GENERAL DESCRIPTION

CATHODE RAY TUBE

The 3" flat faced tube operates at 1,400 Volts, giving an extremely bright fine trace over the whole of the working area (5cms x 5cms). A P1 phosphor is normally supplied but a long persistence tube is available if specified.

A green filter improves the contrast under conditions of high ambient light.

VERTICAL DEFLECTION AMPLIFIER

The four-stage, balanced, D.C. coupled amplifier drives the deflector plates through output cathode-followers. The amplifier is compensated for optimum pulse response with no overshoot and has a bandpass of 6 Mc/s (-3dB-). The rise time is about .06 usec.

The nine-position input attenuator is frequency compensated and gives sensitivities of 100mV, 500mV, 1V, 2V, 5V, 10V, 20V & 50V per centimeter.

The pre-set gain control standardises the sensitivity against an internally generated 1 volt p.p. squarewave.

The input impedance is 1 Megohm, shunted by about 30pf.

VOLTAGE CALIBRATOR

A 1 volt p.p. squarewave, stabilised against line voltage variations is available at a connector of the front panel.

SWEEP CIRCUIT

The sweep generator is a Miller run-down circuit giving excellent linearity. Eighteen pre-set sweep speeds are provided, from 1sec per cm, down to .5 sec per cm, in 1, 2, 5, 10 etc. multiples. Slower speeds, down to about 3 seconds can be obtained by adjusting the SET SPEED control to the bottom end of its range.

HORIZONTAL AMPLIFIER

The X GAIN control expands the trace to over 10 diameters and sufficient shift is provided to enable any part of the expanded trace to be positioned centrally on the screen.

TRACE UNBLANKING

D.C. coupling of the unblanking waveform gives uniform trace brightness at all sweep speeds.

TRIGGERING

Two modes of triggering are provided:

1. AUTO. On this setting the sweep free runs at a slow speed in the absence of an input signal, but will be triggered automatically as soon as an

TRIGGERING (continued)

input signal is applied. This mode of operation can be used for 90% of all normal laboratory uses.

2. TRIGGER LEVEL SELECTION. With the AUTO switch OFF the Trigger Level Control allows the sweep to be triggered at any point on the input waveform.

T.V. SYNC SEPARATOR

The built-in TV sync separator triggers the sweep from the Line or Frame pulses of a composite Television waveform.

REAR CONNECTORS

Connectors on the rear panel provide access to the Horizontal Amplifier, intensity modulation of the beam and the sweep output waveform.

COOLING

The S31 is cooled by convection. Air enters the bottom of the case and is drawn up past the tubes and other hot components which are all located on the left hand side of the chassis, passing out through the slots at the top. Do not obstruct the air flow in any way. Do not put anything on top of the instrument and make sure that there is an air space underneath.

FIRST TIME OPERATION

Unless you are familiar with this type of sweep generator follow these simple instructions carefully and then run through the procedure a few times to feel thoroughly at home with the instrument before putting it into use.

Set the front panel controls as follows:

INPUT SWITCH	D.C.
VOLTS/CM	.5
FOCUS	Mid position
ASTIG	Mid position
Y SHIFT	Mid position
BRILLIANCE	Fully anti-clockwise
X GAIN	Fully anti-clockwise
X SHIFT	Mid position
STABILITY	Fully clockwise
TRIGGER LEVEL	Anti-clockwise to position just before switch operates.
TIME/CM	1 ms
MULTIPLIER	20
SYNC. SELECTOR	+ ve

Switch on and allow a few minutes for the instrument to warm up. Now advance the brilliance control until a trace appears and position the trace in the centre of the screen by means of the X and Y SHIFT controls. Adjust the ASTIG and FOCUS controls for a clean sharp trace.

Now back off the STABILITY control until the sweep just fails to free run. This is the normal position of the STABILITY control and once it is set it should not require any readjustment except at the very highest sweep speeds. The instrument is now ready for use.

You will find that if the TRIGGER LEVEL control is turned fully anti-clockwise to operate the AUTO switch, the trace will reappear. In this condition the instrument is ready to accept almost any input waveform and trigger automatically from it, the only adjustments required are the selection of the appropriate sweep speed and Y Sensitivity (VOLTS/CM). However, in order to use the S31 to best advatage the functions of the controls should be understood fully and the following procedure will demonstrate their use.

Return the TRIG LEVEL control to the position just before the Switch operates. There should now be no trace visible on the screen (there may be a bright spot at the left-hand side of the screen depending on the precise setting of the BRILLIANCE control).

Now join a short connector between the CAL. post and the INPUT sockets and rotate the TRIG. LEVEL control clockwise until the trace appears. (If the sweep does not trigger it is because the STABILITY control has been backed off too far). The Scope is now displaying the calibration voltage waveform which should be a squarewave of 2 cm. amplitude with one cycle occurring every cm. You will find that this is a very convenient waveform for demonstrating the functions of the controls.

FOCUS AND ASTIG

You will find that by adjusting the FOCUS control either the horizontal or vertical edges of the squarewave can be brought into focus, but only if the ASTIG. control is in the correct position will it be possible to focus the whole of the waveform simultaneously. Once the ASTIG. control is set it should require no further adjustment and a clean fine trace will be obtained over the whole of the screen.

SWEEP CONTROLS

TIME/CM. AND MULTIPLIER

The calibration waveform is at supply line frequency so that when operating on 50 c/s, 1 c/s occupies 20 milliseconds. With the TIME/CM. switch set to 1 millisecond and the MULTIPLIER to 20, the TIME BASE speed is 20 milliseconds per cm. so that 1 cycle should occupy 1 cm. The SET SPEED control on the bottom of the instrument is used to adjust the sweep speed on this calibration waveform to give precisely 1 cycle per cm. When using the S31 on a 60 cycle supply, set the MULTIPLIER to the CAL. 60 c/s position. This standardises the whole of the time calibration of the instrument, all other ranges being direct multiples of this. Thus, if the MULTIPLIER is set to 10 (10 ms/cm.) 1 cycle will occupy 2 cm. and similarly at 5 ms./cm. 1 cycle will occupy 4 cm. and so on. In every case the time calibration is obtained by multiplying the TIME/CM. by the MULTIPLIER setting.

You will see that the ranges overlap. For instance 20 ms. can be obtained by 1 ms./cm. multiplied by 20 or 10 ms/cm. multiplied by 2. In general use the 10, 20 and 50 steps on the slow speeds and the 1, 2, and 5 steps on the high speeds. The uncalibrated positions on the multiplier switch give speeds approximately mid-way between the calibrated positions.

For most purposes, however, when time calibration is not required, use these controls to produce a picture of convenient size, the TIME/CM., the coarse control and the MULTIPLIER as the fine control.

If the instrument is calibrated as above the slowest sweep speed obtainable will be 500 ms/cm. For special purposes you may require to use speeds slower than this and the range of the pre-set control has been extended in the lower direction to allow for this. You will find that with this control turned to its minimum position the slowest speed range is extended to about 2 seconds per cm. If the instrument is standardised against the internal calibration waveform on the 5 ms./cm. range and the pre-set control is adjusted to give 1 cycle per cm., all the time ranges are multiplied by a factor of four. On the 60 c/s supplies set the TIME/CM. switch to 100 usecs. and the MULTIPLIER to the CAL. 60 c/s position and adjust the pre-set control to give 1 cycle $\frac{1}{2}$ cm. long, this gives a multiplying factor of (5).

TRIG LEVEL

Set the MULTIPLIER as explained above to 5 ms./cm. giving 1 cycle of the squarewave 4 cm. long. Now rotate the TRIG. LEVEL control and it will be found that the starting point of the trace can be moved up and down the sloping edge of the squarewave. If the control is turned too far clockwise the trigger

TRIG. LEVEL (continued)

point goes over the top of the squarewave and the sweep stops. Similarly, rotation too far anti-clockwise sets the point too low and the sweepagain stops. It should now be appreciated that this control does not govern the amplitude of the trigger signal but sets the precise point or level at which the sweep triggers. Thus, by adjusting this control, the sweep can be made to trigger at any point on the input waveform. (Positive or negative edges can be selected on the TRIG. SELECTOR SWITCH). This facility is extremely useful when dealing with complex waveforms when a normal type of sweep generator will either not trigger at all or will double trigger and produce a multiple pattern. It is also useful as an amplitude discriminator enabling the sweep to ignore small amplitude signals and only trigger when the input voltage reaches a pre-determined value. You will find that adjusting the sweep speed control does not alter the trigger point, the trace simply expands from the given starting point. This will enable you to examine a section of the waveform in detail by setting the TRIG. LEVEL control to trigger just before the portion to be examined and expanding this portion as required by the sweep speed control.

AUTO

On this setting no control over the trigger level is available. The sweep automatically adjusts itself to trigger at approximately the mean level of the input waveform. You can use this setting for practically all applications involving repetitive waveforms of a fairly simple nature and the sweep generator will trigger automatically on signals between about 50 c/s and 1 M/cs. provided the amplitude exceeds about 2 mm.

In the AUTO position with no input signal the trace will become progressively less bright as the sweep speed is increased. This is normal since in the absence of a trigger signal the sweep free runs at about 50 c/s whatever the setting of the speed control. As soon as an input signal is applied the sweep will immediately synchronise to it and the trace will revert to its full brightness.

TRIG SELECTOR

There are twelve positions on this selector switch. For most purposes use the positive or negative normal positions depending on the polarity of the input waveform.

The other four positions bring the internal Sync. Separator into circuit for use on TV waveforms enabling the sweep to be triggered from the Line or Frame pulses independent of the picture content (the + ve TV positions refer to positive-going video signals, i.e. picture + ve sync. - ve). When triggering from a TV frame pulse, adjustment of the TRIG. LEVEL control will determine which of the broad pulses actually triggers the sweep.

TRIG. SELECTOR (continued)

The Sync. Separator includes an integrating circuit for the frame pulse and this can be useful on occasions for frequency discrimination. For instance an audio signal containing a large proportion of HF noise will trigger better on the TV frame position, the integrator acting as a low pass filter.

For triggering from an external signal rotate the control knob until the ext. position is uppermost and connect the signal into the external trigger socket.

X-GAIN AND X-SHIFT

With the X-GAIN control in the minimum (anti-clockwise) position, the trace will be approximately 6 cm. long and the X-SHIFT control should be used to centre this trace about the 5 cm. ruled graticule. Increasing the X-GAIN control expands the trace about the centre of the screen up to a maximum of just over 10 screen diameters giving an effective trace length of 50 cm. and the X-SHIFT control is then used to position the required portion of this trace on the screen.

It should be noted that the time calibration only holds good at the minimum setting of the X-GAIN control. It you want to measure time intervals at any other setting the speed must be standardised at this setting by names of the internal calibration waveform. For instance, if the X-GAIN control is increased so that 1 cycle of the calibration waveform occupies 5 cm. then the gain is exactly five times on all ranges and provided the X-GAIN control is not touched all sweep speeds will be multiplied by a factor of 5. Obviously you can have any multiplication factor between 1 and 10.

VOLTS PER CM.

This is a nine-position switch which inserts a series of frequency compensated resistance dividers between the input socket and the Vertical Amplifier. Normally this is used merely to obtain a picture of convenient height, but if the gain of the Amplifier is standardised, direct readings of input voltage can be made. For this purpose the calibration voltage waveform should be set by means of the SET Y-GAIN pre-set control on the bottom of the instrument so that the 1 volt squarewave occupies exactly 2 cm. on the .5v/cm. scale. The squarewave should be measured between the flats. All other ranges are then direct reading in volts per cm.

D.C./A.C. SWITCH

On the A.C. position this switch inserts a blocking capacitor in series with the input of the Vertical Amplifier removing the D.C. component of the signal. This is the condition in which the S31 will normally be used unless it is specifically required to include the D.C. component or to use the instrument on very low frequency signals. The time constant of the input circuit on the A.C. position is such that the response is 3 dB down at 2 cycles, which, while adequate for all normal purposes, may limit the application in some instances. For instance you will notice that on the 50 cycle squarewave a pronounced tilt occurs on the A.C. position. If a longer time constant is required, a higher capacity external blocking capacitor must be used with the input switch set to D.C.

REAR CONNECTORS

1.. Sweep output. A negative going saw-tooth waveform of approximately 25 volts amplitude is available at this connector and can be used for instance, to drive an external circuit. This socket is D.C. coupled to preserve the shape of the waveform at the lowest sweep speeds and in some instances a blocking condenser may have to be used. The output waveform is only linear when the X-GAIN control is set to the minimum position. At all other settings of the X-GAIN control only the portion of the saw-tooth which is actually on the screen is linear. When using this waveform as a drive for an external circuit it will usually be necessary to turn the STABILITY control clockwise until the sweep free-runs.

2.. X-Amp Input. This socket provides an access to the input of the Horizontal Deflection Amplifier and is suitable for signals between about 1 and 25 volts p.p. The X-GAIN control gives about a 10 to 1 variation of gain. When using the X-Amplifier the sweep can be stopped by turning the STABILITY control fully anti-clockwise. The input inpedance is about 500 K and the input capacity about 100 pf. The frequency response is 3 dB down at 5 cycles and at about 400 K.C's.

In the above instructions the functions of controls have been explained in some detail so that the engineer using the S31 may fully appreciate its capacities and the method of function. There will, however, be a large number of users who will not require all the facilities provided and to whom simplicity of operation is of major importance. The following simplified instructions will suffice for most applications, in fact for any application where the older type of Oscilloscope could be used the following method will provide much better results much more quickly and simply.

Set input switch to A.C.

Switch on and allow a few minutes to warm up.

Turn STABILITY control fully clockwise and adjust BRILLIANCE and FOCUS controls for a sharp trace.

Back off STABILITY control until the TIME BASE stops. The STABILITY control once set should not require any further adjustment.

The instrument is now set for use.

For most applications switch to AUTO, connect input signal and adjust VOLTS/CM. switch to give a convenient size trace. Use TIME/CM. and MULTIPLIER as course and fine frequency controls to suit the input signal.

For T.V. waveforms use L or F positions of TRIG. SELECTOR. If the sweep fails to lock, the STABILITY control has been turned up too far.

For some input waveforms and sometimes for TV waveforms it may be necessary to adjust the TRIG. LEVEL control rather than to use the AUTO position.

CIRCUIT DESCRIPTION.

INPUT ATTENUATOR.

The input capacitor C.I. is normally in series with the input to the Attenuator but is shorted by S.1. in the D.C. position. The input Attenuator has four frequency compensated resistance dividers and these are used singly or in cascade giving nine division ratios. The first section has ratios of 1, 10 and 100, and the second section 1, 2 and 5.

VERTICAL AMPLIFIER

The Vertical Amplifier uses four identical triode pentode tubes. In each case the pentode section is used as the Amplifier and the triode section as a cathode follower. V1a and V2a form a cathode coupled pair with R16 as the common cathode resistor, L1 and L2 are peaking inductances. R19 is the vertical positioning control and adjusts the potentials at the plates of V1a and V2a. V1b and V2b are cathode followers driving input Amplifiers V3a and V4a. The cathodes of V3a and V4a are connected via R28, which is the set GAIN control and the frequency compensating network R29 and C17. Inductances L3 and L4 are included in the plate circuits of V3a and V4a and are adjustable for high frequency peaking. V3b and V4b are cathode followers feeding the vertical deflector plates through networks L5 and R42, L6 and R43. The cathode of V3B is coupled via C18 and R18 to the plate of V2a to compensate for the stray capacity across the Y-SHIFT control. The signal at the cathode of V3b is taken via R41 to the internal position of the TRIGGER SELECTOR switch. The plate and screen supplied for V1a and V2a are taken from a common resistor R40 included in the cathode circuits of V3b and V4b, so that the cathode current of the input stages flows through the two output cathode followers, this is done to reduce the total current consumption of the Amplifier and to provide a measure of stabilisation so that the overall gain of the Vertical Amplifier is proportional to the power supply voltage.

TRIGGER CIRCUIT AND SYNC. SEPARATOR

The TRIG. Selector Switch S3 has three sections. The first selects either internal or external triggering. The second the positive or negative output of the phase splitter V5b and the third section either the output of the phase splitter direct or the output of the T.V. Sync. Separator V5a. V5b is a conventional phase splitter an in-phase signal appearing at its cathode and an out of phase signal at its plate. The T.V. Sync. Separator V5a accepts a negative going input waveform, i.e.Sync. pulses positive, and provides negative going Sync. pulses at its plate. The integrating circuit R52. C23. effectively removes the line pulses leaving only the frame pulses. From the phase splitter or from the Sync. Separator the triggering signal is injected into the grid of V6a. V6a and V6b form a conventional cathode coupled bistable switch, the switching level being adjusted by the potential at the grid of V6a. The grid resistor of V6b and R63 is adjusted to give maximum sensitivity consistant with reliable triggering. On the AUTO position the switch S4 is opened and the grid of V6a is returned to the grid of V6b. In the absence of a signal V6 oscillates at a frequency determined by the time constant of R58 and C24 but as soon as any input signal between about 50 cycles and 2 M/cs. is applied to the grid of V6a this self oscillation ceases and the grid of V6a assumes the same potential as the grid of

TRIGGER CIRCUIT AND SYNC. SEPARATOR. (continued)

V6b. The squarewave at the plate of V6b is differentiated and used to trigger the time base.

TIME BASE AND HORIZONTAL AMPLIFIER.

V7a is the Miller Sweep Generator, the speed of rundown being controlled by Ca and Ra. Ra is switched to provide the MULTIPLIER and Ca is switched by the time per cm. switch. R66 determines the potential to which the charging resistor Ra is returned and is used to set the Sweep speeds. The Miller valve is keyed by V8b which together with V9b form a D.C. coupled multi-vibrator. In the rest position V8b is conducting and V9b is cut-off its plate being clamped to 250v. by the diode V7b. When a negative trigger pulse is applied to the cathode on V7b it momentarily lowers the grid potential V8b. The resulting rise in plate potential V8b is coupled to the grid of V9b via R86 and Cb, this in turn lowers the plate voltage of V9b still further and the regenerative action V8b going to cut-off and V9b conducting. When the rundown has reached the point where the cathode of V8b is at a lower potential than the plate of V9b, V8b again starts to conduct and a negative pulse is applied to the grid of V9b, regeneration again takes place driving V9b to cut-off and V8b conducting. The STABILITY CONTROL R88 sets the grid potential of V9b to the point just short of the free running condition. The linear sweep voltage at the plate of V7a is taken via the network R88 C37 and applied to the grid of the Horizontal Amplifier comprising V8a and V9a. R92 and R93 form the grid resistor of V8a and R93 is made variable to set the trace length at the minimum GAIN position. The Horizontal SHIFT voltage across R94 is applied in series with the sweep voltage to the grid of V8a. The GAIN of the Horizontal Amplifier is varied by the resistor R100 connecting these two cathodes V8a and V9a. The grid potential of V9a is adjusted by the resistor R105 so that the trace is in the centre of the screen with the Horizontal SHIFT control in its mid position. Outputs from the plates of V8a and V9a are taken to the deflector plates of the cathode ray tube. An external signal can be applied to the grid of V8a via the capacitor C39 from the connector at the rear of the instrument. In this condition the sweep generator can be stopped by backing off the STABILITY control. The sweep voltage at the cathode of V8a is taken to another connector on the rear of the instrument and can be used to drive an external circuit.

VOLTAGE CALIBRATOR

A two stage clipper circuit using three neon diodes NT1 NT2 NT3 is used to generate a squarewave of stable peak to peak amplitude. The AC line frequency voltage across the secondary of the power transformer is taken via R124 to the first stage of clipping comprising NT1 and NT2 in series, across these two tubes appears an approximately squarewave of 200 volts peak to peak amplitude, this is applied via R125 to NT3 where further clipping takes place and a squarewave of 100 volts amplitude appears across NT3, this is applied to the CAL.1 volt connector on the front panel via the network R127 R128 and R129. R129 is made variable to set the amplitude of the voltage at the Calibration Post to exactly 1 volt. The Capacitor C51 removes some of the overshoot on the squarewave which is due to the difference between the striking and burning potentials of the gas diodes. Some overshoot is left on the squarewave in order to provide a sharp pulse to facilitate setting the Time Calibration.

POWER SUPPLY.

The Rectifier tube V10 supplies the various B+ voltages via the smoothing resistors R106 R107 and R108. The high voltage supply for the CR tube is derived from the secondary of the power transformer via the MULTIPLIER circuit MR1 MR2 and MR3, these are tubular metal rectifiers of the selenium type. MR1 also provides the negative supply for the sweep generator via R111 and C43. The positive pulse which appears at the screen of V7a in the sweep generator is applied to the grid of the CR tube as unblanking via the network C47 R123 C46 R122, the D.C. level is thus preserved and C47 is adjustable for high frequency compensation. Intensity modulation signals can be applied to the cathode of the CR tube via C44.

COMPENSATION AGAINST LINE VOLTAGE VARIATIONS.

No form of stabilisation is used in the power supplies for the S31 but a high degree of compensation for line voltage variations is achieved in the following way:-

The deflection sensitivity of the CR tube is inversely proportional to its final anode voltage and this varies in proportion to the AC input voltage. The vertical Amplifier has been arranged so that its GAIN varies in proportion to the B+ voltage. If the A.C. input voltage rises the resulting increase in GAIN of the vertical Amplifier and decrease in sensitivity of the CR tube cancel out. At the minimum setting of the horizontal GAIN control (that is in the condition in which the sweep is calibrated) the heavy degenerative feed-back in the cathode circuits of the horizontal output valves V8a and V9a keeps the GAIN of this stage independent of the B+ voltage. In the sweep generator itself both the amplitude sweep voltage and the sweep speed in volts per micro-second vary as a direct function of the supply voltage. Obviously with the inversely varying sensitivity of the CR tube the trace on the screen will remain the same length and have the same speed in CM per usecs. In practice this compensation works extremely well and the calibration of the S31 remains constant for widely varying input voltages.

MAINTENANCE ADJUSTMENTS.

The simplicity of the circuitary of the S31 make it an extremely reliable instrument and for the most part servicing will be limited to the replacement of defective tubes. When replacing tubes in the vertical Amplifier you may find that you will have to select pairs of tubes of approximately the same characteristics in order to get the vertical SHIFT to operate symmetrically about the centre of the screen, apart from this replacements of tubes in the vertical Amplifier will have very little effect on its performance and no re-adjustment should be necessary. In the sweep generator and Horizontal Amplifier the tubes are not particularly critical and you will find that you can replace these without having to alter the internal adjustments. If for any reason the internal pre-set controls do require adjustment the following detailed instructions will allow you to do this quickly and accurately.

ADJUSTMENT PROCEDURE.

INPUT ATTENUATOR.

In order to adjust the input attenuator compensation you will need a squarewave generator with a frequency of approximately 2 KC's and whose output can be varied between .2 volts and 100 volts. The rise time of the squarewave need not be particularly fast but it must have a good flat top and bottom. Connect the squarewave generator to the input socket and adjust the output to approximately .2 volt. Set the input attenuator to .1 volt per cm. and adjust the sweep controls so that you are displaying 3 cycles of the squarewave. Now carry out the following procedure step by step adjusting each trimmer to give a square corner to the squarewave. On each setting of the input attenuator you should adjust the output of the squarewave generator to give a trace of approximately 2 - 3 cm. amplitude.

Set Input Attenuator to:	Adjust
.2 volts per cm.	C12
.5 " " "	C13
1 " " "	C4
2 " " "	C8
5 " " "	C9
10 " " "	C5

If you have carried out these adjustments correctly the 20 volts per cm. and the 50 volts per cm. ranges are automatically correct. In order to adjust the capacitors C2 and C3 it is necessary to use the high impedance probe as these two capacitors only affect compensation when this probe is in use. Remove the squarewave generator from the input socket and plug in the high impedance probe, connect the output of the squarewave generator to the probe tip and set the input attenuator to .1 volt per cm. set the output of the squarewave generator to give approximately 2 cm. amplitude and adjust the probe trimmer (this is accessible through the hole in the probe body) to give a flat top to the squarewave, now switch the input attenuator to the 1 volt per cm. range, re-adjust the output of the squarewave generator and adjust C2, set the input attenuator to the 10 volts per cm. range and adjust C3. All other ranges will automatically be correct.

DJUSTMENT PROCEDURE. (continued)

ERTICAL AMPLIFIER

Adjustment of the high frequency compensation of the vertical mplifier should only be carried out if you have at your disposal a squarewave enerator which is capable of producing an accurate squarewave at a frequency of bout 250 KC's with a rise time less than 40 milli microseconds and which is known o be absolutely free from ring or overshoot. The compensation circuits in the ertical Amplifier are extremely stable and unless such a generator is available ou would be wise not to attempt any readjustment. Suitable squarewave generators re the Tektronix and the Hewlett Packard type 211A, and if one of these or an quivalent is available then the adjustments can be carried out in the following anner:-

Set the input attenuator switch to .1 volt per cm. and adjust the utput of the squarewave generator to give a trace of approximately 2 - 3 cm. mplitude (the output frequency on the generator should be between 200 and 300 C's). The variables L3 L4 C17 and C18 are to some extent independent and it may e necessary to adjust any or all of these to obtain the desired result which is a lat topped squarewave with a fast rise time, square corners and no overshoot. 3 and L4 affect the extreme corners of the squarewave and should be adjusted so hat they are approximately equal inductances. C17 has a longer time constant and hould be set to give a flat top to the squarewave, C18 has an even longer time onstant and sets the overall slope of the top. You may find that you can adjust 18 more easily on a lower frequency squarewave, say about 50 KC's.

The only other adjustment on the vertical amplifier is the set GAIN control, which is accessible through the bottom of the instrument.

TRIGGER CIRCUIT

The only adjustments necessary in the TRIGGER circuit is an occasional setting of the TRIGGER sensitivity control R63, this should be set so that the TRIGGER circuit will operate when the trace amplitude on the screen exceeds 2mm. If any attempt is made to increase the sensitivity beyond this point eratic operation will almost inevitably result. This adjustment can conveniently be made using the internal calibration signal. Join a connector between the CAL. output and the input and adjust the sweep controls so that you are displaying about 5 cycles of the calibration waveform. Now set the input attenuator to the 5 volts per cm. range (giving a trace 2 mm. high) and adjust the TRIGGER sensitivity control so that at a critical setting of the TRIG. LEVEL control the sweep will just trigger, now reduce the trace amplitude to 1 mm. and make sure that the sweep will not trigger on this signal.

SWEEP GENERATOR AND HORIZONTAL AMPLIFIER

To make a complete readjustment of the Sweep Generator and Horizontal Amplifier carry out the following procedure.

Set the TIME/CM switch to 100 usecs. and the MULTIPLIER switch to 10, advance the STABILITY control until the Sweep just free runs. With the X-SHIFT control in its mid position and the X-GAIN control in the minimum position adjust R93 until the trace length is approximately 6 cm. and adjust R105 to centre this trace about the

SWEEP GENERATOR AND HORIZONTAL AMPLIFIER. (continued)

5 cm. marks on the graticule. Now advance the BRILLIANCE control until you can see the spot at the beginning of the trace and you will find that by adjusting C38 you will be able to make a small "tail" appear to one side of the spot or the other. The correct setting for C38 is the point at which this "tail" just disappears into the spot, alternatively, C38 can be adjusted by displaying a signal of approximately 100 KC's and setting C38 for optimum linearity at the beginning of the trace, but the first method is more simple and is quite satisfactory. Now set the TIME/CM switch to 1 millisecond and the MULTIPLIER switch to 20 (to the CAL. 60 cycle position when the instrument is being operated from a 60 cycle supply). Now display the calibration voltage waveform and set the "set speed" control so that 1 cycle of the calibration waveform occupies exactly 1 cm. (still with the X)GAIN control to its minimum position). Now set the TIME/CM switch to one usec and the MULTIPLIER switch to 1. Inject an accurate 1 megacycle signal into the input and adjust the volts per cm. switch to give a trace approximately 2 cm. amplitude. Now adjust C27 so that each cycle of this 1 megacycle signal occupies 1 cm.

VOLTAGE CALIBRATOR.

R129 in the voltage calibrator circuit is provided so that the output can be set to precisely 1 volt. This adjustment can only be made by comparing the output with a known accurate 1 volt peak to peak signal. R129 will normally require no adjustment provided if the gas diode NT3 is replaced one of a similar type is used (NT1 and NT2 have no effect on the amplitude of the output waveform).

CRT. CIRCUIT.

There are two pre-set controls in the CRT Circuit. R120 is a pre-set BRILLIANCE control and is adjusted so that with the front BRILLIANCE control at its minimum position the trace just disappears. Due to ageing of the CR tube you will find that after the initial period of use it will be necessary to make a slight adjustment to this internal pre-set control. The other adjustment is the frequency compensation of the re-trace blanking circuit C47. Set the sweep speed to 20 usecs per cm. and remove the input signal so that you are simply displaying a trace. You will find that adjustment of C47 varies the BRILLIANCE of the first part of the trace and you should set this capacitor so that the trace is of uniform brightness along its length.

HIGH IMPEDANCE PROBE

The adjustment of the probe compensation is best carried out with a squarewave generator with an output frequency of approximately 1 KC. The compensation trimmer is accessible through the hole in the body of the probe and you should adjust this to give a square corner to the squarewave. If a squarewave generator is not readily available the probe can be compensated using an internal signal from the sweep generator in the following manner:-

Set the sweep speed to 1 millisecond per cm. and set the input attenuator to the 20 volts per cm. position. Set the AC/DC switch to AC. Now apply the tip of the probe to the test point and adjust the probe compensating trimmer to give a

HIGH IMPEDANCE PROBE. (continued)

level start to the trace, under compensation and over compensation conditions are shown in the following diagram.

NOTE. In the case of instruments having a serial number smaller than 1530, it is necessary to remove the right-hand side cover of the instrument in order to use this probe test signal. On later instruments this point is accessible through the slot in the top cover as shown in the photograph. Take care not to short this point to ground. Provided that the input attenuator adjustments have been carried out correctly the probe adjustment will hold good on all ranges of the input attenuator.

Abbreviations used in components lists.

Capacitors

MP	Moulded Paper
SM	Silver Mica
Cer.	Ceramic Tubular
Elec.	Electrolytic

Resistors

C	Carbon Composition
HSC	High Stability Carbon
WW	Wire Wound
PS	Preset Carbon (Internal Adjustment)

In the following component lists, no manufacturers names have been included. When replacing components, locally available alternatives may be used if exact replacements are not to hand, provided the physical size is the same.

It is, however, preferable to use exact replacements whenever possible, and these should be ordered direct from TELEQUIPMENT LIMITED or from our agents.

INPUT ATTENUATOR

R1	900K	HSC	1%	$\frac{1}{4}$ watt.
R2	111K	HSC	1%	$\frac{1}{4}$ watt.
R3	990K	HSC	1%	$\frac{1}{4}$ watt.
R4	10.1K	HSC	1%	$\frac{1}{4}$ watt.
R5	18	C	10%	$\frac{1}{2}$ watt.
R6	500K	HSC	1%	$\frac{1}{4}$ watt.
R7	1M	HSC	1%	$\frac{1}{4}$ watt.
R8	800K	HSC	1%	$\frac{1}{4}$ watt.
R9	250K	HSC	1%	$\frac{1}{4}$ watt.
R10	1M	HSC	1%	$\frac{1}{4}$ watt.
R11	100K	C	10%	$\frac{1}{2}$ watt.
R12	82	C	10%	$\frac{1}{2}$ watt.

C1	.1uf	MP	10%
C2	3-30pf	Trimmer	
C3	3-30pf	Trimmer	
C4	3-30pf	Trimmer	
C5	3-30pf	Trimmer	
C6	100pf	SM	10%
C7	1000pf	SM	10%
C8	3-30pf	Trimmer	
C9	3-30pf	Trimmer	
C10	39pf	Cer.	10%
C11	20pf	Cer.	10%
C12	3-30pf	Trimmer	
C13	3-30pf	Trimmer	
C14	30pf	Cer.	10%
C15	15pf	Cer.	10%
C16	.01uf	MP	10%

VERTICAL AMPLIFIER

R13	3.3K	10%	½W	C
R14	3.3K	10%	½W	C
R15	100	10%	½W	C
R16	180	10%	½W	C
R17	56K	10%	½W	C
R18	56K	10%	½W	C
R19	200K	2W Carbon Potentiometer (Y SHIFT)		
R20	100	10%	½W	C
R21	100	10%	½W	C
R22	100	10%	½W	C
R23	100	10%	½W	C
R24	27K	10%	1W	C
R25	27K	10%	1W	C
R26	100	10%	½W	C
R27	100	10%	½W	C
R28	1K	2W Carbon Potentiometer (SET Y GAIN)		
R29	100	10%	½W	C
R30	10K	5%	3W	WW
R31	10K	5%	3W	WW
R32	4.7K	10%	1W	C
R33	4.7K	10%	1W	C
R34	100	10%	½W	C
R35	100	10%	½W	C
R36	100	10%	½W	C
R37	100	10%	½W	C
R38	10K	5%	3W	WW
R39	10K	5%	3W	WW
R40	4.7K	5%	3W	WW
R41	4.7K	10%	½W	C
R42	750	10%	½W	C
R43	750	10%	½W	C

C17	470pf	Compression Trimmer	
C18	1-8pf	Trimmer	
C19a	32uf	Elec.	275v

L1	uH	Iron-cored Inductance
L2	uH	Iron-cored Inductance
L3	uH	Variable
L4	uH	Variable
L5	uH	Iron-cored Inductance
L6	uH	Iron-cored Inductance

TRIGGER CIRCUIT & T.V. SYNC. SEPARATOR

R44	1.2M	10%	½W	C
R45	470	10%	½W	C
R46	4.7K	10%	½W	C
R47	4.7K	10%	½W	C
R48	1.2M	10%	½W	C
R49	1.2M	10%	½W	C
R50	6.8K	10%	½W	C
R51	15K	5%	5W	WW
R52	22K	10%	½W	C
R53	68K	10%	½W	C
R54	100K	2W Carbon Potentiometer (TRIG. LEVEL)		
R55	56K	10%	½W	C
R56	68K	10%	½W	C
R57	100	10%	½W	C
R58	560K	10%	½W	C
R59	3.3K	10%	½W	C
R60	10K	10%	1W	C
R61	56K	10%	½W	C
R62	2.7K	10%	½W	C
R63	1M	Var.	½W	PS (Trigger Sensitivity)
R64	68K	10%	½W	C
C19b	32uf		275V	Elec
C20	.luf	20%	600V	MP
C21	.luf	20%	600V	MP
C22	.luf	20%	600V	MP
C23	.Oluf	20%	600V	MP
C24	.luf	20%	600V	MP
C25	30pf	20%	500V	Cer
C26	100pf	20%	500V	Cer

SWEEP GENERATOR & HORIZONTAL AMPLIFIER.

R65	39K	10%	1W	C
R66	100K	2W Carbon Potentiometer (SET SPEED)		
R67	22K	10%	½W	C
R68	470	10%	½W	C
R69	350K	1%	½W	HSC
R70	400K	1%	½W	HSC
R71	1.2M	1%	½W	HSC
R72	2M	1%	½W	HSC
R73	4M	1%	½W	C
R74	12M	1%	½W	C
R75	220K	10%	½W	C
R76	560K	10%	½W	C
R77	1.2M	10%	½W	C
R78	2.2M	10%	½W	C
R79	560K	10%	½W	C
R80	4.7K	10%	1W	C
R81	100	10%	½W	C
R82	4.7M	10%	½W	C
R83	100	10%	½W	C
R84	39K	10%	1W	C
R85	39K	10%	1W	C
R86	820K	10%	½W	C
R87	560K	10%	½W	C
R88	1M	2W Carbon Potentiometer (STABILITY)		
R89				
R90	100K	10%	1W	C
R91	4.7K	10%	½W	C
R92	560K	10%	½W	C
R93	1M	Var	½W	PS (Set Trace Length)
R94	100K	2W Carbon Potentiometer (X SHIFT)		
R95	220K	10%	½W	C
R96	560	10%	½W	C
R97	15K	10%	1W	C
R98	4.7K	10%	½W	C
R99	2.2K	10%	½W	C
R100	10K	2W Carbon Potentiometer (X GAIN)		
R101	15K	10%	1W	C
R102	4.7K	10%	½W	C
R103	560	10%	½W	C
R104	1.2M	10%	½W	C
R105	1M	Var	½W	PS (Set X Shift)
C27	3-30pf	Trimmer		
C28	180pf	5%	500V	SM
C29	2000pf	5%	600V	MP
C30	.02uf	5%	600V	MP
C31	.2uf (2x.1uf)	5%	600V	MP
C32	30pf	20%	500V	Cer
C33	100pf	20%	500V	Cer

SWEEP GENERATOR & HORIZONTAL AMPLIFIER. (continued)

C34	.001uf	20%	600V	MP
C35	.01uf	20%	600V	MP
C36	.1uf	20%	500V	MP
C37	30pf	20%	500V	Cer
C38	470pf	Compression Trimmer		
C39	.25uf	20%	600V	MP
C40	.1uf	20%	600V	MP

CR1 Crystal Diode Type GD5.

TUBES & C.R.T.

V1 - V9	Type ECF80.	Mullard.	
V10	Type EZ81.	Mullard	
C.R.T.	Type DG7/36.	Mullard	
or	Type 701.	General Electric Company	

POWER SUPPLY, C.R.T. CIRCUIT & VOLTAGE CALIBRATOR.

R106	500	10%	10W	WW
R107	5K	10%	10W	WW
R108	7.5K	10%	10W	WW
R109	18	10%	1W	WW
R110	18	10%	1W	WW
R111	10K	10%	½W	C
R112	1M	2W Carbon Potentiometer (ASTIGMATISM)		
R113	220K	10%	½W	C
R114	2.2M	10%	½W	C
R115	1M	2W Carbon Potentiometer (FOCUS)		
R116	560K	10%	½W	C
R117	10K	10%	½W	C
R118	200K	2W Carbon Potentiometer (BRIGHTNESS)		
R119	56K	10%	½W	C
R120	1M	Var	½W	PS (Set Brightness)
R121	100K	10%	½W	C
R122	560K	10%	½W	C
R123	6.8M	10%	½W	C
R124	560K	10%	½W	C
R125	560K	10%	½W	C
R126	2.2M	10%	½W	C
R127	2M	1%	½W	HSC
R128	18K	1%	½W	HSC
R129	5K	Var	½W	PS (Set Internal 1 v.)

C41	32+32uf		450V	Elect
C42	32+32uf		450V	Elect
C43	8uf		450V	Elect
C44	.01uf	20%	1500V	MP
C45	.1uf	20%	600V	MP
C46	100pf	20%	500V	Cer
C47	3-30pf	Trimmer		
C48	.5uf	20%	1500V	P
C49	.5uf	20%	1500V	P
C50	.1uf	20%	1000V	MP
C51	.01uf	20%	600V	MP

MR1	Selenium Rectifier	Type K/8/20
MR2	Selenium Rectifier	Type K8/35
MR3	Selenium Rectifier	Type K8/20

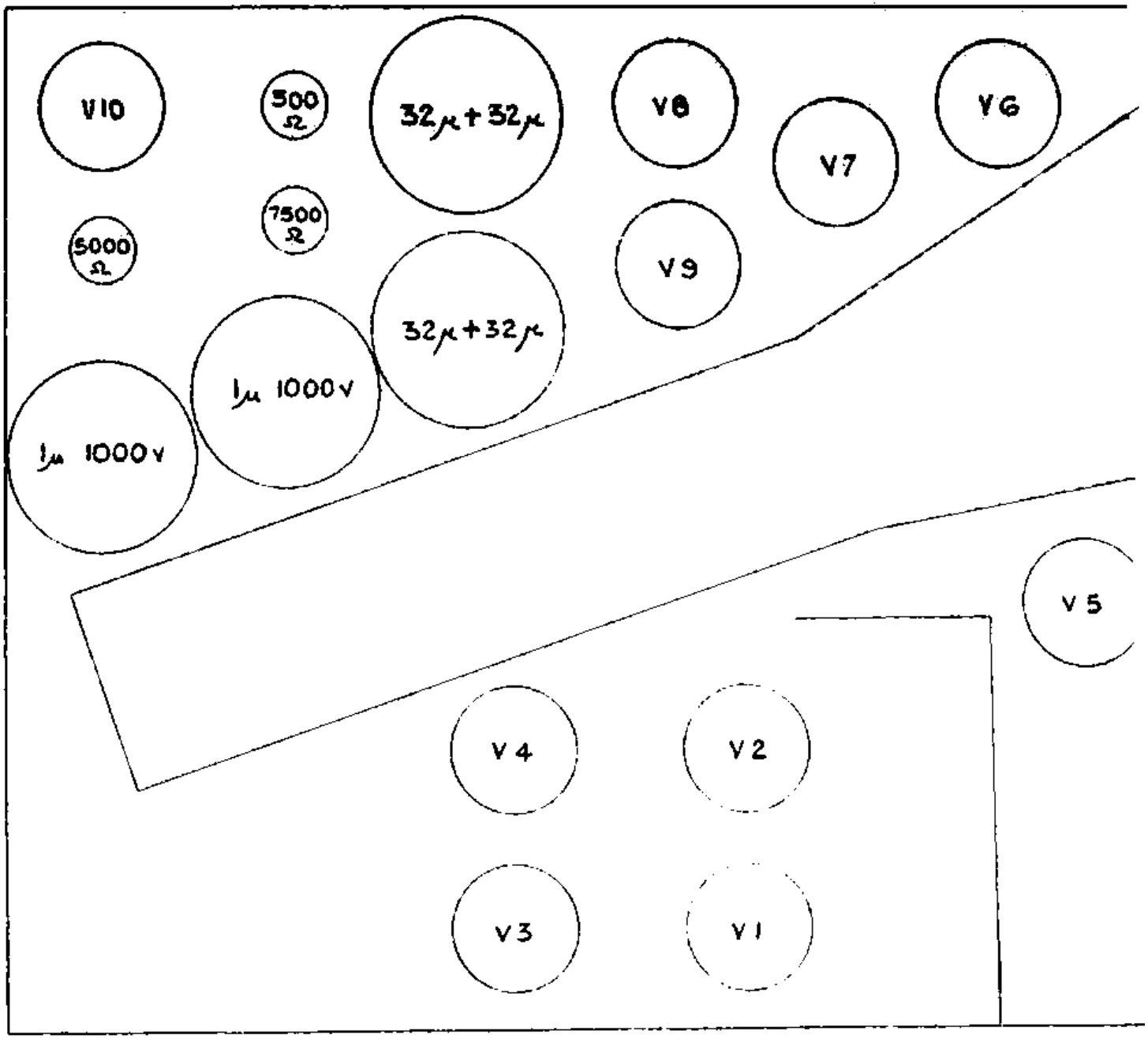
NT1, NT2, NT3 — Neon Voltage Reference Tube Type NT2. 50V.

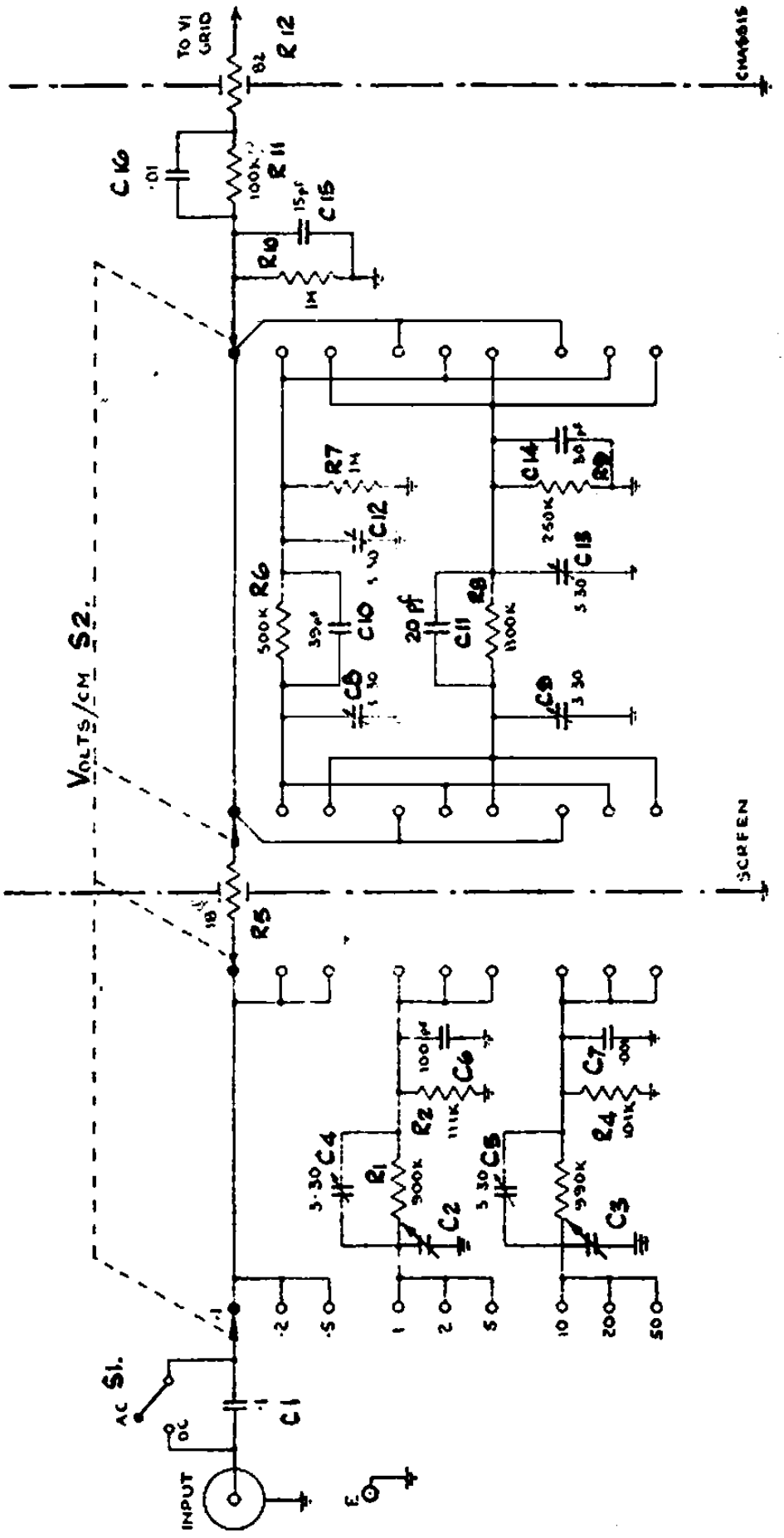
T1 — Power Transformer Type

375-0-375 V. @ 110 mA

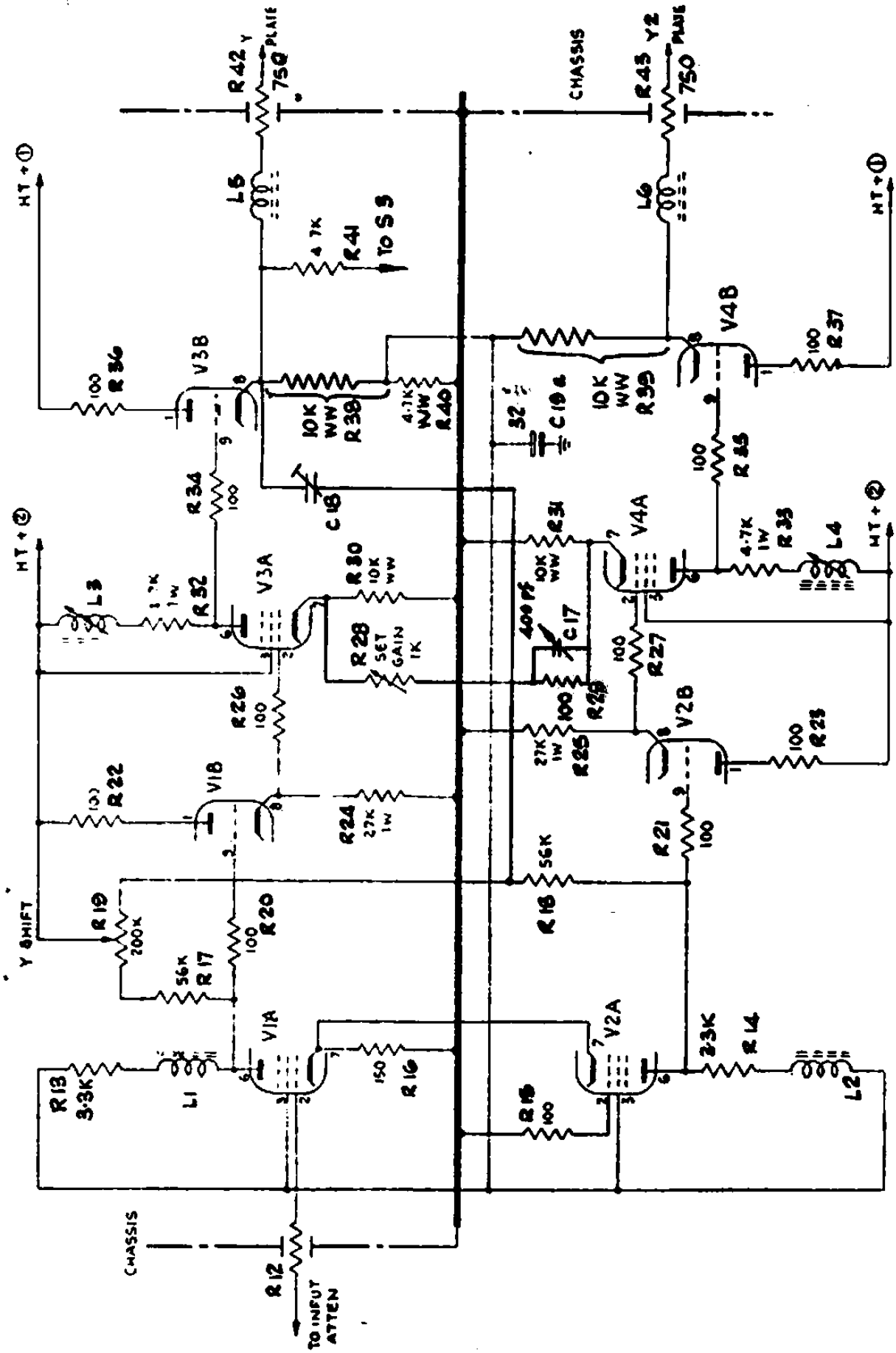
6.3V @ 1A (V10 Heater)
6.3V @ 5A (All other heaters)
6.3V @ 1A (CRT Heater)

V1 ECF 80
V2 ECF 80
V3 ECF 80
V4 ECF 80
V5 ECF 80
V6 ECF 80
V7 ECF 80
V8 ECF 80
V9 ECF 80
V10 EZ 81
C.R.T. DG7/36



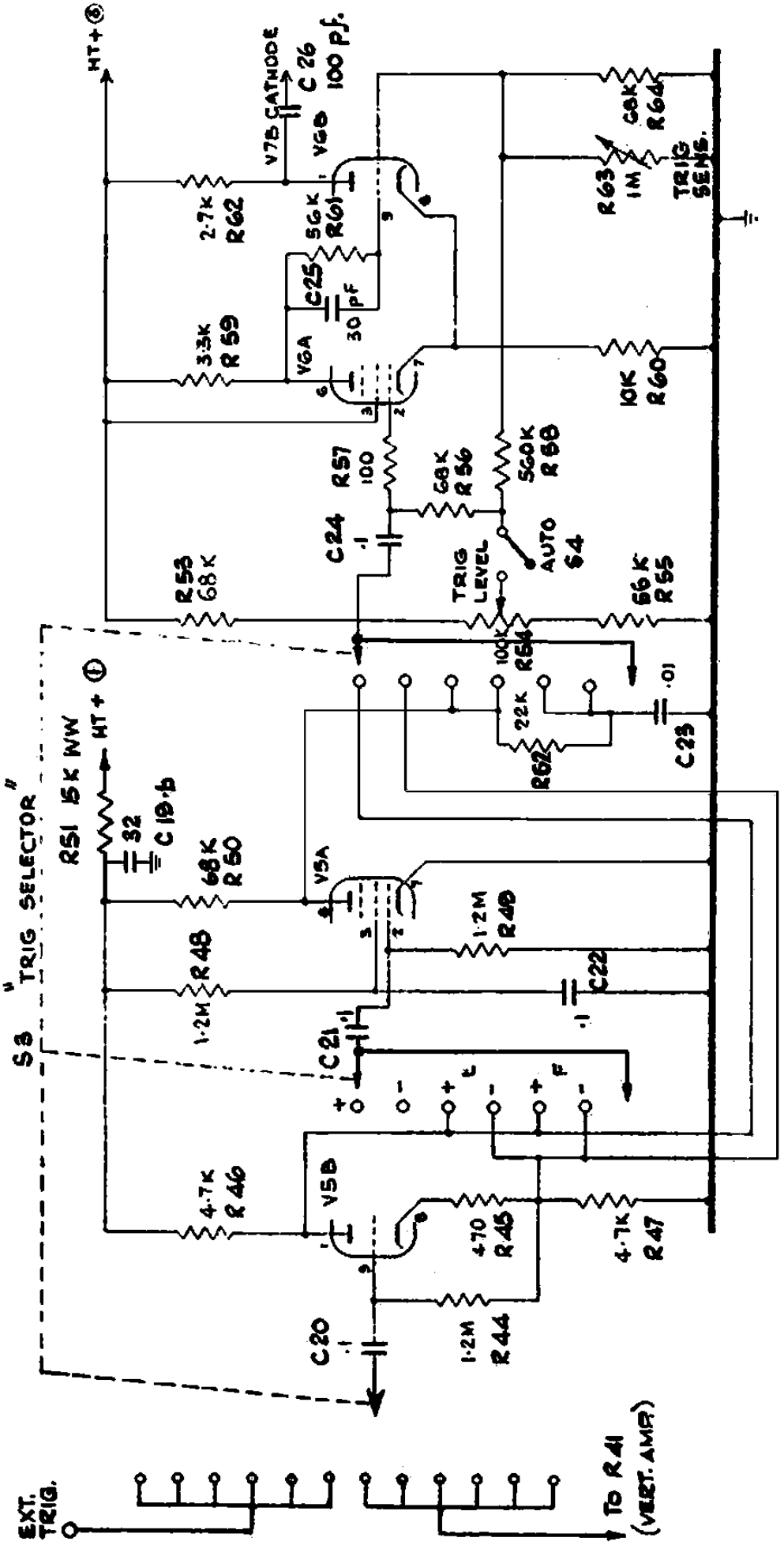


INPUT ATTENUATOR

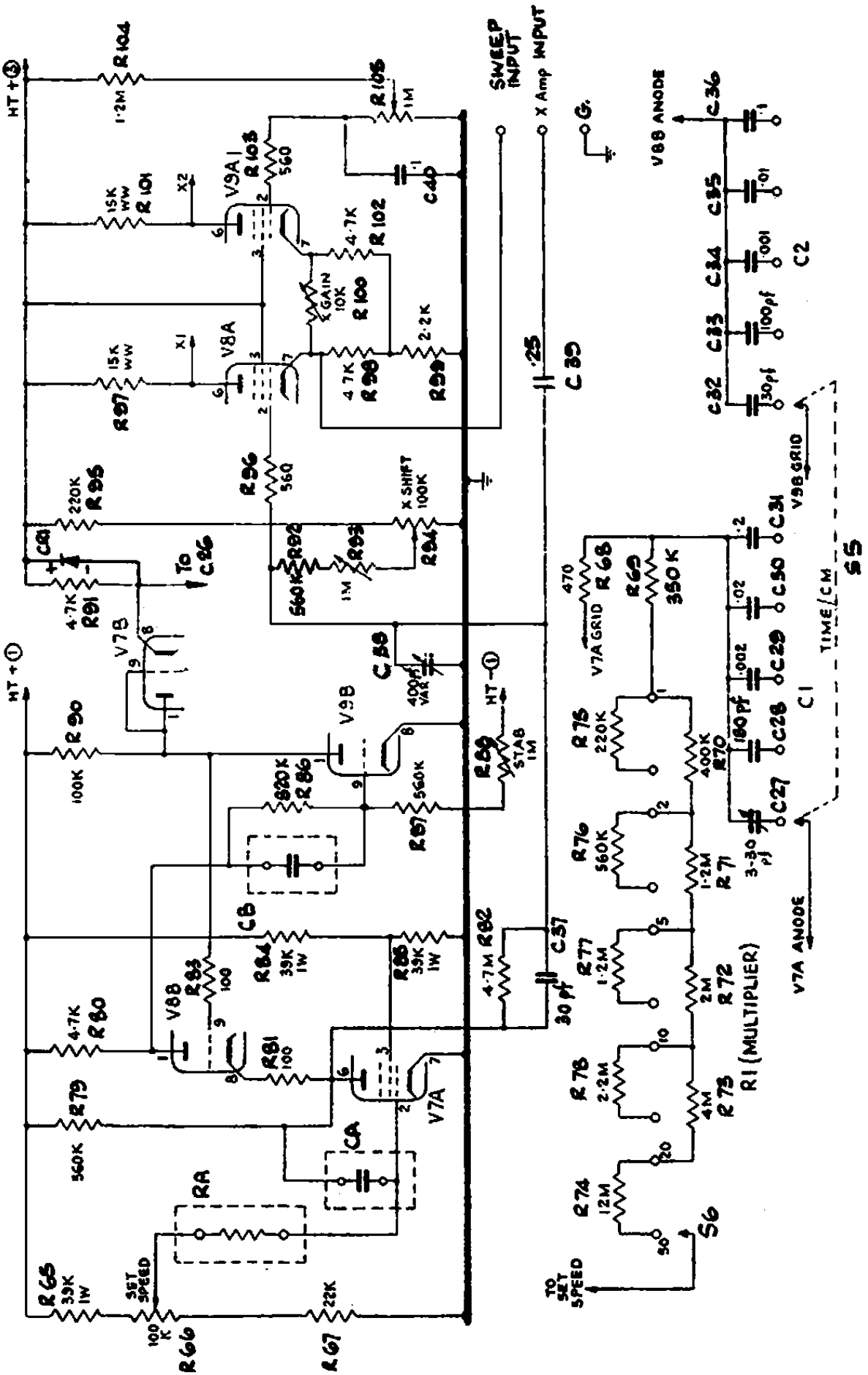


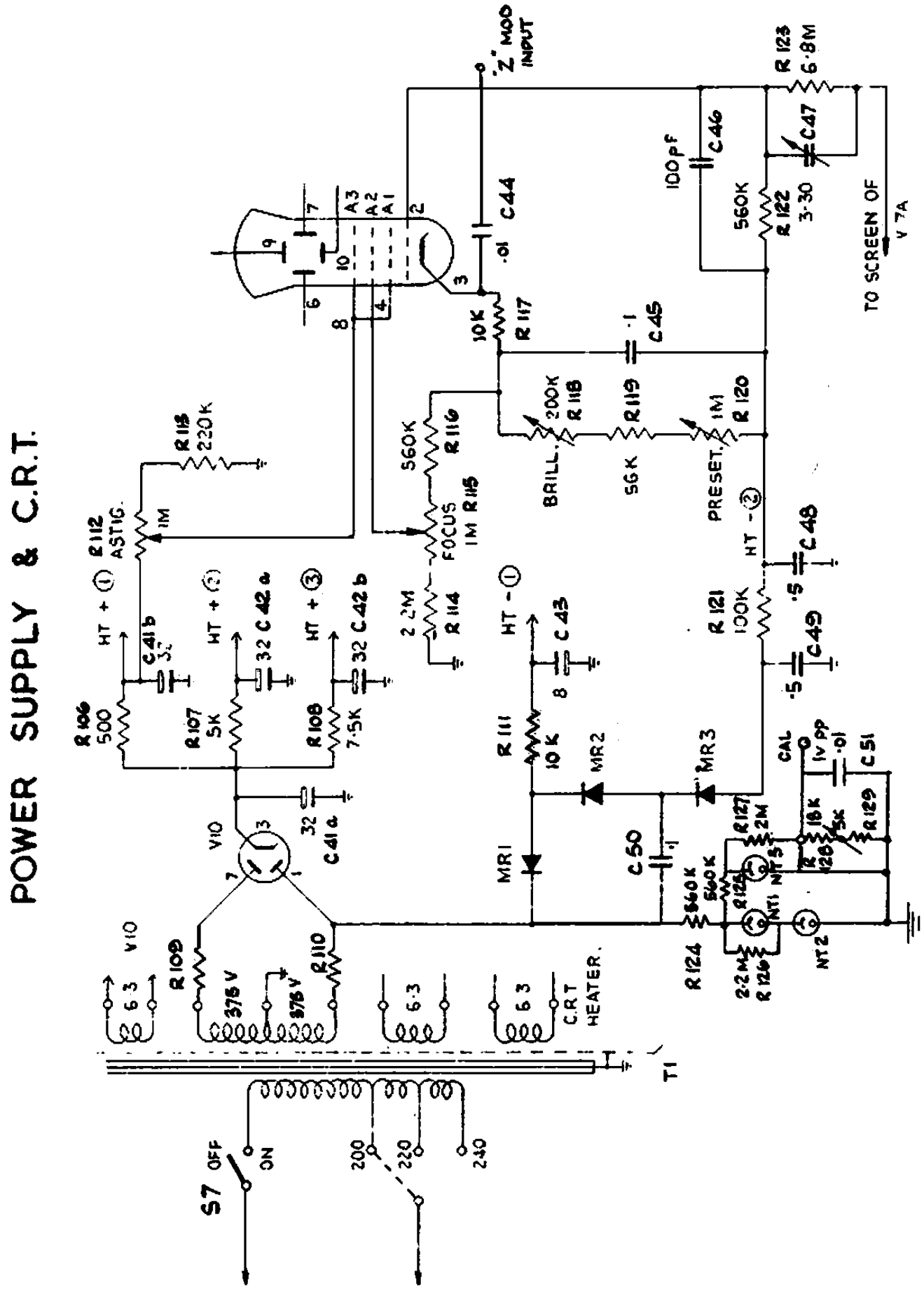
VERTICAL AMPLIFIER

TRIGGER CIRCUIT & SYNC SEPARATOR.



TIME BASE & HORIZONTAL AMPLIFIER




POWER SUPPLY & C.R.T.
"Z" MOD INPUT
R 123 6·8M
C 46 100pF
C 47 3-30
R 122 560K
TO SCREEN OF V 7A
C 44 ·01
R 117 10K
C 45 ·1
R 118 200K BRILL.
R 119 56K
R 120 1M PRESET.
R 116 560K
R 115 1M FOCUS
R 114 2·2M
R 112 ASTIG. 1M
R 113 220K
HT + ①
HT + ②
HT + ③
HT - ①
HT - ②
C 41 b 32
C 42 a 32
C 42 b 32
C 41 a 32
R 106 500
R 107 5K
R 108 7·5K
R 111 10K
C 43 8
R 121 100K
C 48 ·5
C 49 ·5
MR1
MR2
MR3
C 50
R 124 560K
R 125 560K
R 127 2M
R 128 18K
R 129 5K
CAL 1v pp
C 51 ·01
NT1
NT2
NT3
V10
R 109
R 110
375 V
375 V
6·3
6·3
6·3
C.R.T. HEATER.
R 126 2·2M
T1
S7 OFF ON
200
220
240