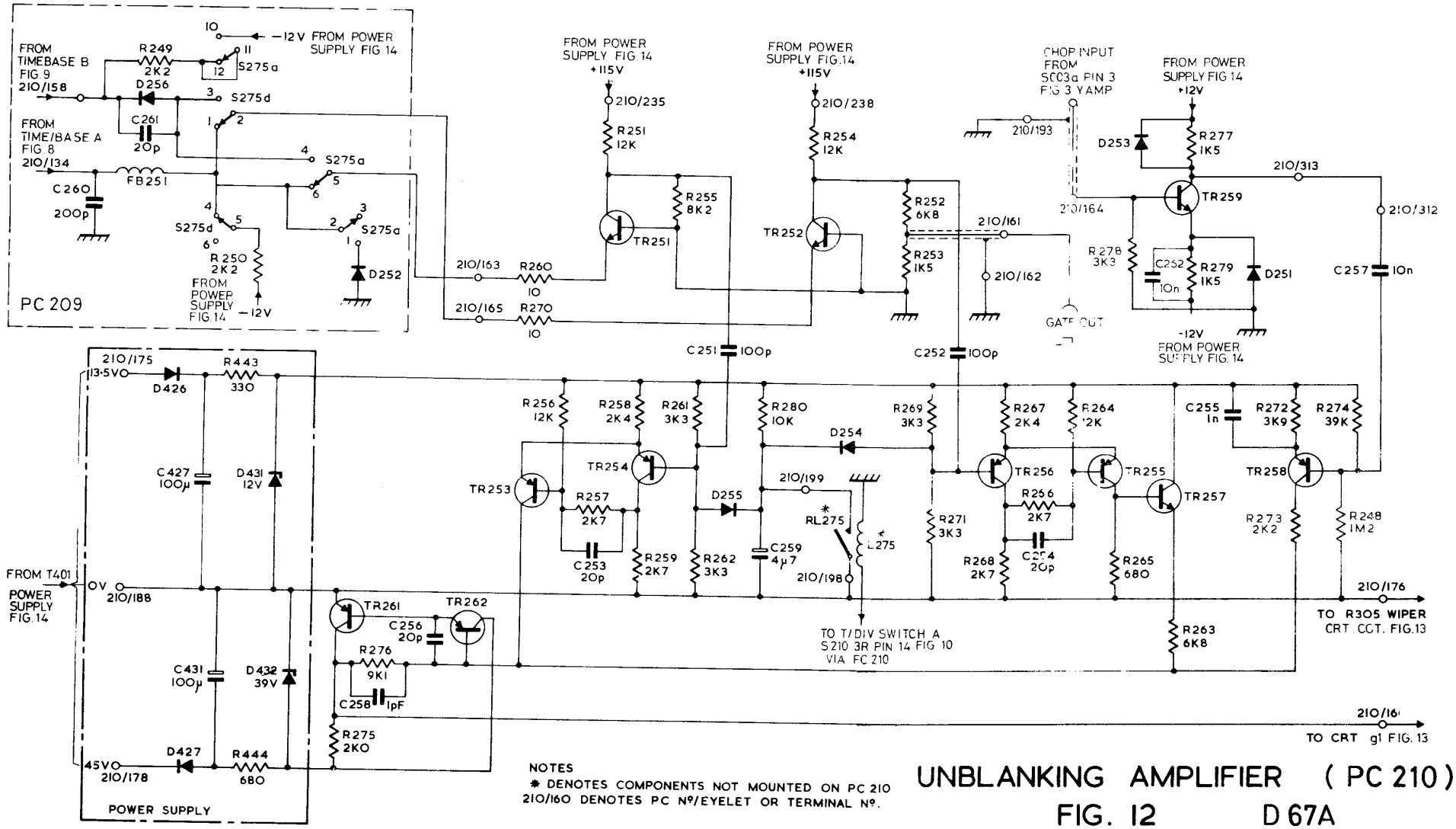
NOTES: 1. ✱ DENOTES COMPONENT NOT MOUNTED ON PC 210

2. 210/244 DENOTES PC BOARD No/EYELET OR TERMINAL No.

X- AMPLIFIER (PC210)

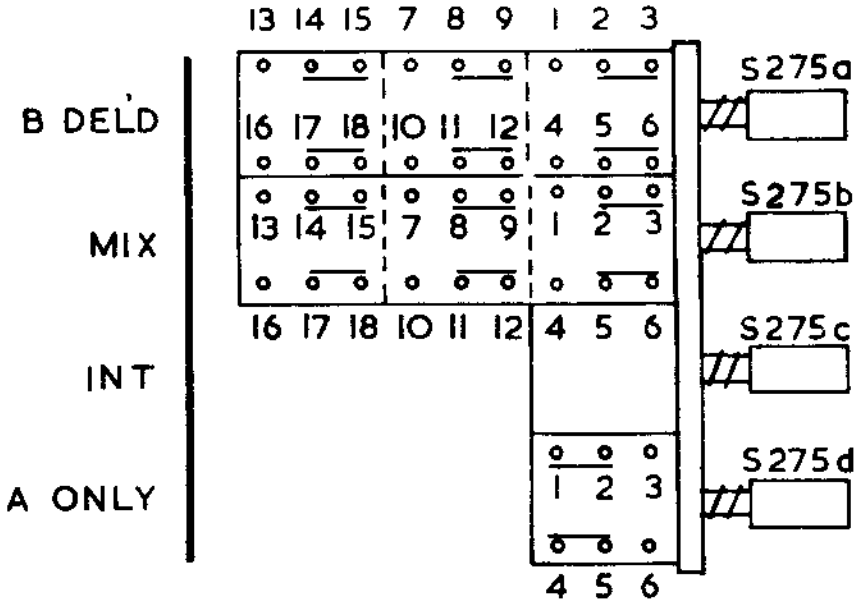
FIG. 11 D 67A

RESISTORS	249 443 444 250 275 276 260 270 256 251 257 258 259 261 255 262 280 254 252 253 269 271 267 268 266 264 265 278 263 277 279 272 273 274 248
CAPACITORS	261 260 427 431 260 258 256 253 251 259 252 254 C262 255 257
MISCELLANEOUS	D256 D426 D427 FB251 S275 D431 D432 TR261 D252 TR262 TR253 TR251 TR254 D255 TR252 D254 L275 RL275 TR256 TR255 TR257 TR259 D253 D251 TR258



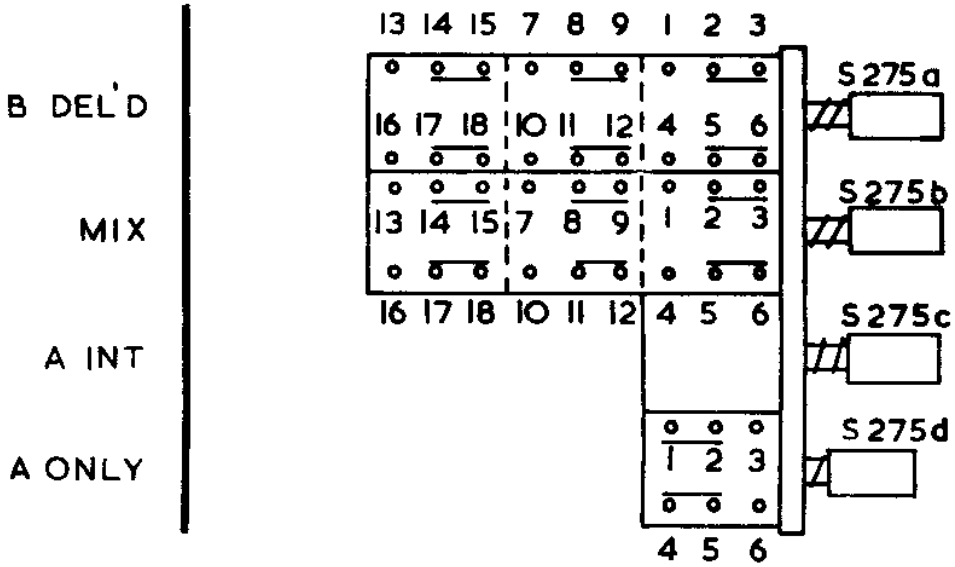
NOTES
* DENOTES COMPONENTS NOT MOUNTED ON PC 210
210/160 DENOTES PC Nº/EYELET OR TERMINAL Nº.

UNBLANKING AMPLIFIER (PC 210)
FIG. 12 D 67A



PUSH BUTTON SWITCHES VIEWED FROM TRACK SIDE OF BOARD.

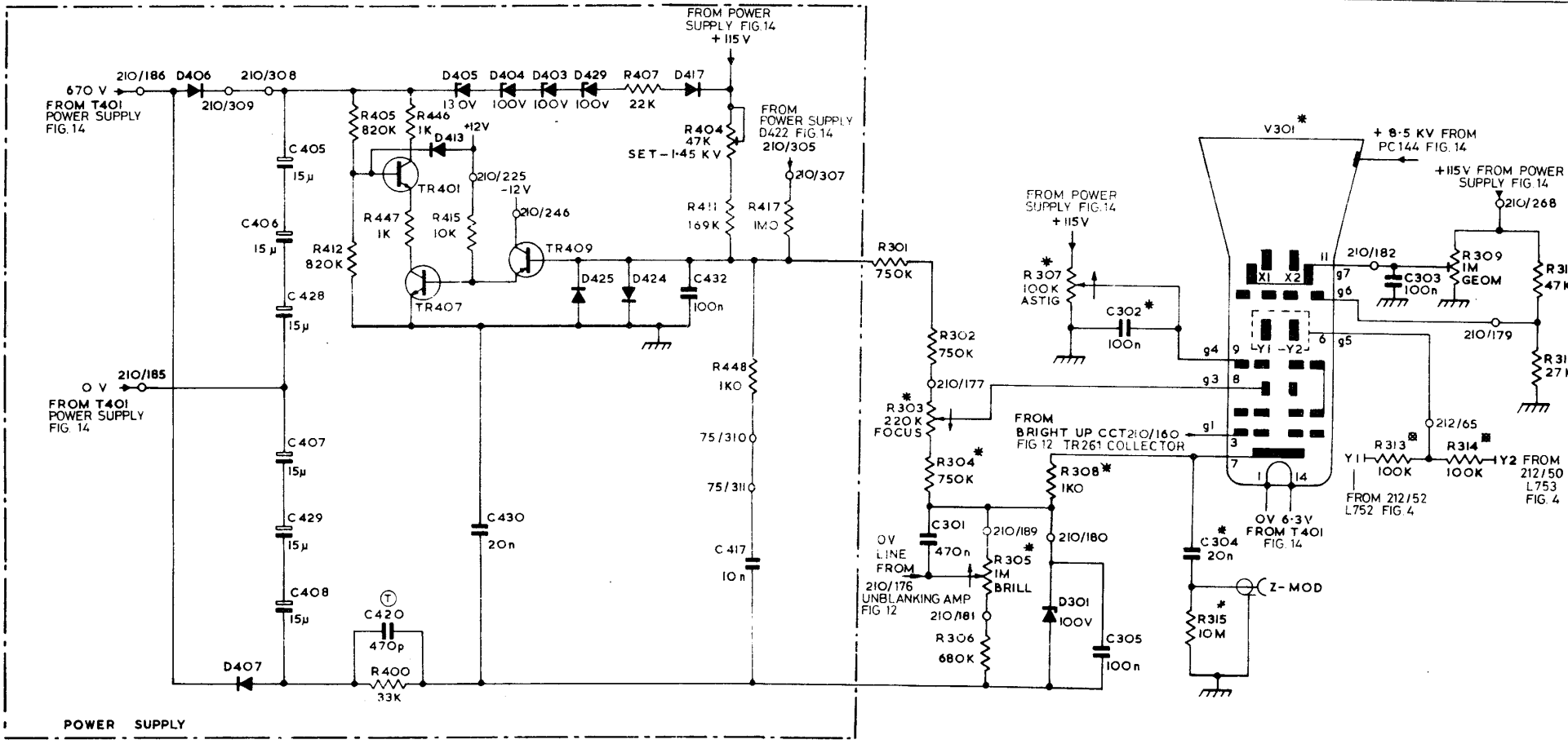
'X' Amplifier Switch



PUSH BUTTON SWITCHES VIEWED FROM COPPER SIDE OF BOARD.

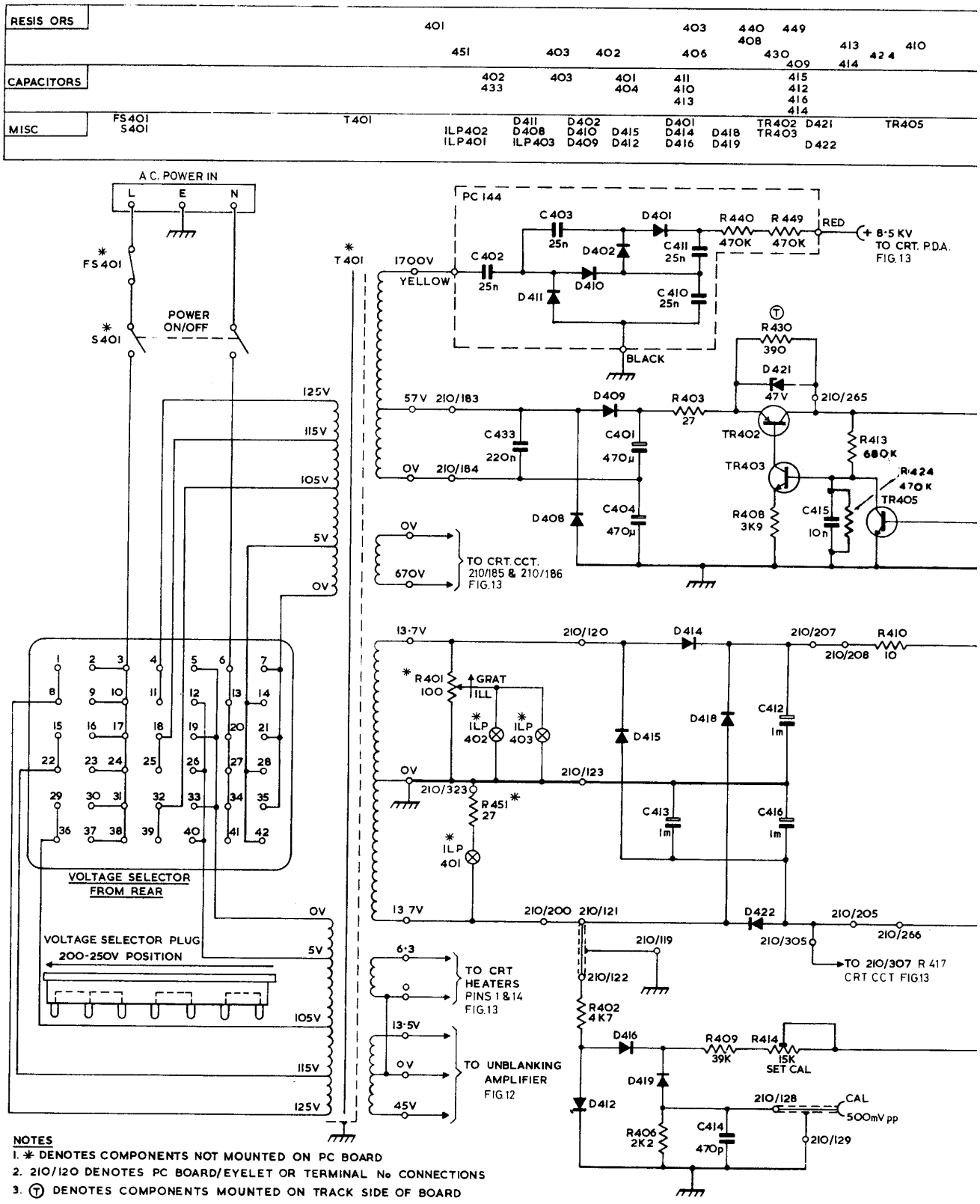
Unblanking Amplifier Switch

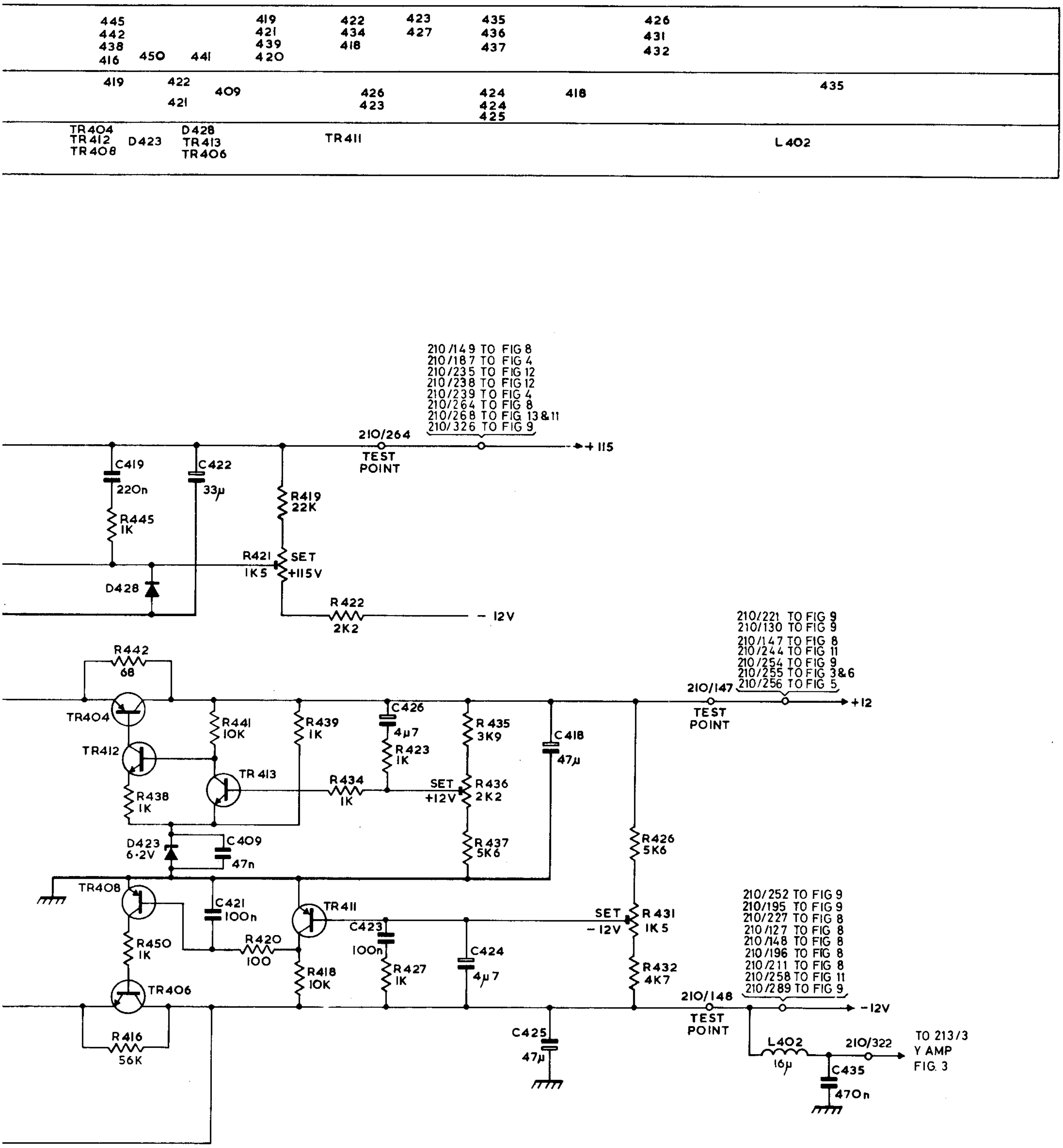
RESISTORS	405 446 400 412 447 415 407 404 411 448 417 301 302 305 303 304 306 307 308 315 313 309 314 311 312
CAPACITORS	406,405 407,428 408,429 420 430 432 417 301 305 302 304 303
MISCELLANEOUS	D406 D407 TR401 TR407 D413 D405 D404 D403 D429 TR409 D425 D424 D417 D301 V301



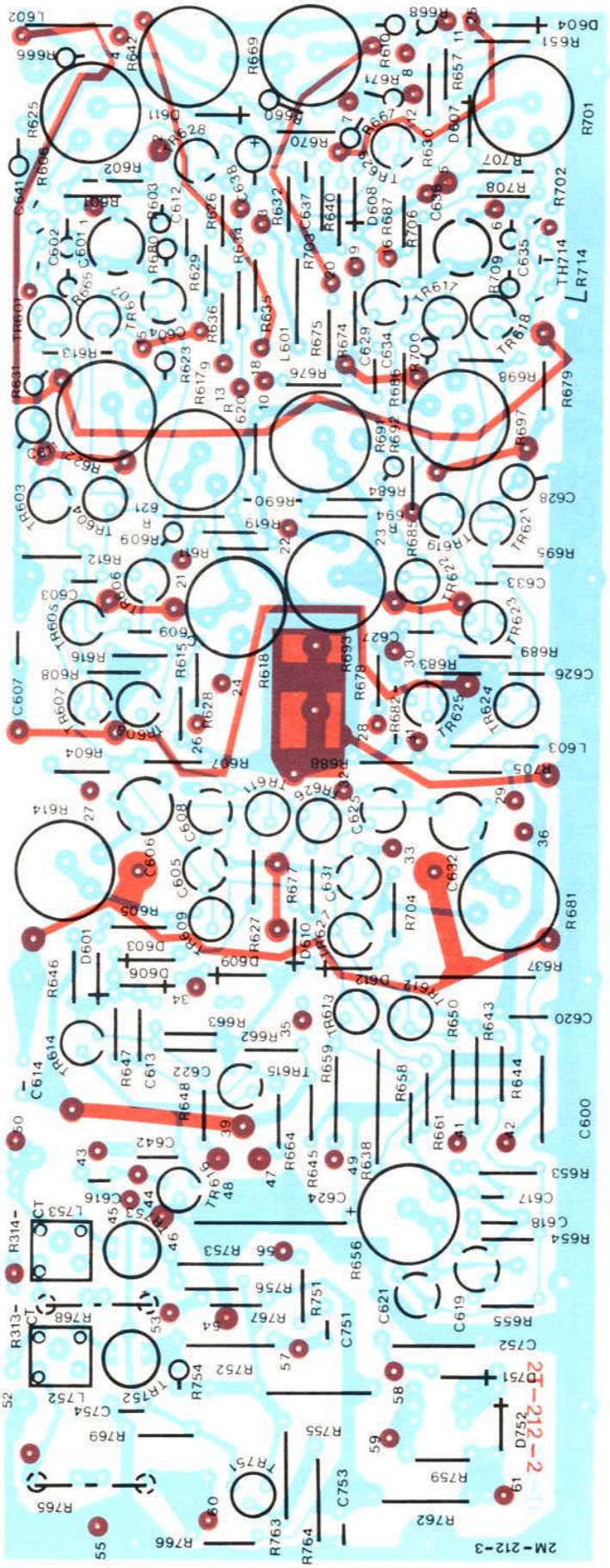
NOTES
1 ▩ DENOTES COMPONENTS MOUNTED ON PC212
2 * DENOTES COMPONENTS NOT MOUNTED ON PC 210 OR PC212
3 210/177 DENOTES PC BOARD No/EYELET OR TERMINAL No.
4 Ⓣ DENOTES COMPONENTS MOUNTED ON TRACK SIDE OF BOARD

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

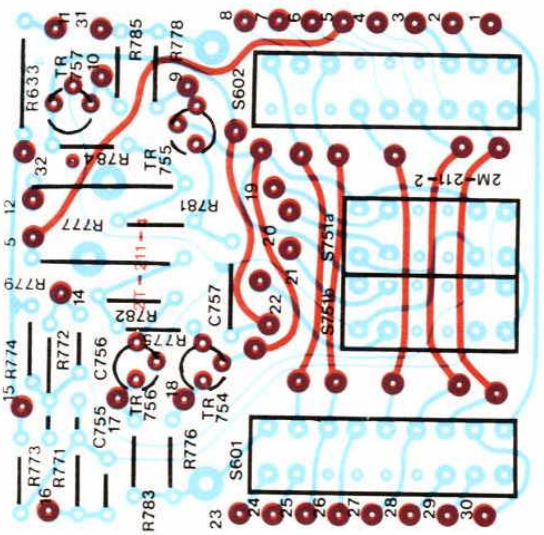

RESIS ORS
401 451 403 402 403 406 440 408 449 430 409 413 414 424 410
CAPACITORS
402 433 403 401 404 411 410 413 415 412 416 414
MISC
FS401 S401 T401 ILP402 ILP401 D411 D408 ILP403 D402 D410 D409 D415 D412 D401 D414 D416 D418 D419 TR402 TR403 D421 D422 TR405
A.C. POWER IN
L E N
FS401
S401
POWER ON/OFF
T401
125V
115V
105V
5V
0V
VOLTAGE SELECTOR FROM REAR
VOLTAGE SELECTOR PLUG 200-250V POSITION
PC 144
C403 25n
D401
R440 470K
R449 470K
RED
+8·5 KV TO CRT. P.D.A. FIG.13
C402 25n
D402
C411 25n
1700V
YELLOW
D411
D410
C410 25n
BLACK
R430 390
D421
57V 210/183
D409
R403 27
47V
210/265
TR402
C433 220n
C401 470µ
R413 680K
0V 210/184
TR403
R424 470K
TR405
C404 470µ
D408
R408 3K9
C415 10n
0V
670V
TO CRT CCT. 210/185 & 210/186 FIG.13
13·7V
210/120
D414
210/207
R410 10
210/208
R401 100
GRAT ILL
ILP 402
ILP 403
D415
D418
C412 1m
0V
210/123
210/323
R451 27
C413 1m
C416 1m
ILP 401
13·7V
210/200 210/121
D422
210/205
210/266
210/305
TO 210/307 R417 CRT CCT FIG.13
210/119
210/122
6·3
TO CRT HEATERS PINS 1 & 14 FIG.13
R402 4K7
13·5V
0V
45V
TO UNBLANKING AMPLIFIER FIG.12
D416
R409 39K
R414 15K SET CAL
D419
D412
210/128
CAL 500mV pp
R406 2K2
C414 470p
210/129
NOTES
1. * DENOTES COMPONENTS NOT MOUNTED ON PC BOARD
2. 210/120 DENOTES PC BOARD/EYELET OR TERMINAL No CONNECTIONS
3. (T) DENOTES COMPONENTS MOUNTED ON TRACK SIDE OF BOARD



POWER SUPPLY (PC210)
D67A FIG. 14

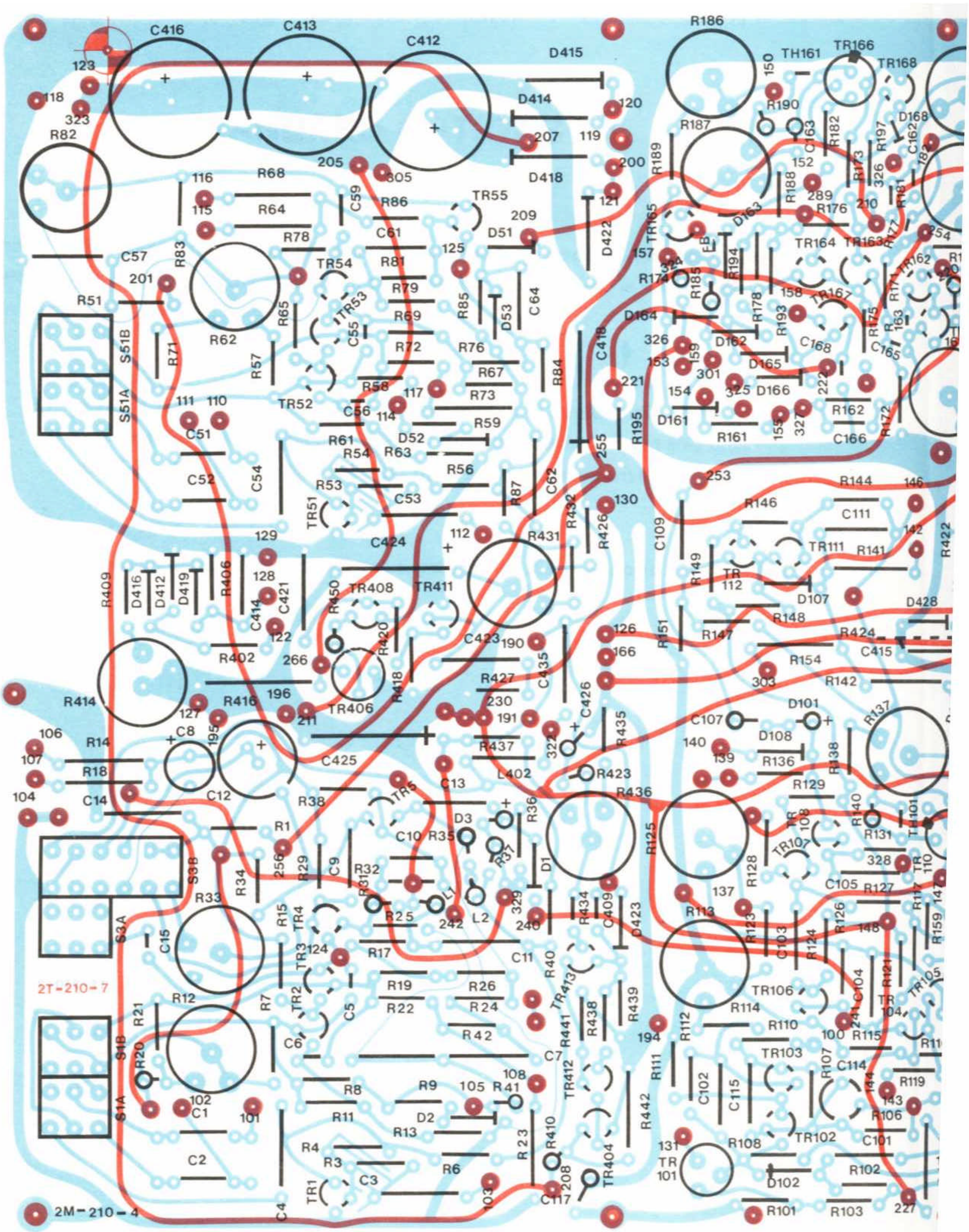


PC212



PC211

FIG. 15


C416
C413
C412
D415
R186
TH161
TR166
TR168
D414
D418
D422
R82
R68
R64
R78
R86
C59
C61
R81
R79
R69
R72
R76
R67
R73
R59
TR55
TR54
TR53
TR52
TR51
D51
D52
D53
C64
R85
R84
C418
R83
C57
R51
R62
R65
R57
C55
R71
S51B
S51A
C51
C52
C54
R58
C56
R61
R54
R63
R56
R53
C53
R87
C62
R432
R426
R431
C424
C421
C414
D416
D412
D419
R406
R409
R402
R450
TR408
TR411
R420
R418
TR406
C423
C435
C426
R427
R437
L402
R435
R423
R436
R414
R416
R14
R18
C14
C8
C12
C425
R38
R1
TR5
C13
C10
R35
D3
R36
R37
D1
R34
R29
C9
R32
R31
R25
L1
L2
R33
S3B
S3A
C15
R15
TR4
TR3
R17
C11
R40
TR413
R434
C409
D423
R19
R22
R26
R24
R42
C5
C6
TR2
R7
R12
R21
R20
S1B
S1A
C1
C2
C4
R8
R9
R11
R4
R3
C3
TR1
R13
D2
R6
R41
R23
R410
C117
TR404
TR412
R441
R438
R439
R442
R187
R189
R188
R190
C163
R182
R197
D168
C162
R173
R176
R181
TR165
D163
TR164
TR163
R177
R174
R185
R194
R178
R193
TR167
TR162
R175
D164
D162
C168
C165
D165
D166
D161
R161
R162
C166
R195
R172
R144
R146
C111
TR111
R141
R422
C109
R149
TR 112
D107
D428
R148
R147
R424
R151
C415
R154
R142
D101
C107
R137
D108
R136
R338
R129
R140
TR 108
TR107
R131
TH101
R125
R128
TR 110
C105
R127
R113
R123
C103
R124
R126
R117
R159
C104
R121
TR 104
TR105
TR106
R114
R110
R115
R112
R111
TR103
R107
C114
R119
C102
C115
R106
TR102
C101
R108
TR 101
D102
R102
R101
R103
2T-210-7
2M-210-4

PC210

FIG. 16

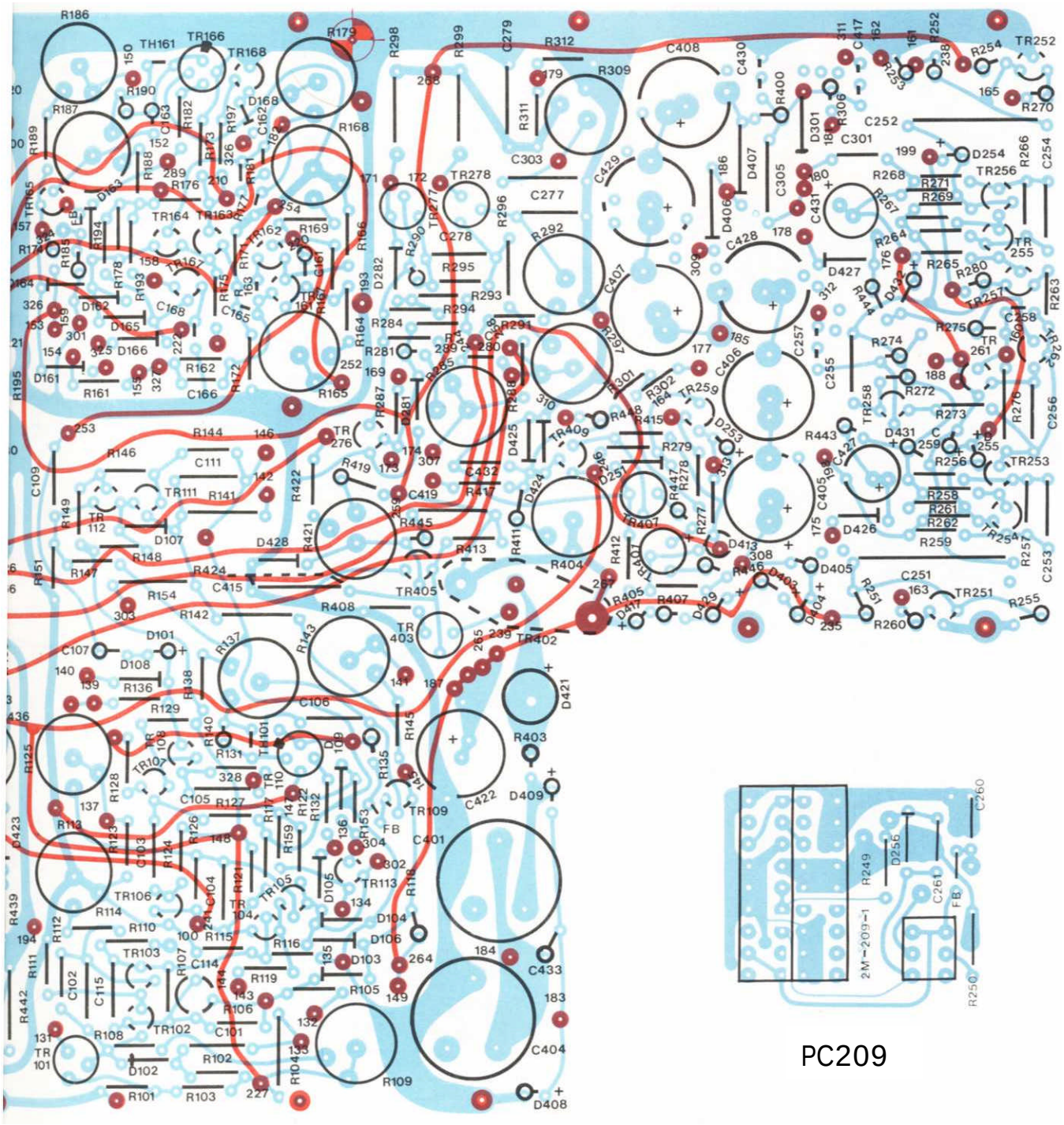


FIG. 16 (Cont.)