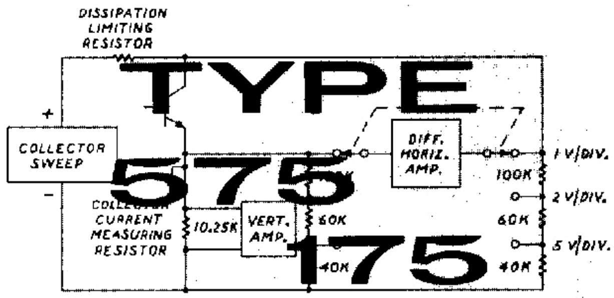
INSTRUCTION MANUAL

TYPE 575 175



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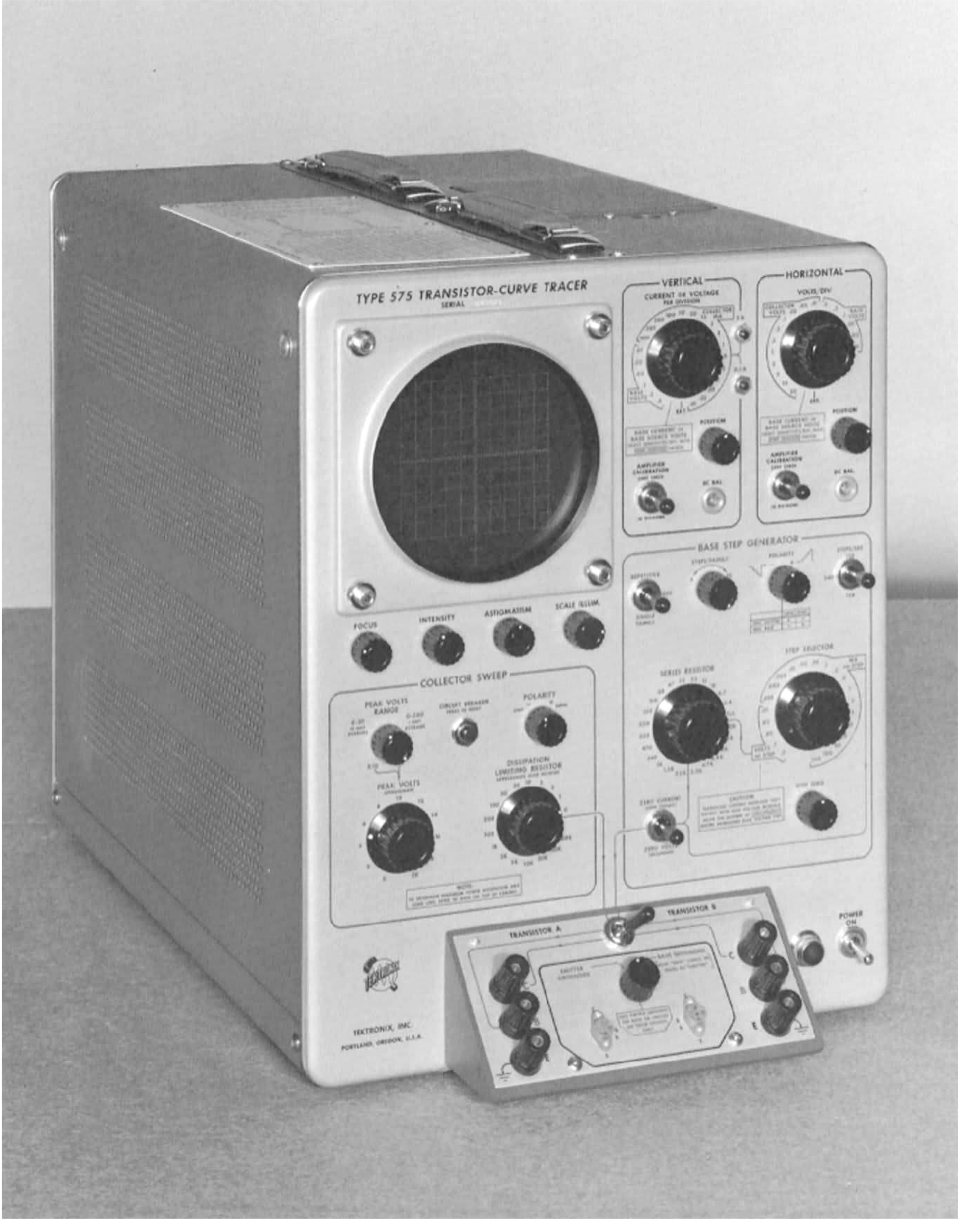
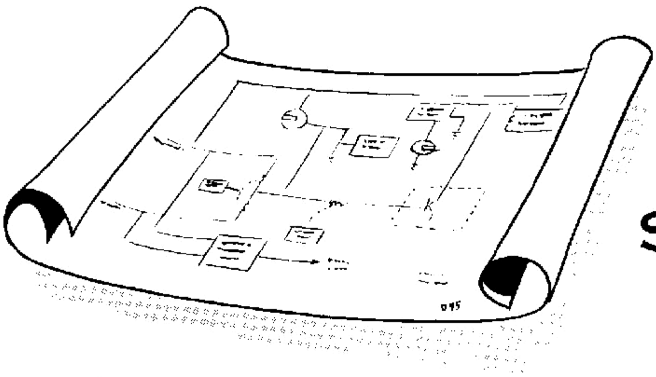

TYPE 575 TRANSISTOR-CURVE TRACER
VERTICAL
HORIZONTAL
FOCUS
INTENSITY
ASTIGMATISM
SCALE ILLUM.
COLLECTOR SWEEP
PEAK VOLTS RANGE
POLARITY
PEAK VOLTS
DISSIPATION LIMITING RESISTOR
BASE STEP GENERATOR
SERIES RESISTOR
STEP SELECTOR
POSITION
AMPLIFIER CALIBRATION
DC BAL.
TRANSISTOR A
TRANSISTOR B
POWER ON
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.



SECTION 1

SPECIFICATIONS

General Description

The Type 575 Transistor Curve Tracer displays the dynamic characteristic curves of both junction and point-contact transistors on the screen of a 5-inch cathode-ray tube. Several different transistor characteristic curves may be displayed, including the collector family in the common-base and common-emitter configuration. Regulated current or voltage steps are applied to the input of the transistor under test. A rectified sine wave of controllable amplitude is used for the collector sweep. The family of characteristic curves is accurately plotted as either a repetitive or single-family display.

Tolerances and accuracies as stated in Specifications section and the Recalibration Procedure of this manual apply only to Type 575 instruments above serial number 8030.

Operating Specifications

Collector Sweep

0-200 volts minimum peak with 1-ampere current curves.

0-20 volts minimum peak with 20-amperes current curves.

Base Step Generator

Generates 4-12 current- or voltage-steps per family of curves at 120- or 240-steps per second (2- or 4-times power-line frequency) for either repetitive or single-family displays.

17 current-step ranges from 1 μa/step to 200 ma/step ±3%.

5 voltage-step ranges from .01 volt/step to .2 volt/step ±3%, with output impedance adjustable from 1 ohm to 22 thousand ohms ±5%.

Vertical Display

Plots collector current from 0.01 ma/div. to 1000 ma./div. ±3% in 16 calibrated steps. Pushbuttons provide multiplying each current step by 2 or dividing by 10, increasing the current range from 0.001 ma./div. to 2000 ma./div. ±3%.

Plots base voltage from .01 volt/div. to .5 volt/div. ±3% in 6 calibrated steps.

Plots base current or base source volts with sensitivity read from step selector switch ±3%.

Horizontal Display

Plot collector voltage from .01 volt/div. to 20 volt/div. ±3% in 11 calibrated steps.

Plots base voltage from .01 volt/div. to .5 volt/idv. ±3% in 6 calibrated steps.

Plots base current or base source volts with sensitivity read from step collector switch ±3%.

Other Features

Comparison switch permits rapid manual switching between two transistors for comparison tests.

Regulated power supplies and negative-feedback amplifiers assure the accuracy of the calibration and the stability of the display.

Cathode-ray tube is a Tektronix T52P. Accelerating potential is approximately 4 kv. P1 phosphor is supplied unless another phosphor is requested. P2, P7, or P11 phosphors are available at no extra charge.

Differential inputs to both vertical and horizontal amplifiers are available at the rear of the instrument, or at the Type 175 adaptor socket on instruments after S/N 3659. The sensitivity of each channel is .1 volt/div. and the bandpass is approximately 300 kc. The rejection of a common-mode signal is better than 100:1 with a peak-to-peak signal of 10 volts or less.

Mechanical Characteristics

Ventilation—Filtered- forced-air circulation maintains safe operating temperature.

Construction—Aluminum-alloy chassis and three-piece cabinet.

Finish—Photoetched, anodized front panel, with blue vinyl finished cabinet.

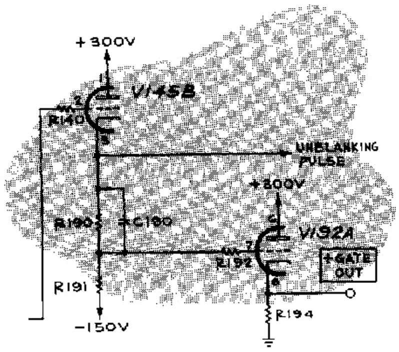
Dimensions—24" long, 13" wide, 16¾' 'high.

Weight—Approximately 70 lbs.

Power Requirements—105-125 or 210-250 volts, 50-60 cycles; 410 watts maximum at 117 v, 60 cycles, depending upon the type of transistor being tested, 200 watts standby.

Accessories

2—Transistor adapters, long, 013-010.
2—Transistor adapters, short, 013-012.
1—3 to 2-wire adapter, 103-013.
2—2N1381 Transistors, 151-039.
1—3-conductor power cord, 161-010.
1—Green filter, 378-514.
2—Instruction Manuals.



SECTION 3

CIRCUIT DESCRIPTION

Block Diagram

The Block Diagram shows the relationship of the Collector Sweep, the Step Generator, the Step Amplifier, and the CRT Deflection Amplifiers to the transistor under test. The Step Generator is driven by the 60-cycle line voltage and the waveform from the Step Amplifier is applied to the input of the transistor under test. The Collector Sweep Generator supplies the full-wave rectified pulses that are applied to the collector of the transistor. Notice that the pulsations occur at twice the line frequency. The crt deflection amplifiers are shown connected for a display of the transistor I_c - V_c characteristic curves.

The three possible time relationships between waveforms of the Collector Sweep and the Step Generator are shown in Fig. 3-1. In waveform (b), each voltage step begins at a time when the Collector Sweep voltage is zero. In waveform (c), each step begins at a time when the Collector Sweep voltage is at its maximum value. In waveform (d), steps begin both at times when the Collector Sweep voltage is at its maximum value and when it is at its minimum value.

Collector Sweep

The Collector Sweep circuit rectifies the 60-cycle line voltage (full-wave circuit) to produce 120 sweeps per second for the collector of the transistor under test.

The primary voltage of T702 is variable from 0 to 140 volts rms by the variable autotransformer T701 (PEAK VOLTS control). The secondary of T702 provides output voltages up to 20 volts and 200 volts, peak, depending on the setting of the PEAK VOLTS control and the PEAK VOLTS RANGE switch SW706. The collector-supply primary is protected by a circuit breaker, set to trip within 30 seconds at 1.2 ampere rms current but to hold on a rms current of 1 ampere. The turns ratio of the transformer for the 20-v range is such that a maximum peak current of 15 amperes is available with 1 ampere rms in the primary. Because the current pulses for transistors are not sinusoidal nor of constant amplitude, and their duty cycle is dependent upon the characteristics of the device being tested, it is difficult to say what maximum collector-current curves can be plotted. Generally, a family of collector-current curves can be plotted to 20 amperes or more

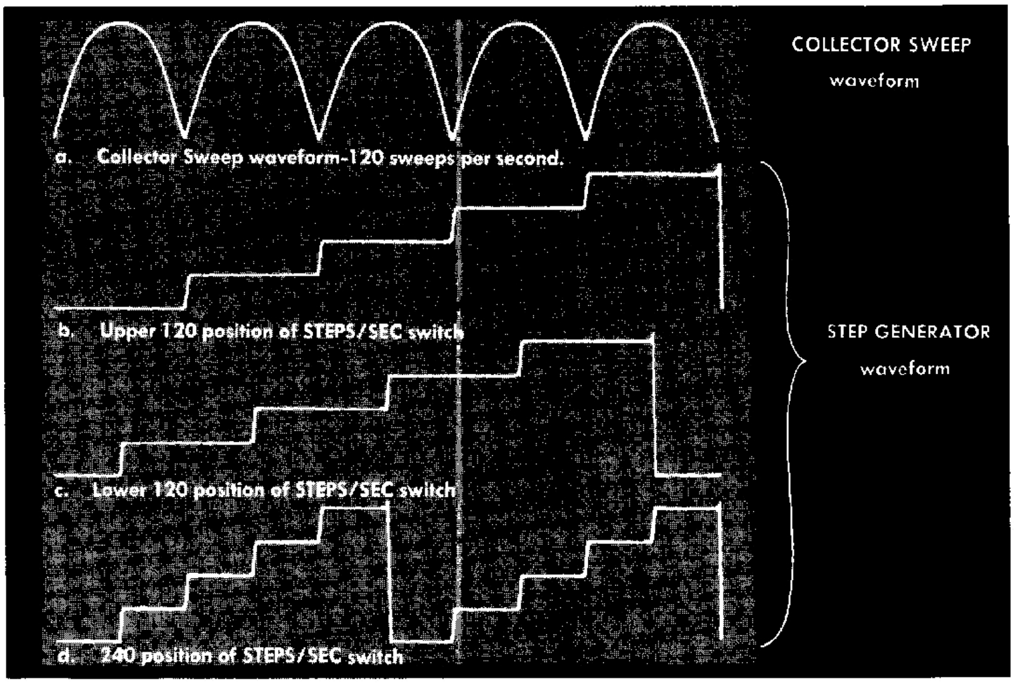


Fig. 3-1. The time relationship between waveforms of the Collector Sweep circuit and the Step Generator.

when the transistors have a beta of 8 or greater. When checking diodes, you will notice that the waveform of current pulses is such that a curve of approximately 15 amperes maximum is drawn.

By means of the PEAK VOLTS RANGE switch, each set of rectifier diodes is connected in parallel for the 0-20 volt range, or in series for the 0-200 volt range. The polarity of the output sweeps is determined by the POLARITY switch SW708. The DISSIPATION LIMITING RESISTOR switch SW710 connects the desired value of resistance in series with the collector to protect the transistor.

To compensate for the stray-circuit-capacitance charging current through the Current Sampling Resistor, a sample of the collector sweep voltage is applied through the cathode-follower V733 to the top of the Current Sampling Resistor. Capacitors C706 and C735 are used to balance the circuit capacitances.

Step Generator

The circuit diagram of the Step Generator may be considered in two sections: the pulse-generator section (left side) which develops rectangular pulses from the sine-wave input, and the staircase-generator section which uses these pulses to develop a staircase waveform. V171 is the "heart" of the Step Generator and its operation will be described first.

Staircase Generator

The staircase waveform is generated by increasing the charge on a capacitor by equal steps and then discharging the capacitor after the desired number of steps has been generated. A simplified example is shown in Fig. 3-2. When the switch is closed the voltage will rise at the normal RC charging rate as in curve A. If the switch is closed in a series of short, equal intervals, a staircase waveform like that of waveform B is produced. It is a very poor staircase waveform because the steps become progressively smaller as the voltage across the capacitor increases. To achieve a series of equal-amplitude steps, the capacitor charging current, and hence the voltage across the resistor, must be kept constant.

The diagram of Fig. 3-3 shows a method of achieving this end. It is called the Miller integrator. With the switch in position 1, the plate of the pentode is at +100 volts, the quiescent output voltage, and the charge on C177 is 101.5 volts.

When the switch is moved to position 3, C177 charges through R1 and the grid of V171 tends to become more negative. But since a negative signal on the control grid reduces the plate current, the plate voltage increases, raising the voltage at the top of C177. The coupling of this positive change at the top of C177 to the control grid almost completely cancels the negative-going tendency of the control grid. Since the dc gain of the pentode stage is very high, the plate-voltage change is always very large compared to the voltage change that occurs on the grid.

When the switch is moved to position 1, the charging process stops and the tube returns to its initial condition, discharging C177 to 101.5 volts.

Waveform A of Fig. 3-3 is the output waveform which results from moving the switch from position 2 to position 3 at a regular rate. Note that this staircase waveform has steps which are of equal amplitude, since C177 is charged at the same rate whenever the switch is in position 3. Waveform B is the corresponding grid waveform.

The circuit of Figure 3-4 is a modification of the one in Fig. 3-3, the only changes being the addition of a cathode follower between the plate of the pentode and the top of C177 and an additional switch position which permits the coupling of negative-going pulses to the bottom of C177.

With the switch in position 1, the plate of the pentode is again at +100 volts; however, the output terminal (top of C177) will be about ground potential.

With the switch in position 4, and with no input pulses fed into diodes V172A and V172B, the output voltage is constant since the electrical path through C177 is incomplete. When

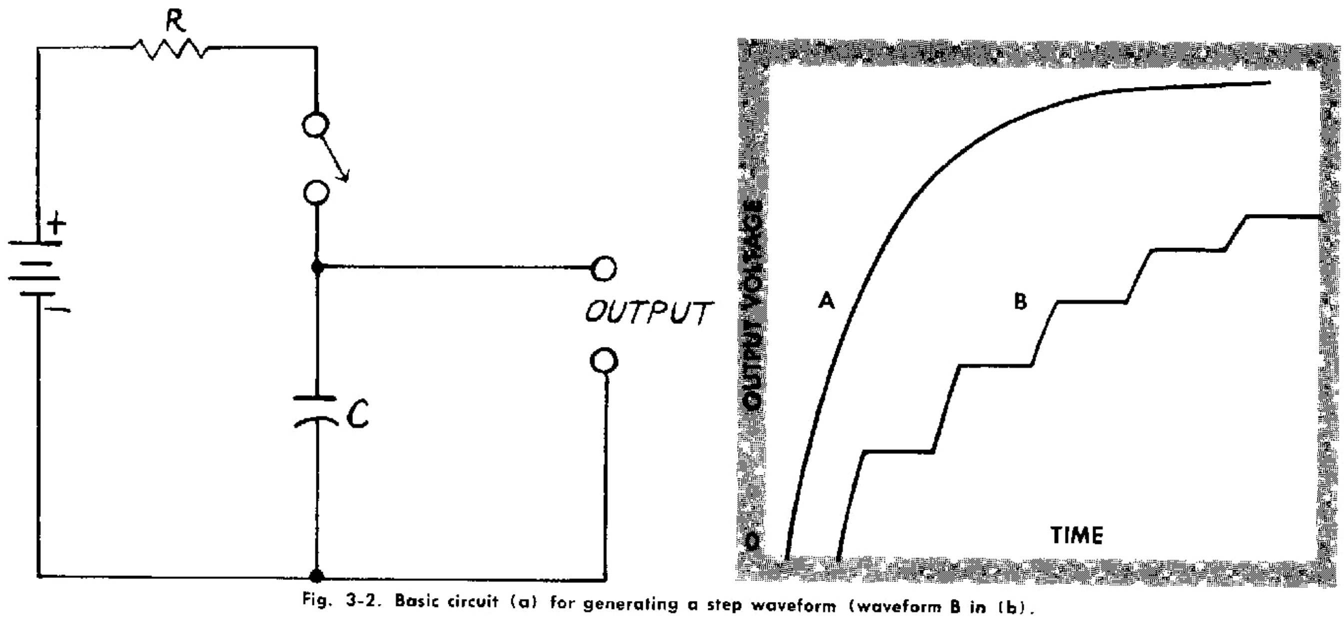
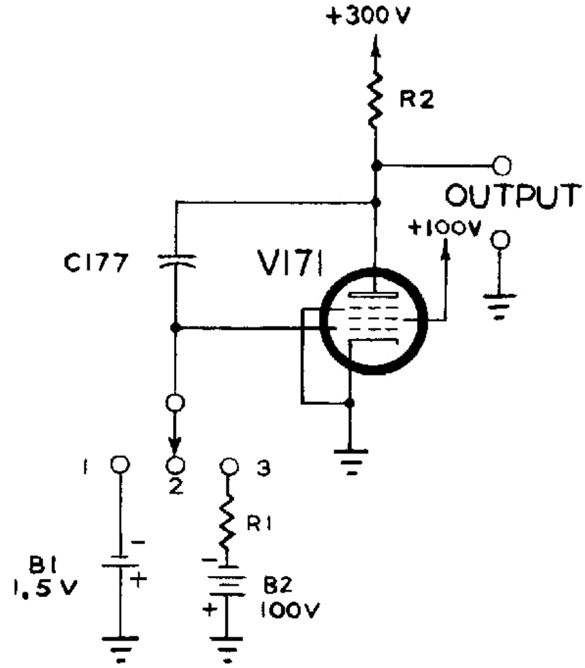


Fig. 3-2. Basic circuit (a) for generating a step waveform (waveform B in (b).



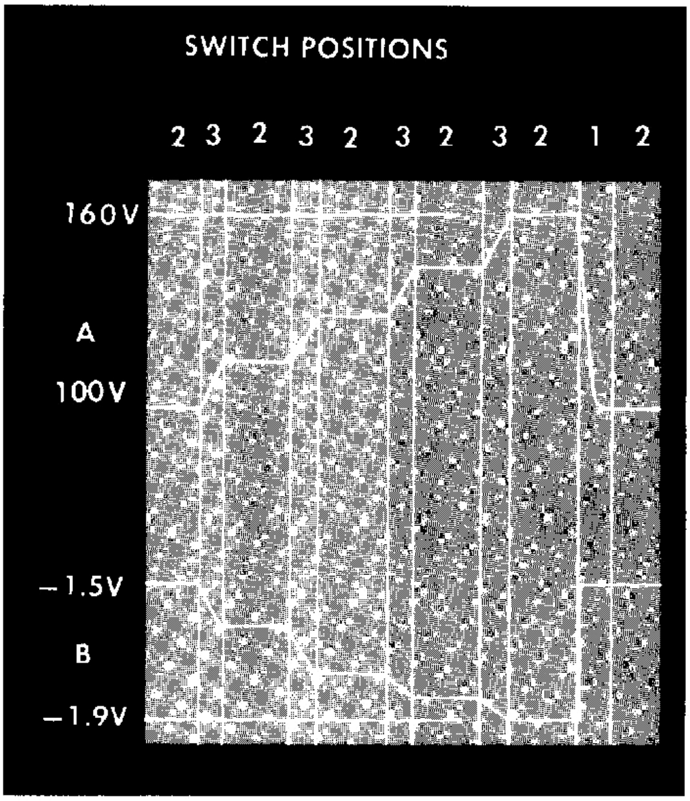


Fig. 3-3. The basic Miller Integrator circuit and the resulting plate and grid waveforms for linear step operation.

a negative pulse is fed to the cathode of V172A, C142 transfers a quantity of its charge to C177. As the negative input pulse returns to its base level, V172A stops conducting. V172B, however, begins to conduct heavily to restore the charge on C142.

Because the Miller integrator keeps the voltage at the bottom of C177 nearly constant, the same quantity of charge is transferred to C177 with each pulse. The voltage steps occuring at the output are equal, because the voltage across a capacitor is directly proportional to its charge.

The changing charge on C142 is an important part of the generation of steps. On waveform C, point "a" (between negative pulses) shows the left end of C142 to be +150 volts. Waveform B shows that at the same time, the junction of diodes V172A and V172B is near ground. The charge on C142, then, must be about 150 volts. As a negative pulse begins, the left end of C142 is driven negatively toward +50 volts. As the right end of C142 tries to follow, V172A provides a current path for C177 and its charge is increased as shown on waveform A. Since the capacity of C177 is about 7 times as large as that of C142, the increase in voltage across C177, 15 volts is equal to 1/7 of the decrease in voltage across C142. Because the Miller integrator keeps the bottom of C177 at a constant voltage, the 15-volt step occurs at the output and not at the grid of V171.

Repetitive Triggering

The circuit of Fig. 3-5 is used to show the operation of the Schmitt Trigger and the Hold-Off Cathode Follower. Their action provides a repetitive display, since they cause C177 to be discharged and then permit the formation of steps to proceed again in the same manner as described previously.

For our purposes, we think of the Schmitt Trigger as a voltage-activated switch. In its operation, the entire current through R156 in the cathode circuit is shifted from one section of V155 to the other. When one side of V155 conducts the other side is cut off.

Typical conditions for conduction are as follows: when the grid voltage of V155A is above —42 volts, V155A conducts; when the grid voltage of V155A is below —58 volts, V155B conducts. When the grid voltage of V155A is within the range from —42 to —58 volts, either tube section may conduct, but not both sections. The output of the trigger circuit is at the plate of V155B. The voltage at this plate switches between zero (V155B cut off) and a negative voltage (V155B conducting).

When V155B is conducting, the diodes V152A and V152B are cut off because their plate voltages are more negative than their cathodes. This condition permits the staircase generator to generate a stairstep waveform as described previously. As the output stairstep waveform rises, the cathode voltage of V143B follows. When the cathode voltage (and the grid voltage of V155A) reaches —42 volts, the Schmitt trigger will switch to its other stable state; that is, V155A will be conducting and V155B will be cutoff.

When V155B is not conducting, its plate voltage will be at ground potential, permitting diodes V152A and V152B to conduct. As V152B conducts, the grid of V171 is clamped at ground potential causing the plate voltage to fall rapidly.

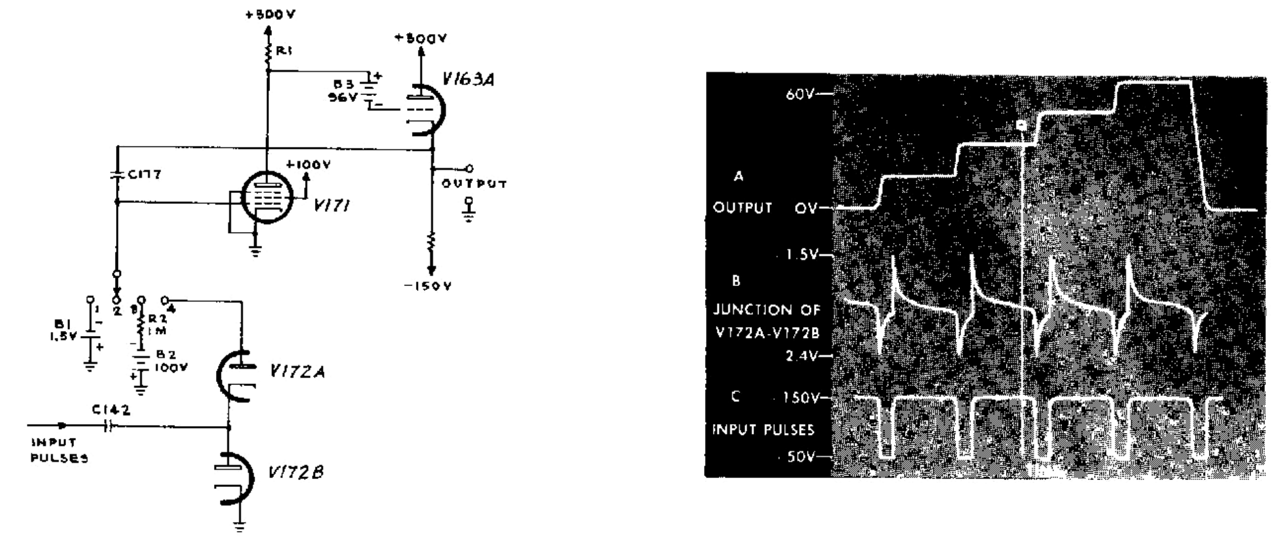


Fig. 3-4. Modification of Fig. 3-3.

As the plate voltage of V171 falls, the cathode voltage of V163A also falls, discharging C177. The cathode of V163A is prevented from going below ground potential by conduction of V152A. Because the Miller tube grid is clamped at ground potential by V152B, its plate voltage will quickly reach an equilibrium condition.

As the cathode voltage of V163A falls, so do the voltages at the cathode of V143B and the grid of V155A. If they go more negative than —58 volts, V155A will be cutoff, V155B will conduct, V152B will no longer clamp the grid of the Miller tube, and the stepping process will be resumed.

Note that the cathode circuit of V143B consists of a resistor shunted by a capacitor. If V143B is driven below cutoff, the rate of fall of the cathode voltage will be limited by the discharge rate of C186 through R186. This time-delay circuit affects only relatively fast negative-going signals; positive-going signals are not delayed. C180 emphasizes rapid changes in the output signal at the grid of V143B, and tends to compensate for the loading effect of C186 in the positive direction.

The time delay in the negative direction is necessary to allow C177 to be discharged to the point where the output voltage of the Step Amplifier has fallen to the base level before the Schmitt trigger reverts and permits the stepping process to be resumed.

Single-Family Triggering

On the circuit diagram of the Step Generator, notice the section of switch SW145 which is shown near C143B. In the OFF position of SW145, a voltage divider formed by R184 and R186 fixes the grid voltage of V155A to keep it in conduction. As a result, V155B is cutoff, disabling the Staircase Generator.

The display of a single family of curves requires that the Schmitt trigger change to its other conduction state long enough for the desired number of steps to be generated, then revert to the OFF position condition. To start the generation of one stairstep waveform, the top of C146 is grounded by depressing SW145 to the SINGLE FAMILY position. This drops the grid of V155A about 50 volts, causing the trigger circuit to change to its other state (V155B conducting).

When V155B conducts, V171 is no longer clamped and the staircase generator is ready to generate a series of voltage steps. When the desired number of steps has been generated, V143B acts in the usual way to bring V155A into conduction again.

Pulse Generator

The circuit diagram of the step Generator shows the split-load phase inverters, V104A and V124A, driven by sine waves at the power-line frequency. The single angle between these signals is adjusted to 90 degrees by the RC networks R102/C102 and R122/C122. The resulting waveforms, A and B, are shown in Fig. 3-6; the voltages are approximate. The output of each phase inverter is rectified to produce a pulsating dc waveform (C) (D) at a frequency of 120 cps. The rectified outputs of the phase inverters are fed into two pentodes (V104B and V124B) having a common plate-

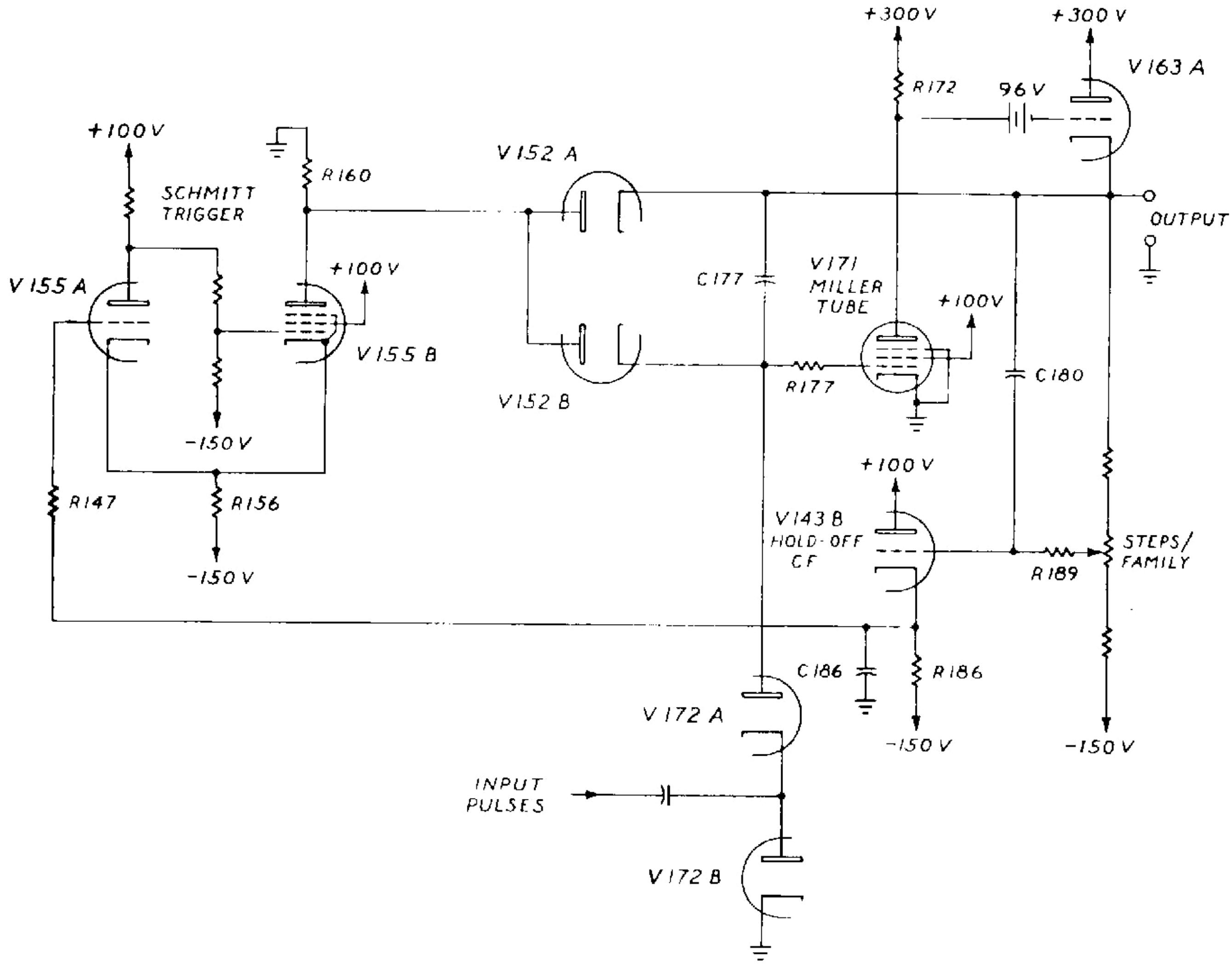


Fig. 3-5. The complete stairstep generator.

load resistor. The voltage at the common plate swings between the plate-supply voltage and ground because the voltage at the input grids drive the tubes from below cutoff to saturation. The frequency of these pulses is 240 per second (or 4 times power-line frequency). The first negative-going pulse is extra wide because the pulse generator is disabled by the clamping action of V163B during the time V155B is cut off. A cathode follower (V143A) provides a low-impedance output.

The upper limit of the pulses appearing at the cathode of V143A, determined by the setting of the VOLTS/STEP ADJ, is 150 volts. The lower limit, determined by R142/R143 is 50 volts.

Each negative-going pulse applied to the left side of C142 causes C142 to partially discharge into C177. C142 recharges through diode V172B as the input pulse returns to 150 volts. The voltage across C177 increases 15 volts with each transfer of charge. The action of the Miller integrating circuit causes this voltage increase to appear at the top of C177. The voltage at the bottom of C177 remains almost constant.

Between pulses, C177 has no discharge path and the voltage at the output of the Step Generator remains constant.

After the trigger has reverted to its initial state (V155B conducting), V163B and V152B no longer conduct and another staircase waveform is generated in response to the pulses applied to the left of C142.

Fig. 3-7 illustrates the sequence of events occuring in the generation of a staircase waveform. Voltages shown are approximate.

Step Amplifier

The voltage gain of the Step Amplifier is less than one, but the current gain is several thousand. The functions of the Step Amplifier are as follows:

1. It permits selection of the size of the output steps (current or voltage).

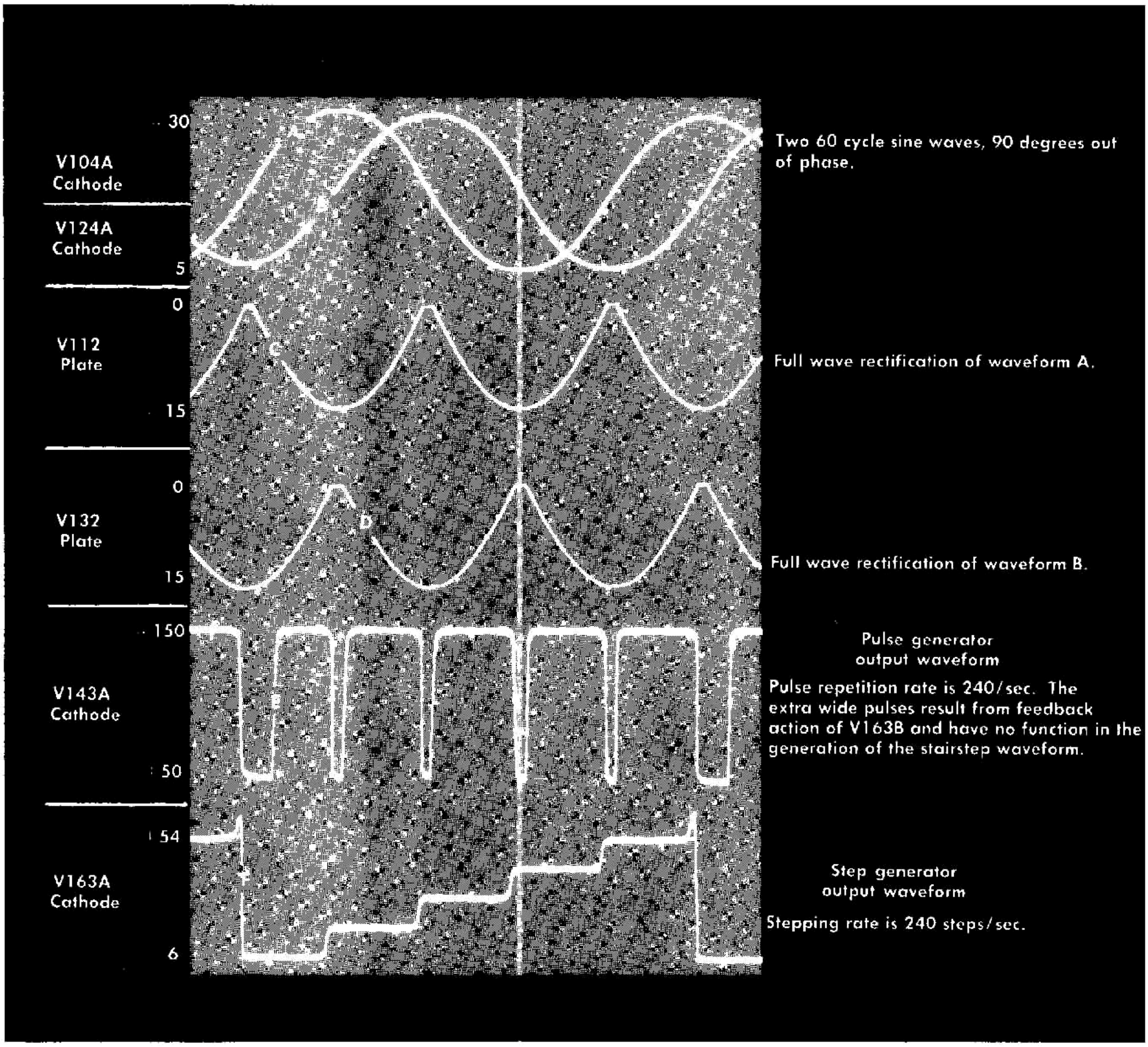


Fig. 3-6. Time relationships between the Step Generator output waveform at key points in the pulse generator section.

2. It regulates the size of the output steps (within limits) to the value chosen by means of the STEP SELECTOR switch.

3. It provides either a positive-going or a negative-going output waveform.

Figure 3-8 illustrates the role of the Step Amplifier in providing either *voltage* or *current* steps to the input of PNP transistor.

The two positions shown on SW246, the STEP SELECTOR switch, correspond to the volts-per-step and ma-per-step ranges.

The Step Amplifier consists of three functional units; a current-regulated power supply, a power-transistor output stage, and an amplifier with a voltage gain of about one.

Output Stage

A transistorized power output stage is used to deliver the output current of the Step Amplifier because of the relatively large regulated currents which must sometimes be applied to the input of the transistor under test. Since the Step Amplifier must furnish high current of either polarity, a floating power supply is used in the output stage.

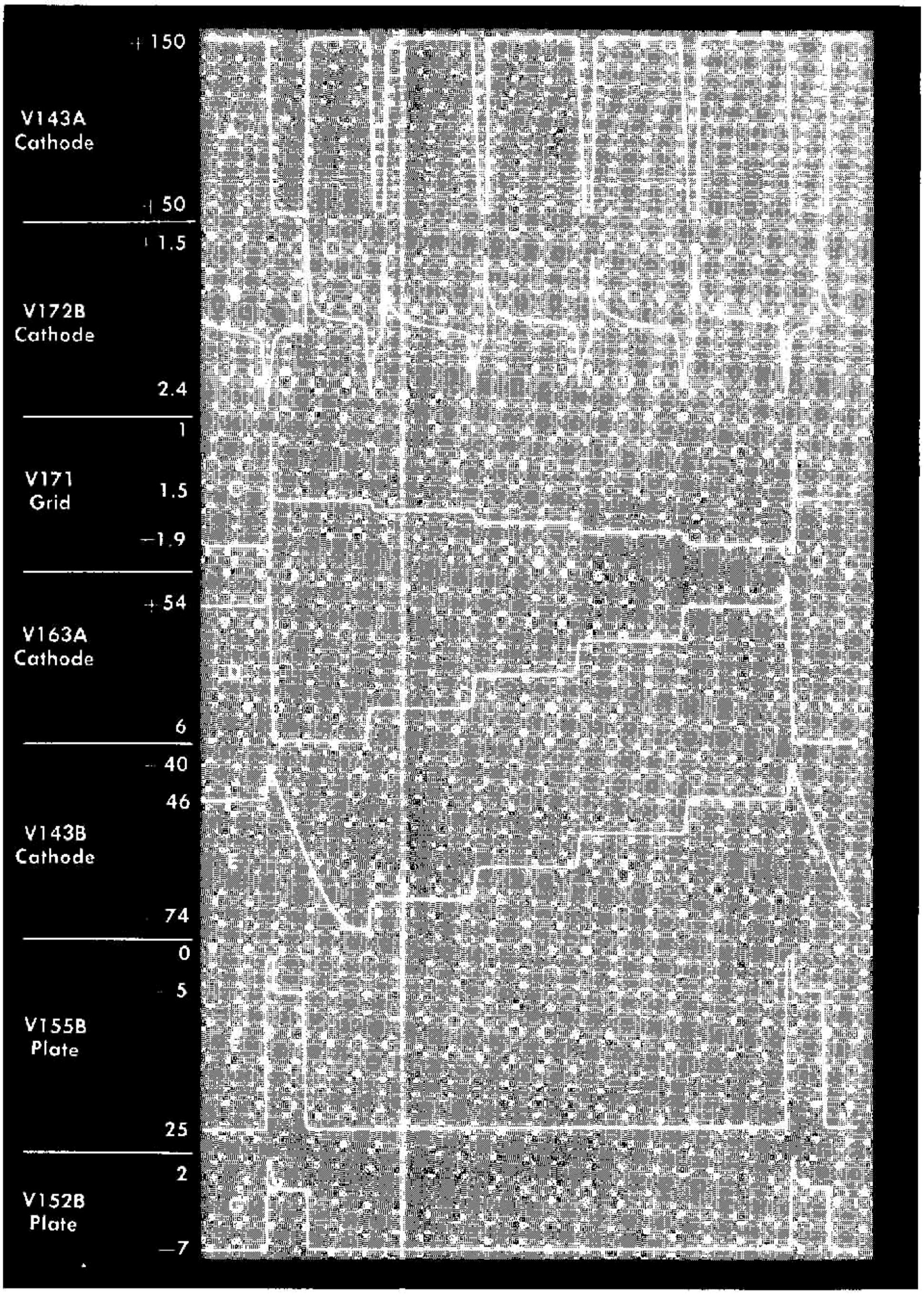


Fig. 3-7. Time relationships between the Step Generator output waveforms (D) and waveforms at key points in the step generator section.

Fig. 3-9 (a) is a diagram of a transistor operating as an emitter follower. Fig. 3-9 (b) is the vacuum-tube equivalent of the same circuit. Note that in both cases the output signal is *in phase with* the input signal. The average value of the output voltage may be set to zero by proper biasing of the input.

Fig. 3-10 shows how an *out-of-phase* signal centered around ground can be obtained with the same general configuration. Note that only the ground point has been moved. The transistor is no longer operating as an emitter follower, but as an ordinary voltage amplifier. The 100-ohm resistor is now the collector load resistor.

The approximate positive and negative limits of the no-load output voltage of Fig. 3-10 can be determined by considering the transistor as a switch which is either opened or closed. When the switch is closed (emitter and collector shorted), the output voltage must be +15 volts. When the

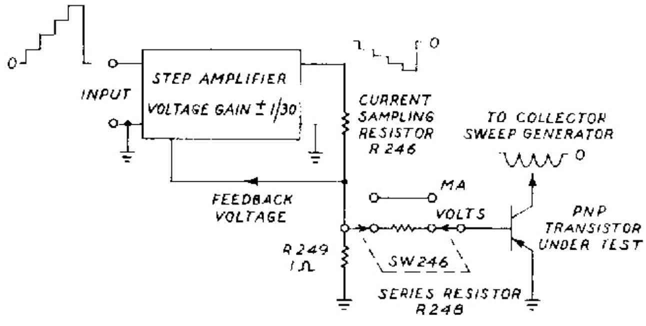


Fig. 3-8. The Step Amplifier furnishes either current or voltage steps to the input of the transistor under test.

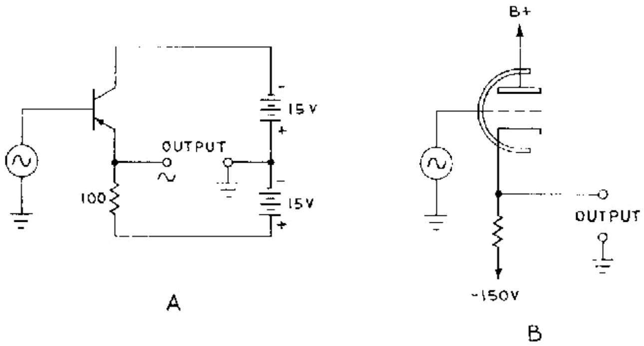


Fig. 3-9. The emitter-follower (a) operates the same as the cathode-follower (b).

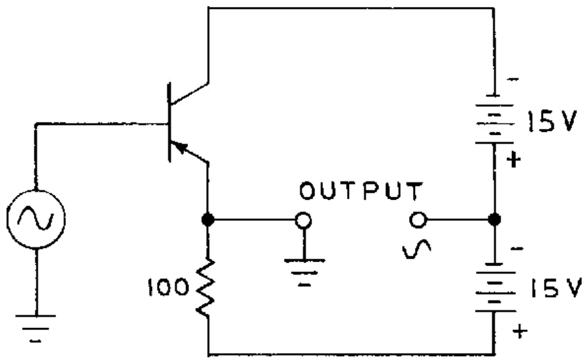


Fig. 3-10. By switching the output connections, the emitter-follower of Fig. 3-9 (a) becomes a collector-loaded amplifier.

switch is open (no current through the collector), the no-load output voltage must be —15 volts.

The circuits of Fig. 3-9 (a) and Fig. 3-10 have maximum-current limitations which are different. The circuit of Fig. 3-9 (a) can supply much more current in the *negative* direction, (making the ungrounded end of the load resistance negative) than it can supply in the positive direction (through the 100-ohm resistor).

By the same method, it can be shown that the circuit of Fig. 3-10 can supply much more current in the *positive* direction than in the negative direction.

Since the path of the higher current through the load in both circuits was always through the upper battery, the upper battery must be able to deliver more current than that which is required of the lower one.

The drawing of Fig. 3-11 shows the electron-current flow through the circuit components as the Step Generator drives a load resistance in the negative direction. The lower battery supplies only the current which flows through the 100-ohm resistor. The upper battery must supply current to the load as well.

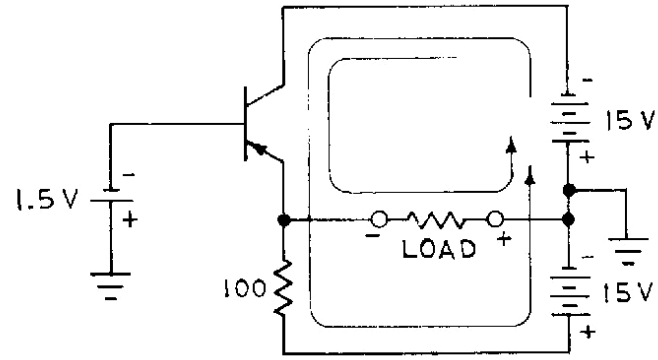


Fig. 3-11. Electron flow through the transistor V253 circuit when negative-going steps are required.

Figure 3-12 is a simplified diagram of the output circuit of the Step Amplifier. Note that the load resistance across the output circuit is always the current-sampling resistor in series with either a 1-ohm resistor (voltage steps) or the input of the transistor under test (current steps). The feedback paths go directly to vacuum-tube grids and do not load the output circuit.

The maximum current the Step Amplifier will deliver to an external load is 2.4 amperes of either polarity (ma-per-

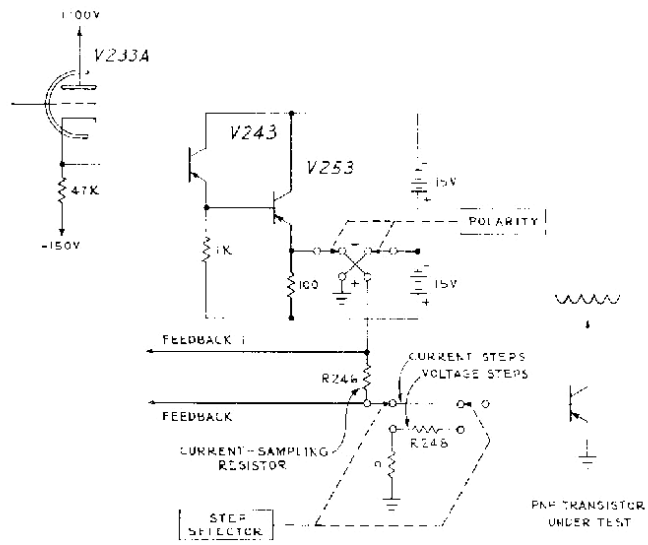


Fig. 3-12. Simplified diagram of the output circuit of the Step Amplifier.

step positions of the STEP SELECTOR switch). However, the characteristics of the external load must be such that the voltage drop across the external load resistance is no more than 5 volts when the current through it is 2.4 amperes. At lower currents, however, the 5-volt figure may be exceeded.

The simplified diagrams of Fig. 3-13 and 3-14 show the operation of the entire Step Amplifier when delivering current steps to the input of the transistor under test. Current regulation is accomplished by maintaining a constant voltage drop across R246 for each step of the input voltage from the Step Generator. That is, each time the input voltage is stepped 15 volts, the voltage drop across R246 should change 1/30 of 15 volts, or 0.5 volt, and remain at the new voltage for the duration of the step. This will provide steps of constant current proportional to the input voltage steps.

It would be a simple matter to maintain a constant voltage across R246, proportional to the input steps, if the voltage at the lower end of R246, (that is, the voltage at the input to the resistor under test) were constant. In other words, if we fix the voltage at the lower end of R246 at some potential, say ground, the voltage across R246 would remain constant for the duration of each of the input steps, and would change only when the input voltage steps from one level to the next.

However, the lower end of R246 is connected to the input of the transistor under test and not to a fixed reference. When the collector sweep voltage is applied to the collector of the transistor the voltage at the input of the transistor will change and the voltage at the lower end of R246 will change. In order to maintain a constant voltage, the voltage at the upper end of R246 must change the same amount and in the same direction as the voltage at the lower end. To accomplish this action the +1 Amplifier and the feedback loops couple any voltage change at the lower end of R246 to the difference amplifier V214-V224 which in turn, through the cathode-follower V233A and the output amplifier V243- V253, produces the same voltage change at the top of R246. Fig. 3-13 shows the circuit configuration when the POLARITY switch is set for a negative output. The operation of the circuit will be explained in two parts; first, to show how the voltage at the top of R246 changes in proportion to the input steps, and second, to show how the voltage at the top of R246 changes as a result of any voltage change at the bottom of R246.

Assume the input voltage changes from 0 to +15 volts (1 step). This tends to make the voltage at the grid of V214 go in the positive direction, and the plate voltage to go in the negative direction. The voltage at both the grid and cathode of the cathode-follower V233A goes in the negative direction, following the plate of V214. Q243 is an emitter-follower, so its emitter goes in the negative direction carrying with it the base of Q253. Since Q253 is also connected as an emitter-follower, for negative-polarity operation, its emitter and hence the voltage at the top of R246 goes in the negative direction.

A positive step at the input will therefore produce a negative step at the top of R246. This negative step also appears at the lower end of R203, since this point is connected to the top of R246. This means that as the top of R202 goes positive the lower end of R203 goes negative. The amplifier and feedback network therefore acts as a "teeter-totter" circuit that pivots about the junction of R202-R203; the grid of V214 is at virtual ground, or zero, potential.

Since the top of R203 is at ground potential, the change in voltage across R246, due to an input step, is equal to the change in voltage across R203. R202 and R203 make up a

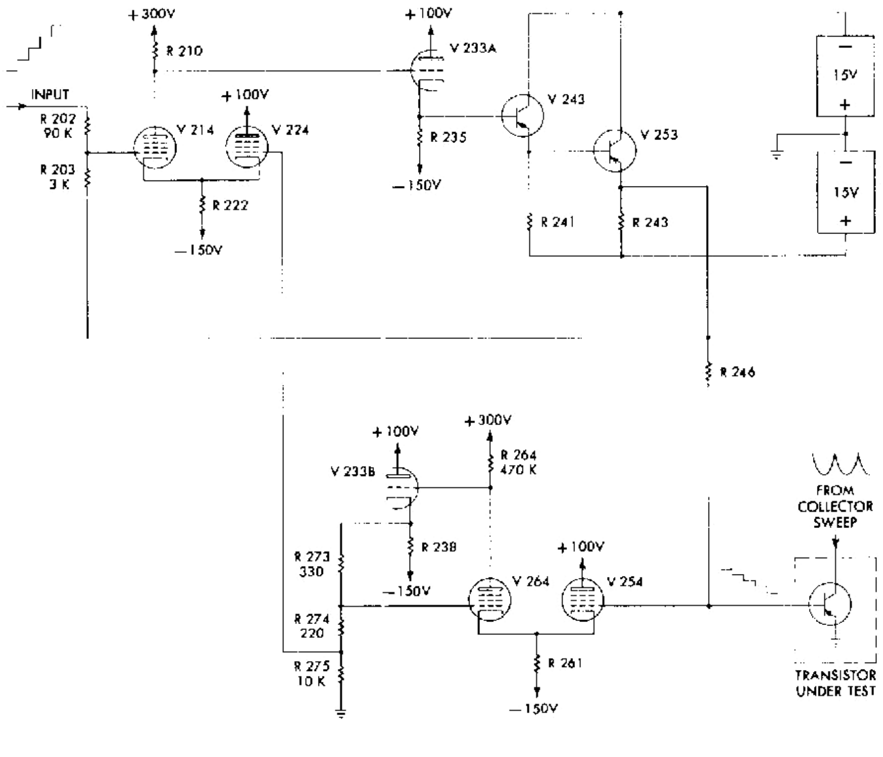


Fig. 3-13. Simplified diagram of the Step Amplifier for negative-going current steps.

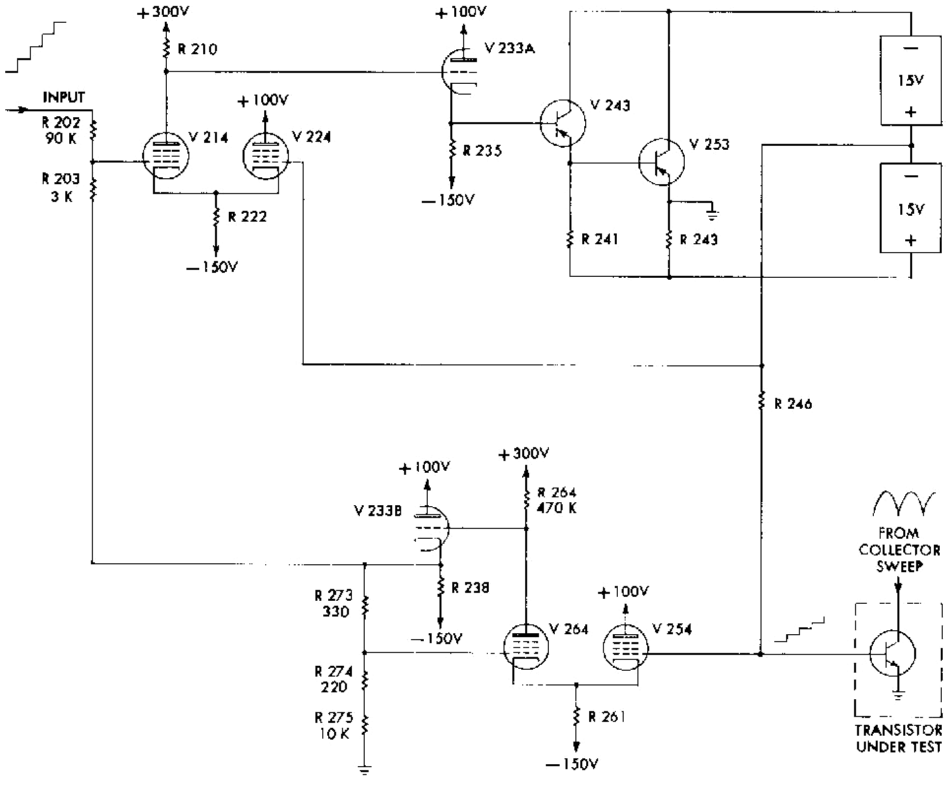


Fig. 3-14. Simplified diagram of the Step Amplifier for positive-going current steps.

30 to 1 divider; a 15-volt step in the positive direction at the top of R202 will therefore produce a 0.5-volt step in the negative direction across R246.

If the voltage at the lower end of R246 changes, the voltage at the top of R246 must change the same amount and in the same direction. This will insure that the voltage drop across R246 is proportional only to the input step voltage.

The +1 Amplifier is a feedback amplifier whose gain is just slightly greater than unity. The input impedance of this circuit is very high, so that it does not load the input of the transistor under test.

Let us assume that the voltage at the lower end of R246, and hence at the grid of V254, goes in the positive direction. This will cause the cathodes of V254 and V264 to go in the positive direction. The voltage at the plate of V264 will then go up carrying with it the voltage at the grid and cathode of V233B. Because the gain of the circuit is slightly greater than unity the change in voltage at the cathode of V233B will be slightly greater than that at the lower end of R246, but will be of the same polarity.

The output of V233B is applied to a divider consisting of R273, R274 and R275. One tap on the divider couples almost all of the output voltage back to the grid of V264. This causes the grid of V264 to move in the same direction as its cathode, and hence reduces the gain of the stage to just slightly greater than unity. The gain of the +1 Amplifier is therefore relatively independent of tube characteristics and is determined almost entirely by the ratio of R273 to R274 + R275.

The resistance values in the divider are chosen so that the change in voltage at the top of R275 is the same as that at the grid of V254 (the lower end of R246). This positive-going voltage at the top of R275 is then applied to the grid of V224, and the cathodes of V224 and V214 go in the positive direction. This causes the voltage at the plate of V214 to go up, and since there is no polarity shift in V233A or the emitter-followers, the voltage at the top of R246 will go up. Thus, the voltage at the top of R246 follows any voltage change that may occur at its lower terminal. This prevents any change in the voltage at the input of the transistor under test from affecting the current through R246, and provides for steps of constant current into the input of the transistor.

If voltage steps are desired, R249 (not shown on Fig. 3-13) is connected between R246 and ground. The current steps through R246 and R249 then produce voltage steps across R249 which are coupled through the series resistor R248 (not shown) to the input of the transistor under test.

When negative steps are required, the voltage steps at the top of R246 must be reversed in polarity from those at the input (positive-going steps are always applied to the input of the Step Amplifier). The 180-degree shift in signal polarity is accomplished in V214, since this stage is a plate-loaded amplifier. And, since V233A is a cathode-follower and the transistors are connected as emitter-followers, the polarity shift in V214 satisfies the circuit requirements.

When positive-going steps are required at the top of R246, however, the output of V214 must be reversed in polarity. This is accomplished by reversing the output and ground terminals in the Q253 circuit. Q253 is connected in the common emitter configuration, as shown in Fig. 3-14, and the load resistor R243 is connected into the collecter circuit. With this configuration V253 is a collector-loaded amplifier and will produce a 180-degree shift in the signal polarity. This will put voltage steps at the top of R246 in phase with input steps (positive-going steps).

To compensate for the additional shift in signal polarity, the grids of the difference amplifier V214-V224 must be switched insofar as the feedback loops are concerned. That is, the grid of V224 is now connected to the top of R246 and the grid of V214 is connected through R203 to the divider at the output of the +1 Amplifier. Notice, in Fig. 3-14, that the grid circuit of V214 is connected to the top of the divider at the output of the +1 Amplifier, while in Fig. 3-13 the grid circuit of V224 is connected to a tap on the divider.

Since the gain of the +1 Amplifier is just slightly greater than 1, the voltage at the cathode of V233B is slightly greater than that at the grid of V254. The voltage applied to the difference amplifier from the +1 Amplifier must be equal to the amount of correction needed to keep the voltage across R246 constant. The resistance values in the divider at the output of the +1 Amplifier are such that the voltage drop across R275 is the same as the voltage at the grid of V254. This satisfies the requirements of the circuit, in Fig. 3-13, where the feedback is applied directly to the grid of V224. In Fig. 3-14, the feedback is applied to the grid of V214 through R203, and, since there is a voltage drop across R203, the voltage at the output of the +1 Amplifier must exceed the required feedback voltage by an amount equal to this drop. For positive-polarity signals, therefore, the voltage at the output of the +1 Amplifier must exceed the voltage at the grid of V254 by an amount equal to the drop across R203.

CRT Deflection Amplifiers

The diagram of the Vertical and Horizontal Amplifiers include a simplified diagram of most of the switching related to these amplifiers. The purpose of the simplified diagram is to help you understand the relationships between the Vertical and Horizontal Amplifiers and other parts of this instrument. Accordingly, this discussion will include switching information.

The circuits of the Vertical and Horizontal Amplifiers are quite similar. Both consist of three difference amplifiers in cascade. A difference amplifier, or cathode-coupled phase inverter, rejects any signal applied to both input grids, responding only to a voltage difference between the input grids. The gain of the difference amplifiers in the Type 575 is stabilized by negative-feedback paths from the plates of the output amplifier to the opposite cathodes of the input stage.

The ranges of the VERTICAL and HORIZONTAL switches are shown in capital letters. Only a few of the positions in the COLLECTOR MA, BASE VOLTS, and COLLECTOR VOLTS ranges are shown. In the following paragraphs, the signal paths to the Vertical and Horizontal Amplifiers will be traced for each range of the corresponding switch.

Collector MA Display

Collector current is displayed on the vertical axis only. The collector current is proportional to the voltage drop across a current-sampling resistance. This voltage is fed directly to the control grid of V454, the other input to the vertical amplifier being grounded. One volt must be developed across the current-sampling resistance to cause a full-scale vertical deflection of ten major divisions. In all switch positions within the COLLECTOR MA range, the Vertical Amplifier works at a reduced constant gain. This reduced gain, one-tenth of maximum, is accomplished by inserting a resistance of about 10K ohms, R447 in parallel with R432B, between the cathodes of the input stage. R432B is located on the detailed switching diagram.

Base Volts

In the BASE VOLTS position of the VERTICAL switch, the control grid of V454 is grounded and a signal from the base of the transistor under test is fed to the control grid of V444. The sensitivity of the Vertical Amplifier is varied by changing the resistance between the cathodes of V454 and V444.

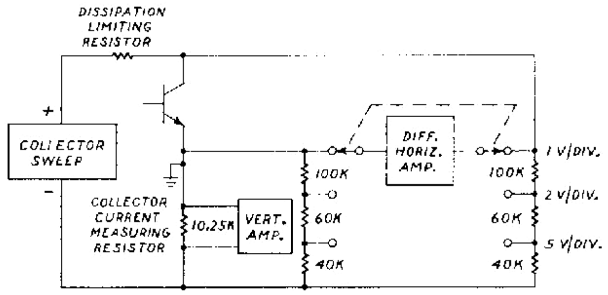


Fig. 3-15. With this configuration an accurate display of collector current (Vert. Amp.) and collector voltage (Horiz. Amp.) is obtained.

Collector Volts Display

The diagram of Fig. 3-15 shows the method used to solve the problem of presenting an accurate display of both collector current and collector voltage at the same time. Discussion of this diagram does not necessarily apply to corresponding parts of the Type 575. Note that two attenuators are used and that the horizontal display of collector voltage is obtained by using the common-mode rejection feature of the Horizontal Amplifier. As shown in Fig. 3-15, the Horizontal Amplifier amplifies only the voltage difference existing between its input grids.

Also note that the true current-sampling resistance is made up of the 10.25-K resistor and the attenuator in parallel with it.

Low-Voltage Power Supply

Plate and filament power for the Type 575 is furnished by a single power transformer T601. The primary windings may be connected in parallel for 105- to 125-volt operation, or in series for 210- to 250-volt operation.

The three regulated supplies furnish voltages of —150-volts, +100 volts and +300 volts. The +300-volt supply also has an unregulated output of about +400 volts for the oscillator tube in the high-voltage supply for the crt.

Reference voltage for the —150-volt, full-wave power supply is established by a voltage-regulator tube V649. This tube, which has a constant voltage drop of about 85 volts, is connected between the —150-volt bus and the grid circuit of V644A, one-half of a difference amplifier. The grid potential for the other half of the difference amplifier, V644B, is obtained from a divider consisting of R662, R664 and R666. The —150-V ADJ, R664, determines the percentage of total voltage appearing at the grid of V644B and thus determines the total voltage across the divider. When this control is properly set, the output voltage is exactly —150-volts.

The operation of the circuit can be explained by assuming the output voltage tends to change. For example, assume the loading on the supply tends to make the output voltage go more negative. The voltage at the grid of V644A will go negative the same amount as the output, since the voltage across the voltage-regulator tube is always constant. The voltage at the grid of V644B will go negative only a proportionate amount, however, since this grid obtains its voltage from the divider, an error voltage will then exist between the two grids of the difference amplifier, which will be in a direction to make less current go through the left side and more current through the right side.

The voltage at both the plate of V644B and the grid of V657 will then go in the negative direction, which will cause the voltage at the plate of V657 to go in the positive direction. The change in voltage at the plate of V657, which will be in a direction to compensate for the change in the output voltage, is coupled through the rectifier to the output and forces the output voltage back to its established value of —150 volts.

C644 and C655 improve the ac response of the feedback loop, thereby increasing the response of the circuit to sudden changes in output voltage.

The +100-volt supply uses silicon rectifiers in a full-wave bridge circuit. Reference voltage for this supply is obtained from the regulated —150-volt supply. The voltage divider R636-R638 establishes a voltage of essentially zero at the grid of V624. (The actual voltage at this grid is equal to the bias required by the tube). If the loading should tend to change the output voltage, an error signal will exist at the grid of V624. The error signal will be amplified and inverted in polarity, and will appear at the grids of the parallel cathode-followers V627A and V627B. The cathodes will follow the grids and will force the output voltage back to its established value of +100 volts. C630 improves the response of this circuit to sudden changes in output voltage.

A small sample of the unregulated bus ripple will appear at the screen grid of V624 through R624. The ripple signal appearing at the screen (which acts as an injector grid) will produce a ripple component at the grids of V627 which will be opposite in polarity to the ripple appearing at the plates of V627. This tends to cancel the ripple at the cathodes, thereby reducing the ripple on the 100-volt bus. The same circuit also improves the regulation of the supply in the presence of line-voltage variations.

The operation of the regulator circuit in the +300-volt supply is the same as that in the +100-volt supply.

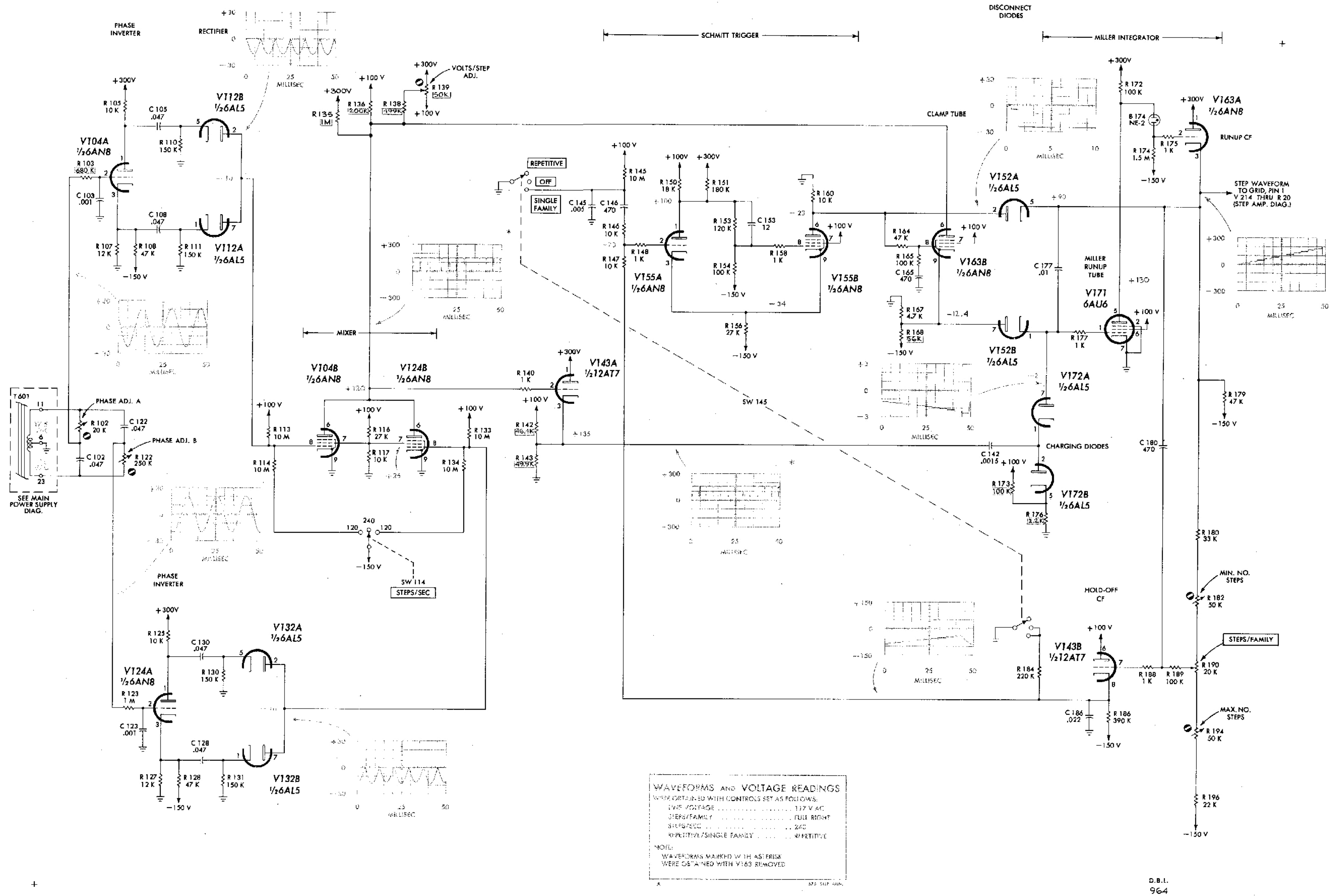
CRT Circuit

A 30-kc Hartley oscillator circuit furnishes energy for the two half-wave power supplies that provide accelerating potentials for the crt. The main components of the oscillator circuit are V810 and the primary of T801 tuned by C809.

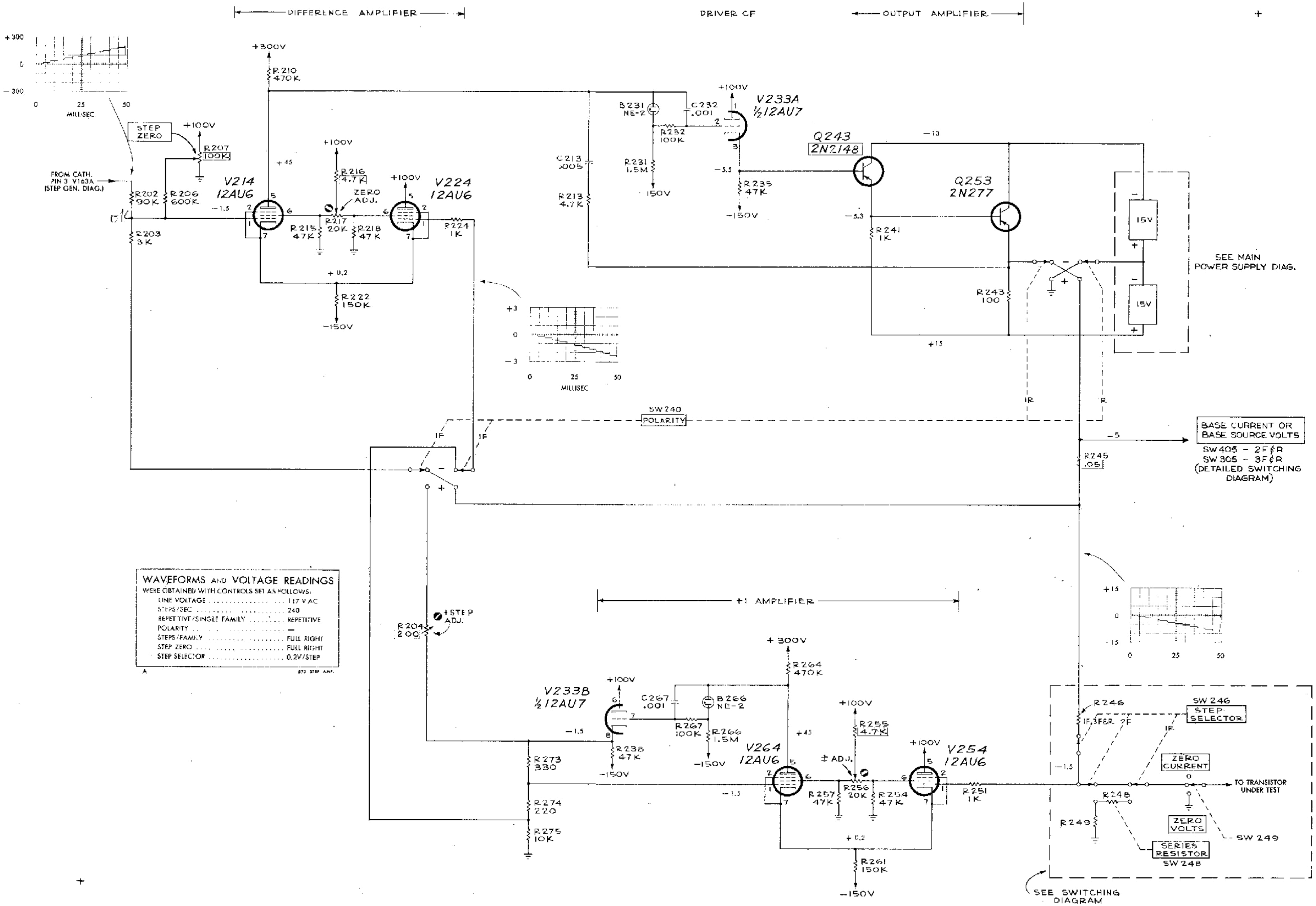
V812 supplies about +2400 volts for the post-deflection accelerating helix. V822 supplies about —1850 volts to a divider to provide the grid and cathode potentials. The other end of the divider is connected to the regulated +300-volt bus. The —1700 V ADJ control R816 determines the total resistance in the divider and hence the total voltage across the divider. When this control is properly set, the voltage at the test point will be exactly —1700 volts.

The accelerating potentials are kept constant by regulating the supplies by comparing a sample of the negative high voltage to the regulated —150-volt supply. This sample of the negative high voltage is obtained from a tap on the divider (the junction of R816 and R818) and is applied to the grid of an amplifier V804A. The cathode of this tube is connected to the —150-volt regulated supply. If the negative supply tends to drift, an error signal appears at the grid of V804A. The error signal is amplified by V804A and V804B, and produces a change in the screen voltage at the oscillator tube. This varies the amplitude of the oscillator output in a direction to compensate for the change in output voltage.

The positive high-voltage supply is regulated indirectly, as the output of both supplies is proportional to the oscillator output.



TYPE 575 TRANSISTOR-CURVE TRACER AB₁ STEP GENERATOR



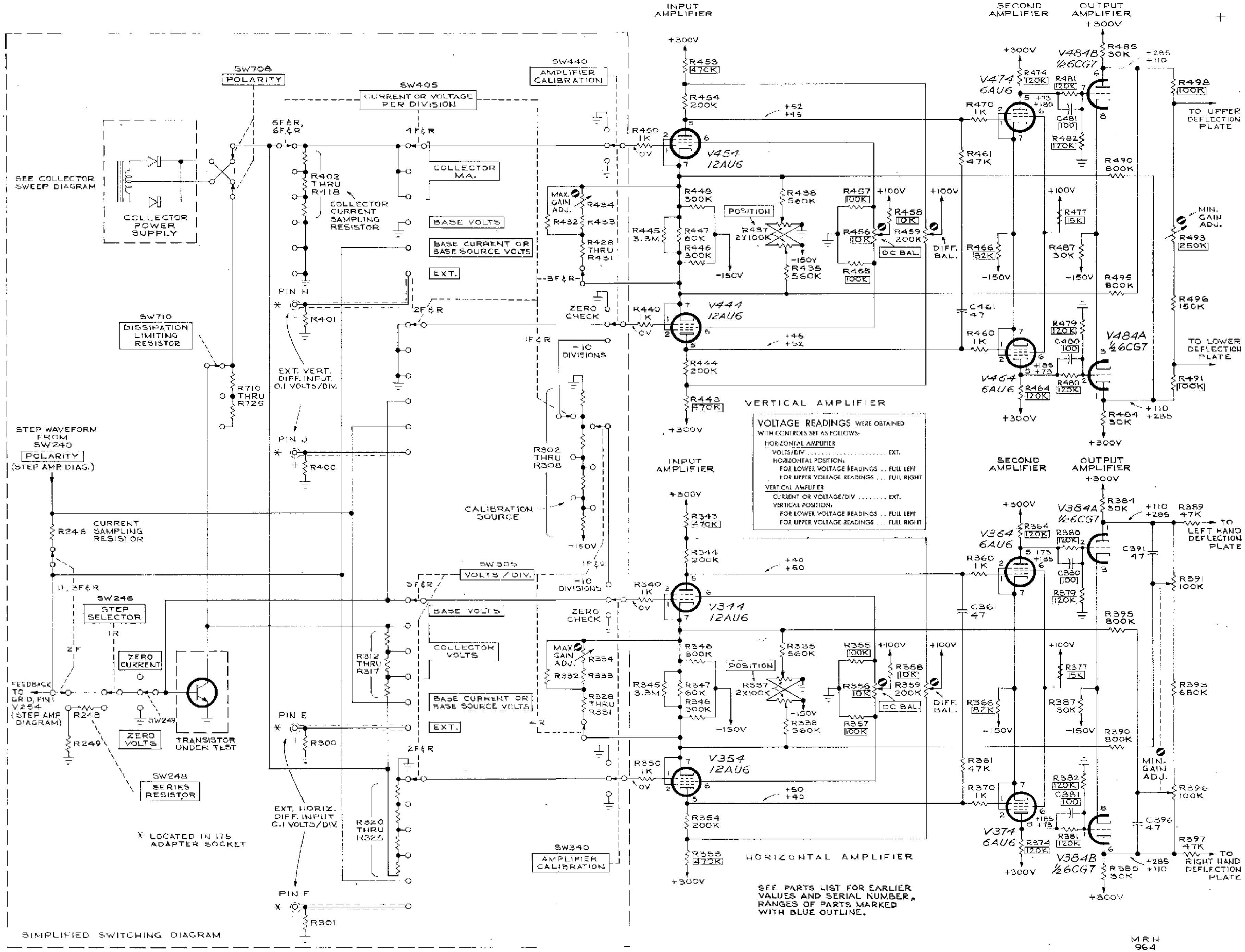
SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

GAB 764

TYPE 575 TRANSISTOR-CURVE TRACER

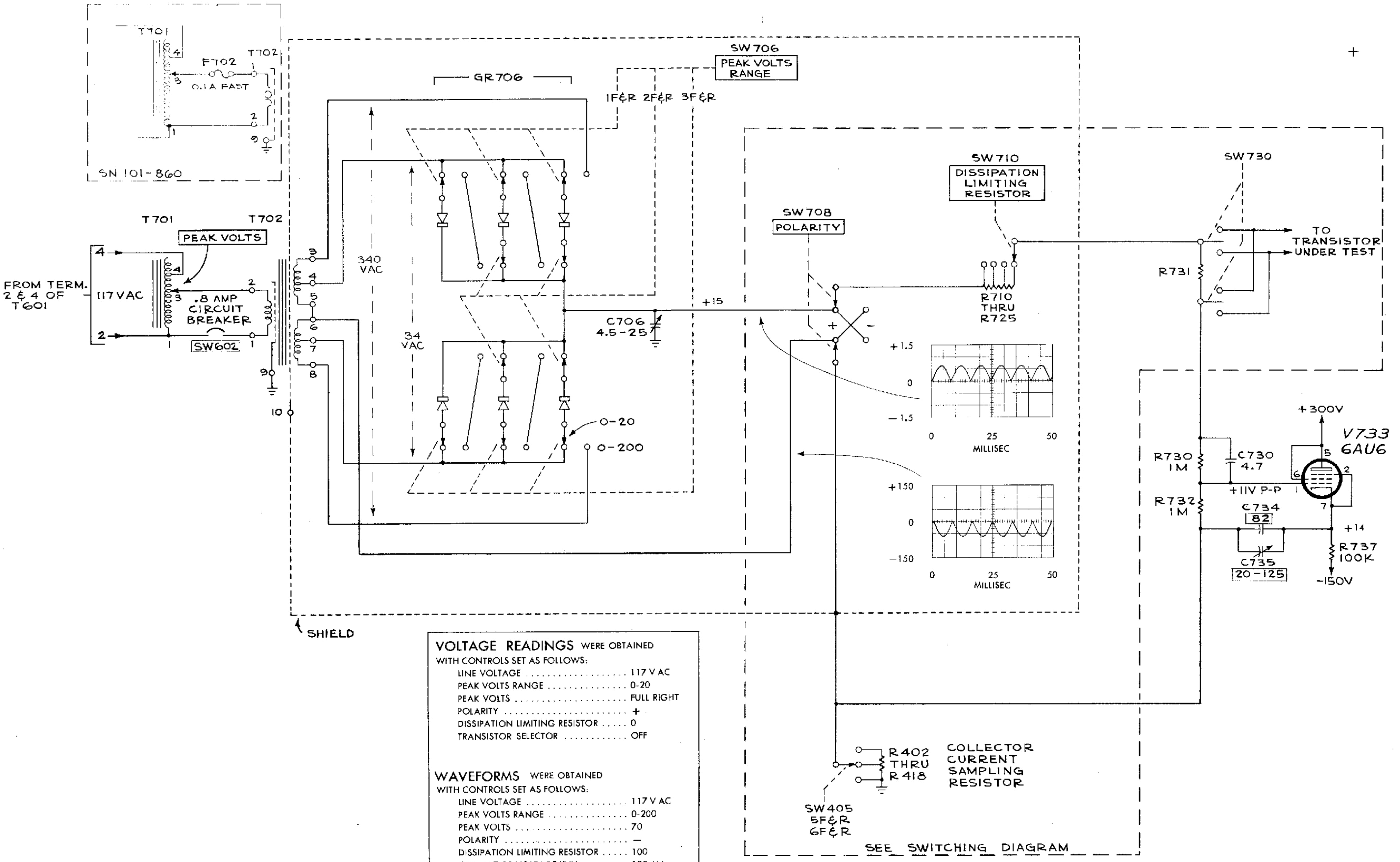
AD

STEP AMPLIFIER



TYPE 575 TRANSISTOR-CURVE TRACER

HORIZONTAL & VERTICAL AMPLIFIERS



VOLTAGE READINGS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117 V AC
PEAK VOLTS RANGE	0-20
PEAK VOLTS	FULL RIGHT
POLARITY	+
DISSIPATION LIMITING RESISTOR	0
TRANSISTOR SELECTOR	OFF

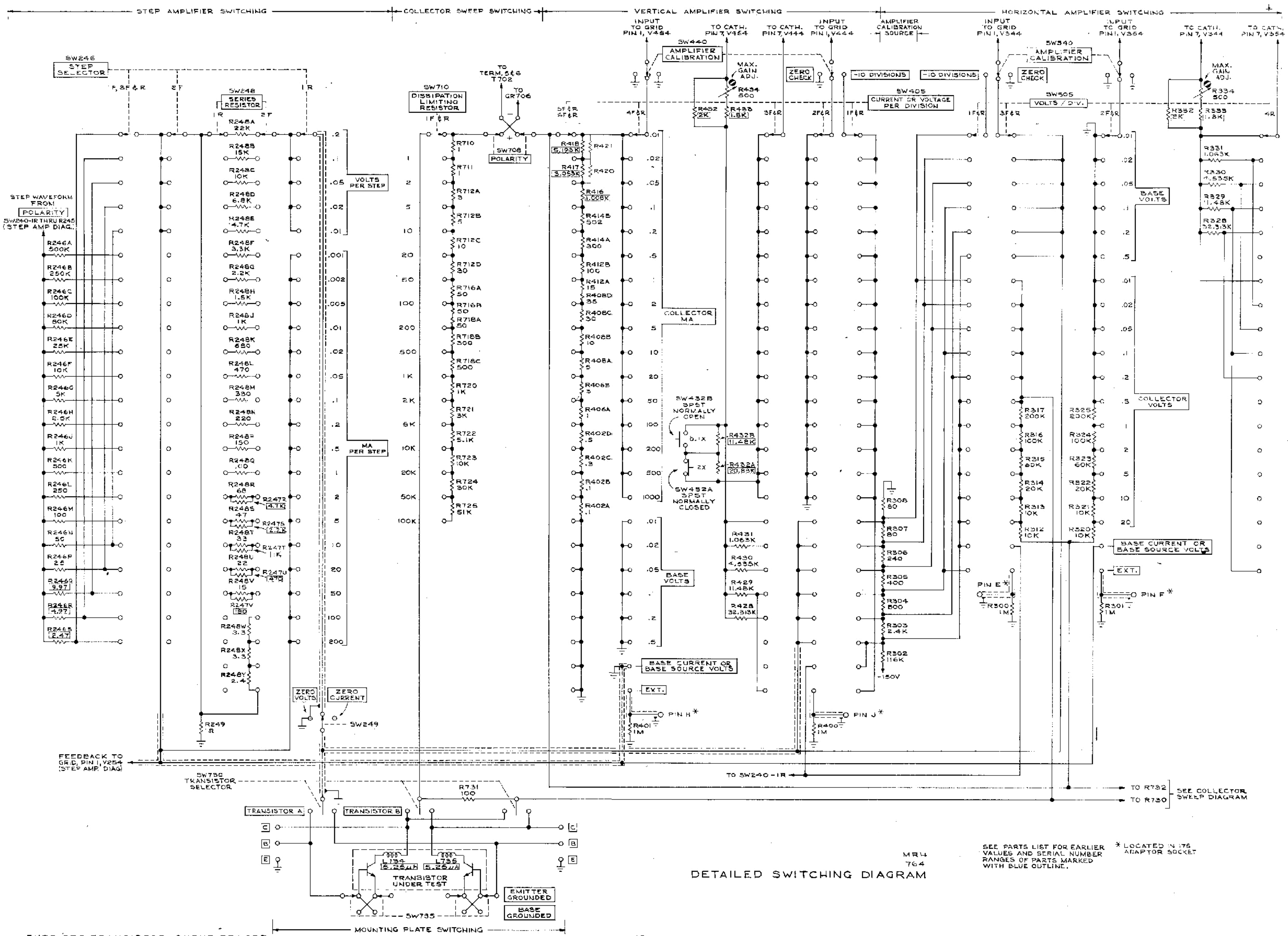
WAVEFORMS WERE OBTAINED WITH CONTROLS SET AS FOLLOWS:

LINE VOLTAGE	117 V AC
PEAK VOLTS RANGE	0-200
PEAK VOLTS	70
POLARITY	−
DISSIPATION LIMITING RESISTOR	100
CURRENT OR VOLTAGE/DIV	100 MA
TRANSISTOR SELECTOR	TRANSISTOR A
TERMINAL C	GROUNDED

A 575 COLL. SWP.

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

GAB 964



DETAILED SWITCHING DIAGRAM

MRH
764

SEE PARTS LIST FOR EARLIER VALUES AND SERIAL NUMBER RANGES OF PARTS MARKED WITH BLUE OUTLINE.

* LOCATED IN 175 ADAPTOR SOCKET

TYPE 575 TRANSISTOR-CURVE TRACER

AE

MODIFICATION KIT

SILICON RECTIFIER

For Tektronix Type 575 Transistor-Curve Tracer
Serial numbers 101-4929

DESCRIPTION

This modification replaces the selenium rectifiers with silicon rectifiers. Silicon rectifiers offer more reliability and longer life.

The following selenium rectifiers are replaced: SR241 (part number 106-0043-00); SR620 (106-0044-00).

040-0223-00

Publication:
Instructions for 040-0223-00
March 1966

Supersedes:
December 1965

PARTS LIST

Quantity	Description				Part Number
1 ea	Assembly, silicon rectifier, consisting of:				
	2 ea	Strip, cer, 3/4 x 7 notches, clip-mounted			124-0089-00
	6 ea	Diode, silicon,	500-750 mA	400 PIV	152-0066-00
	2 ea	Diode, silicon	15 A	100 PIV	152-0088-00
	2 ea	Fuse, w/pigtail,	5 A	fast-blo	159-0053 00
	1 ea	Lug, solder, SE4, w/2 wire holes			210-0201-00
	1 ea	Grommet, rubber, 1/4"			348-0002-00
	4 ea	Spacer, nylon-molded, 0.156			361-0008-00
	1 ea	Bracket, silicon rectifier mounting			406-0815-00
	1 ea	Wire, #20 solid,	4 in.	white-red	(175-0510-00)
3 ea	Washer, flat, 6L x 3/8				210-0803-00
3 ea	Screw, 6-32 x 5/16 PHS, Phillips				211-0507-00
2 ea	Screw, 4-40 x 1/4 PHS, thread-forming type B, Phillips				213-0088-00
1 ea	Spool, w/3 ft. silver-bearing solder				214-0210-00

INSTRUCTIONS

IMPORTANT: When soldering to the ceramic strips, use the silver-bearing solder supplied with this kit.

( ) 1. Remove the air filter from the rear of the instrument.

( ) 2. Remove the six screws which hold the fan ring to the rear panel and move the fan assembly to one side. Do not unsolder the two fan motor leads.

( ) 3. Unsolder all the wires from the selenium rectifier stacks, SR241 and SR620, located behind the fan motor.

( ) Unsolder the two wires from the thermal cutout, mounted on the selenium rectifier bracket.

( ) 4. Remove the selenium rectifiers and brackets from the instrument.

NOTE: One of the nuts holding a bracket to the chassis is under the high voltage shield and can be removed with the use of a needle-nose pliers.

( ) 5. Remove the thermal cutout from the selenium rectifier bracket and install it on the silicon rectifier bracket (from kit), using the 4-40 x 1/4 thread-forming screws from the kit.

NOTE: Mount the solder lug between the screw head and the thermal cutout (see Fig 1, step 5).

( ) 6. Mount the silicon rectifier assembly (from kit), as shown in Fig 1. Use the 6-32 x 5/16 PHS screws and #6 flat washers (from kit), placing a flat washer under each screw head. (Insert screws from bottom of chassis.)

INSTRUCTIONS (cont)

( ) 7. Wire the silicon rectifier assembly, as shown in Fig 2.

( ) Resolder the wires, unsoldered in step 3, to the thermal cutout.

THIS COMPLETES THE INSTALLATION.

( ) Check wiring for accuracy.

( ) Replace the air filter, removed in step 1, and the fan assembly, displaced in step 2.

( ) Turn the instrument on and check the power supplies for proper voltages and regulation.

NOTE: If adjustments are made to the power supply, it will be necessary to check the calibration of the instrument.

( ) Place the Manual insert page in your Instruction Manual.

JT:cet

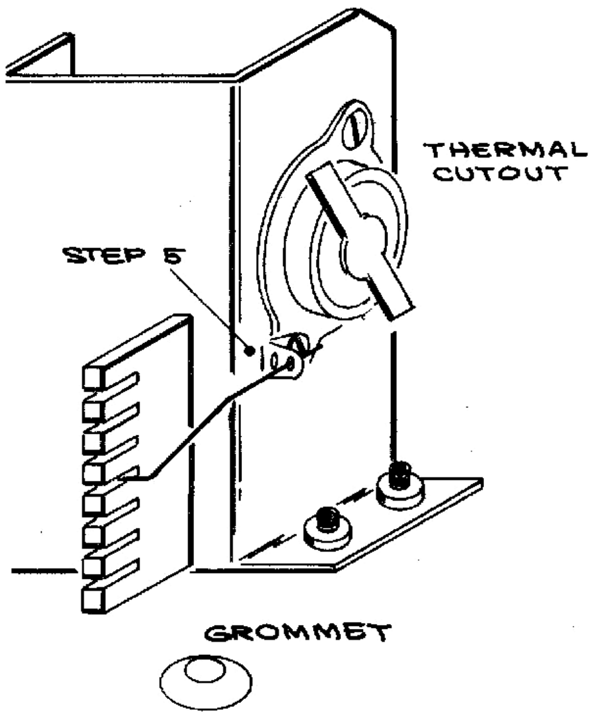


Fig 1

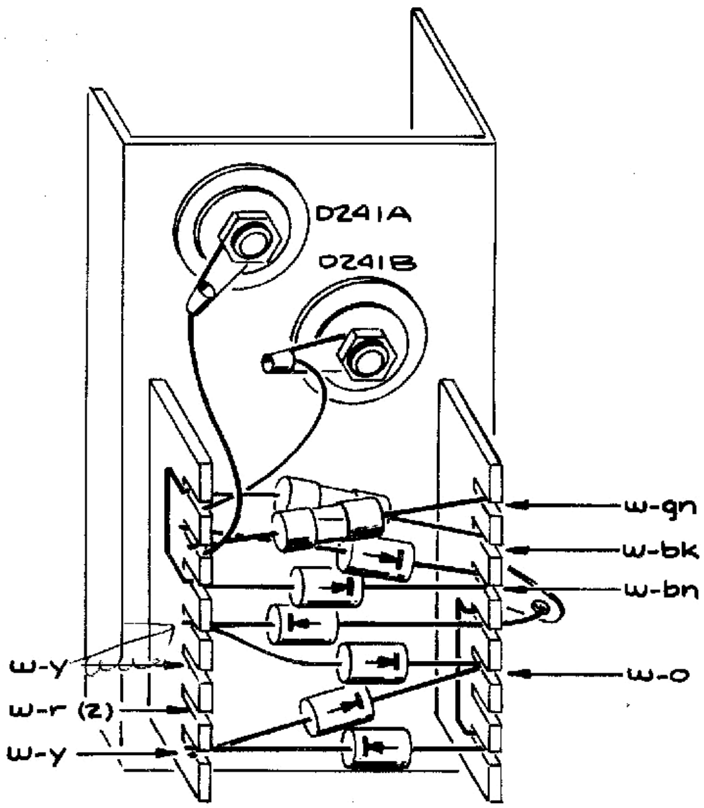
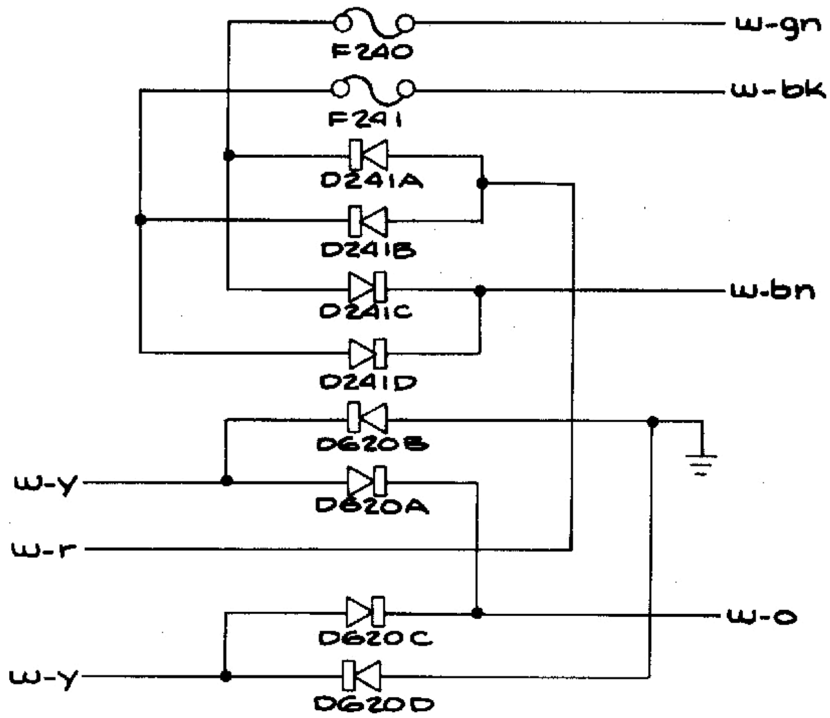


Fig 2
(See wiring schematic on following page.)



w-gn
F240
w-bk
F241
D241A
D241B
w-bn
D241C
D241D
D620B
w-y
D620A
w-r
w-o
D620C
w-y
D620D

SILICON RECTIFIER

Type 575 -- s/n 101-4929

Installed in Type 575 s/n _______ Date _______

GENERAL INFORMATION

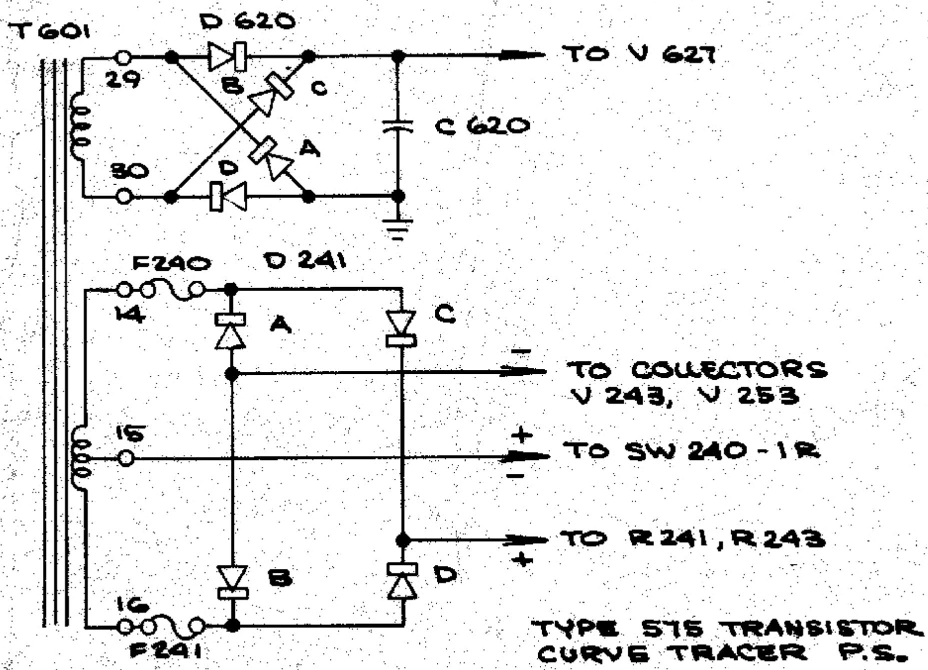
This modification replaces the selenium rectifiers with silicon rectifiers. Silicon rectifiers offer more reliability and longer life.

ELECTRICAL PARTS LIST

Only new parts listed.

Ckt. No.	Part Number	Description		
		DIODES		
D241A, B	152-0088-00	15 A	100 PIV	silicon
D241C, D	152-0066-00	500-750 mA	400 PIV	silicon
D620A, B, C, D	152-0066-00	500-750 mA	400 PIV	silicon
		FUSES		
F240	159-0053-00	5 A	fast-blo	w/pigtail
F241	159-0053-00	5 A	fast-blo	w/pigtail

SCHEMATIC



040-0223-00