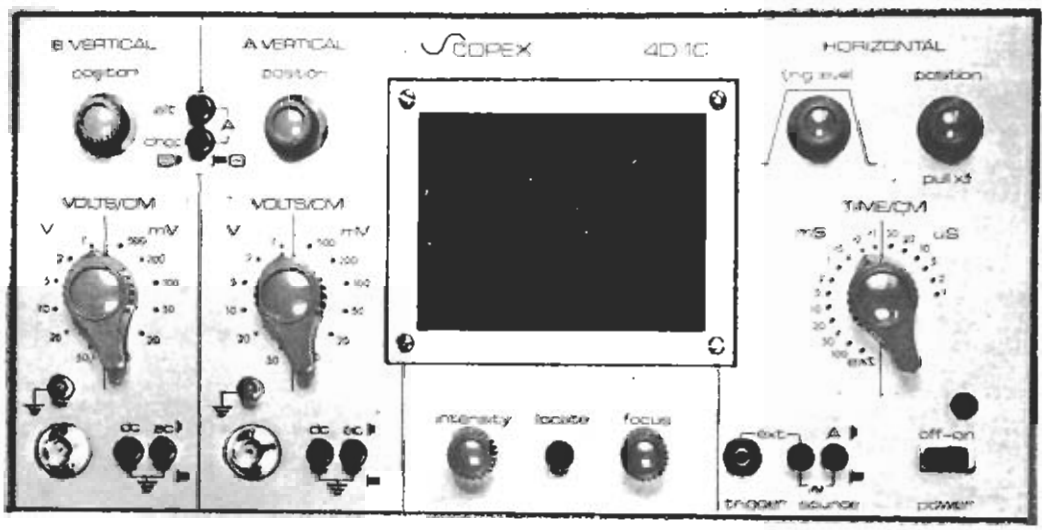
SCOPEX 4D10

CONTENTS



'SCOPEX' is the trade mark of:

Scopex Instruments Ltd.,
Pixmore Industrial Estate,
Pixmore Avenue,
Letchworth, Herts. SG6 1JJ

Telephone: Letchworth 72771

A & B Vertical	
Sensitivity ± 5%	10mV/cm - 50V/cm (12 calibrated ranges)
Bandwidth to -3dB points	
DC coupled	DC - >10MHz
AC coupled	<3Hz - >10MHz
Risetime (calculated)	35nS approx.
Overload protection	Max.400V (DC + peak AC to 3KHz)
Input impedance	1MΩ ± 3% and 33pF approx.
Modes	"A" Channel only
	ALT.
	CHOP. (approx. 100KHz)
Horizontal	
Sweep Speeds ± 5%	1μS/cm - 100mS/cm (16 calibrated ranges)
Magnifier ± 5%	5 times
External sensitivity	1V/cm approx. (200mV/cm magnified)
External bandwidth	DC - 50KHz
External input impedance	1MΩ ± 10% and 20pF approx.
Max. external input	250V (DC + peak AC to 1KHz)
Trigger Circuit	
Sources	External input - "A" Channel - Power line frequency
Sensitivity. Internal	5mm minimum 10Hz - 1MHz rising to 3cm at 5MHz.
External	300mV peak to peak 30Hz - 5MHz
	600mV peak to peak 10Hz - 10MHz
Input impedance	220KΩ approx. and 20pF approx.
Max. input	250V. (DC + peak AC to 1KHz)
General	
Display size	Graticule ruled 6cm x 8 cm
Power requirements	210 - 250VAC. 48 - 60 Hz. 25VA approx.
Dimensions (excluding handle)	H 6". W 12¼". D14¼".
Weight	17 lbs.
Ambient operating temperature	- +40°C.

We reserve the right to amend the specification without prior notice.

Operating Instructions

Single Trace Operation

Plug into mains supply
Set controls as shown in Page 1 Photograph (all push buttons out)
Check red power light on
Press in 'A' on TRIGGER SOURCE switch.
Allow a one minute warm up period, when a trace should appear. If not, press locate switch, adjust INTENSITY control until a line appears. Use HORIZONTAL POSITION and 'A' VERTICAL POSITION controls to place the line on the centre line of the graticule
Connect a signal between input 'A' and ground.
Switch AC-G-DC switch to AC

NB: This type of switch has three positions -

Either of the buttons depressed

or

Both buttons released

Adjust 'A' VOLTS/cm switch to obtain a display of convenient amplitude, say 4 cms.
Rotate TRIG LEVEL control until picture "locks" (i.e. gives a stationary picture). Adjust TIME/cm switch to display as much detail as required. Adjust FOCUS and INTENSITY to suit.

Dual Trace Operation

Carry out instructions for single trace operation. Then switch ALT-A-CHOP switch to ALT (see later note on the function of this switch). Find and position the second trace, (if necessary using LOCATE switch) using the 'B' VERTICAL POSITION control
Connect the second input signal between 'B' INPUT and ground.
Switch corresponding AC-G-DC switch to AC.
Adjust VOLTS/cm switch of both channels to give convenient display amplitudes.

Control Functions

ALT-A-CHOP switch. Use position 'A' for single trace and one of the other positions for dual trace operation. Generally speaking, use CHOP when TIME/cm switch is in the mS SECTOR. (on CHOP the trace is switched between 'A' and 'B' at approx. 100Khz). On ALT the 'A' and 'B' traces are swept alternately.

Trig Level Control

There are two sectors where the signal will "Lock", one on the positive and the other on the negative slope. Within these sectors the control decides the exact point at which triggering starts. In all other positions, the time base "free runs" at an arbitrary frequency, and will not lock.

AC-G-DC Switch

In the ground position, the amplifier (but not the input signal) is grounded, giving a true ZERO voltage reference. On the AC position, a capacitor is placed in series with the input signal, so as to exclude its DC component. On DC, this capacitor is short circuited, and the DC component will be seen on the screen as a positive or negative shift of the zero baseline. Too large a DC component may displace the trace right of the screen.

Horizontal Position Control

This control simultaneously positions both traces in the horizontal axis. When pulled OUT it increases the horizontal gain by a factor of 5. and in effect provides a trace 40 cms long. When measuring time, this gain of 5 must be corrected by dividing the time by the same amount. (e.g. with TIME/cm SWITCH at 1μ second & horizontal X5 switch OUT, the true time calibration is $\frac{1}{5}$ = .2μsec/cm)

External-A-line Switch

On position 'A' the time base is locked to the signal applied to the 'A' vertical channel. On "External" it is locked to whatever signal is applied to the EXTERNAL TRIGGER source. On " ∿ " it is locked to the frequency of the mains supply, normally 50 Hertz in the U.K.

X Input (on rear of instrument)

This permits signal input to the X (horizontal) amplifier providing the time base is switched to EXT. This may be used with an external time base, or for making lissajous figures. When used the horizontal position control functions normally.

Sweep Output (on rear of instrument)

This socket provides a negative going sawtooth waveform of 10 volts, and of the same duration as the timebase sweep.

Auto trigger disable

Linking the two pins to the rear of TR404 disables the auto trigger. This may prove useful on applications involving sweep repititions of less than 2 per second.

Circuit Description

The following description applies to both amplifiers. The signal to be observed is applied to the input socket where it passes to the attenuator. The attenuator comprises five frequency compensated dividers which can be bypassed, used singly or in cascade, thus enabling the signal to be adjusted to a level suitable for application to the input amplifier. The diodes D51 and D52 prevent the amplifier from being damaged by excessively large input signals.

The input amplifier comprises two dual gate M.O.S. field effect transistors TR51 and TR52 in a long tailed pair configuration. The source supply for this stage in 'A' channel is supplied by the internal trigger amplifier. 'B' channel is supplied from a decoupled supply formed by R61B and C53B.

The drain current of TR51A flows through TR202 where the variations produce an amplified signal at TR202 collector without loading the output of the long tailed pair. The signal appearing at TR202 collector is further amplified by TR201 and supplied to the trigger source switch S401. The signals appearing at the drains of the input stage are further amplified by another long tailed pair TR53 and TR54. A variable resistor RV53 between the two sources permits the gain of the amplifier to be adjusted. When the channel is being displayed the shunt diodes D53 and D54 are turned off and the series diodes D55 and D56 conduct connecting the drains to the load resistors R101 & R102 and hence the output stage. To switch the stage off the shunt diodes D53 and D54 are caused to conduct by the switching multivibrator thus elevating the cathodes of the series diodes more positive than their anodes.

The network D101, D102, R112, R113 and R114 ensures that the output stage can recover quickly from overloads. The filter networks in the collectors of TR101 and TR104 minimise the effects of stray capacitance hence improving the high frequency response.

The beam switch bistable TR302 and TR303 can be placed in three different modes by applying the appropriate bias levels through the mode switch S301.

In the 'A' only mode, R307 is returned to 0V ensuring TR303 is bottomed and R305 is returned to +30V ensuring TR302 is always turned off. The CHOP mode returns both R305 and R307 to 0V and the stage becomes astable switching at approximately 100KHz. The ALT mode biasses the stage such that it becomes bistable and switching occurs only at the end of the sweep when TR301 is turned off by a pulse from the timebase.

Horizontal Circuits

The source of signal to the trigger stage is determined by the source switch S401. This signal is superimposed on a DC level determined by the setting of the TRIG LEVEL control RV401. This composite signal is applied to the input base of the Schmitt trigger circuit TR402 and TR403 via the emitter follower TR401 which provides a high input impedance to the signal. If the base potential of TR402 is more positive than the base of TR403 the current provided by R411 flows through D403 into TR402, any further positive excursions of the base of TR402 will have very little effect on the circuit condition. However, on any subsequent negative excursion a point may be reached where by cumulative action the stage switches rapidly (approx. 20ns). This switching action takes place when the base of TR402 is at approximately +15V. Thus the lower the potential set by RV401, the more positive the input signal must go before the stage switches. Should the potential set by RV401 be more positive than + 15V then only when the input signal is negative going will switching take place.

The antiphase outputs from the collectors of TR402 and TR403 are taken via the gating diodes D402 and D405 and differentiating capacitors C402 and C404 to the sweep generator. The resistors R407 and R412 ensure that the anodes of the gating diodes are negative with respect to their cathodes and are thus turned off thereby blocking the passage of the signals. Only when a diode is caused toconduct by applying a forward bias from the 220V rail will it allow the signal to pass to the timebase, S402 which is ganged to RV401 determines which diode shall conduct. A negative going trigger pulse is required to start the timebase.

A sample of the signal at the collector of TR403 is peak rectified by D406, D407 and C406 to turn off TR404. If for any reason (i.e. no input signal) the trigger stage is not producing pulses then TR404 conducts, causing the timebase to free run. Immediately trigger pulses are produced, TR404 is turned off and the timebase reverts to the triggered state.

In the quiescent state (i.e. ready to be started) the conditions in the timebase circuit are as follows. The Miller run down circuit formed by the field effect transistor TR503 is biassed such that its drain is at approx. +20V. Should it attempt to rise higher, the base of TR502 will go positive. The corresponding positive excursion at TR501 collector will allow the gate of TR503 to go positive which will act against the original rise to restore equilibrium.
The sweep gate multivibrator TR504, TR505 is biassed such that TR504 takes the current supplied by R514. Under this condition the collector of TR504 is at 0V holding the base of TR505 approximately 1V more positive than the base of TR504. This potential is set by D502, D503, D504. The collector of TR505 is approximately -25V and D508 is turned off. The collector of TR502 is negative with respect to earth and D506 is conducting.

A negative going trigger signal applied to the cathode of D506 causes it to conduct taking the collector of TR504 negative. By cumulative action the circuit switches so that TR505 now takes all the current supplied by R514. The collector of TR505 rises turning on D508, this positive going signal is also used to unblank the cathode ray tube. D505 is now reversed biassed and the Miller Stage is free to run down at a rate determined by the timing capacitors C551 to C555 and the timing resistors R551 to R554. During the run down period D501 is turned off and TR502 conducts all the current supplied by R506 thus elevating its collector to approximately +10V.

The run down continues until the base of TR504 becomes more negative than the base of TR505 whereupon the sweep gate multivibrator switches back to its quiescent state. The collector of TR505 falls to approximately -25V blanking the cathode ray tube and turning off D508. The current supplied by R505 now flows through D505 to the gate of TR503 causing it to turn off.

The current supplied by R511 flows into the timing capacitor causing the junction with the drain of TR503 to rise. Eventually a potential is reached whereby D501 starts to conduct and TR501 collector rises taking D505 in a positive direction re-establishing the stable quiescent state.
During the run down period and subsequent resetting action, the collector of TR502 has been at approx. +10V ensuring that D506 is turned off. This action prevents trigger pulses causing the timebase to run before it has completely reset. Only when the timebase has completely reset does the collector of TR502 fall sufficiently negative for D506 to pass a trigger signal.
The output from the time base is applied via the emitter follower TR506 to one input of the long tailed pair TR507, TR508 and the shift voltage from RV504 to the other input. The gain of the stage is set by R524 and RV502 which controls the amount of coupling between the emitters of TR507 and TR508. A further gain control R525 and RV503 can be switched in parallel by operating the magnifier switch S503 when the gain is increased by a factor of 5.
The low voltage supplies are obtained by conventional half wave rectification. The E.H.T. is obtained by voltage doubling the output from an overwind on the transformer. The supplies for the cathode ray tube are obtained by a conventional potential divider network which also incorporates the smoothing capacitors.

Calibration

The advanced circuit design coupled with solid state reliability will make frequent recalibration unnecessary. Before assuming that a fault condition exists always set up the oscilloscope as outlined in the first time operation; this will eliminate any apparent faults caused by incorrect settings of the controls.

Removal of Covers

The top covercan be removed by sliding it backwards and up after removing the two upper screws located on the rear of the two wide side trims. The two lower screws release the bottom cover. Having removed the covers, great care should be exercised as the E.H.T. supply takes several minutes to completely discharge

after switching off; DO NOT however, discharge the E.H.T.supply by shorting it to earth through any resistor less than 100KΩ.

Vertical Amplifier Sensitivity & Position Centre

An AC signal of accurately known amplitude (better than $\pm$ 1%) should be applied to each input in turn. The gain control RV53 should be adjusted to give a display of the correct height.

In the absence of a suitable signal source a good approximation can be obtained by connecting a new mercury cell at the input and with the VOLTS/cm switch set to .5V switch the AC-G-DC switch between G and DC, now adjust the gain control to give a displacement of 2.7 cms. Return both vertical POSITION controls to precisely mid range and adjust RV52A and RV52B such that both traces lie along the centre of the line of the graticule.

Trigger Threshold RV501

The auto free run circuit must firstly be immobilised; this is done by connecting the shorting link between the two pins adjacent to TR404. Connect a voltmeter between TR504 collector and chassis and adjust RV501 for zero volts. Remove the voltmeter but the shortening link should be left connected if the trigger sensitivity is to be adjusted.

Trigger Sensitivity RV402

Apply a signal of approximately 500 mV and 1KHz simultaneously to 'A' channel input and the external trig socket. Now adjust RV402 such that by rotating the Trig level control over the + slope sector it is only possible to trigger from the top 2 cms.

Sweep Timing

A source of accurate timing signals (i.e. better than ± 1%) is required to calibrate the time base.
With the TIME/cm switch set to 1 mS/cm and a source of 1mS time marks applied to 'A' channel obtain a locked display. Adjust RV 502 to give 1 mark every cm. Pull the X5 magnifier and adjust RV503 to give 1 mark every 5 cms.
Switch off the magnifier and select 1µS/cm, apply 1µs time marks and adjust CV501 located behind the TIME/cm switch to give 1 mark per cm. Now return through all the ranges to check that they remain within specification.

Attenuator compensation

Compensation of the attenuators will require the following equipment. A fast rise (less than 1µs) square pulse generator of approximately 2KHz with an output up to at least 100V and an attenuator probe.

At each step the signal amplitude should be adjusted to give a display height of approximately 4cms where possible.

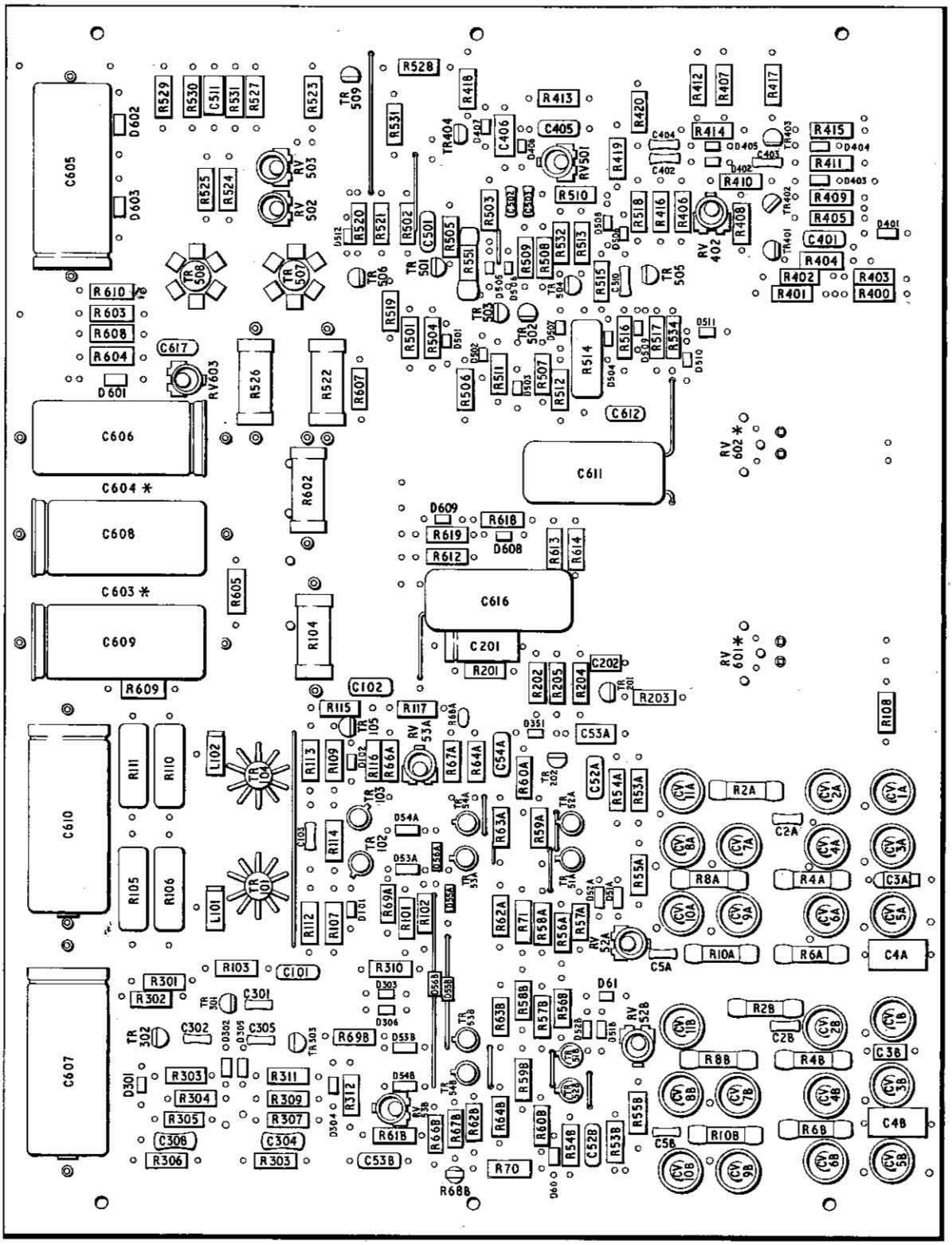
The capacitors listed below should be adjusted to give a flat top with a good square corner to the displayed waveform.

Volts/cm	Adjust
10mV	CV11 to mid range
20m V	CV8
50mV	CV10
100mV	CV2
200mV	CV7
500mV	CV9
1V	CV4
10V	CV6

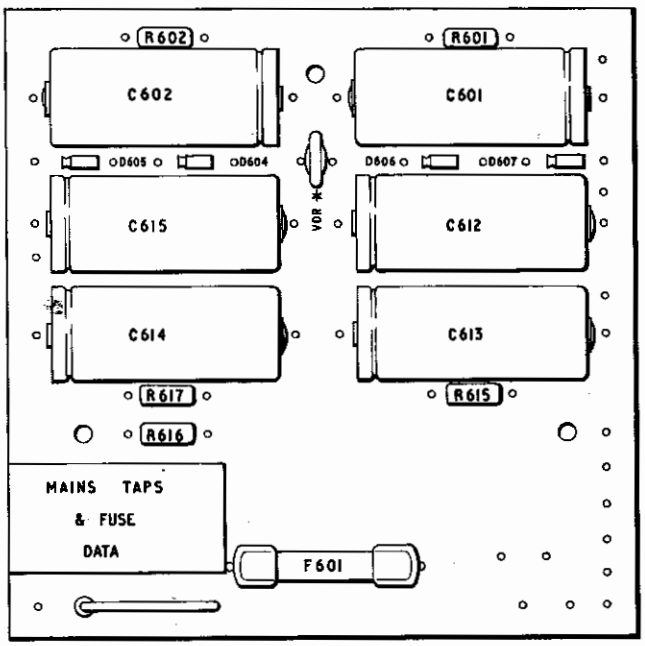
Connect divider probe and switching to 10mV/Cm adjust its compensation correctly. With the divider probe still in circuit adjust the following -

100mV/cm	CV1
1V/cm	CV3
10V/cm	CV5

Without altering the probe compensation adjust the other attenuator but this time with the divider probe in circuit adjust CV11 on 10mV/cm first.

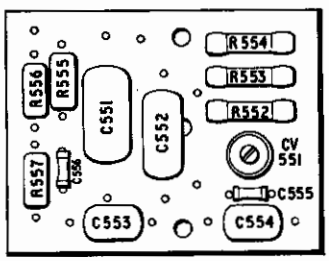


MAIN BOARD

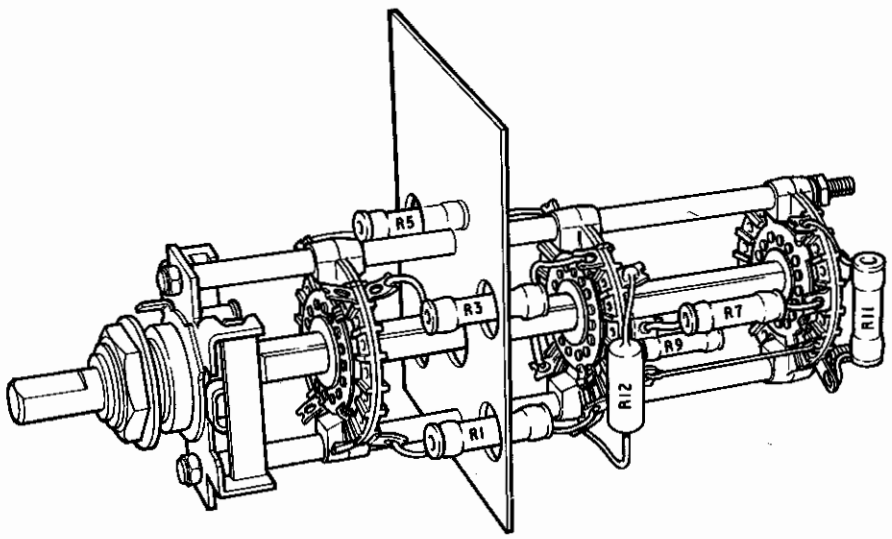


* EARLY INSTRUMENTS ONLY.

EHT BOARD



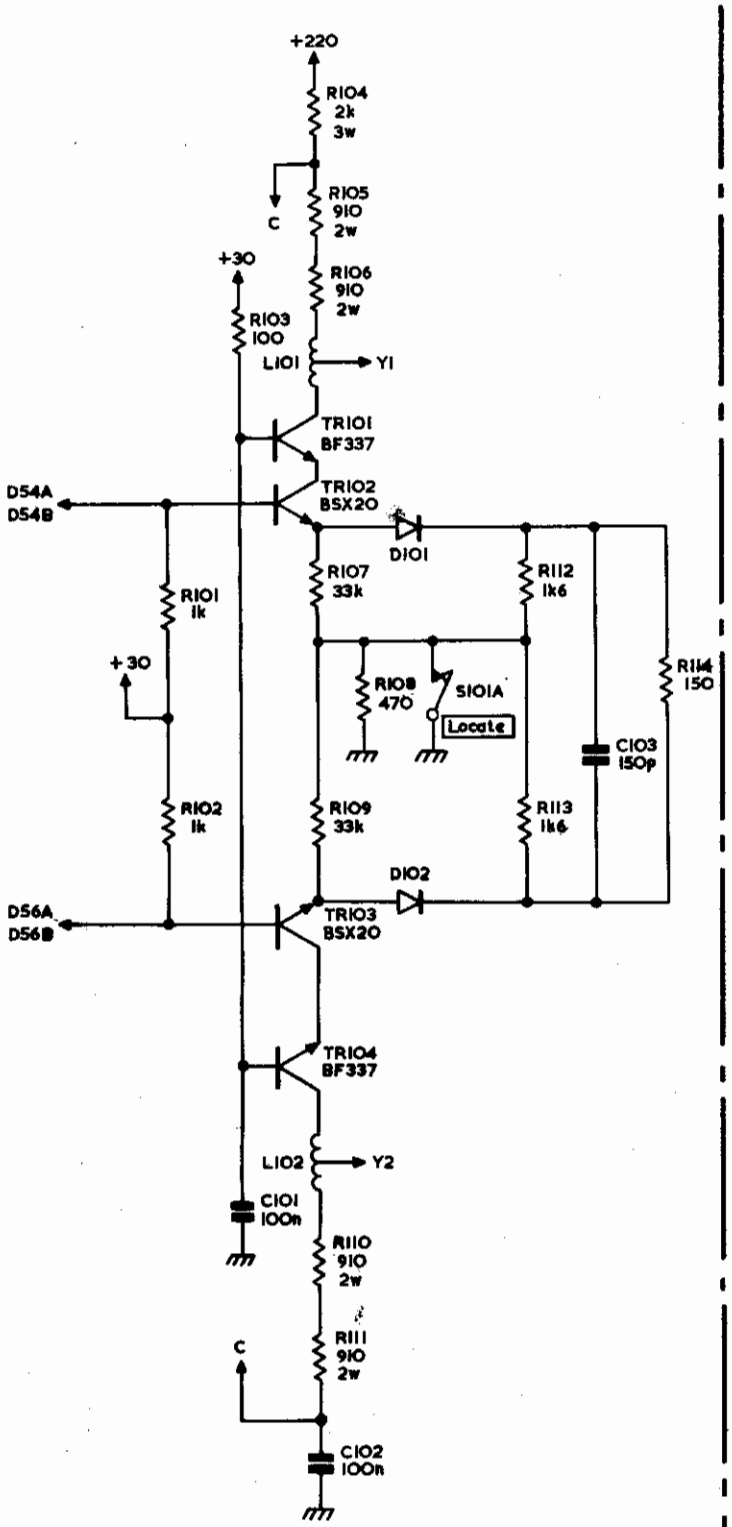
TIMING SWITCH BOARD



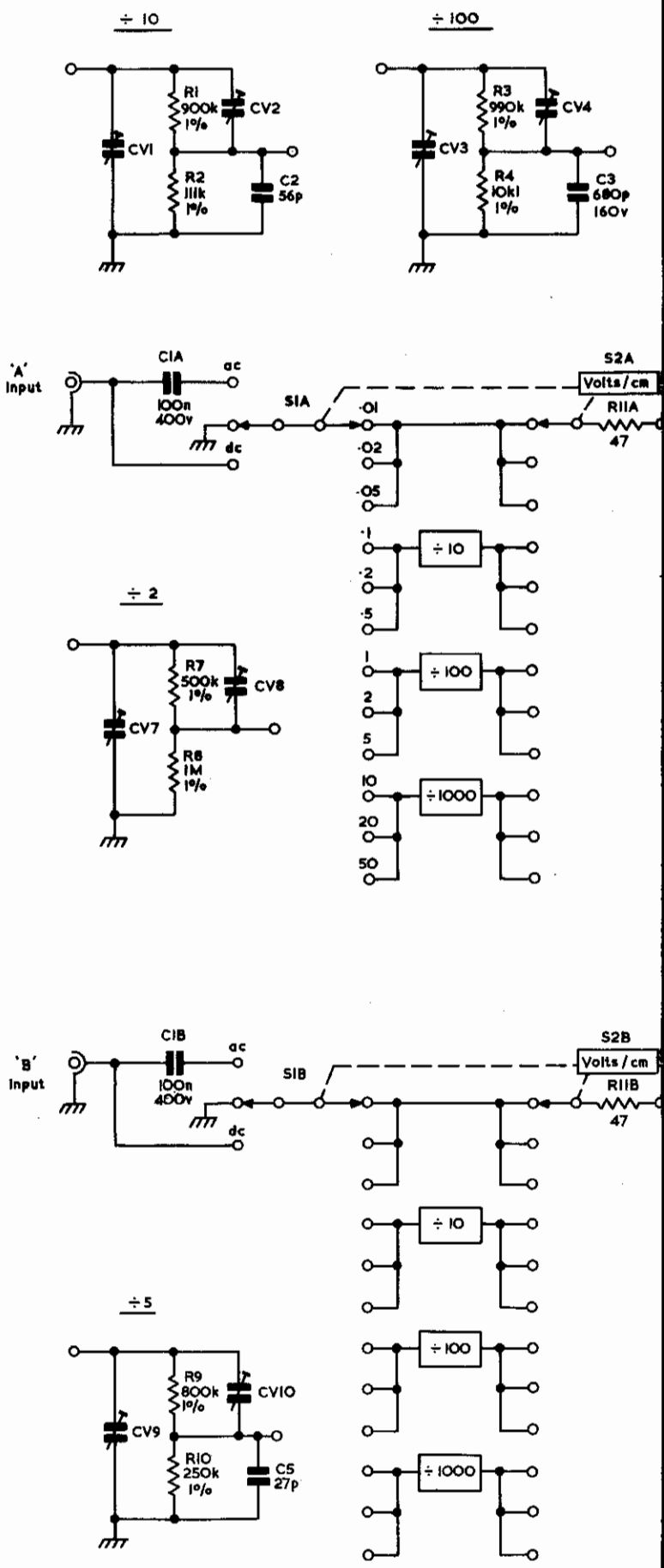
ATTENUATOR SWITCH

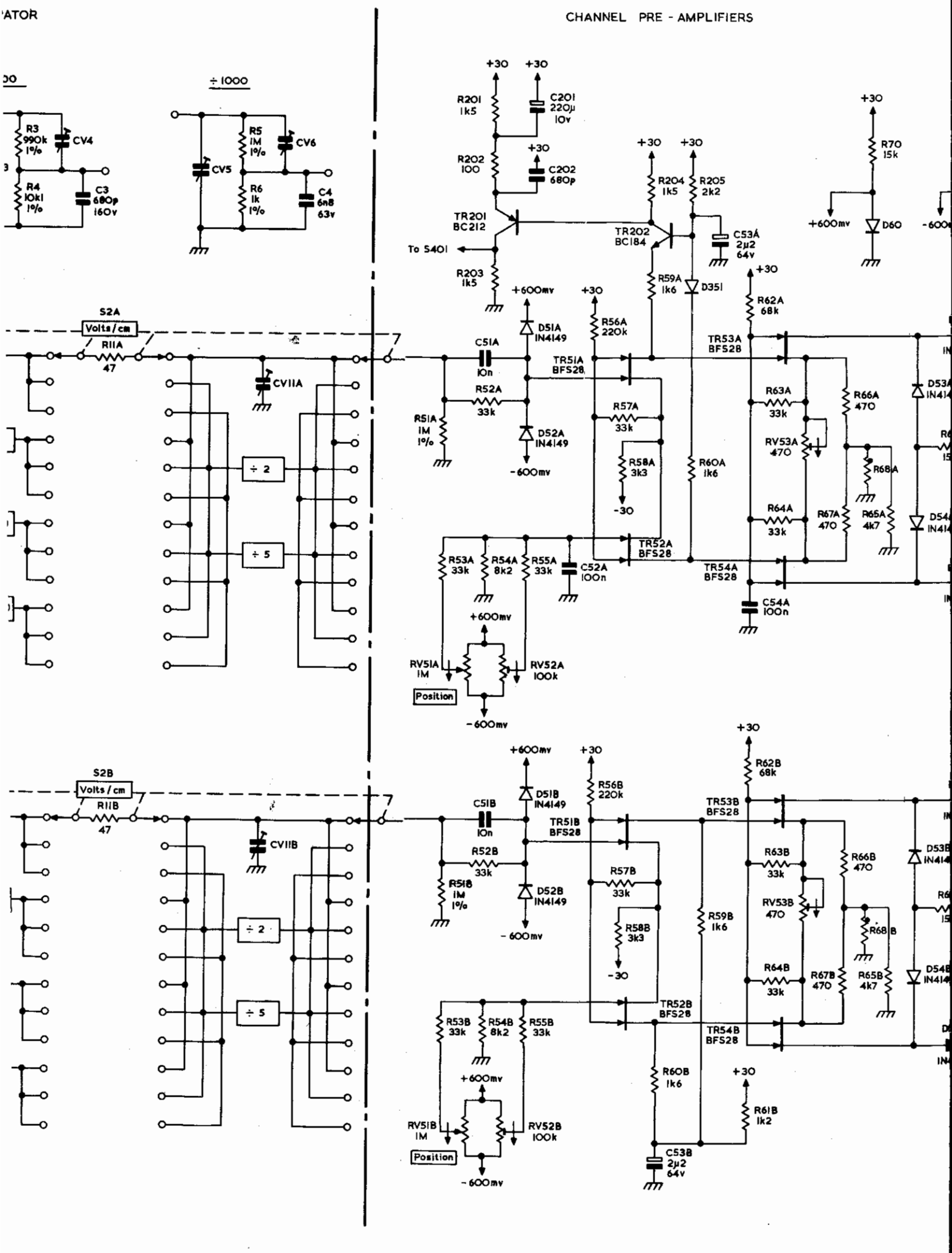
OUTPUT AMPLIFIER

FITTED TO PC3B BOARDS



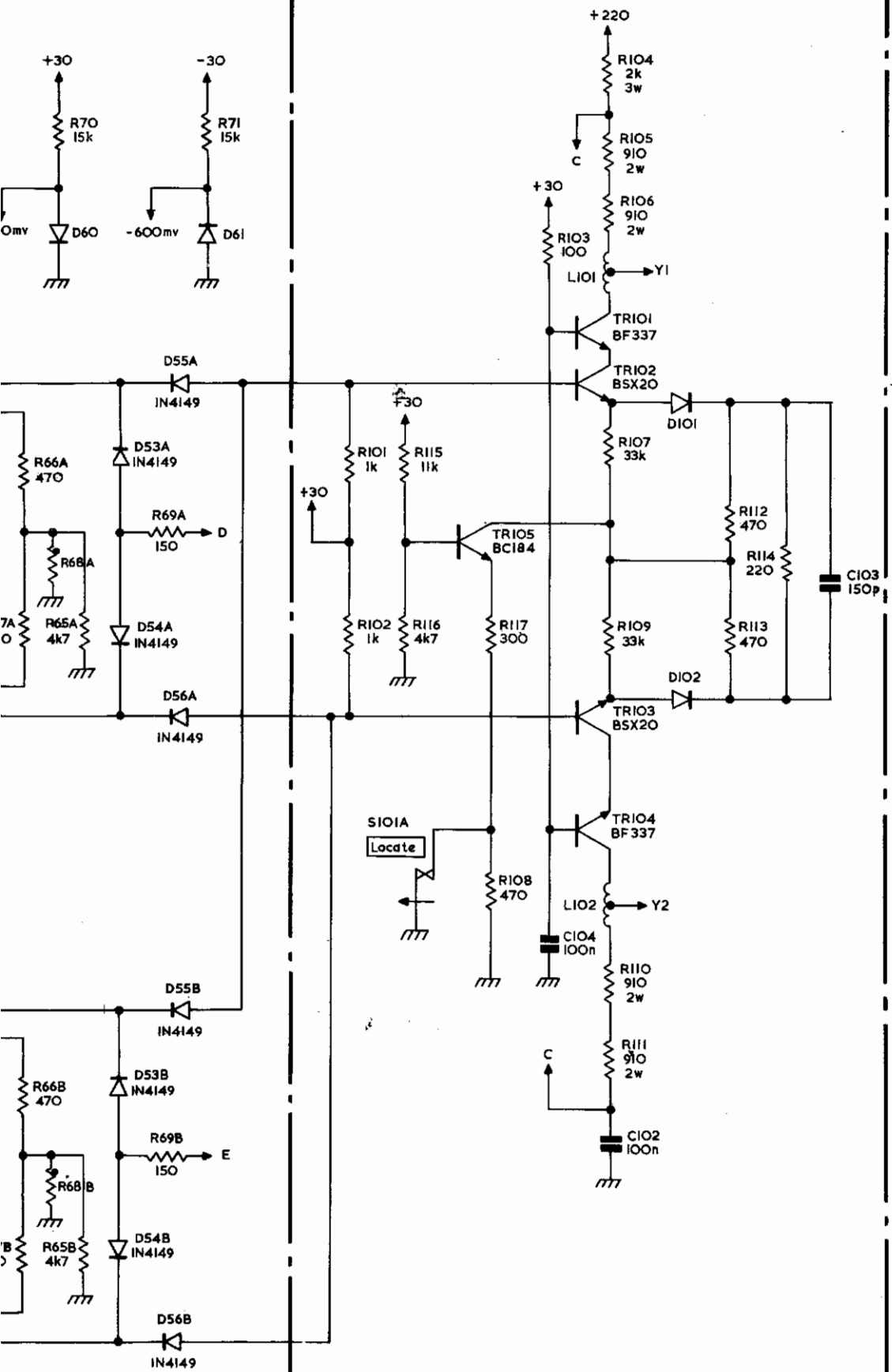
INPUT ATTENUATOR




ATOR
CHANNEL PRE - AMPLIFIERS
÷1000
R3 990k 1%
CV4
R4 10k1 1%
C3 680p 160v
CV5
R5 1M 1%
CV6
R6 1k 1%
C4 6n8 63v
+30
+30
R201 1k5
C201 220µ 10v
R202 100
C202 680p
TR201 BC212
To S401
R203 1k5
TR202 BC184
R204 1k5
R205 2k2
C53A 2µ2 64v
R70 15k
+600mv
D60
R59A 1k6
D351
R62A 68k
S2A
Volts/cm
R11A 47
CV11A
+600mv
D51A IN4149
C51A 10n
R56A 220k
TR51A BFS28
TR53A BFS28
R52A 33k
R57A 33k
R51A 1M 1%
D52A IN4149
-600mv
R63A 33k
R66A 470
RV53A 470
R68A
R58A 3k3
-30
R60A 1k6
R64A 33k
R67A 470
R65A 4k7
÷2
÷5
R53A 33k
R54A 8k2
R55A 33k
C52A 100n
TR52A BFS28
TR54A BFS28
C54A 100n
+600mv
RV51A 1M
RV52A 100k
Position
-600mv
S2B
Volts/cm
R11B 47
CV11B
+600mv
D51B IN4149
C51B 10n
R56B 220k
TR51B BFS28
TR53B BFS28
R62B 68k
R52B 33k
R57B 33k
R51B 1M 1%
D52B IN4149
-600mv
R63B 33k
R66B 470
RV53B 470
R68B
R58B 3k3
-30
R59B 1k6
R64B 33k
R67B 470
R65B 4k7
÷2
÷5
R53B 33k
R54B 8k2
R55B 33k
TR52B BFS28
TR54B BFS28
+600mv
RV51B 1M
RV52B 100k
Position
-600mv
R60B 1k6
+30
R61B 1k2
C53B 2µ2 64v

OUTPUT AMPLIFIER

ALL RESISTOR VALUES IN OHMS ±5%
ALL TRIMMER RESISTORS ·1W LINEAR
ALL CAPACITOR VALUES IN FARADS 25
ALL TRIMMER CAPACITORS 6-25p
BFS28 TRANSISTORS FITTED AS MATCH
ALL DIODES IN4148 UNLESS OTHERWIS



BEAM SWITCH B1 – STA

ALL RESISTOR VALUES IN OHMS ±5% 1/2W UNLESS OTHERWISE INDICATED

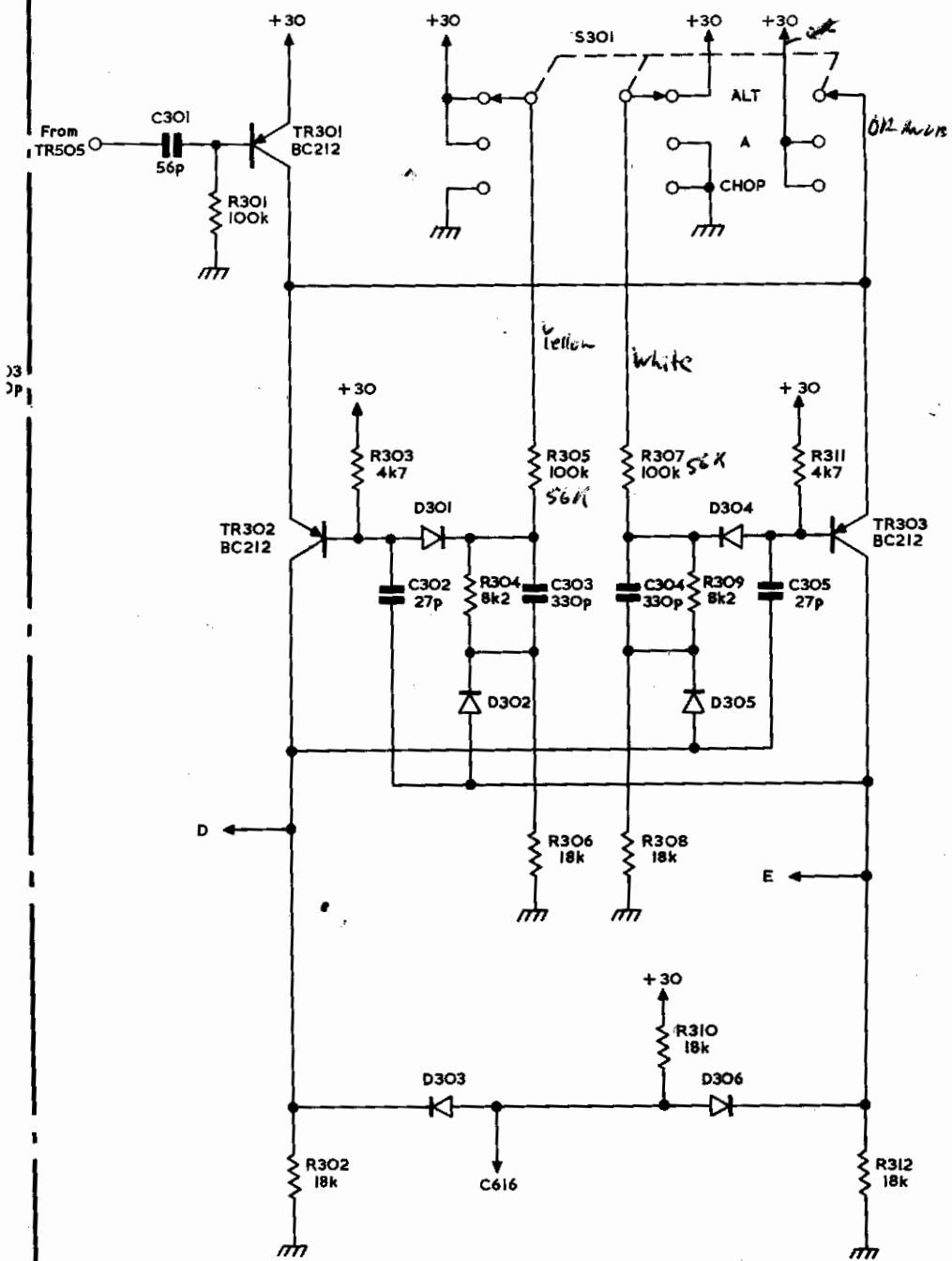
ALL TRIMMER RESISTORS 1W LINEAR LAW

ALL CAPACITOR VALUES IN FARADS 250V WORKING UNLESS OTHERWISE INDICATED

ALL TRIMMER CAPACITORS 6-25p

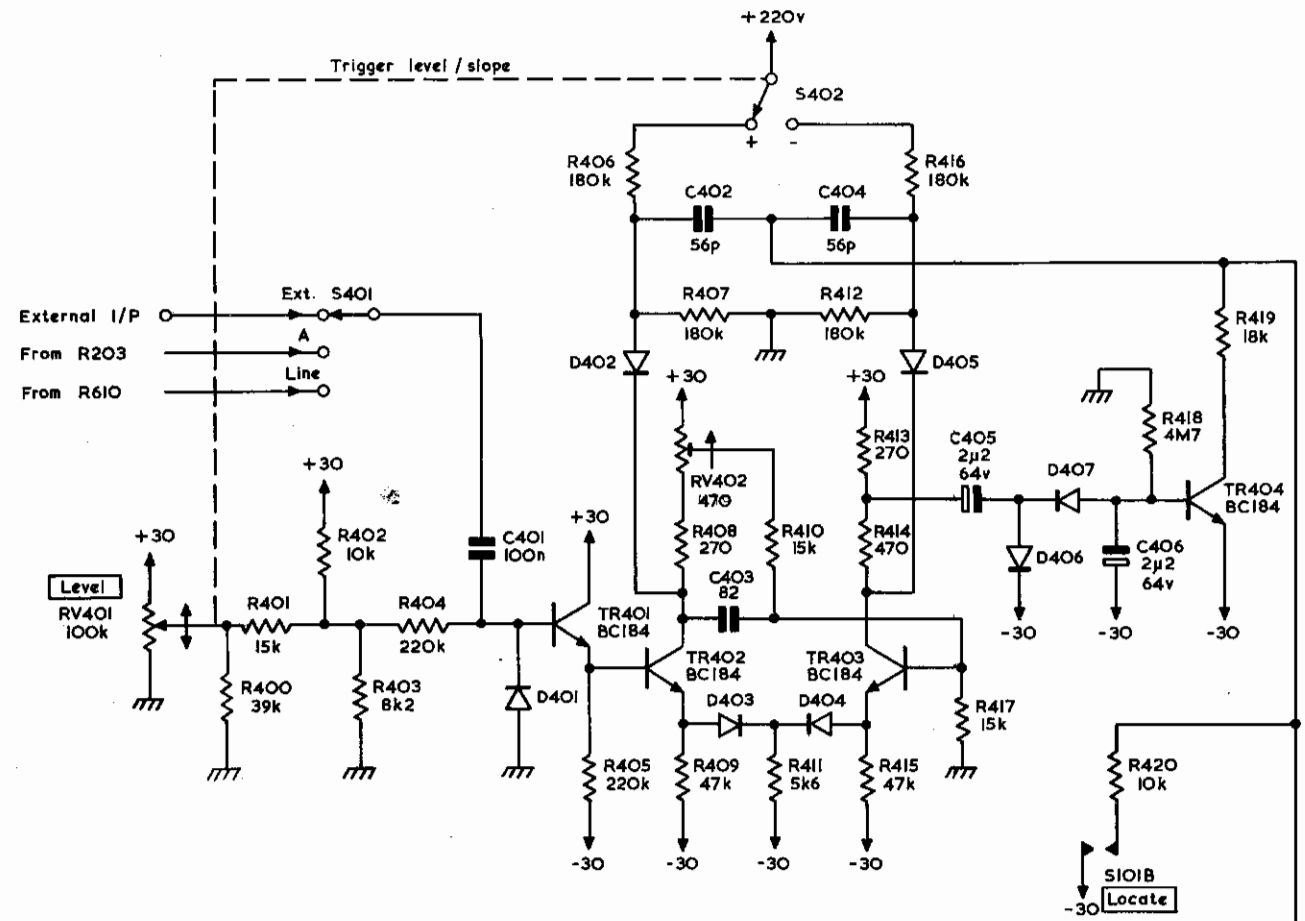
BFS28 TRANSISTORS FITTED AS MATCHED PAIRS eg. TR51 - TR52

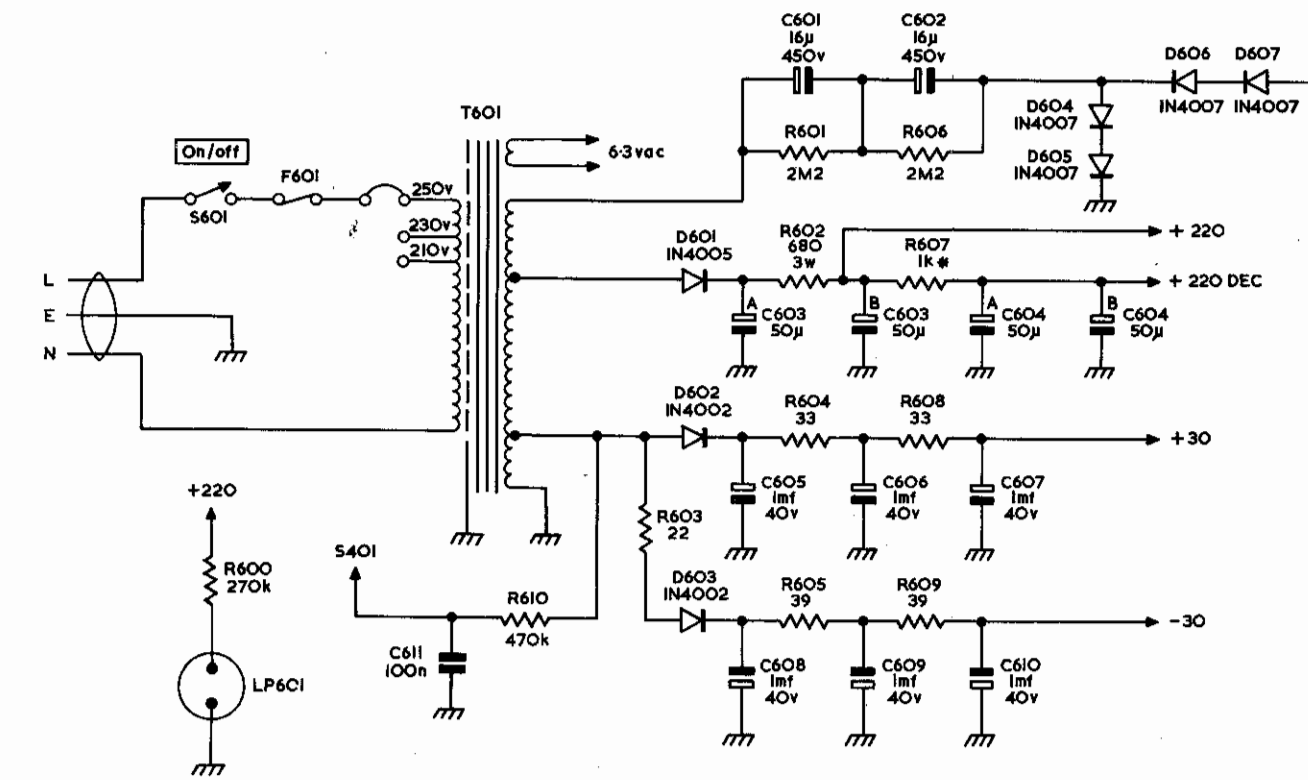
ALL DIODES IN4148 UNLESS OTHERWISE INDICATED



BEAM SWITCH BI - STABLE

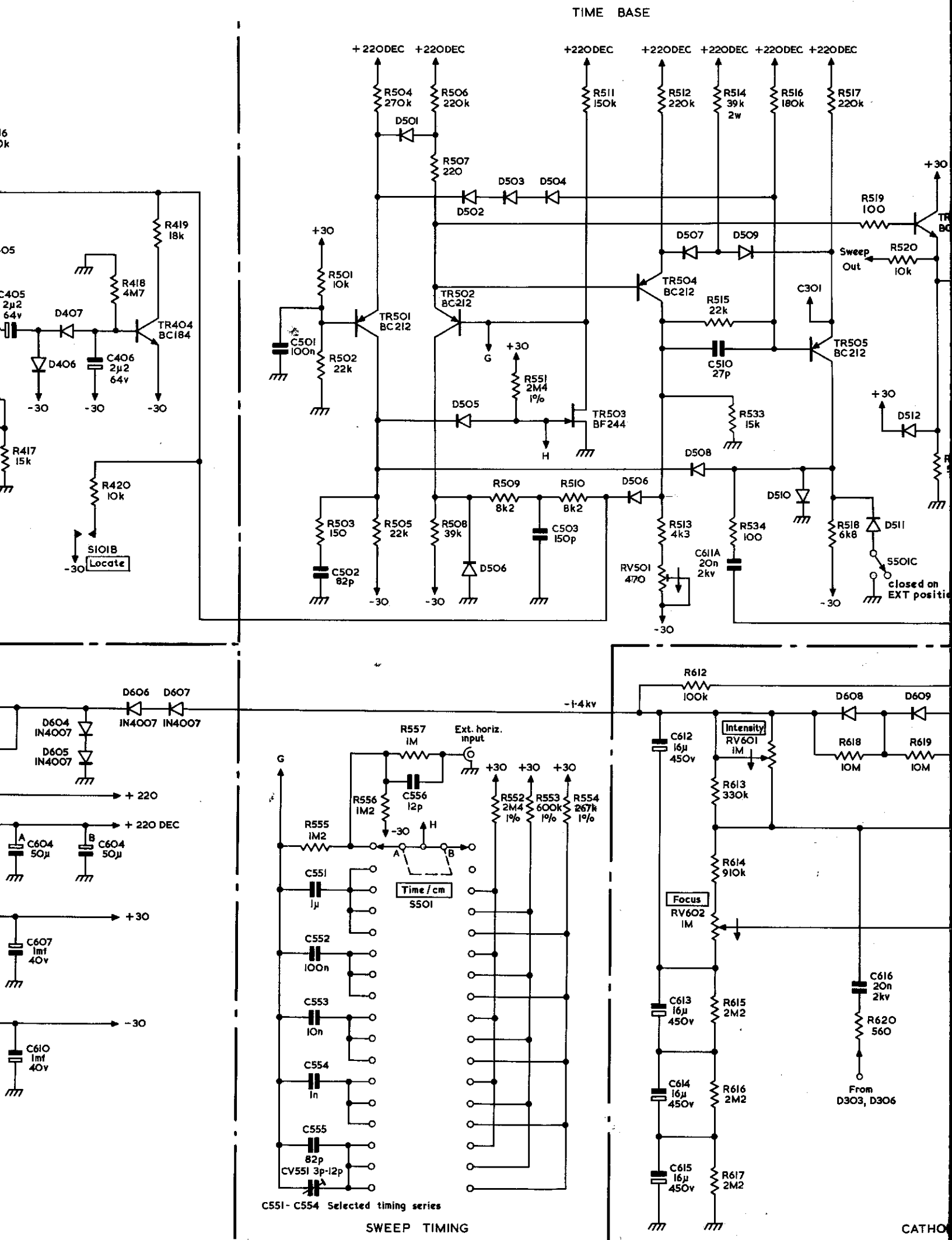
TRIGGER STAGE



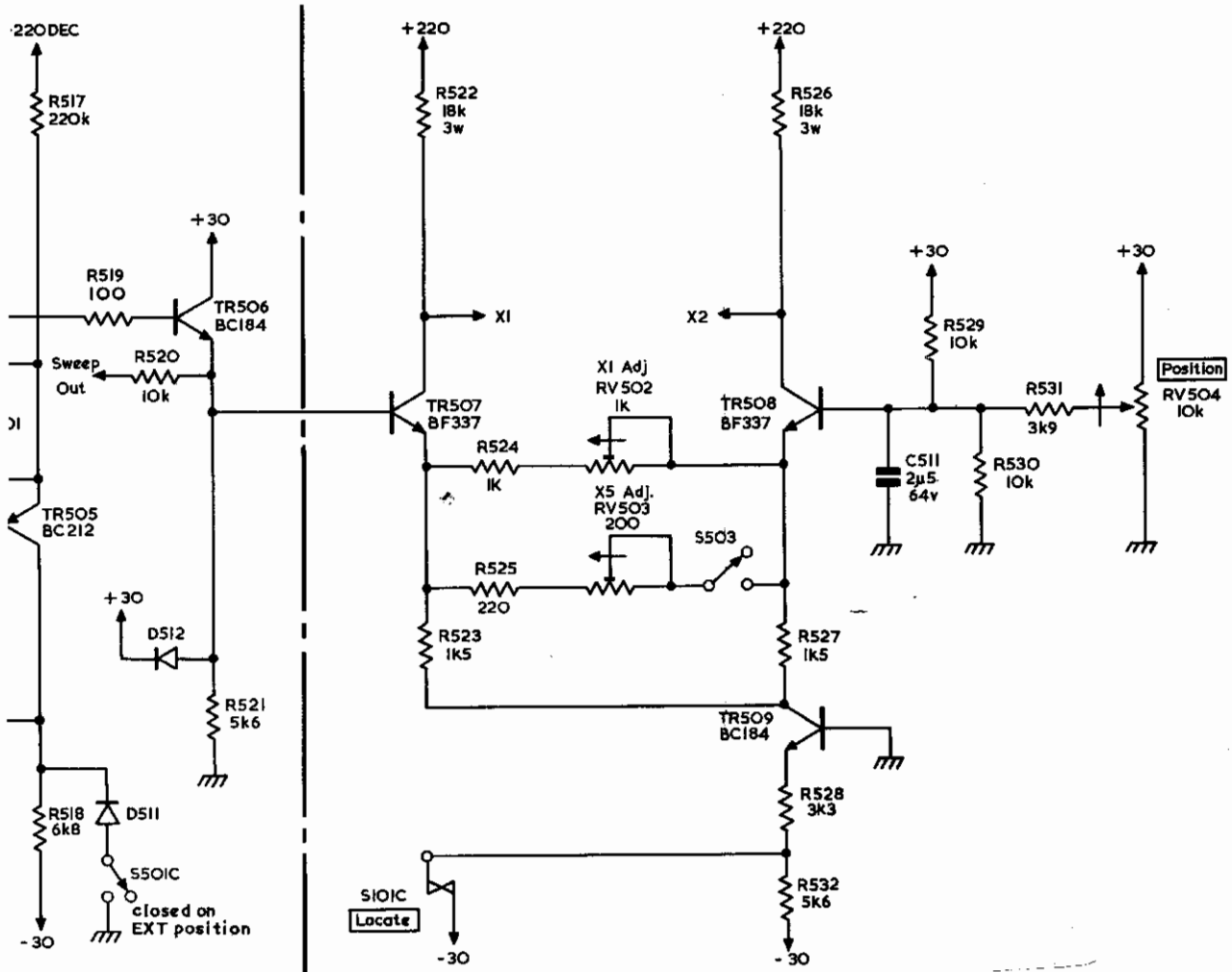


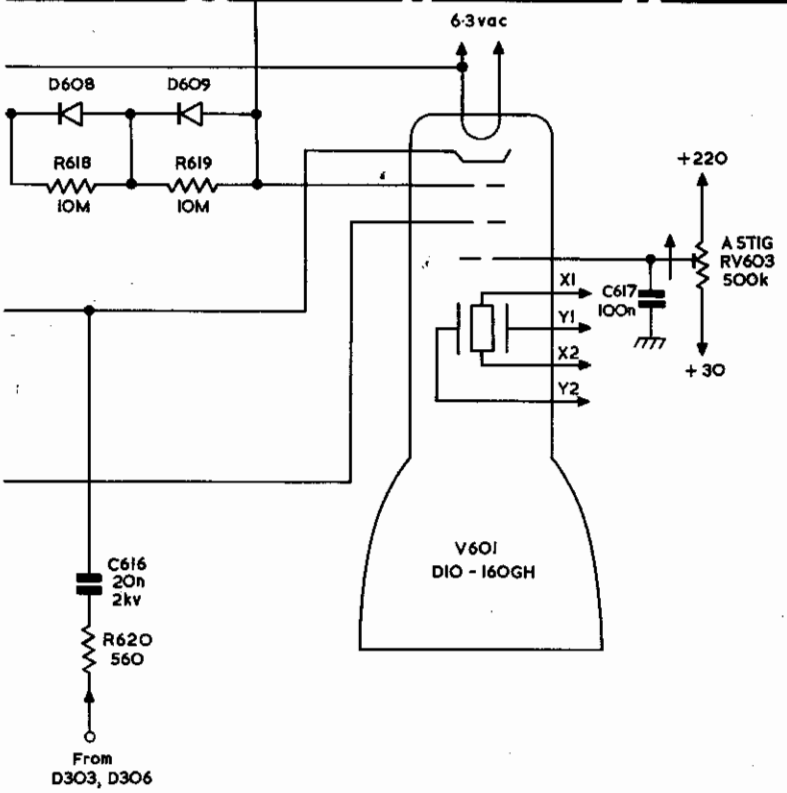
* 2K FITTED TO SOME MODELS

POWER SUPPLY


TIME BASE
+220DEC
R504 270k
R506 220k
R511 150k
R512 220k
R514 39k 2w
R516 180k
R517 220k
D501
R507 220
D502
D503
D504
R519 100
+30
D507
D509
Sweep Out
R520 10k
R501 10k
TR501 BC212
TR502 BC212
TR504 BC212
TR505 BC212
C501 100n
R502 22k
G
H
R551 2M4 1%
TR503 BF244
D505
R515 22k
C301
C510 27p
R533 15k
D512
D508
R509 8k2
R510 8k2
D506
R503 150
R505 22k
R508 39k
C503 150p
C502 82p
D510
R513 4k3
R534 100
R518 6k8
D511
S501C
closed on EXT positi
RV501 470
C611A 20n 2kv
-30
R419 18k
R418 4M7
C405 2µ2 64v
D407
TR404 BC184
D406
C406 2µ2 64v
R417 15k
R420 10k
S101B
Locate
D606
D607
IN4007
D604 IN4007
D605 IN4007
+220
+220 DEC
C604 50µ
C607 1mf 40v
C610 1mf 40v
-1·4kv
R612 100k
D608
D609
R557 1M
Ext. horiz. input
R556 1M2
C556 12p
R555 1M2
R552 2M4 1%
R553 600k 1%
R554 267k 1%
C551 1µ
C552 100n
C553 10n
C554 1n
C555 82p
CV551 3p-12p
Time/cm S501
C551 - C554 Selected timing series
SWEEP TIMING
C612 16µ 450v
Intensity RV601 1M
R618 10M
R619 10M
R613 330k
R614 910k
Focus RV602 1M
C613 16µ 450v
C614 16µ 450v
C615 16µ 450v
R615 2M2
R616 2M2
R617 2M2
C616 20n 2kv
R620 560
From D303, D306
CATHO

OUTPUT AMPLIFIER

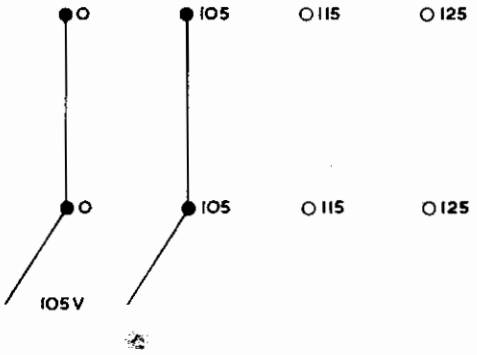




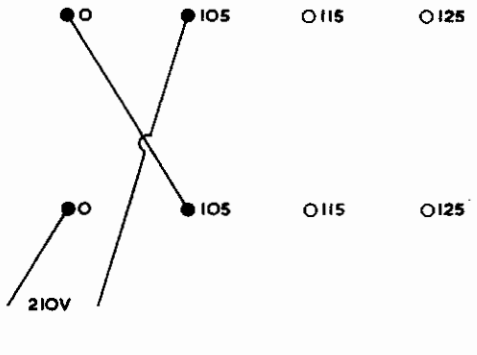
ALL RESISTOR VALUES IN OHMS ± 5% ½W UNLESS OTHERWISE INDICA
ALL TRIMMER RESISTORS ·1W LINEAR LAW
ALL CAPACITOR VALUES IN FARADS 250V WORKING UNLESS OTHERWISE
ALL DIODES IN914 UNLESS OTHERWISE INDICATED

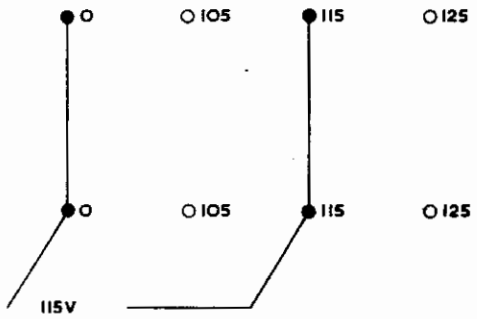
CATHODE RAY TUBE SUPPLIES

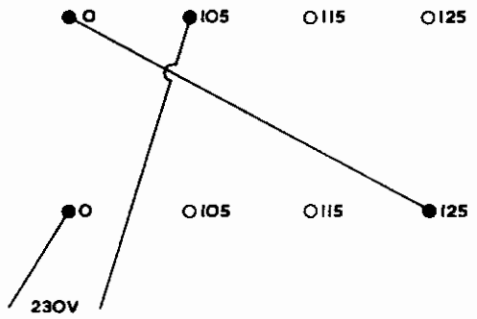
PARALLEL OPERATION
105 - 125V

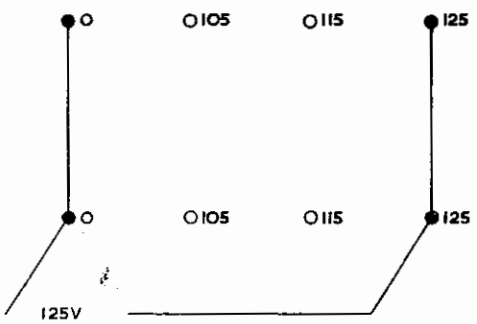


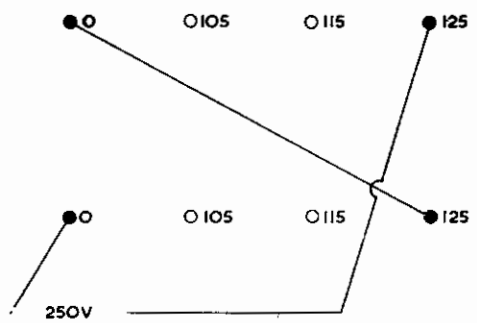
SERIES OPERATION
210 - 250V











TRANSFORMER CONNECTIONS