

# **Scopex**

## **4D10A**

### **Dual Trace Oscilloscope**

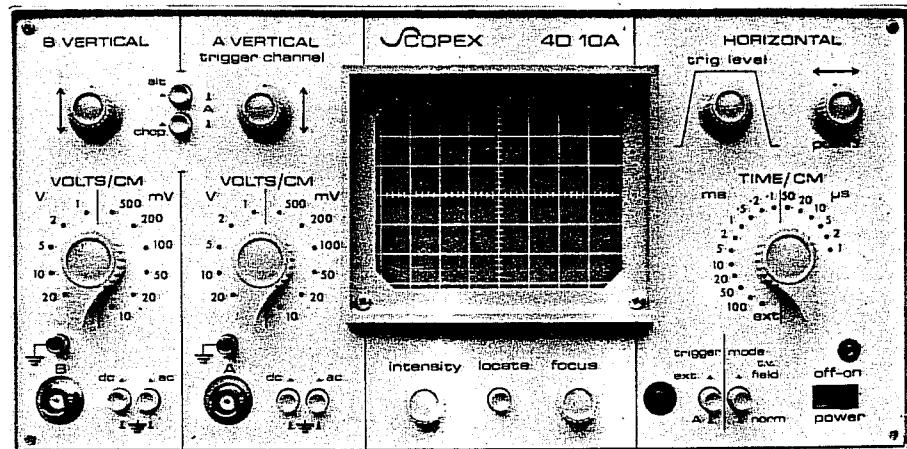
West Mall Engineers - WME

# SCOPEX 4D10A

## CONTENTS

### Page

2	Specification
3	First time operation
4	Function of controls
6	Circuit description
9	Calibration
	Vertical amplifier circuits
	Horizontal & power supply circuits



SCOPEX is the registered trade mark of:

Scopex Instruments Limited

Pixmore Industrial Estate,

Pixmore Avenue,

Letchworth, SG6 1JJ

Telephone: Letchworth 72771

West Mall Engineers - WME

## A &amp; B Vertical

Sensitivity $\pm 3\%$	10mV/cm - 50V/cm (12 calibrated ranges)
Bandwidth to -3dB points	
DC coupled	DC - $>10\text{MHz}$
AC coupled	$<3\text{Hz} - >10\text{MHz}$
Risetime (calculated)	35nS approx.
Overload protection	Max. 400V (DC + peak AC to 3KHz)
Input impedance	$1\text{M}\Omega \pm 3\%$ and 33 pF approx.
Modes	"A" Channel only
	ALT.
	CHOP. (approx. 100KHz)

## Horizontal

Sweep Speeds $\pm 3\%$	$1\mu\text{S/cm} - 100\text{mS/cm}$ (16 calibrated ranges)
Magnifier $\pm 5\%$	5 times
External sensitivity	1V/cm approx. (200mV/cm magnified)
External bandwidth	DC - 500 KHz
External input impedance	$1\text{M}\Omega \pm 5\%$ and 20pF approx.
Max. external input	250V (DC + peak AC to 1KHz)

## Trigger Circuit

Trigger Source	External - Internal from "A" Channel
Trigger Mode	Normal - T.V. frame
Sensitivity. Internal	5mm minimum 10Hz - 1MHz rising to 1.5 cm at 10MHz
External	300mV peak to peak 30Hz - 5MHz
	600mV peak to peak 10Hz - 10MHz
Input impedance	220K $\Omega$ approx. and 20pF approx.
Max. input	250V. (DC + peak AC to 1KHz)

## General

Display size	Graticule ruled 6cm x 8cm
Power requirements	210 - 250VAC. 48 - 60 Hz. 25 VA approx.
Dimensions (excluding handle)	H 155mm. W 310mm. D 370mm.
Weight	5 KG.
Max. Ambient operating temperature	+40°C.

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

West Mall Engineers - WME

## 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 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.

Depress AC button on "A" channel AC-G-DC switch

NB: This type of switch has three positions -  
Either of the buttons depressed

or

Both buttons out

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 for optimum definition.

## 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 "B" channel 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 only 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.

## Auto Trigger Disable

Linking the two pins to the rear of TR404 disables the auto trigger. This may prove useful on applications involving sweep repetitions of less than 5 per second.

## AC-G-DC Switch

In the ground position "G", 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 off 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  $1\mu$  second & horizontal X5 switch OUT, the true time calibration is  $\frac{1}{5} = .2\mu$  sec/cm)

## External-A 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.

## Normal - T.V. Field

For all applications other than examining T.V. video signals at frame rate use the NORMAL mode. This includes triggering from T.V. line sync pulses.

When the button is depressed a passive integrator circuit is introduced which enables the timebase to be triggered from the frame sync block in video waveform. The TRIGGER LEVEL control should be on the positive edge for positive sync and on the negative edge for negative sync.

## 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 approx. 10 volts symmetrical about ground and of the same duration as the timebase sweep.

## Circuit Description

## Vertical Amplifiers

The following description applies to both amplifiers. The signal input passes to the attenuator which 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 source followers TR51 and TR52.

The first stage amplifier comprises TR53, TR54 in a long-tailed pair. The collector supply in "A" channel is provided by the trigger amplifier TR201, TR202. "B" channel is supplied by R60B decoupled by C54B.

The collector currents of TR53 & TR54 flow into the grounded base stages TR201 & TR202 where the variations produce an amplified signal without loading the output of TR53, TR54. The signal produced is further amplified by TR203, TR204 and supplied to the TRIGGER SOURCE switch S401. The signal developed at the collectors of TR53, TR54 is further amplified by another long-tailed pair TR55, TR56. The variable resistor RV53 between the emitters permits the gain of the amplifier to be adjusted. When the channel is being displayed the shunt diodes D54, D55 are turned off and the series diodes D53, D56 conduct connecting the collectors of TR55, TR56 to the load resistors R101, R102. To switch the stage off, the shunt diodes are made to conduct by the switching multivibrator thus elevating the cathodes of the series diodes more positive than their anodes.

The output stage consists of balanced cascade amplifiers with filters L101, L102 in the collector loads to improve the high frequency performance.

## Beamswitch

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

In the "A" only mode, R309 is returned to 0V ensuring TR303 is bottomed and R306 is returned to + 20V ensuring TR302 is always turned off. The CHOP mode returns both R306 and R309 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. To facilitate triggering from the frame block of a television video waveform a low pass filter R405, C401 can be placed in the signal path by S402. 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 R414 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 + 10V. 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 + 10V 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 C403 and C405 to the sweep generator. The resistors R409 and R415 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 to conduct by applying a forward bias from the + 200V rail will it allow the signal to pass to the timebase, S403 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 C407 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 biased such that its drain is at approx. +18.5V. 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 biased such that TR504 takes the current supplied by R516. Under this condition the collector to TR504 is at 0V holding the base of TR505 approximately 1V more positive than the base of TR504. This potential is set by D508. The collector of TR505 is approximately -16V and D503 is turned off. The collector of TR502 is negative with respect to earth and D505 is conducting.

A negative going trigger signal applied to the cathode of D505 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 R516. The collector of TR505 rises turning on D503, this positive going signal is also used to unblank the Cathode Ray Tube. D502 is now reverse biased and the Miller Stage is free to run down at a rate determined by the timing capacitors C552 to C556 and the timing resistors R554 to R557. During the run down period D501 is turned off and TR502 conducts all the current supplied by R505 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 bistable TR504, TR505 switches back to its quiescent state. The collector of TR505 falls to approximately -16V blanking the Cathode Ray Tube and turning off D503. The current supplied by R507 now flows through D502 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 D502 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 D505 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 D505 to pass a trigger signal. The output from the timebase 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 R532 and RV502 which controls the amount of coupling between the emitters of TR507 and TR508. A further gain control R533 and RV503 can be switched in parallel by operating the Magnifier switch S503 when the gain is increased by a factor of 5.

#### Power supplies

The power supplies are all regulated so that the instrument is unaffected by mains supply variations. The E.H.T. supply produced by the voltage doubler D661-D664 C661-C667 is regulated by the zener diode chain D665 to D672 from which the various Cathode Ray Tube operating potentials are tapped off. The low voltage supplies are referenced to the + 20 supply which employs conventional feed-back stabilisation. The + 20V output is compared with the zener diode D642 by TR641. The -20V supply is stabilised by TR621 which compares the output against the + 20V supply. The + 200V supply is stabilised by TR603 by comparing the output against the + 20V supply. The output voltages of both the + 200V and -20V supplies are set by precision resistor chains and require no other adjustment. All the power supplies are protected against overload by fusible resistors R601, R622, R642.

#### 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. Should recalibration become desirable all the necessary highly accurate signals are provided by the SCOPEX SC1 oscilloscope calibrator.

#### Removal of Covers

The top cover can 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 100K $\Omega$ .

## Vertical Amplifier Sensitivity and Position Centre

Using the  $50\Omega$  terminated lead connect the 40mV square wave output from the SC1 calibrator to "A" channel input socket connect the "Time mark" output to the "ext trig" socket. Select 1mS on the SC1 and 10mV/cm DC coupling, ext trig on the 4D10A, now adjust RV53A to give exactly 4cms between the top and bottom flat portions of the waveform.

Return the vertical position control to precisely mid range and with the AC-G-DC switch at G, adjust RV52 such that the trace lies along the centre line of the graticule.

Now repeat the above procedure for "B" channel.

### 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 shorting link should be left connected if the trigger sensitivity is to be adjusted.

### Trigger Sensitivity RV402

Apply a sine wave signal of 1 KHz simultaneously to "A" channel input socket and the ext. trig. socket. With the VOLTS/cm switch set to 100mV adjust the amplitude of the signal to give 5cms and obtain a locked display.

Now adjust RV402 such that by rotating the Trig level control over the + slope sector it is only possible to trigger from the top 2.2cms of the displayed waveform.

### Sweep Timing

Using an unterminated  $50\Omega$  lead, connect the 500mV time marks from the SC1 calibrator to "A" channel input socket. Select 1mS on the SC1 and set the 4D10A controls as follows: DC coupling, 200mV/cm, 1mS/cm and trig level adjusted to give a locked display. Now adjust RV502 to give one mark every cm. Now pull the X5 magnifier and adjust RV503 to give one mark every 5cms. Select  $1\mu$  S/cm and apply 1 $\mu$ s time marks and adjust CV501 located behind the TIME/cm switch to give one mark per cm. Return through all the ranges to check that they remain within specification.

## Attenuator Compensation

When adjusting any trimmers listed in this section, they should be set to give a flat top and square corner to the displayed waveform.

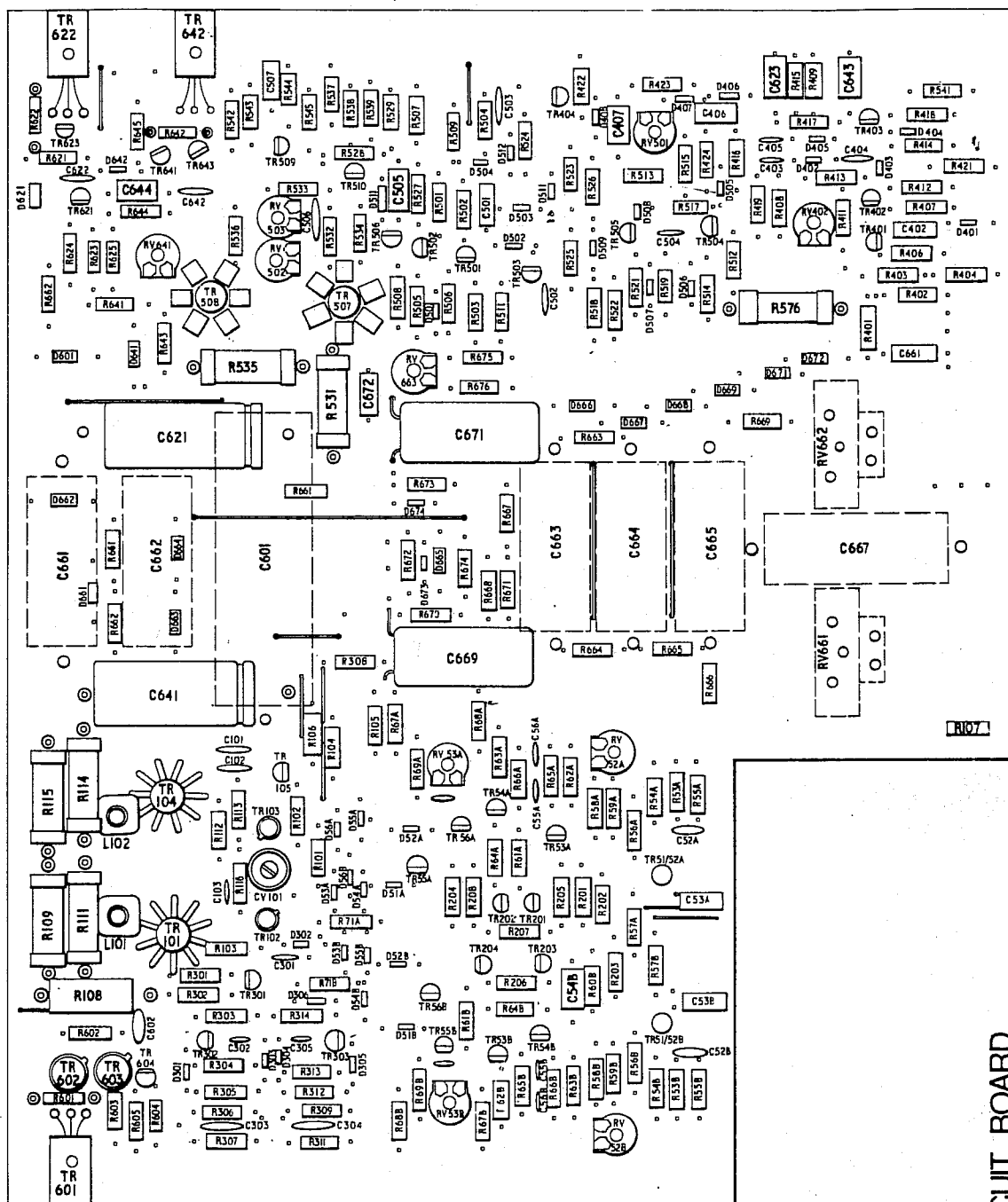
Connect the H1 head directly to the "input sockets" of the 4D10A. DO NOT USE ANY LEADS. Connect the trigger signal from the SC1 directly to the EXT TRIG socket of the 4D10A. Set the 4D10A controls as follows:

"A" Channel DC coupled, 10mV/cm, 1mS/cm, EXT TRIG and on the H1 head, 10mV/cm and "set ratio". Now obtain a locked display, and adjust CV10A on the 4D10A. Select "set input" and adjust the trimmer on the side of the H1 head. The following table gives the correct sequence and appropriate control settings. The VOLTS/cm switch on the 4D10A and the VOLTS/cm range switch on the SC1 should always be set to the same position. The "set ratio" should be adjusted first followed by "set input".

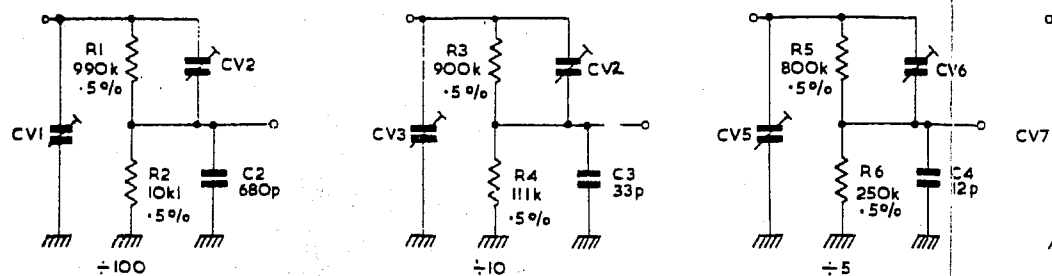
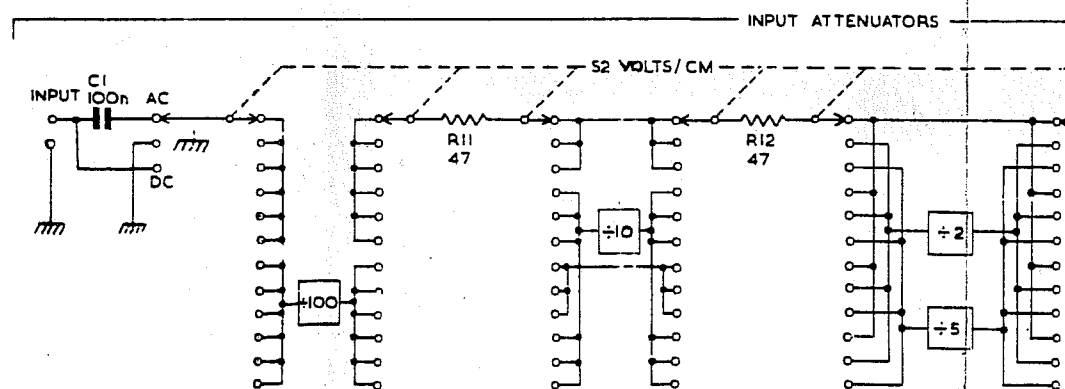
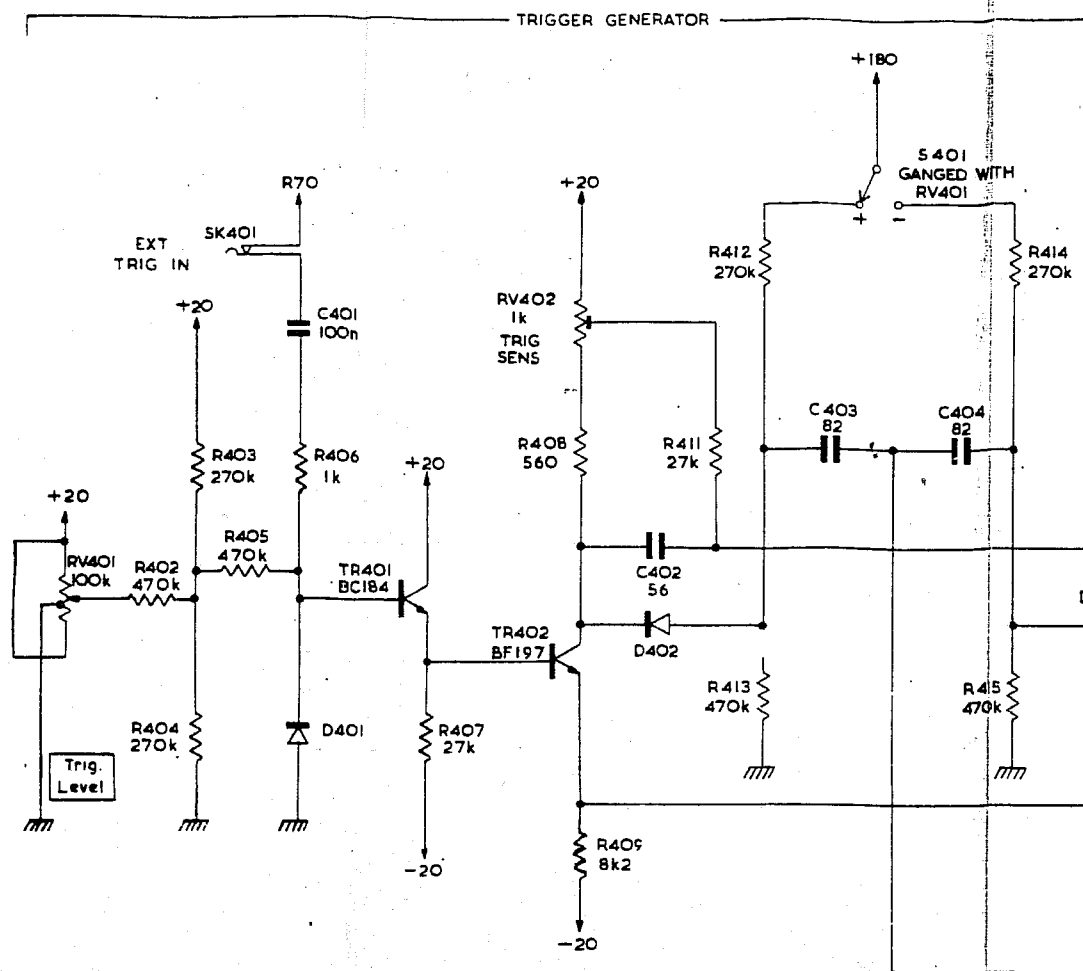
<u>VOLTS/CM SWITCH</u>	<u>HEIGHT OF WAVEFORM</u>	<u>SET RATIO</u>	<u>SET INPUT</u>
10mV	4 divisions	CV10A	CV9A
20mV	4 divisions	CV8A	CV7A
50mV	4 divisions	CV6A	CV5A
100mV	4 divisions	CV4A	CV3A
1V	4 divisions	CV2A	CV1A

All other ranges should now be checked to see that they are correct.

Transfer the H1 head to "B" channel input, select ALT and repeat the above procedure for "B" channel attenuator.



MAIN PRINTED CIRCUIT BOARD



ALL RESISTOR VALUES IN OHMS  $\frac{1}{2}$  W 5%  
 ALL CAPACITOR VALUES IN pF  
 ALL DIODES IN4148  
 ALL PRESET POTENTIOMETERS 1W LINEAR  
 ALL TRIMMER CAPACITORS 6-30pF

UNLESS OTHERWISE STATED











