9386
25MHz Dual Trace Oscilloscope
Technical Manual

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Technical manual

9386
25 MHz Dual Trace Oscilloscope

RACAL
THE ELECTRONICS GROUP

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Operating Instructions

Single Trace Operation

Plug into mains supply.

Set controls as shown on front cover photograph (all push buttons out, Trig Level and Horizontal Position controls pushed in, all pointer knobs as near vertical as possible).

Switch on and check red power light is illuminated.

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. Pulling the control out disables the "free run" facility which is essential when triggering to pulses lower than 30Hz repetition frequency.

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 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 40cms 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 1μS and horizontal X5 switch OUT, the true time calibration is $\frac{1}{5}$ = .2μS/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

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the mains supply, normally 50Hz in the UK.

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, approximately symmetrical about ground and of the same duration as the timebase sweep. Output impedance is 10KΩ approximately.

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 input attenuator either direct or through capacitor C1 depending on the coupling selected by S101. The VOLTS/cm switch S102 selects or bypasses the four frequency compensated attenuators such that the signal is reduced to a level suitable for the amplifier. The output from the VOLTS/cm switch passes through X 0.9 attenuator to the input amplifier TR101. This further attenuator ensures that there is a sufficiently high impedance in series with TR101 gate to prevent damage when the device avalanches with excessive inputs.

The vertical amplifier consists of three balanced cascode amplifiers in cascade with frequency compensation in their emitter circuits. The first is a hairpin cascode which is driven from the low impedance outputs at the sources of TR101, TR102. The grounded base amplifiers TR151, TR152 of the second stage together with R151, R152 correctly terminates the output of the delay line. The low impedance at the input of the delay line provides a suitable point at which the "A" and "B" channels can be combined. The diode gates formed by D105-D108 controlled by the bistable TR302, TR303 determine which of the two channel pre-amplifiers is connected to the output stage. The collector supply for the grounded base stages TR105, TR106 of the first cascode amplifier in "A" channel is provided by two further grounded base stages TR201, TR202 which provide isolation of the trigger amplifier

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from the channel amplifier. The output from TR201, TR202 is further amplified by TR203 and TR204.

The emitter follower TR205 provides a low impedance output for the signal appearing at the collector of TR205. This signal is used for the internal trigger mode.

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 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 100 KHz. 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 TRIG SOURCE switch S401. This signal is superimposed on a DC level determined by the setting of the TRIG LEVEL control RV401. The X 0.9 attenuator formed by R404, R405 C403 ensures that there is a sufficiently high impedance in series with TR401a gate to prevent damage when TR401 avalanches on excessive signal inputs. The signal from the source of TR401a is applied to the long tailed pair TR402, TR403. Diodes D403, D404, D405, D406 controlled by S402 determine which of the two collectors will be connected to the tunnel diode stage.

Tunnel diodes exhibit a unique characteristic as shown in Fig. 1.

Increasing the current through the device in the forward direction from zero results in a potential difference which increases up to point C. Any further increase in current causes the potential difference across the device to change rapidly to the much higher value at E, this change occurs in approximately 1nS. Any further increase in current results in a gradual increase of potential difference.

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Reducing the current causes the potential difference to fall until point D is reached whereupon any further decrease causes the potential difference to fall rapidly to point B. The current at point C is extremely stable thus the division of current in TR402 and TR403 which is determined by both the input signal and the TRIG LEVEL bias can be adjusted such that the tunnel diode will switch at any desired point of the input signal.

The negative going signal which appears across the tunnel diode D407 when it switches to its high state causes TR404 to discharge C406 into the primary of T501 which produces a very sharp negative going pulse across its secondary. The signal appearing at the emitter of TR404 is amplified by TR405 and produces positive going pulses across R419.

When there are no trigger pulses the monostable TR406 TR408 remains in its quiescent state with TR406 turned off. The current in R421 turns off TR407 thus allowing its collector volts to fall which in turn causes the timebase to free run. When the trigger stage produces trigger pulses, the pulses appearing across R419 cause the monostable to switch, the potential at the collector of TR406 falls and in turn TR407 bottoms, this biasses the timebase such that it will only run when triggered. Pulling the trigger control closes S403 which prevents the timebase free running even when there are no trigger signals.

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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. +18.5V. Should it attempt to rise higher, the base of TR502 will go positive. The corresponding postive 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 TR505, TR506 is biassed such that TR505 takes the current supplied by R528. Under this condition the collector of TR505 is at 0V holding the base TR506 approximately 1V more positive than the base of TR505. The collector of TR506 is approximately -16V and D506 is turned off. The collector of TR502 is at earth and D508 is just conducting.

A negative going trigger signal applied to the cathode of D508 causes it to conduct taking the collector of TR505 negative. By cumulative action the circuit switches so that TR506 now takes all the current supplied by R528. The collector of TR506 rises turning on D506, this positive going signal is 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 C503 to C507 and the timing resistors R501 to R506.

During the run down period D501 is turned off and TR502 conducts all the current supplied by R513 thus elevating its collector.

The run down continues until the base of TR505 becomes more negative than the base of TR506 whereupon the sweep gate multivibrator switches back to its quiescent state. The collector of TR506 falls to approximately -16V blanking the cathode ray tube and turning off D506. The current supplied by R511 now flows through D505 to the gate of TR503 causing it to turn off. The current supplied by R518 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 the collector of TR502 goes positive charging C701 through D701. TR701 turns on and TR702 turns off and its collector goes positive to approx. +6V. The emitter follower TR504 reverse biasses D508 thus preventing any further trigger pulses passing to the time base. The collector of TR502 remains positive until the drain of TR503 resets to start level when TR502 collector goes negative turning off D701. C701 now charges negatively through R701 until it reaches a potential when TR701 turns off causing TR702 to turn on. The collector of TR702 can either fall to a negative potential when the time base will free run or be caught by D702 when the time base will only run when triggered.

The output from the time base is applied via the emitter follower TR507 and D515 to one input of the long tailed pair TR508 TR509 and the shift voltage from RV504 via TR511 to the other input. The gain of the stage is determined by R541 and RV503 which controls the amount of coupling between the emitters of TR508 and TR509. A further gain control R542 and RV502 can be switched in parallel by operating the magnifier switch S503 when the gain is increased by factor 5.

The fast edge of the unblank signal from the timebase is coupled by C618 whilst the DC component is provided by the optically coupled isolator and its output amplifier TR602. During the sweep the collector current of TR506 flows through the light emitting diode of the optically coupled isolator causing the light sensitive transistor to conduct turning on TR602.

The supplies for the cathode ray tube are provided by an overwind on the mains transformer. The output from the voltage doubler formed by C601-606 and D601-604 is stabilised by the zener diode chain D619-624 to provide the gun volts. The final anode supply is provided by the voltage septupler C607-612 D605-616. The final anode voltage has little effect on the sensitivity of the C.R.T. and thus no effort is made to stabilise it.

The +110V rail is obtained by stabilising the output of the half wave circuit D641, C640a, C640b.

A sample of the output from network R768, R769, RV761 is compared against the reference provided by D761, D762 by TR761 which in turn controls the Darlington pair TR762, TR763. Transistor TR764 reduces damage caused by accidental shorts.

The output of D661, D662 and C661 is stabilised to provide the +20V rail. The voltage at the slider of RV661 is compared with that of the reference diode D663 by TR661 causing its collector voltage to vary so that the output voltage is maintained at +20V, TR664 gives overcurrent protection for TR662, TR663.

The -20V rail is obtained by stabilising the output of D681 D682 C681. The output voltage is compared against the +20 rail by TR681 whose collector

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volts vary to keep the output voltage constant. TR684 provides overcurrent protection.

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. Allow the instrument 20 minutes to stabilise before calibrating

Should you have to return the instrument for service PLEASE do not return accessories unless you believe they are faulty.

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 Ω.

Low Voltage Supplies

The +20V supply sets the accuracy of the instrument and should only be set using a digital voltmeter of 1% accuracy or better. With the +20V supply set, the -20V supply should lie between -19.8 to -20.2. The 110V supply should be adjusted to approx. 115V. Final adjustment follows later. Early instruments do not have an adjustable 115V supply.

High Voltage Supplies

The gun volts for the cathode ray tube can be checked at the junction of C615, D619 and should be between 1060V and 1160V.

The final anode supply can be measured at the top of the rear panel printed circuit board. This supply has a very high impedance and can only be measured at all accurately using an electrostatic voltmeter. The value will vary depending upon the intensity setting and mains input voltage but should lie between 4KV and 5KV.

Cathode Ray Tube Controls

Before recalibrating the instrument it is essential to correctly set the ASTIGMATISM and GEOMETRY controls as these have considerable effect on the cathode ray tube deflection sensitivities.

To adjust the ASTIG, apply a 10KHz approx. signal to "A" channel and obtain a locked display of about 6 cycles 6 cms. high, now select ALT with "B" channel grounded and its position on the centre line. The ASTIGMATISM and FOCUS controls should be adjusted together to obtain the sharpest possible display of the horizontal and vertical lines.

In order to adjust the GEOMETRY control with the above signal applied, select a single trace display and approximately 1µS/cm sweep speed so that a raster is produced. The GEOMETRY control should now be adjusted to obtain the squarest and straightest edges to sides, top and bottom of this raster. If the GEOMETRY control has been reset the FOCUS and ASTIG should be rechecked.

Trigger Threshold

Pull out the TRIGGER LEVEL control and turn fully clockwise to stop the timebase running. Measure the voltage on the collector of TR505 and adjust the threshold control for approximately -200mV. On early instruments this control is adjacent to the TIME/cm switch, later instruments have the control in front of the vertical E.H.T. panel.

Sweep Timing

Using an unterminated 50 Ω lead, connect the 500mV time marks from the SC1 calibrator to "A" channel input socket. Select 1mS on the SC1 and set the 4D25 controls as follows: DC coupling, 200mV/cm, 1mS/cm and trig level adjusted to give a locked display. Now adjust RV503 to give one mark every cm. Now pull the X5 magnifier and adjust RV502 to give one mark every 5cms. Select 1µS/cm and apply 1µS time marks and adjust CV552 located behind the TIME/cm switch to give one mark per cm. Return through all the ranges to check that they remain within specification.

Vertical Amplifier Sensitivity and Position Centre

Using the 50Ω 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 4D25, now adjust RV103 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.

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 4D25. DO NOT USE ANY LEADS. Connect the trigger signal from the SC1 directly to the EXT TRIG socket of the 4D25. Set the 4D25 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 4D25. 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 4D25 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".

VOLTS/CM SWITCH	HEIGHT OF WAVEFORM	SET RATIO	SET INPUT
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.

Amplifier Pulse Response

Connect the 40mV square wave output of the SC1 to "A" channel using the 50Ω terminated lead. Select 1µS on the SC1 and on the 4D25, 10mV, DC coupled, 2µS/cm and lock the display on the negative edge.

Rotating RV104 will cause the trace to "rock" about a point approximately 2mm from the front edge of the pulse and should be adjusted to give the flattest top to the pulse after the rocking point. Now adjust CV151 to give the flattest top to the pulse before the rocking point. L151 and L152 should be adjusted to give the squarest corner to the pulse with a minimum of ringing.

The above procedure should be repeated for "B" channel. Compromise settings of CV101A, CV101B and CV151 may be necessary to obtain the optimum pulse shape on both channels.

External "X" Input Phase

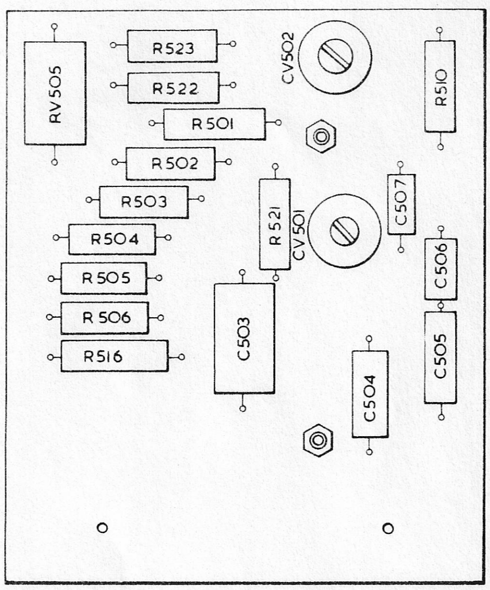
Select "A" only, 1V/cm and EXT on TIME/cm switch. Feed a sine wave signal of 30KHz and 6 volts pk/pk simultaneously to "A" channel and external "X" input and adjust CV101 to give a straight line at 45°.

Remove the signal, and where fitted adjust RV551 to give a spot in the middle of the tube when the horizontal position control is centred.

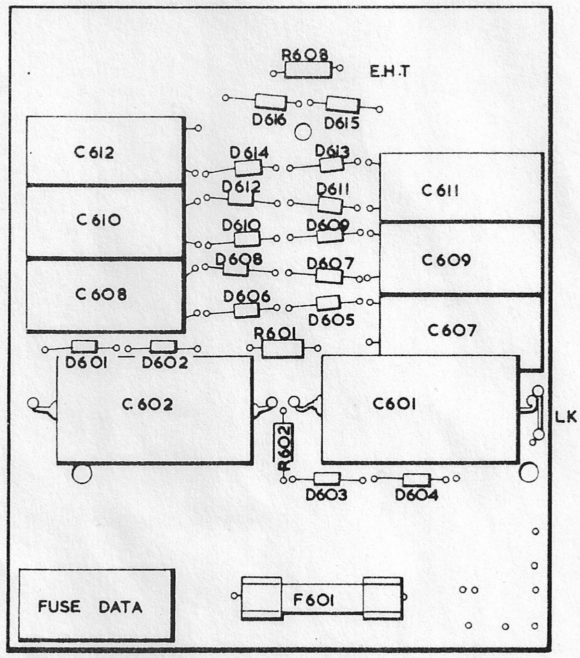
Servicing the unblank amplifier

To facilitate servicing the unblank amplifier it may become necessary to disable the -1100V power supply. The following procedure should be adopted: remove the link by the positive end of C601 on the E.H.T. board which will prevent the voltage doubler operating and temporarily connect a 47KΩ between the two pins adjacent to R549 to ensure that the -20V supply operates. The instrument will operate normally except that there will be no display on the Cathode Ray Tube.

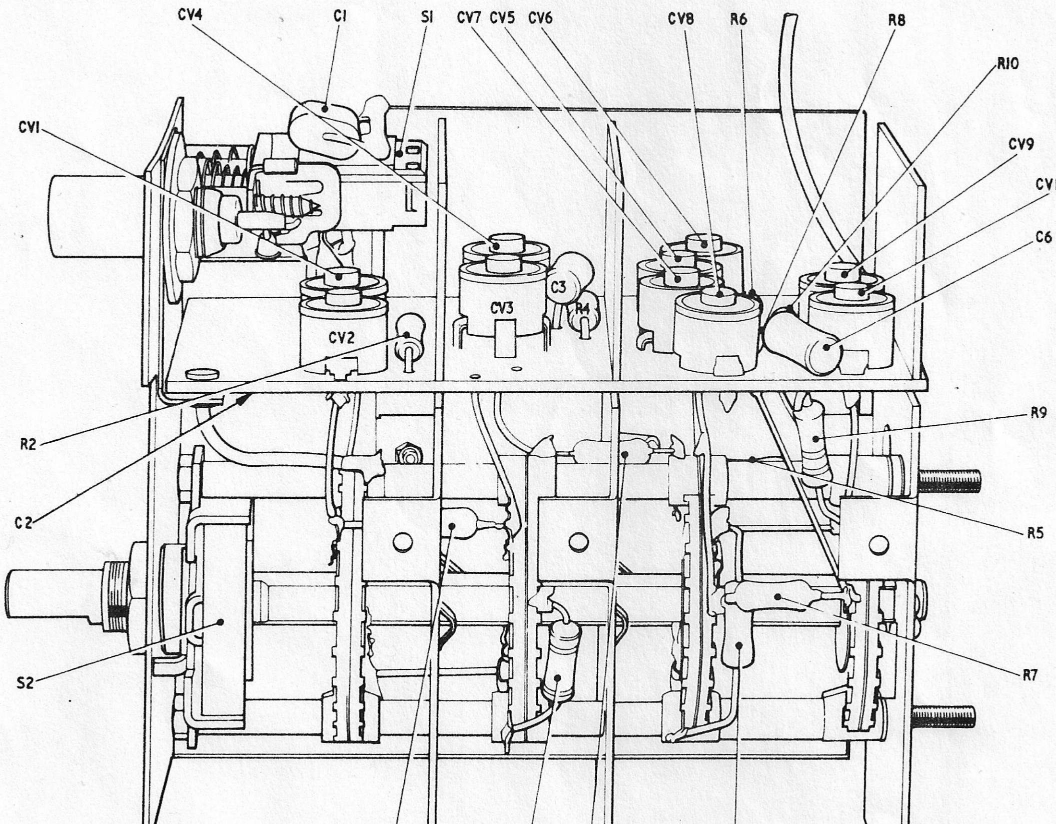
Should you have to return the instrument for service PLEASE DO NOT RETURN ACCESSORIES unless you believe they are faulty.



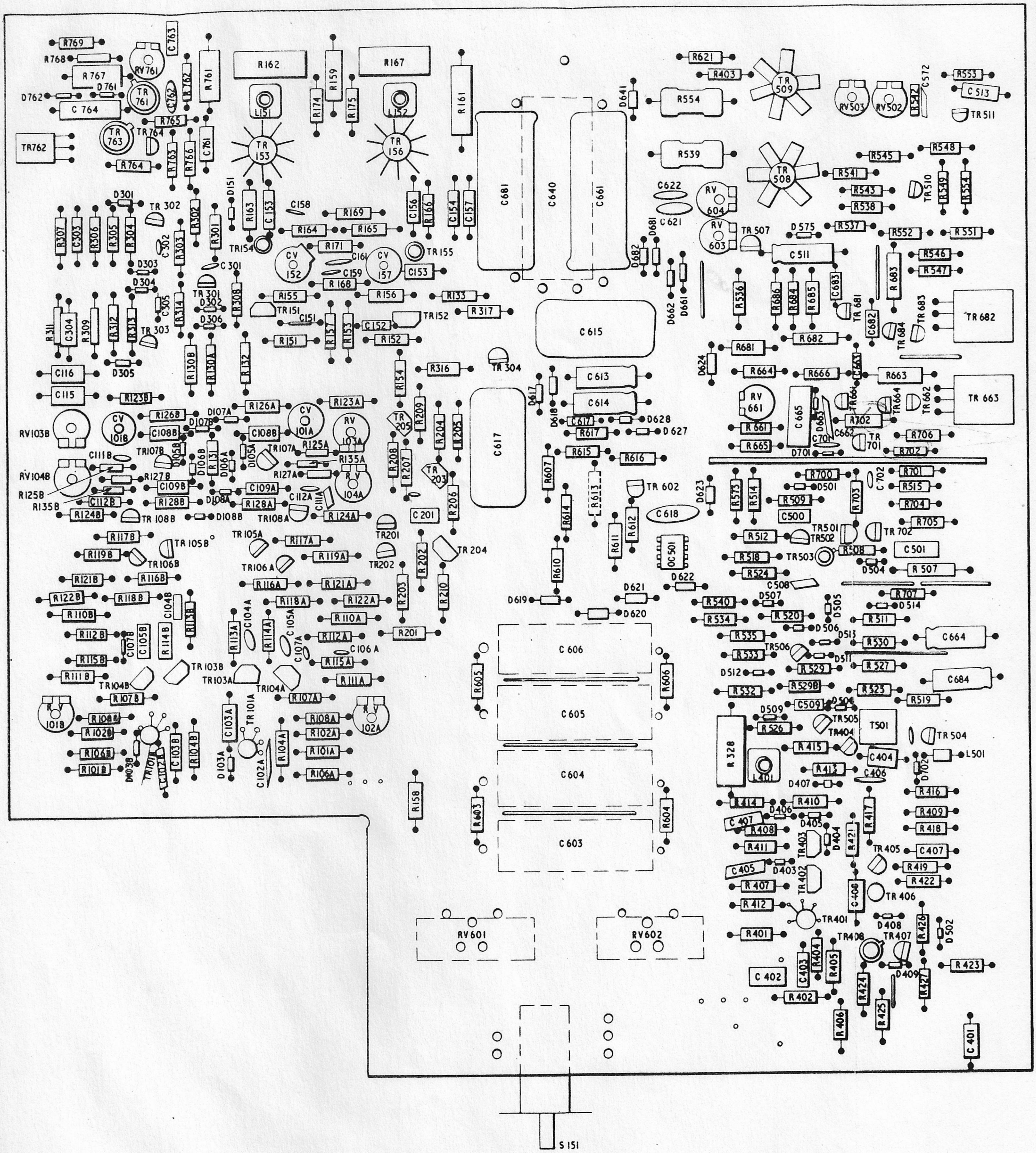
TIME/CM SWITCH BOARD



E.H.T. SUPPLY BOARD



ATTENUATOR


R769
R768
R767
RV761
C763
D762
D761
TR761
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C764
R765
TR763
TR764
TR762
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R763
R766
C761
R162
R159
R174
R175
L151
TR153
R167
L152
TR156
R161
D151
R163
C153
C158
R169
R164
R165
C156
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C154
C157
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R313
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D305
R130B
R130A
R132
C116
C115
R123B
R126A
R123A
R126B
C108B
D107B
D107A
CV101B
CV101A
RV103A
RV103B
C108B
TR107B
D105B
D106B
R131
D106A
D105A
TR107A
R125A
R135A
C111B
RV104B
R127B
R125B
R135B
C112B
C109B
R128B
D108A
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R127A
RV104A
C112A
C111A
R124B
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R702
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D701
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R700
D623
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R509
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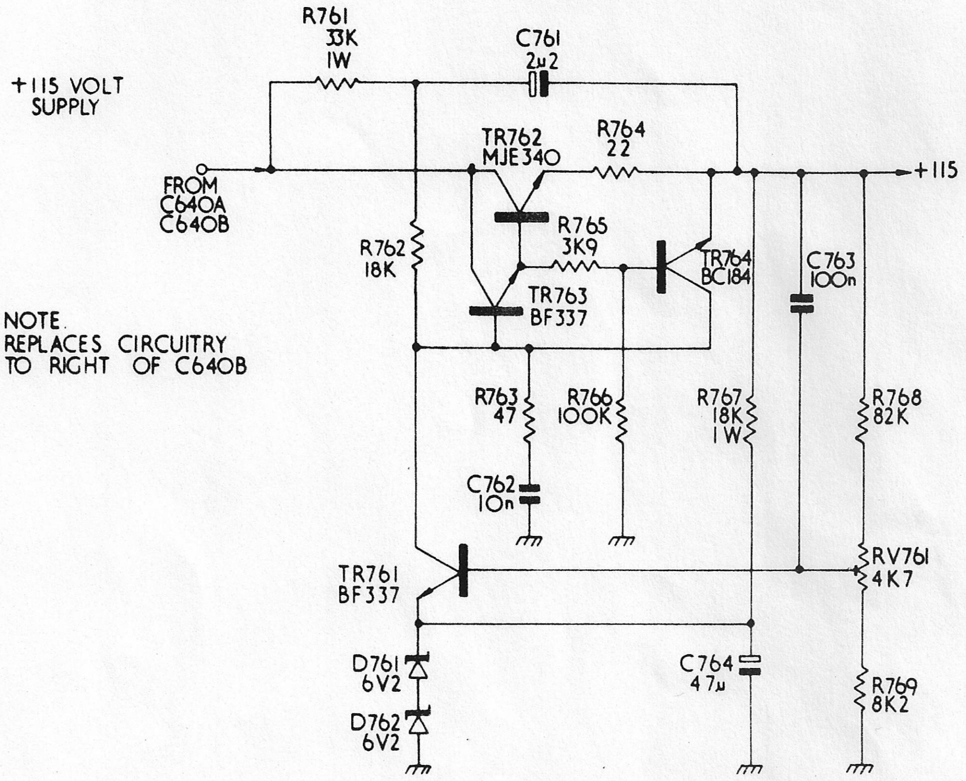
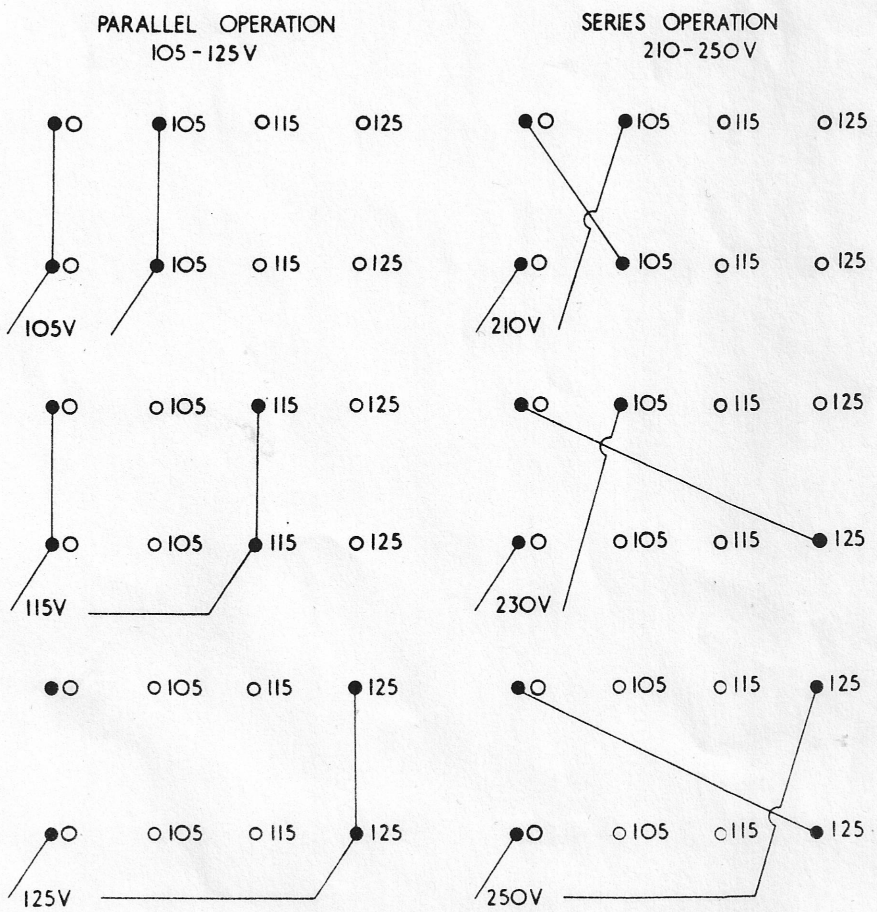
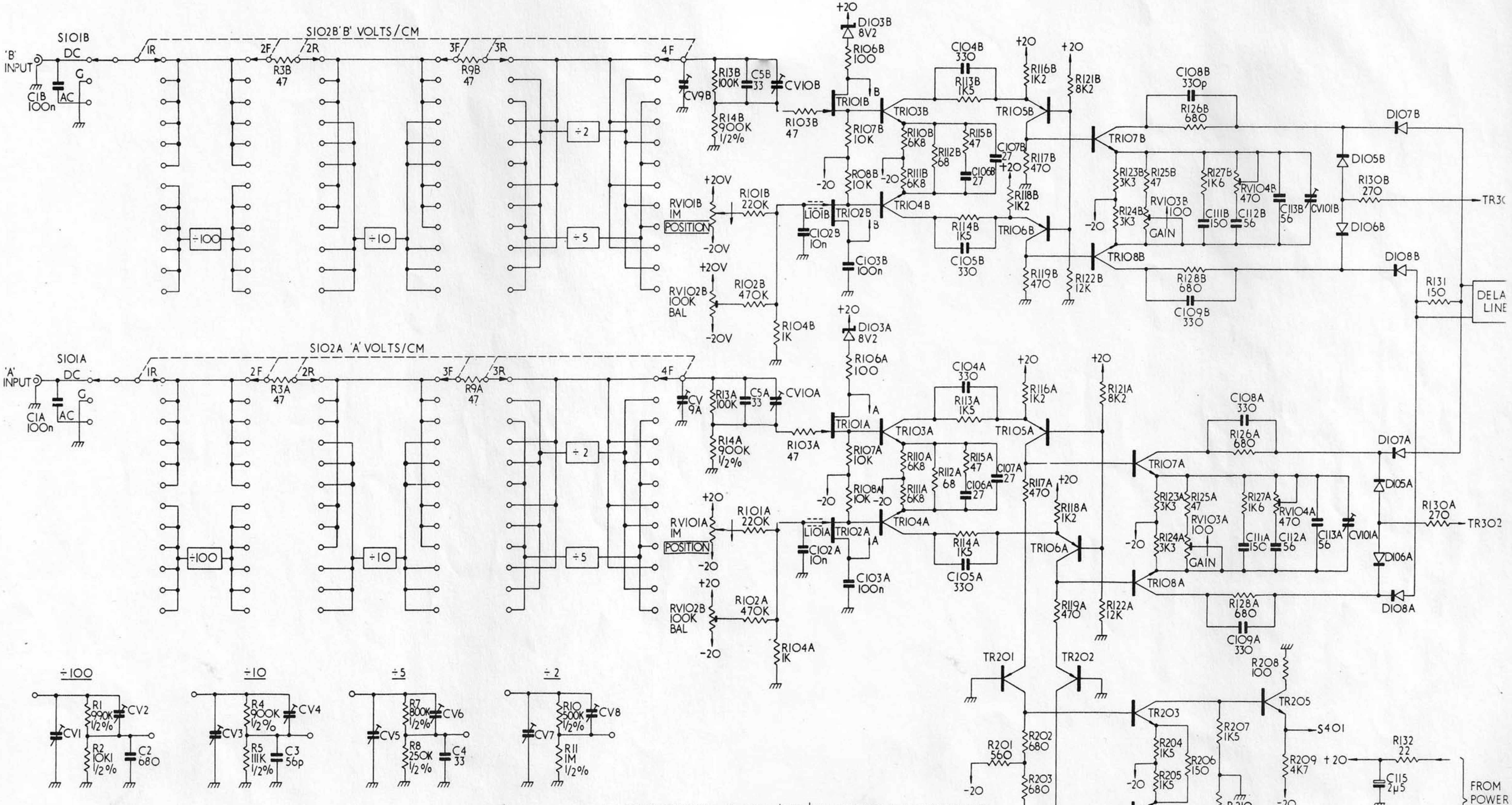
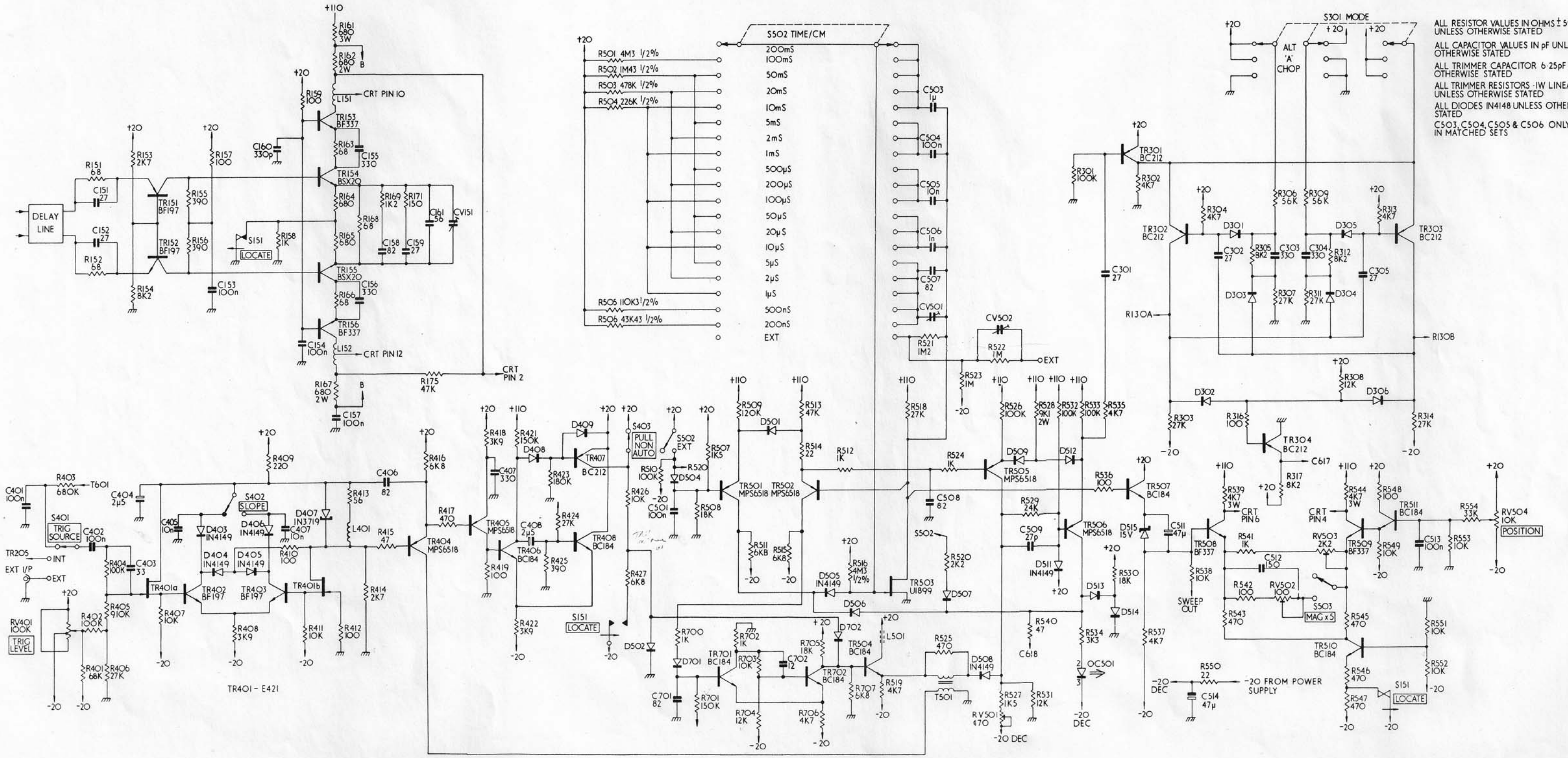




TRANSFORMER CONNECTIONS



ALL RESISTOR VALUES IN OHMS ±5% ½W UNLESS OTHERWISE SPECIFIED
ALL CAPACITOR VALUES IN pF UNLESS OTHERWISE SPECIFIED
ALL TRIMMER CAPACITORS 2-20pF UNLESS OTHERWISE SPECIFIED
ALL TRIMMER RESISTORS ·1W LINEAR LAW UNLESS OTHERWISE SPECIFIED
ALL DIODES IN4149 UNLESS OTHERWISE SPECIFIED
ALL FIELD EFFECT TRANSISTORS E421 UNLESS OTHERWISE SPECIFIED
ALL PNP TRANSISTORS MPS6518 UNLESS OTHERWISE SPECIFIED
ALL NPN TRANSISTORS BF197 UNLESS OTHERWISE SPECIFIED



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

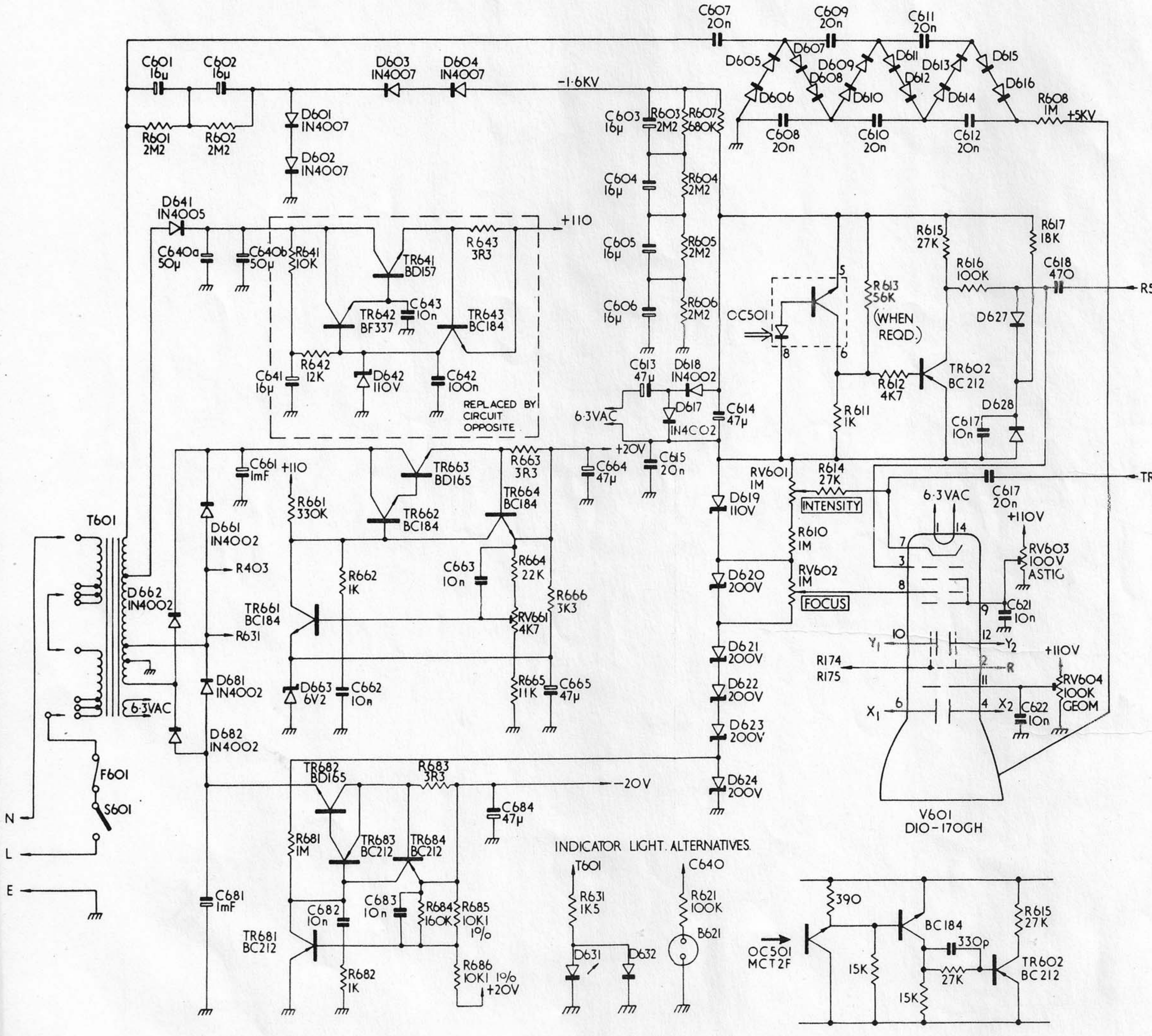
ALL CAPACITOR VALUES IN pF UNLESS OTHERWISE STATED

ALL TRIMMER CAPACITOR 6·25pF UNLESS OTHERWISE STATED

ALL TRIMMER RESISTORS ·1W LINEAR LAW UNLESS OTHERWISE STATED

ALL DIODES IN4148 UNLESS OTHERWISE STATED

C503, C504, C505 & C506 ONLY SUPPLIE[D] IN MATCHED SETS



UNBLANK AMPLIFIER FITTED TO EARLY INSTRUMENTS
RECOGNISED BY 6 PIN OPTICAL COUPLER

Racal Instruments

25MHz DUAL TRACE OSCILLOSCOPE 9386

AMENDMENTS

TEXT

Page 10 and 11 : Circuit Description

Delete the paragraphs beginning "The 110V rail is obtained by stabilising the output of the ...." and ending "........ thereby reducing the current and preventing damage to TR641 and TR642.

Insert "The 115V rail is obtained by stabilising the output of the half wave circuit D641, C640a and C640b.

The Darlington connected pair TR641 and TR642 maintains a constant output voltage determined by the variable resistor RV641, TR644, D643 and D644. In the event of a current overload TR643 reducing the voltage on the base of TR642 which causes the output volts to drop and thereby reduces the current and prevents damage to TR641 and TR642."

Page 12 : Calibration

Delete "The 110V supply should be checked and should fall between 103V and 115V"

Insert "The 115V supply should be adjusted by RV641 to give 0V at the collector of TR504.

CIRCUIT DIAGRAMS

Power Supply

Delete: Shaded components shown in circuit extract Fig. 1a.

Insert: Circuit as shown in Fig. 1b.

Vertical Amplifier

Delete: Shaded components shown in circuit extract Fig. 2a.

Insert: Circuit as shown in Fig. 2b.

COMPONENTS

The following component values have been changed:

R127	was	1.6kΩ	Now	2.2kΩ
R169	was	1.2kΩ	Now	1kΩ
R171	was	150Ω	Now	68Ω
R201	was	560Ω	Now	1.2kΩ
R204	was	1.5kΩ	Now	3.3kΩ
R205	was	1.5kΩ	Now	3.3kΩ
R526	was	100kΩ	Now	4.7kΩ
R527	was	1.5kΩ	Now	1.6kΩ
R684	was	18kΩ	Now	10.1kΩ
R685	was	330kΩ	Now	160kΩ
R686	was	18kΩ	Now	10.1kΩ
C112	was	56pF	Now	82pF
C113	was	56pF	Now	27pF
C158	was	82pF	Now	150pF
C159	was	27pF	Now	56pF
C161	was	56pF	Now	27pF

RV501 Deleted
R531 Deleted
D626 Deleted
R613 Deleted

R159)
C154)
C160)
R641)
R642)
R643)
C641)
C642)
C643)
D642)
TR641)
TR642)
TR643)

For changes in the value of these components refer to Fig. 1b and 2b.

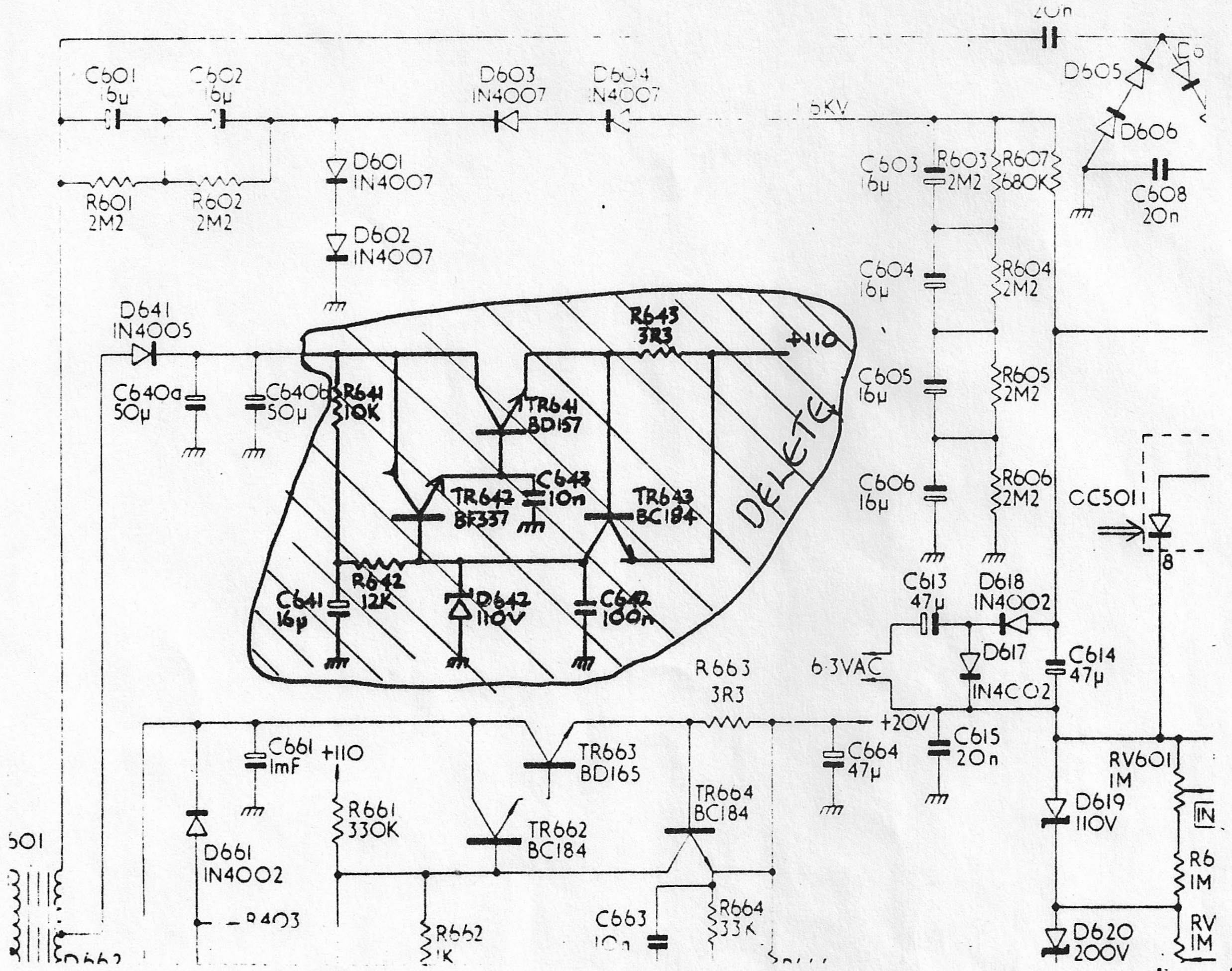
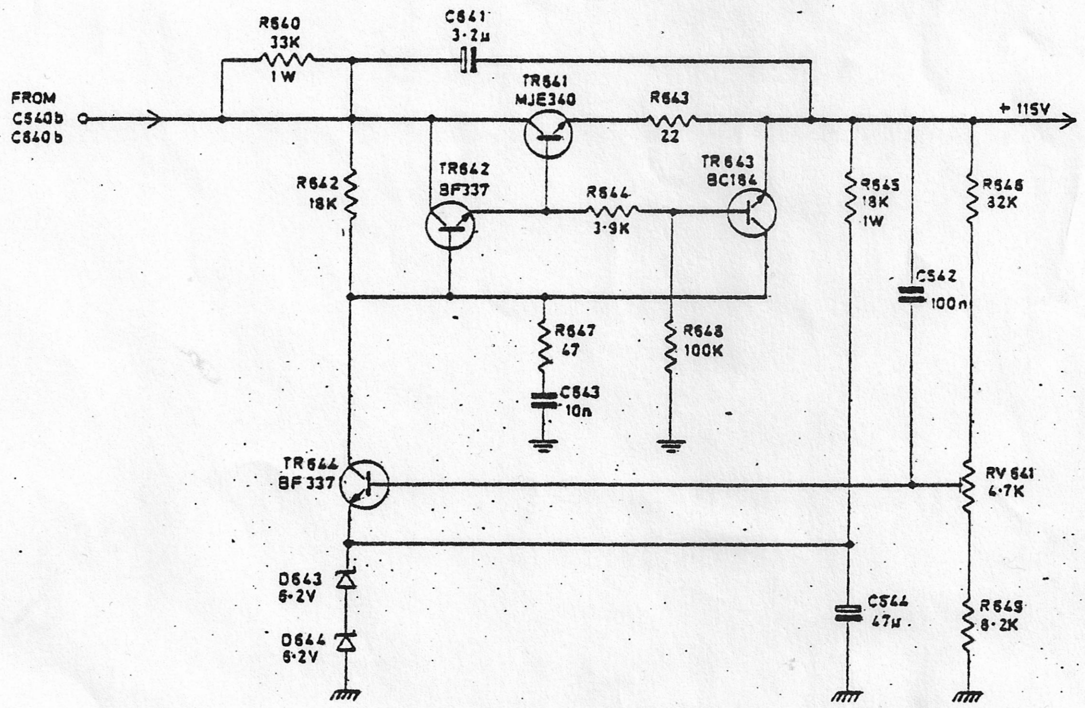


Fig. 1a



+115V Supply

Fig. 1b

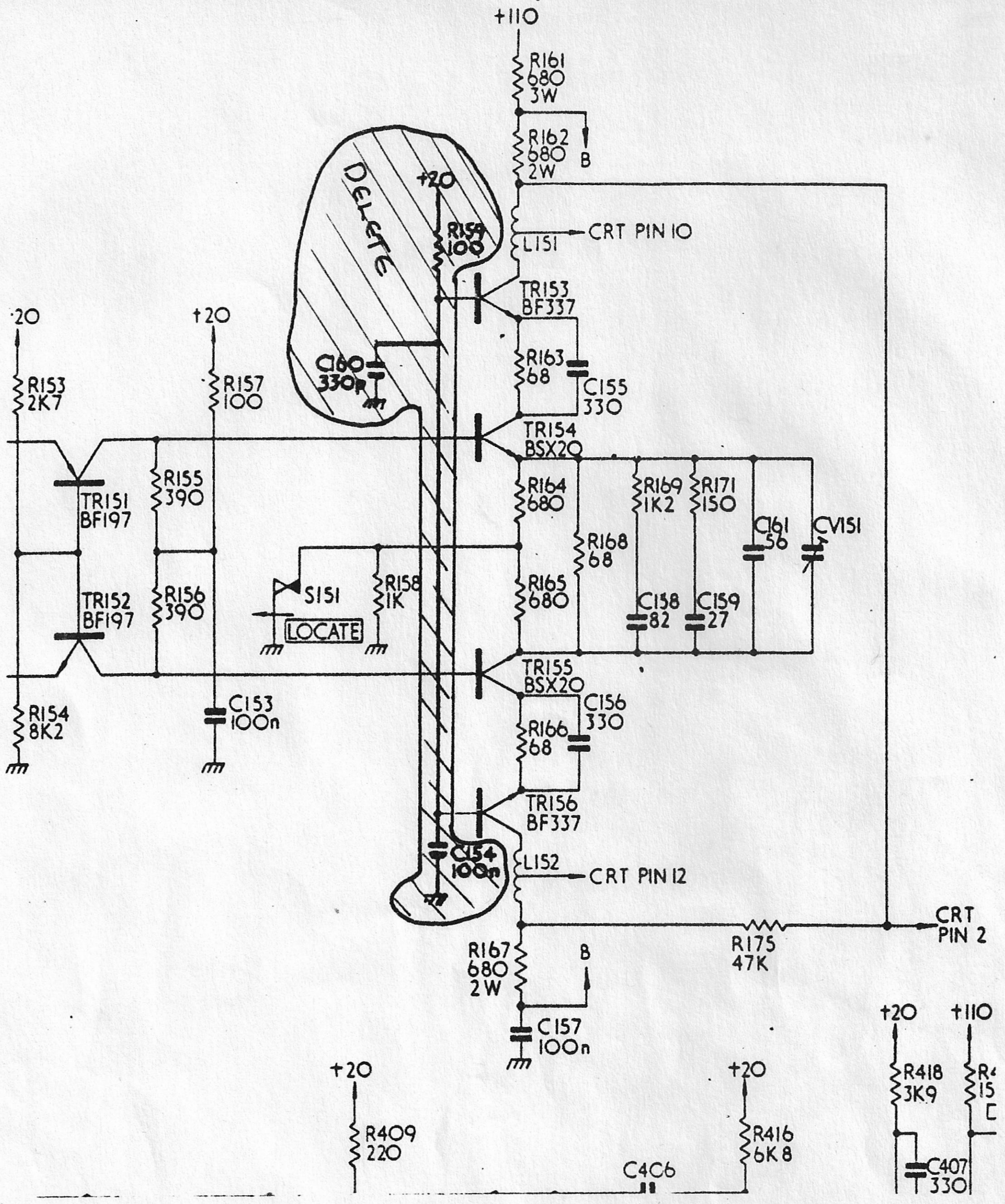
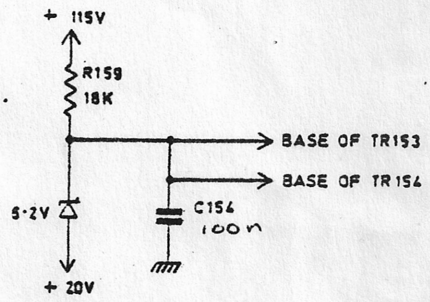


Fig. 2a



Vertical Amplifier

Fig. 2b