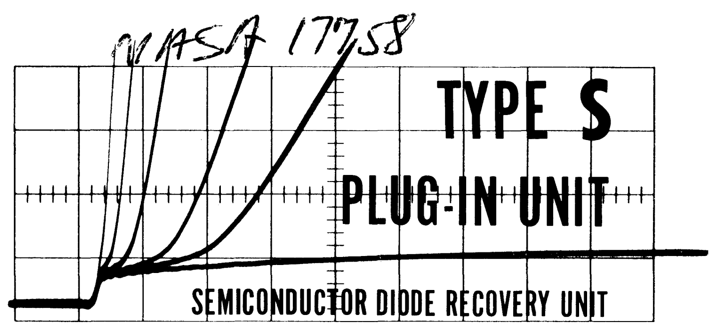
INSTRUCTION
MANUAL

NASA 17758



SN 598

NASA 17758

S. W. Millikan Way ● P.O. Box 500 ● Beaverton, Oregon ● Phone MI 4-0161 ● Cables: Tektronix

070-223

WARRANTY

All Tektronix instruments are fully guaranteed against defective materials and workmanship for a period of one year. Should replacement parts be required, whether at no charge under warranty or at established net prices, notify us promptly. You should include the instrument type, serial number, and sufficient details to identify the required parts. We will ship them prepaid (via air if requested) as soon as possible, usually within 24 hours.

Tektronix transformers manufactured in our own plant carry an indefinite warranty.

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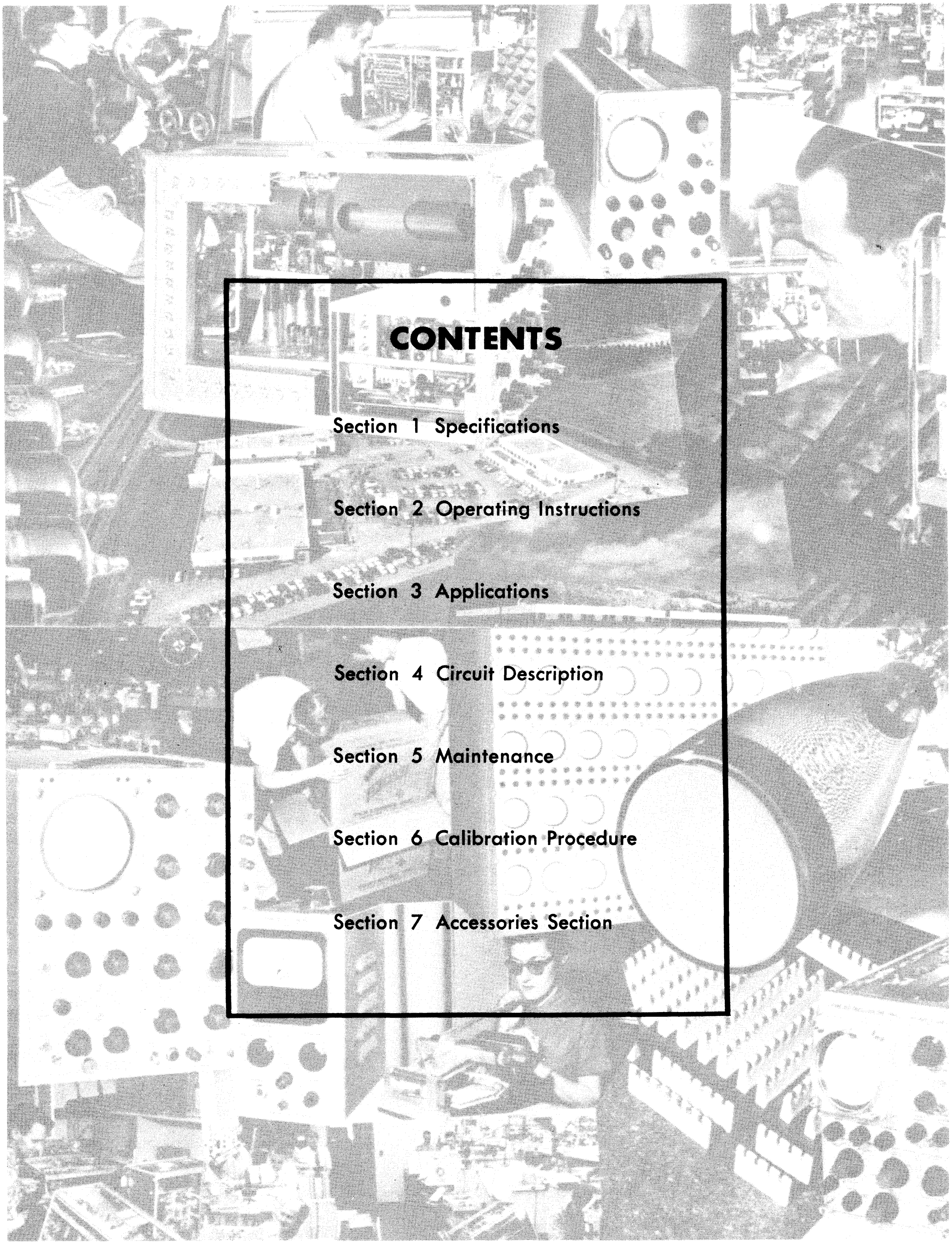

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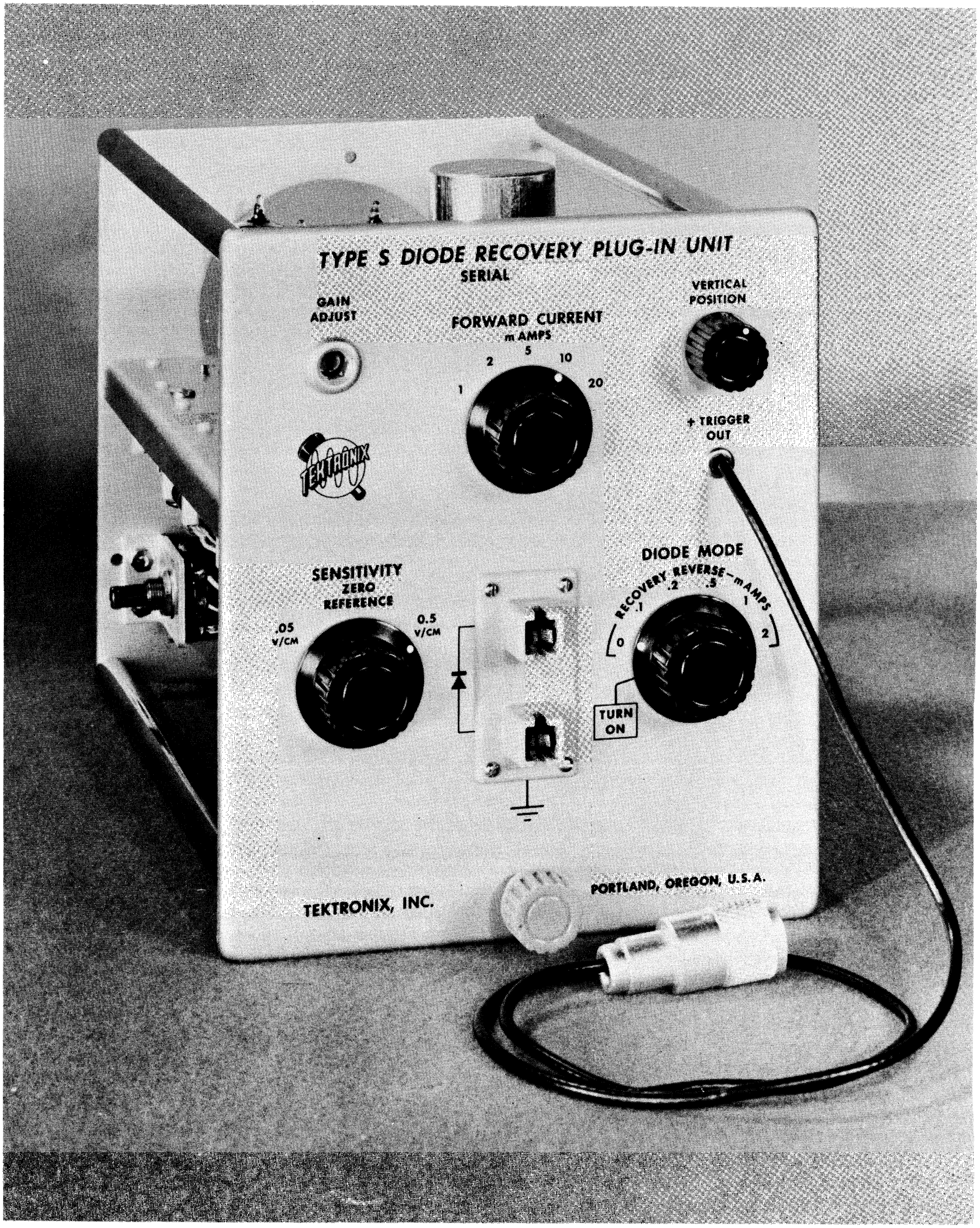
TYPE S DIODE RECOVERY PLUG-IN UNIT
SERIAL
GAIN ADJUST
FORWARD CURRENT
m AMPS
1
2
5
10
20
VERTICAL POSITION
+ TRIGGER OUT
TEKTRONIX
SENSITIVITY
ZERO REFERENCE
.05 V/CM
0.5 V/CM
DIODE MODE
RECOVERY
REVERSE—m AMPS
0
.1
.2
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1
2
TURN ON
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

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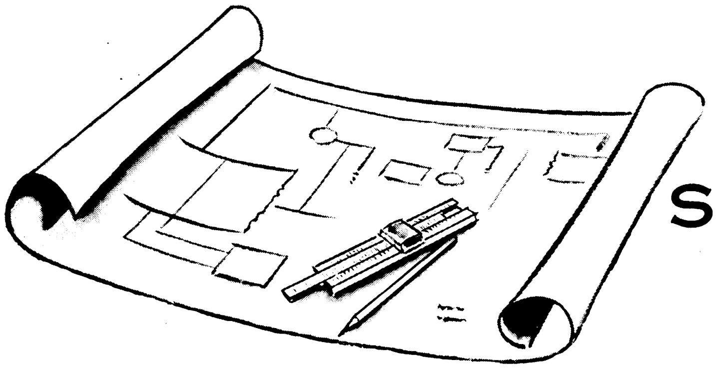


SECTION 1

SPECIFICATIONS

General Information

The Tektronix Type S Unit is a special purpose plug-in unit intended for use in conjunction with Tektronix Type 540- or Type 550-Series Oscilloscopes. The unit displays semiconductor diode switching characteristics on the screen of an associated oscilloscope. The display shows the voltage across the test diode as a function of time during the desired switching operation. Certain diode parameters such as the effective lifetime of minority carriers, junction capacitance, stored charge at the junction, and junction resistance can be obtained readily from the oscilloscope display. Through careful analysis of the reverse recovery and "turn-on" characteristics, the diode performance in a particular circuit can be predicted.

Applications for the Type S Unit are not limited to diode measurements. For example, it is also possible to use the S unit to study the junction characteristics of a transistor. Also, since the S Unit is essentially a means for plotting the voltage across an element while passing a constant current through that element, the unit can be used to study impedance variations in other types of circuit elements.

Diode Measurements

Recombination Rate of Minority Carriers—Effective lifetimes as low as 2 nsec.

Capacitance—Junction capacitance as low as 2 pf.

Stored Charge—Stored charge as low as 5 pcoul.

Resistance—Junction resistance as low as 0.25 ohms.

Pulser

Repetition Rate—Approximately 550 pps for reverse recovery measurements, 275 pps for turn-on measurements.

Risetime—Approximately 1 nsec.

Triggering Signals

Unit supplies external triggering signals to the associated oscilloscope.

Amplitude—Approximately +4 volts.

Calibrated Currents

Forward Currents—1, 2, 5, 10, and 20 ma.

Reverse Currents—0, 0.1, 0.2, 0.5, 1.0, and 2.0 ma.

Vertical Deflection Factors

Two ranges—0.5 and 0.05 volts per centimeter, calibrated.

Diode Shunt Capacitance

Approximately 9 pf at 0.5 volts per centimeter.

Approximately 16 pf at 0.05 volts per centimeter.

Physical Characteristics

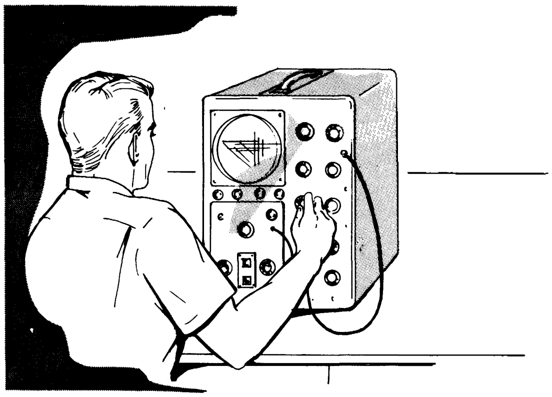
Construction—Aluminum-alloy chassis, photo-etched anodized panel

Weight—Approximately 5 pounds.

Dimensions—Approximately 6 inches wide, 7 inches high, and 10 inches deep.

Tube and Semiconductor Complement

V5934	ECC86
V5973	6AK5
V6904	12AU6
V6914	12AU6
V6923	12AT7
V6943	12AT7
Q5904	2N544
Q5945	2N226
Q5955	2N226
Q5993	2N270
D5937	T13G



SECTION 2

OPERATING INSTRUCTIONS

General

In this section of the manual instructions are given for operating the Type S Plug-In Unit in conjunction with a Tektronix Type 540- or Type 550-Series Oscilloscope. Information contained here tells you how to connect the plug-in unit to the oscilloscope, how to connect the diode to the unit and how to obtain the desired display of switching characteristics. In the Applications Section that follows, instructions are given for interpreting the resulting oscilloscope display.

Connecting the Unit to the Oscilloscope

With the oscilloscope power off, insert the unit firmly into the plug-in compartment of the oscilloscope. Tighten the plug-in locking control and switch on the oscilloscope power. Connect the triggering cable from the Type S Unit to the External Trigger Input connector of the oscilloscope (see Fig. 2-1). Set the oscilloscope triggering controls for + external triggers and allow a moment or two for instrument warmup. Then adjust the oscilloscope triggering controls for stable operation of the oscilloscope sweep.

Connecting the Test Diode to the Unit

A special connector is provided on the front panel of the S Unit for connection of the test diode (or other test device). Just to the left of the connector is a diagram which shows you the proper way to connect the diode. The cathode of the diode should be connected to the upper terminal and the anode should be connected to the lower (ground) terminal

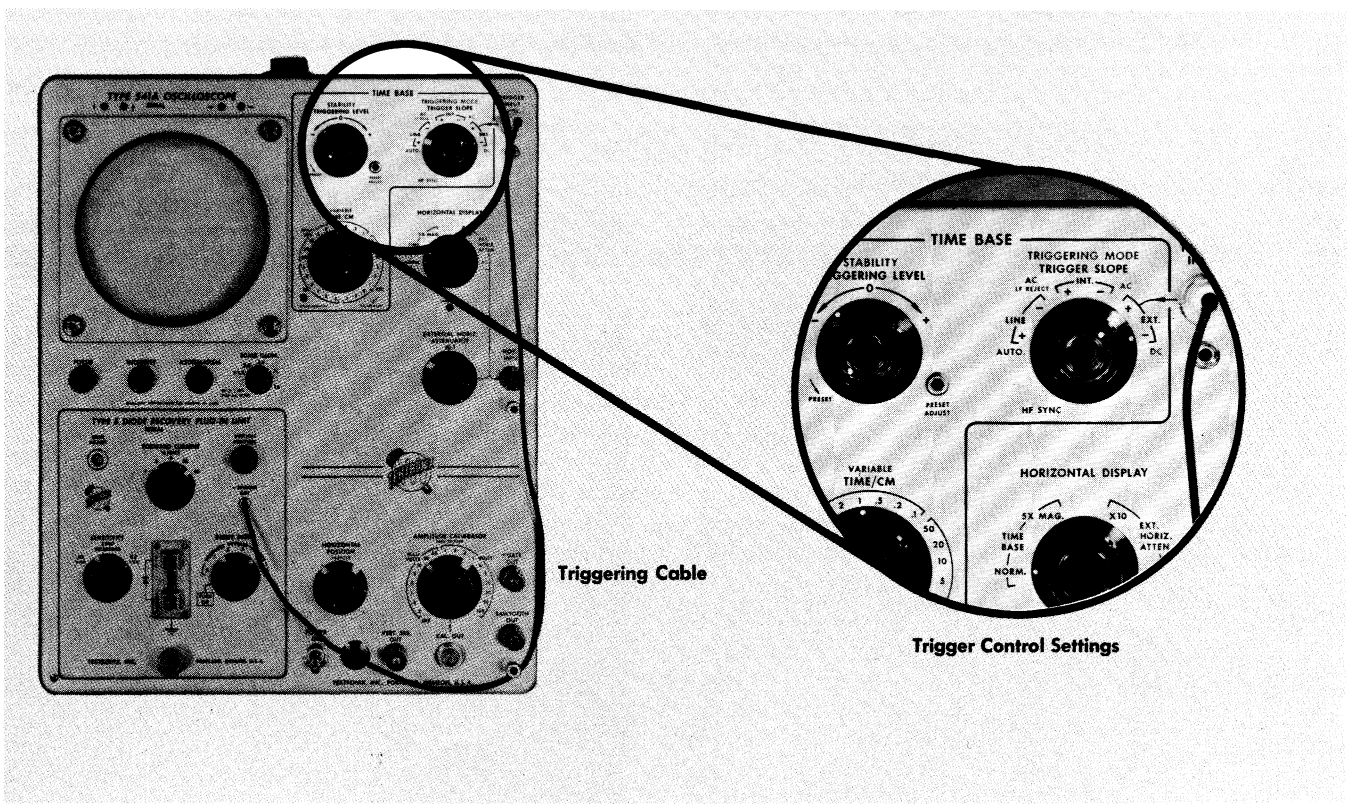


Fig. 2-1. Connecting the Type S Plug-In Unit to a Type 543 Oscilloscope. Typical triggering control settings are shown.

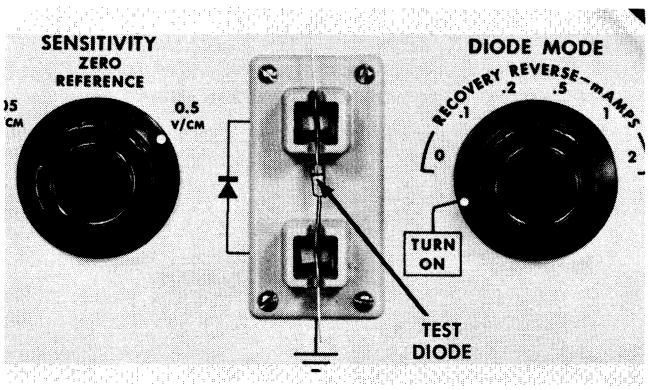


Fig. 2-2. Test diode connections to the Type S Plug-In Unit.

(see Fig. 2-2). The voltage on the front panel connector is quite low so that you may connect or remove diodes at any time without turning off the oscilloscope power.

Setting the Zero-Voltage Reference Point

In diode recovery measurements it is important to know what voltage corresponds to each horizontal line on the graticule. However, since the Type S Unit has calibrated vertical deflection factors it is only necessary to know the voltage at one line on the screen. The voltage at other lines can be determined from the deflection factor and the displacement from the known-voltage (reference) line.

On the Type S Unit, the ZERO REFERENCE position of the SENSITIVITY Switch is used to establish a zero-voltage reference line on the screen. When the switch is placed in this position, the signal to the amplifier is grounded to insure zero input voltage. The oscilloscope trace can then be positioned to any convenient point on the screen by using the VERTICAL POSITION Control. The line on the screen where the trace is positioned then corresponds to zero volts. Voltages at other lines on the screen should be measured with respect to the zero reference line. The point where the zero reference line is set will depend upon the type of measurement to be made and the values involved.

Selecting the Diode Test Mode

The Type S Unit can be used to observe either the "turn-on" or "turn-off" characteristics of a diode (see Fig. 2-3). The mode of operation is selected with the DIODE MODE Switch. When the switch is in the TURN ON position, the diode is turned on by the start of the pulse. In all other positions of the DIODE MODE Switch the diode is switched off by the start of the pulse. In each case a positive triggering signal is applied to the oscilloscope at the start of the pulse and a negative triggering signal is applied at the end of the pulse. To make the oscilloscope display correspond to the setting of the DIODE MODE Switch, it is necessary for you to adjust the oscilloscope to trigger from external positive-going signals. This will insure that the oscilloscope is triggered at the start of the pulse rather than at the end of it.

When the S Unit is operated with the DIODE MODE Switch in the TURN ON position, the trace may appear somewhat dimmer than when the switch is in one of the other positions. This is because the pulse repetition frequency is decreased by one half in this position of the switch. This additional time between pulses is necessary to allow the test diode to completely recover before it is switched on.

Setting the Diode Forward Current

It has been calculated and verified experimentally that the amount of forward current passed through a diode just

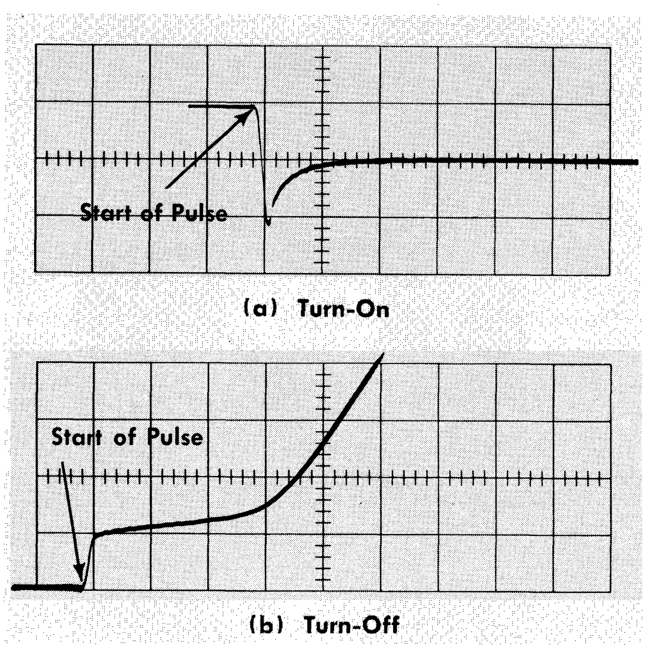


Fig. 2-3. Typical displays of diode switching characteristics obtained with the Type S Unit.

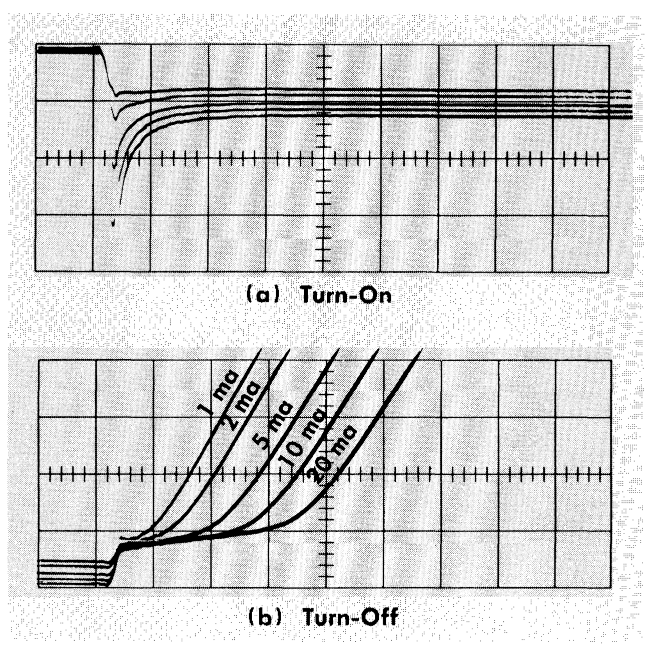


Fig. 2-4. Effects on the oscilloscope display produced by various settings of the FORWARD CURRENT Switch.

prior to cutting it off directly affects the recovery time of the diode. To permit you to measure the recovery time for several values of forward current, the Type S Unit provides 5 calibrated forward currents as selected by the FORWARD CURRENT Switch (see Fig. 2-4).

Since the current through the diode is held constant, the voltage across the diode, as indicated on the oscilloscope, indicates the impedance variations of the diode with respect to time. These impedance variations are in turn dependent on the junction capacitance, minority carrier lifetime, ohmic resistance, the charge stored at the junction, and several other factors. The diode voltage curve displayed on the oscilloscope can be used to find several of these quantities. This is explained in detail in the Applications Section of this manual.

Setting the Diode Reverse Current

The diode reverse current is selected with the DIODE MODE Switch from current values of 0, 0.1, 0.2, 0.5, 1.0, and 2.0 milliamperes (see Fig. 2-5). The zero current position

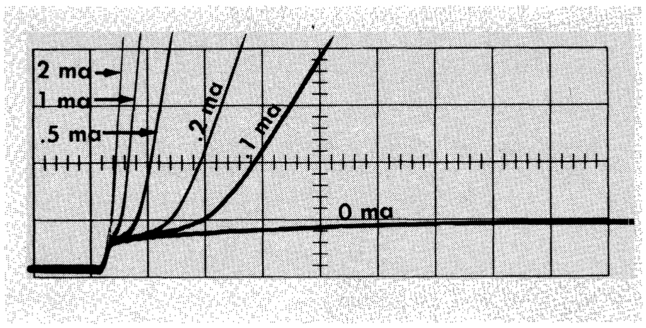


Fig. 2-5. Effects produced on the oscilloscope display by various settings of the DIODE MODE Switch and the resulting different reverse currents.

of the switch is used to measure the effective lifetime of the minority carriers. Other positions of the switch can be used to dissipate the charge at the junction at various rates, thereby controlling the horizontal spread of the display.

Again, since the current is kept constant, the voltage across the diode is dependent on the impedance variations. The display on the screen then is essentially a display of impedance with respect to time.

Selecting the Vertical Deflection Factor

The S Unit permits you a choice of two vertical deflection factors for the oscilloscope display. The shunt capacitance across the test diode is different for the two vertical deflection factors, being approximately 9 pf in the 0.5 V/CM position of the SENSITIVITY Switch and approximately 16 pf in the .05 V/CM position. Since it is desirable to have as little shunt capacitance as possible, the 0.5 V/CM position will normally be used unless the extra sensitivity of the .05 V/CM position is required.

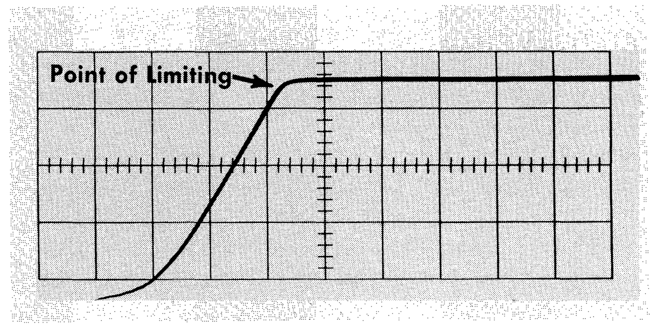


Fig. 2-6. The limiting point produced on the oscilloscope display by the limiting diode.

The S Unit does not permit the voltage across the test diode to go positive by more than approximately 2.5 volts.

Any voltage greater than this is limited by a diode placed in shunt with the test diode. When the SENSITIVITY Switch is in the 0.5 V/CM position, approximately 4 centimeters of vertical deflection from the zero voltage reference line is permitted before limiting occurs. If the display is positioned sufficiently far down on the screen this limiting point can be seen on the recovery curves (see Fig. 2-6). The display should normally be positioned so that the point of limiting is off the screen to the top.

Selecting the Sweep Speed

The time required to observe the switching characteristics of different diodes varies considerably. Therefore any one particular sweep speed will not be satisfactory for all diode measurements. The sweep speed to be used will depend on the type of test diode used and on the particular characteristics you wish to observe. The best general purpose display of reverse recovery characteristics is obtained when the voltage across the diode crosses the zero voltage reference point about midway across the screen. For turn-on measurements the best general purpose display is obtained when the voltage reaches the steady state value about midway across the screen. The proper sweep speed can only be selected after the forward and reverse currents are set.

Adjusting the Type S Unit Gain

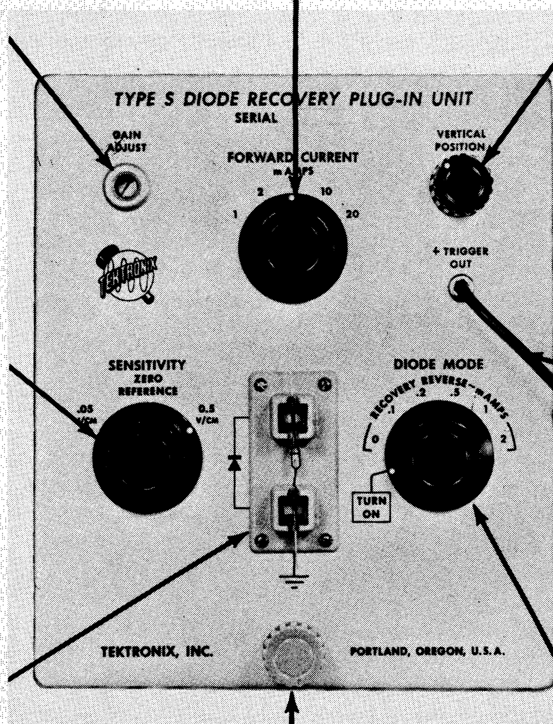
The front panel GAIN ADJUST Control is used to set the gain of the vertical amplifier so that the deflection factors correspond to the settings of the SENSITIVITY Control. An accurate 100-ohm low-capacitance resistor is required to make the adjustment.

Set the SENSITIVITY Switch to 0.5 V/CM, the FORWARD CURRENT Switch to 20 mAMPS, and the DIODE MODE Switch to TURN ON. Connect the 100-ohm resistor to the diode connector. Adjust the GAIN ADJUST Control so that the pulse produces 4 centimeters of vertical deflection on the oscilloscope screen.

FORWARD CURRENT—Selects the test diode forward current.

GAIN ADJUST—Sets the gain of the vertical preamplifier to agree with the setting of the SENSITIVITY Control.

VERTICAL POSITION—Sets the vertical position of the trace on the associated oscilloscope.



SENSITIVITY—Selects the oscilloscope vertical deflection factors. The ZERO REFERENCE position permits you to establish a zero voltage line on the screen.

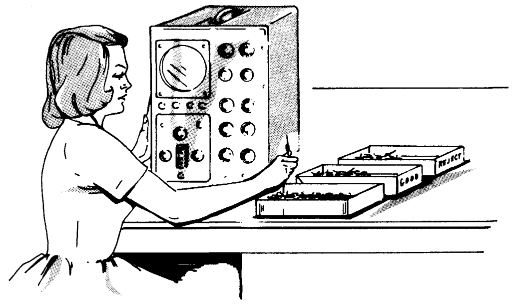
Triggering Cable — Connects triggering signals from the Type S Unit to the External Trigger Connector of the oscilloscope.

Test Diode Connector—Holder for the test diode (or other test device).

DIODE MODE—Determines whether the Turn-On or Turn-Off characteristics of a diode are displayed. The switch also selects the Reverse Recovery Current.

Plug-In Unit Locking Control—Locks the plug-in unit in the associated oscilloscope.

Fig. 2-7. Functions of front panel controls and connectors.



SECTION 3

APPLICATIONS

Forward Switching Characteristics of Semiconductor Diodes

When a semiconductor diode (p-n junction) is abruptly switched from a nonconducting state to forward conduction, a large switching transient occurs in the voltage waveform appearing across the diode (see Fig. 3-1). This transient occurs during the time that minority carriers are being distributed throughout the semiconductor materials. When a stable minority carrier distribution is obtained the voltage across the diode reaches the steady state value.

The major point of interest in the turn-on characteristics of a diode is this switching transient. The transient indicates an initial high impedance across the diode rather than the low impedance of an ideal diode. It is important in the design of equipment utilizing semiconductor devices to know both the duration of this high impedance condition and the magnitude of the impedance at any particular instant of time. As it will be seen later, both of these measurements can be made with the Type S Unit.

Reverse Recovery Characteristics of Semiconductor Diodes

When a diode is switched from forward conduction to a reverse bias condition, a further deviation in the action of the actual device from that of an ideal diode is noted. Instead of an immediate high impedance across the diode, a momentary low impedance is noted. This is indicated by a very low voltage across the diode immediately after the switching occurs. This effect is due primarily to the storage of minority carriers in the semiconductor materials, since the reverse bias applies only to the majority carriers. The junction is forward biased for minority carriers. The minority carriers must either be withdrawn from the materials or be allowed sufficient time to recombine before a high reverse impedance is obtained. In addition to the low initial impedance condition the voltage across the diode does not change polarity immediately as the diode is switched. The voltage instead decreases gradually, passes through zero, and then increases in the opposite direction.

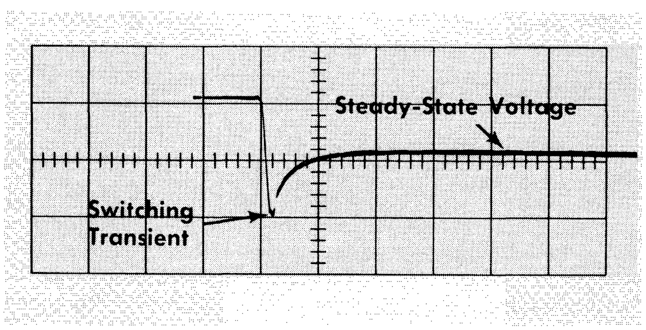


Fig. 3-1. Typical display of diode forward switching characteristics showing the large forward switching transient.

Referring to the waveform shown in Fig. 3-2, there are three areas of particular interest. These areas are designated by A, B, and C. The sudden positive rise in the voltage at area A occurs at the time forward conduction ceases. During forward conduction, this voltage is produced by the ohmic drop across the diode. When forward current is cutoff, this voltage drop disappears forming the positive voltage step. The resistance of the diode during forward conduction can be determined from the voltage change at area A and the forward current.

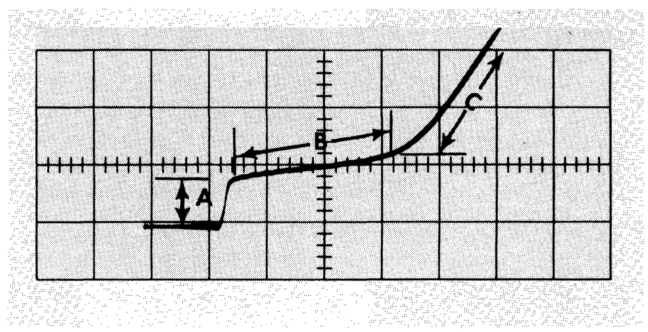


Fig. 3-2. Typical display of diode reverse recovery characteristics.

Immediately after the sudden positive rise in voltage the voltage decays linearly for a relatively long period of time (area B). During this interval, minority carriers in the semiconductor material are being swept out by the reverse current. The length of time required for the reverse current to remove the minority carriers gives an indication of the amount of charge stored in the material. The stored charge is found to be proportional to the forward current passing through the junction just before the diode is switched off. If the reverse current is halved, the time required to sweep all of the minority carriers out of material does not quite double. Since under identical conditions of forward current the stored charge should also be identical, this indicates that some other effect (namely recombination) must be responsible for clearing the material of minority carriers. If zero reverse current is drawn from the diode, the voltage decay is then due entirely to the recombination of minority carriers. By measuring the rate that the voltage across the diode decays, the effective lifetime of the minority carriers can be found.

When the minority carriers in the semiconductor material have either been swept out or recombined, a depletion region is formed at the junction due to the movement of the majority carriers away from the junction. Further reverse current is then required to charge the capacitance of this depletion region. This accounts for the rise in voltage across the diode shown in area C. Since the depletion region is dependent on the voltage across the junction, the junction capacitance is also dependent on the voltage. The capacitance then does not remain constant but varies with the voltage across the junction. The capacitance at any voltage level can be determined by dividing the reverse current by the time rate of change of the voltage across the diode.

The three areas of the reverse recovery voltage curve just described enable you to determine most of the essential facts about the diode. In the paragraphs that follow, detailed instructions are given for making each of these measurements.

Measuring the Diode Impedance

The impedance of the diode at any instant of time can be determined from the diode voltage curve displayed on the oscilloscope. The voltage drop across the diode is produced by the current flow through it. This current remains essentially constant with a value given by the settings of the front panel controls. The impedance of the junction at some particular instant of time is determined by finding the voltage at that instant from the voltage curve and then dividing this voltage by the current. Whether the forward current or the reverse current should be used is dependent on whether the junction is turned on or turned off. This will be readily apparent from the oscilloscope display.

Measuring the Diode Ohmic Resistance

As was mentioned earlier, at the termination of the forward current period there is a sudden positive step in the voltage across the diode. This step is caused by the elimination of the voltage drop produced by the forward current. From the size of this step it is possible to determine the diode resistance to forward current.

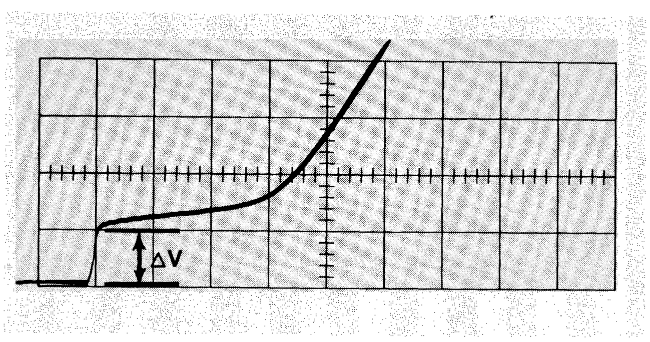


Fig. 3-3. Measuring the voltage change at the end of the forward current period. This voltage change permits you to measure the ohmic resistance of the diode.

To make this measurement, first set the FORWARD CURRENT Switch to the desired value of forward current and the DIODE MODE Switch to 0. Set the SENSITIVITY Switch to obtain a usable amount of vertical deflection. Measure the change in diode voltage as the forward current is switched off. The diode resistance is the change in voltage divided by the forward current (see Fig. 3-3).

Measuring the Forward Recovery Time

The forward recovery time may be defined as the time required for the voltage across the junction to reach its steady state value after the forward switching pulse is applied. The forward recovery time can thus be determined by measuring the duration of the forward switching transient.

Use the FORWARD CURRENT Switch to obtain the desired forward current and set the DIODE MODE Switch at TURN ON. Measure the horizontal distance on the screen of the oscilloscope between the start of the switching pulse and the end of the forward switching transient (see Fig. 3-4). Multiply this distance by the sweep rate to obtain the recovery time.

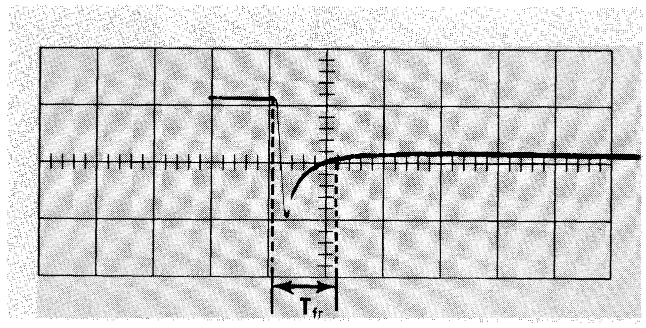


Fig. 3-4. Measuring the duration of the forward switching transient, or forward recovery time.

Some diodes have so short a forward recovery time that the oscilloscope used with the Type S Unit is incapable of displaying the forward switching transient. In such cases, it is only possible to determine that the diode switches in less than 12 nanoseconds. The 12-nanosecond risetime of the oscilloscope and S Unit combination must be considered when measurements are made on fast diodes.

Measuring the Reverse Recovery Time

The reverse recovery time is the time required for all excess minority carriers to either be recombined or withdrawn from the semiconductor material. (The excess minority carriers are those injected into the material during the previous forward current period.) The reverse recovery time is thus a variable which depends primarily on the reverse current, the stored charge, and the effective lifetime of the minority carriers. Since the stored charge is in turn dependent on the forward current, the recovery time must be specified with its corresponding forward and reverse currents.

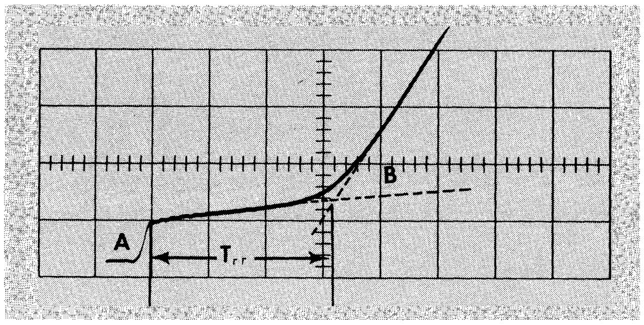


Fig. 3-5. Determining the reverse recovery time of a diode by drawing tangents to the curve. The intersection of the tangents is shown at point B. The distance from the start of the pulse, point A, to point B represents the reverse recovery time.

Fig. 3-5 shows a typical diode reverse recovery curve which illustrates the method used to measure the recovery time. Two tangents are drawn to the curve, one at the start of the linear voltage decay and the other at the linear portion of the voltage rise occuring when the junction capacitance is charging. The intersection of these two tangents is the point where the diode is considered to be recovered.

To measure the diode reverse recovery time, first select the desired forward current using the FORWARD CURRENT Switch. Then adjust the reverse current to obtain a well-defined linear voltage decay following the application of the reverse pulse. Adjust the sweep speed so that the display is spread horizontally as much as possible. Measure the horizontal distance between the point of application of the reverse pulse and the point where the two tangents intersect. This distance multiplied by the sweep time per centimeter is the reverse recovery time. In the example shown in Fig. 3-5, the sweep rate is 50 nanoseconds per centimeter, the distance between A and B is 3.7 centimeters, and the recovery time is 0.185 μseconds.

For comparison purposes between like diodes, the reverse recovery time can be taken as the time required for the voltage across the diode to rise to some preestablished reference level after application of the reverse switching pulse. An alternative method of specifying the recovery time for comparison purposes is to state the time after application of the reverse switching pulse required for the impedance across the junction to reach a specified level. Both methods are equivalent.

To measure the comparison reverse recovery time, first determine which values of forward and reverse current are to be used and set the FORWARD CURRENT and DIODE MODE Switches for these currents. Then determine at which level of voltage or impedance the diode is to be considered recovered. Measure the horizontal distance on the oscilloscope screen between the start of the reverse switching pulse and the recovery point. This distance multiplied by the sweep rate used is the reverse recovery time.

If the recovery point is specified as a voltage, the recovery time can be determined directly from the display. However, if the recovery time is defined as the time required for the diode impedance to rise to a certain level it will first be necessary for you to determine which voltage level corresponds to this impedance, before finding this point on the display. The voltage level corresponding to a specified impedance is found by multiplying the impedance by the reverse current.

As an example, with $+\frac{1}{2}$ volt as the specified recovery point, 20 ma forward current and 0.1 ma reverse current, the reverse recovery times of a series of eleven 1N116 diodes ranged from 0.5 to 3.0 μsec with an average recovery time of 1.6 μsec. The $+\frac{1}{2}$-volt level at 0.1 ma reverse current corresponds to a recovery to 5 kilohms.

NOTE

It is important to differentiate between actual diode reverse recovery time and the arbitrary recovery time measurements used to make comparisons between like diodes. If an arbitrary reference level is established for the purpose of making recovery measurements, data on recovery times must include the reference level as well as the forward and reverse currents.

Measuring the Effective Lifetime of Minority Carriers

During the period of forward current conduction, excess minority carriers are injected into the semiconductor material. These excess minority carriers are in addition to the normal number of minority carriers present at room temperatures due to the formation of electron-hole pairs. The effective lifetime of these excess minority carriers is the time required for the number of excess minority carriers to decrease to $1/e$ of the original number after termination of the forward current. The effective lifetime expresses the relative rate at which minority carriers recombine and is a constant for a given diode at a particular absolute temperature. It does not depend on either the forward or reverse current drawn from the diode. Effective lifetimes should be specified with the temperature at which the measurements were made.

When dealing with times (t) which are small compared to the effective lifetime (τ_e) and where kT/q is much smaller than the voltage across the diode, the approximation shown below holds:[1]

$$(1) \qquad \tau_e \cong -\frac{kT}{q}\frac{\Delta t}{\Delta V}$$

where k is Boltzmann's constant in mks units, T is the absolute temperature in degrees Kelvin, and q is the charge of the carrier in mks units. The quantity kT/q at room temperature (T=300°K.) is equal approximately to .026 volts and approximation (1) can be written as:

$$(2) \qquad \left[\tau_e\right]_{T=300^\circ K} \cong \frac{0.026}{\frac{\Delta V}{\Delta t}}$$

Relationship (2) states that the effective lifetime of minority carriers at T=300°K. is .026 volts divided by the decay rate of the voltage across the diode. In the development of approximation (1) it is assumed that t is small compared with τ_e. This means that the decay rate of the voltage

1. S. R. Lederhandler and L. J. Giacoletto, "Measurements of Minority Carrier Lifetime and Surface Effects in Junction Devices," PROC. I.R.E., Vol. 43, April 1955, pp 477-483.

across the diode should be measured just after the forward current is switched off. Mathematically stated, $\Delta V/\Delta t$ should be measured as $t \rightarrow t_o$, where t_o is the time when the forward current is switched off. For completeness, relationship (2) should be written as:

$$(3) \quad [T_e]_{T=300^\circ K} \cong \frac{0.026}{\left[\frac{\Delta V}{\Delta t}\right]_{t \rightarrow t_o}}$$

The assumption that kT/q is much smaller than the voltage across the diode also holds quite generally as $t \rightarrow t_o$.

Fig. 3-6 shows a typical waveform used to measure the effective lifetime of minority carriers. In the example, a tan-

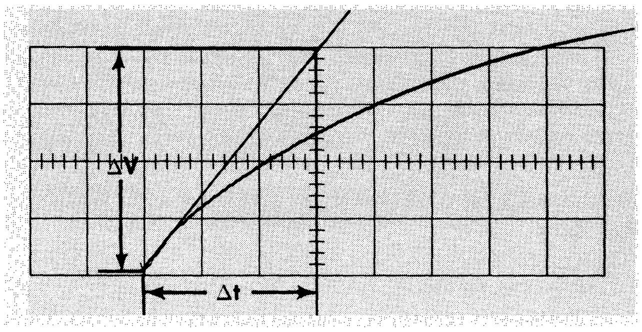


Fig. 3-6. Determining the effective lifetime of minority carriers. The tangent line to the curve permits you to find the voltage decay rate across the diode resulting from carrier recombination.

gent line is drawn to the voltage curve near the point where t=0. The slope of this tangent line is the initial decay rate of the voltage. The method used to obtain this type of display is indicated in the following paragraph.

Use the FORWARD CURRENT Switch to set the forward current at any convenient value. Then set the DIODE MODE Switch for zero reverse current to insure that the voltage decay is due entirely to recombination. Set the SENSITIVITY Switch to .05 V/CM and measure the voltage decay rate. The decay rate may either be determined from a photograph as shown in Fig. 3-6, or directly from the oscilloscope screen. If the decay rate is measured from the oscilloscope screen, place a short rule tangent to the curve and position the curve so that the edge of the rule passes through the corner of a least one 1-centimeter square before crossing through the vertical centerline (see Fig. 3-7). This permits you to obtain the most accurate reading of the voltage decay rate. Measure the horizontal distance corresponding to Δt and the vertical distance corresponding to ΔV. Multiply these distances by the corresponding deflection factors. When the decay rate has been determined, divide it into .026 for measurements of room temperature. If the measurement is made at other than 300°K., use approximation (1). The figure obtained in either case is the effective lifetime.

Measuring the Junction Capacitance

After the excess minority carriers have all been withdrawn or recombined, additional reverse current charges the junction capacitance. The junction capacitance can be determined from a knowledge of the time rate of change of voltage across the diode after recovery, the current charging the capacitance, and the shunt capacitance.

When a capacitor is charged, the charging current is equal to the product of the capacitance and the time rate of change of the voltage across the capacitor. In the Type S Unit the charging current is held constant. Therefore the capacitance at a particular voltage level is equal to the charging current divided by $\Delta V/\Delta t$. Not all of the reverse current supplied by the Type S Unit is used to charge this capacitance, however, since some of this current is leakage current through the diode. To obtain the actual charging current then, the leakage must be subtracted from the indicated reverse current. The leakage current cannot be easily determined by using the S Unit and the measurement should be made using auxiliary equipment. The leakage current must be measured at the voltage level where the capacitance measurement is to be made. In most cases the leakage current is very small compared to the reverse current supplied by the S Unit and can be ignored. A typical value of the leakage current of a silicon diode at 2 volts is approximately 1 μa. This is very small compared to the minimum reverse current of 100 μa supplied by the S Unit. The leakage current for germanium diodes at 2 volts is slightly higher (typically less than 10 μa) than for silicon diodes but still can often be ignored. Since leakage current depends on the thermal formation of electron-hole pairs, the leakage current is highly dependent on the diode temperature. If the junction capacitance is measured at relatively high temperatures, the leakage current cannot be ignored.

The figure obtained by dividing the charging current by $\Delta V/\Delta t$ is the total capacitance. The total capacitance includes not only junction capacitance but the shunt capacitance of the S Unit as well. The junction capacitance is the total capacitance less the shunt capacitance of the S Unit. The shunt capacitance of the unit with the SENSITIVITY

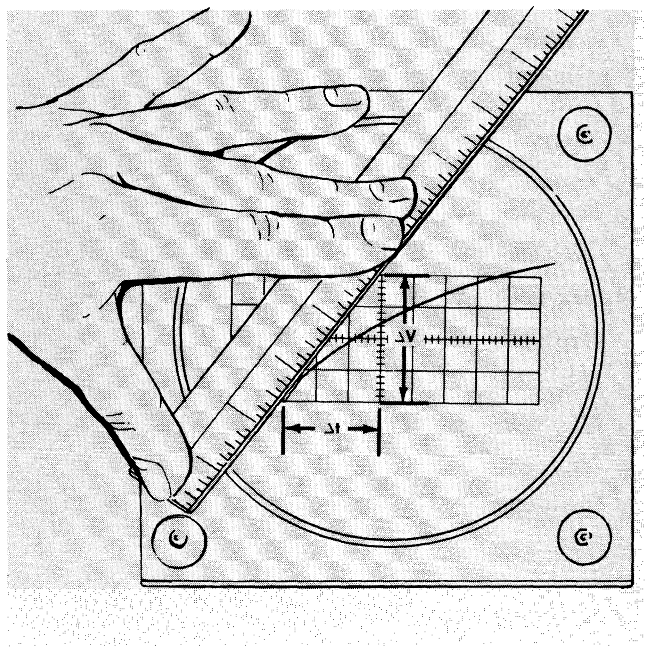


Fig. 3-7. Using a small ruler to find the voltage decay rate across the diode for purposes of measuring the effective lifetime of minority carriers.

Switch in the 0.5 V/CM position is approximately 9 pf. In the .05 V/CM position the shunt capacitance is approximately 16 pf. The junction capacitance is found from the following equation:

(4) $$C_j = \frac{I}{\left[\frac{\Delta V}{\Delta t}\right]_{V=V_1}} - C_s$$

In equation (4), C_j is the junction capacitance, I is the charging current, $\Delta V/\Delta t$ is the time rate of change of the voltage across the diode, C_s is the shunt capacitance of the S Unit, and V_1 is the voltage where the capacitance measurement is to be made.

To obtain a display suitable for junction capacitance measurements, use a suitable sweep speed and set the reverse current so that the slope of the voltage curve across the diode after recovery is about 1. (See Fig. 3-8, where a typical display is shown.) Draw a tangent line to the curve at V_1 and measure the ΔV and Δt shown in the figure from the oscilloscope display. Use equation (4) and the appropriate value of shunt capacitance to determine the junction capacitance.

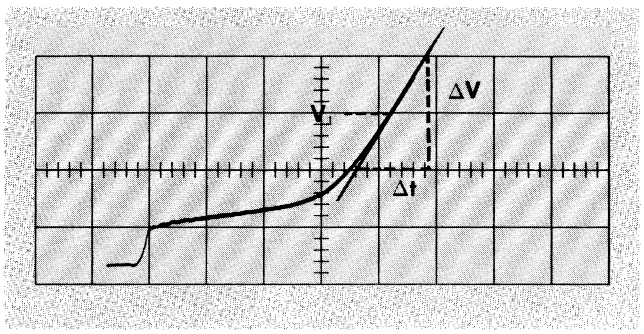


Fig. 3-8. Measuring the slope of the curve after recovery at the voltage V_1. The slope of the curve after recovery permits you to find the junction capacitance of the diode.

Measuring the Stored Charge

As mentioned previously, during the period of forward conduction minority carriers are stored in the semiconductor material. The amount of stored charge depends primarily on the forward current. When the period of forward current ends, the stored charge is dissipated either by the reverse current, carrier recombination, or both. If the reverse current is great enough that the minority carriers are swept out in a small fraction of an effective lifetime, the effects of recombination are negligible. The stored charge in such a case is the product of the current times the reverse recovery time of the diode. If the time of recovery is not a small fraction of an effective lifetime, then the charge dissipated by carrier recombination will have to be considered.

The reverse current during the period of diode recovery is actually the sum of three separate currents. One current charges the junction capacitance of the diode, one charges the shunt capacitance, and the third dissipates the stored charge in the materials. The current of interest, then, is the total reverse current less the current charging the two capacitances. The current dissipating the charge in the materials (I_q) is found from the following relationship:

(5) $$I_q = I_R - I_C = I_R - \frac{C_j + C_s}{\left[\frac{\Delta V}{\Delta t}\right]_{t=0}^{t \to t_r}}$$

where I_R is the reverse current set with the DIODE MODE Switch, I_C is the charging current for the capacitances, C_j is the junction capacitance, C_s is the shunt capacitance, t_r is the reverse recovery time, and $\Delta V/\Delta t$ is the decay rate of the diode voltage during the recovery time (see Fig. 3-9).

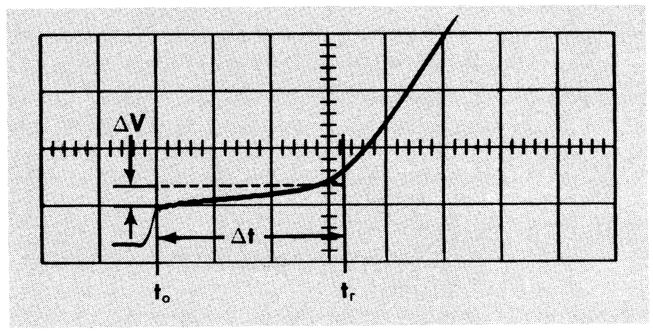


Fig. 3-9. Measuring the decay rate of the voltage across the diode during recovery. This measurment can be used to find the amount of excess charge stored in the material immediately after the forward current period.

The amount of stored charge is given by:

(6) $$Q = I_q \tau_q \left(e^{\frac{t_r}{\tau_q}} - 1\right)$$

where Q is the stored charge, τ_q is the lifetime of the charge, and t_r is the diode reverse recovery time. In actual measurements, τ_q may be more, less or equal to τ_e. For any particular diode the value of τ_q is an unknown which must be determined. Its value is nearly independent of the forward and reverse currents. The value of Q is a constant for any particular forward current. Since I_q is known for any particular measurement and t_r can be measured, these values can be substituted into equation (6). If the reverse current is then changed while all other factors are left the same, the new values of I_q and t_r can also be substituted into equation (6). This gives two equations in two unknowns thereby permitting determination of the values of Q and τ_q simultaneously. Since τ_q varies only slightly with the reverse and forward currents the values of Q and τ_q can be used to predict approximately the reverse recovery time with any other value of reverse current by solving either (6) or (7) for t_r. Also since τ_q is essentially a constant for a particular diode, its value can be used in equation (6) to find the stored charge resulting from any other value of forward current.

When the diode recovery time is less than one tenth of the lifetime of the charge (τ_q), the effects of carrier recombination can be neglected. The stored charge is then just the product of the reverse current and the recovery time. Equation (6) reduces then to:

(7) $$Q \cong \left[I_q t_r\right]_{\frac{t_r}{\tau_q} < 0.1}$$

TYPE S UNIT CORRECTION

On page 3-5 of your Type S Manual, Formula (5) is incorrect. The corrected version should read: $I_q = I_R - I_C = I_R - \left[C_j + C_s\right]\left[\frac{\Delta V}{\Delta t}\right]_{t=o}^{t \to t_r}$

voltage across the diode, C_s is the shunt capacitance of the S Unit, and V_1 is the voltage where the capacitance measurement is to be made.

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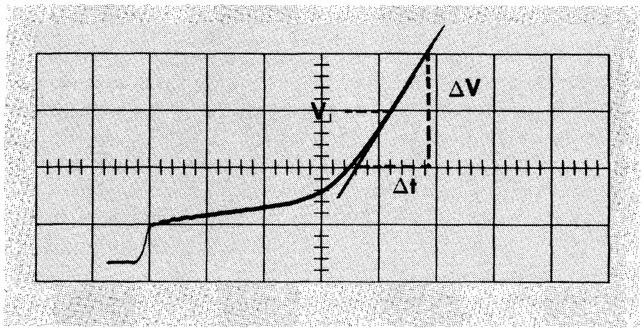

Fig. 3-8. Measuring the slope of the curve after recovery at the voltage V_1. The slope of the curve after recovery permits you to find the junction capacitance of the diode.

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The reverse current during the period of diode recovery is actually the sum of three separate currents. One current charges the junction capacitance of the diode, one charges the shunt capacitance, and the third dissipates the stored charge in the materials. The current of interest, then, is the total reverse current less the current charging the two capaci-

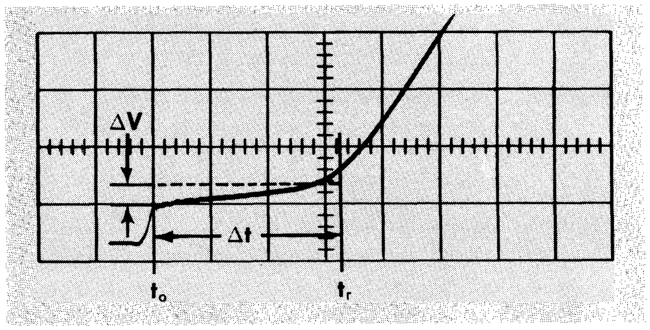

Fig. 3-9. Measuring the decay rate of the voltage across the diode during recovery. This measurment can be used to find the amount of excess charge stored in the material immediately after the forward current period.

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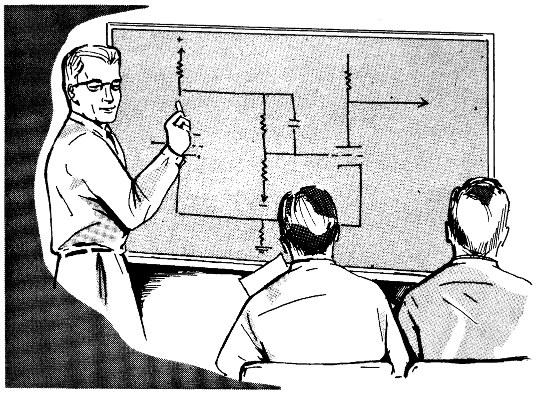
where Q is the stored charge, τ_q is the lifetime of the charge, and t_r is the diode reverse recovery time. In actual measurements, τ_q may be more, less or equal to τ_e. For any particular diode the value of τ_q is an unknown which must be determined. Its value is nearly independent of the forward and reverse currents. The value of Q is a constant for any particular forward current. Since I_q is known for any particular measurement and t_r can be measured, these values can be substituted into equation (6). If the reverse current is then changed while all other factors are left the same, the new values of I_q and t_r can also be substituted into equation (6). This gives two equations in two unknowns thereby permitting determination of the values of Q and τ_q simultaneously. Since τ_q varies only slightly with the reverse and forward currents the values of Q and τ_q can be used to predict approximately the reverse recovery time with any other value of reverse current by solving either (6) or (7) for t_r. Also since τ_q is essentially a constant for a particular diode, its value can be used in equation (6) to find the stored charge resulting from any other value of forward current.

When the diode recovery time is less than one tenth of the lifetime of the charge (τ_q), the effects of carrier recombination can be neglected. The stored charge is then just the product of the reverse current and the recovery time. Equation (6) reduces then to:

(7) $$Q \cong \left[I_q \, t_r\right]_{\frac{t_r}{\tau_q} < 0.1}$$

Fig. 3-9 shows a typical display used to measure the stored charge. To obtain a suitable display for this measurement, set the FORWARD CURRENT Switch for the desired forward current. Set the reverse current and the oscilloscope sweep speed to obtain a well-defined linear decay during the recovery time. In general this should be accomplished with the greatest possible reverse current. Measure the reverse recovery time using the procedure described previously in this section of the manual. Change the reverse current slightly and make a second measurement of the recovery time. The value of the stored charge and τ_q can be found then from either (6) or (7) as applicable.



SECTION 4

CIRCUIT DESCRIPTION

Block Diagram

A block diagram of the Type S Unit is shown in Fig. 4-1. This diagram will be used for a general discussion of unit's operation, after which a thorough treatment of the circuit operation will be given.

The Switching Multivibrator is used to produce approximately 275-cycle square waves which are applied to a mercury switch. These square waves drive the reed of the mercury switch causing the switch to generate either 275 or 550 pulses per second, depending on whether 1 or 2 sets of contacts are used. The fast-rising pulses generated by the mercury switch are applied through a pulse divider network to the grid circuit of the switching tube.

The switching tube controls the current flowing through the test diode. The total amount of forward and reverse current is set by adjusting the cathode resistance of the switching tube. One section of the switching tube has the test diode in its plate circuit. When this section conducts, forward current is passed through the test diode; when the section is cut off, reverse current is drawn through the diode and the plate load resistor. When the DIODE MODE switch is set at TURN ON, the pulse from the mercury switch causes forward current to flow through the test diode. When the DIODE MODE switch is in any of the other positions, the pulse from the mercury switch cuts off the forward current and reverse current is drawn from the test diode.

The voltage waveform across the test diode is applied to the input of a wide passband vertical preamplifier. The amplifier increases the signal level sufficiently to drive the vertical amplifier of the associated oscilloscope.

Switching Multivibrator

The switching multivibrator is operated from approximately +12.5 volts obtained from the series filament string. Bias for the two transistors is obtained from a divider consisting of R5953 and R5957. Initial operation of the multivibrator depends on a slight unbalance between transistors Q5945 and Q5955. When power is first applied to the unit, one of the two transistors conducts first. For illustrative purposes, assume that Q5945 conducts.

As Q5945 conducts, current passing through one half of the primary of T5955 induces a negative voltage at the base of Q5945 and a positive voltage at the base of Q5955. This

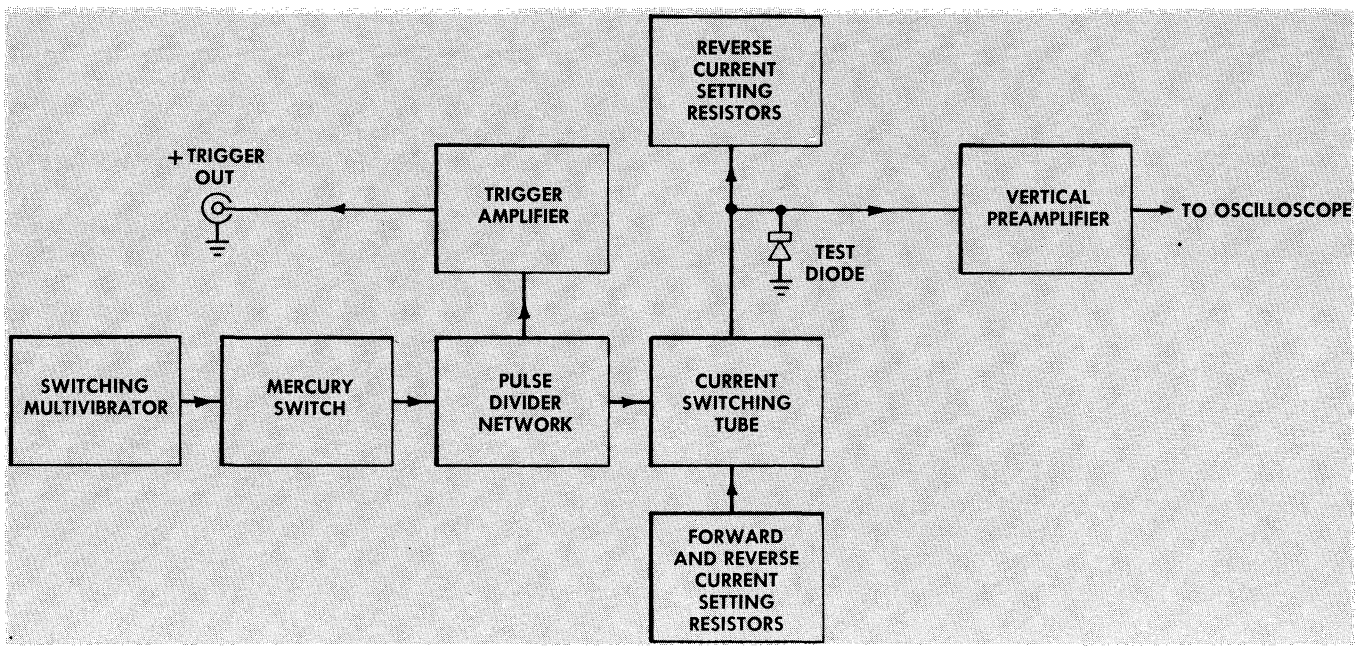


Fig. 4-1. Type S Unit Block Diagram.

causes Q5945 to conduct more heavily and holds Q5955 in cutoff. This regenerative action continues until Q5945 conducts so heavily that T5955 saturates.

When the transformer saturates, the driving voltage at the bases of the two transistors is reduced. This causes current flow through Q5945 to decrease, which in turn causes the induced voltages at the bases of the two transistors to shift polarity. With a negative voltage on the base of Q5955, the transistor conducts thereby inducing a still greater negative voltage at its base. This action then continues until the transformer again saturates. The cycle then repeats as Q5945 and Q5955 alternately conduct and cut off.

The time required for the transformer to saturate and for the field to collapse is dependent on the inductance of the transformer and on resistances in the circuit. The resistance of greatest importance in the cycle is the base-emitter resistance of the transistor which is not conducting.

The FREQ. ADJ. Control R6977 sets the operating voltage and bias on transistors Q5945 and Q5955. By varying both of these characteristics, R6977 determines the amount of time required for the base drive voltage to become insufficient to hold the nonconducting transistor cutoff. This in turn controls the multivibrator frequency. The multivibrator frequency can be varied between approximately 260 and 285 cycles per second by means of this control.

The output from the multivibrator is taken from a secondary winding of T5955 and applied to L5955. The field set up by L5955 is used to operate the reed of the mercury switch.

Mercury Switch

The mercury-wetted switch, SW5955, is used to produce fast-rising pulses when excited by the output of the switching multivibrator. The reed of the mercury switch is magnetically biased by a permanent magnet placed near the switch. When the multivibrator operates, the field set up by L5955 aids or opposes the field of the permanent magnet causing the reed to alternate between the two contacts. The permanent magnet is adjusted so the period of closure with each contact is approximately the same. Use of the mercury switch eliminates contact bounce at the start of the pulse and the resulting irregularities in the generated pulse. Use of high pressure in the mercury switch prevents precontacting ionization.

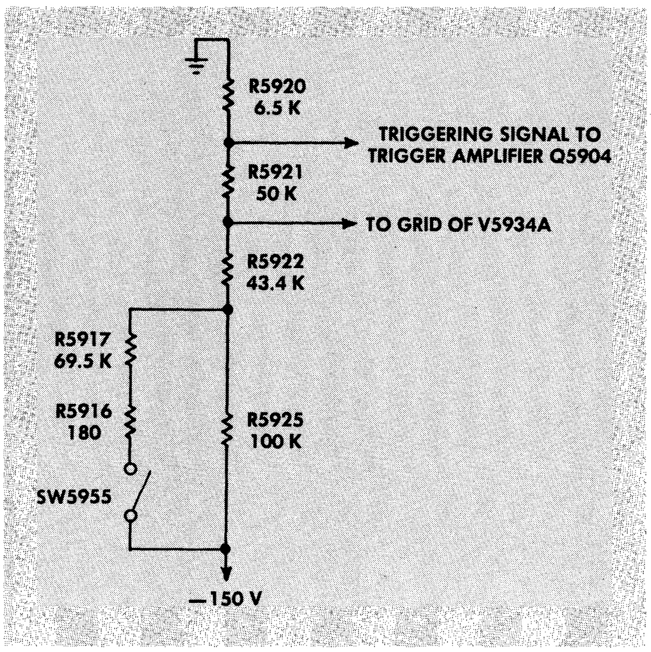


Fig. 4-2. Simplified schematic diagram of the pulse divider network when the DIODE MODE Switch is at TURN ON.

When the DIODE MODE Switch is in the TURN ON position, one of the two contacts of the mercury switch is not used. The pulse output frequency is then the same as the multivibrator frequency, or approximately 275 cycles. One contact is not used so that the time between pulses is sufficient to allow a test diode to completely recover from one turn-on cycle before the next cycle occurs.

In all positions of the DIODE MODE Switch except TURN ON, both contacts of the mercury switch are used. The pulse output frequency is then twice the switching multivibrator frequency, or nominally 550 cycles. The long period of time between pulses is not required for reverse recovery measurements.

Pulse Divider Network

The mercury switch forms part of a network which controls the grid voltage of one section of the current switching tube V5934. When the mercury switch closes, the resulting change in voltage at the grid of V5934A either causes that section to conduct or to cut off depending on the position of the DIODE MODE switch. Simplified diagrams of the pulse divider network are shown in Figs. 4-2 and 4-3. These diagrams show that closure of the mercury switch causes the grid voltage of V5934A to go more negative when the DIODE MODE Switch is in the TURN ON position and more positive when the DIODE MODE Switch is in any of the other positions. In the TURN ON position, the grid voltage of V5934A goes from approximately —42 volts to approximately —60 volts as the mercury switch closes. In the other positions of the DIODE MODE switch the voltage change is from approximately —59 volts to approximately —41 volts.

In all positions of the DIODE MODE Switch a negative triggering signal is produced when the mercury switch closes. Again referring to the simplified diagrams shown in Figs. 4-2 and 4-3, it can be seen that the triggering signal is developed across R5920 when the DIODE MODE Switch is in the TURN ON position and across R5913 when the switch is in any of the other positions. In the TURN ON position, the voltage across R5920 changes from approximately —7 volts to approximately —5 volts, thereby producing a 2-volt signal. In other positions of the DIODE MODE Switch, the voltage change across R5913 is from zero to approximately —1 volt. In each case the triggering signals are applied through C5911 to the Trigger Amplifier, Q5904. Capacitor C5911 and resistor R5911 form a differentiating circuit which produces a negative-going signal at the start of the pulse and a positive-going signal at the end of the pulse.

Transistor Q5904 operates as the Trigger Amplifier and clipper. Negative signals from the pulse divider network

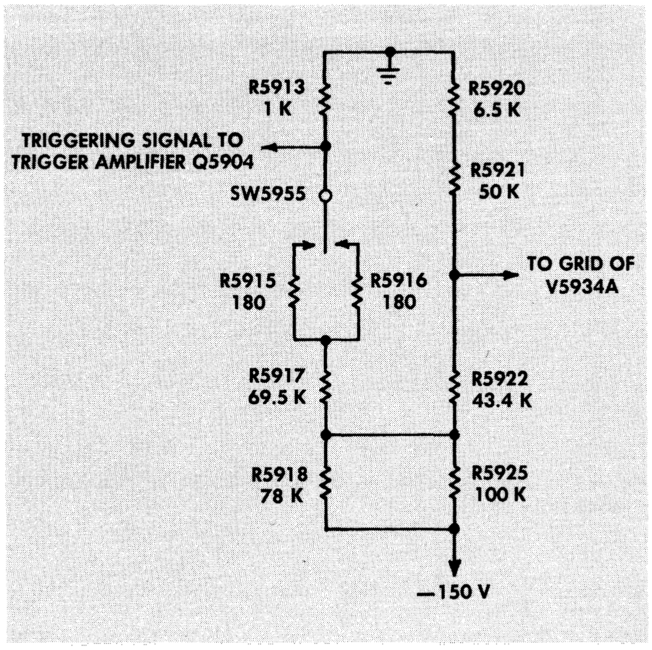


Fig. 4-3. Simplified schematic diagram of the pulse divider network when the DIODE MODE Switch is in any position but TURN ON.

are applied to the base of the transistor. These signals are amplified and then applied from the collector of Q5904 through the +TRIGGER OUT Cable to the External Trigger Input of the associated oscilloscope. Output signals from the Trigger Amplifier are clipped at the 4-volt level so that the amplitude of the triggering signals remains constant regardless of the position of the DIODE MODE Switch. These +4-volt triggering signals initiate the sweep of the associated oscilloscope.

Several capacitors are used to compensate the pulse divider network. These include C5913, C5918, C5921, and C5922. Capacitor C5922 is variable so that proper compensation may be obtained. Inductors L5915 and L5916 are used to shape the rise of the pulse produced by the mercury switch.

When the DIODE MODE Switch is at TURN ON, the input capacitance of Q5904 is in parallel with R5920. When the DIODE MODE Switch is shifted to any of the other positions, this shunt capacitance is removed since the input to Q5904 is then connected across R5913. To prevent this transfer of capacitance from affecting the compensation of the network, capacitor C5920 is connected in parallel with R5920 in all positions of the DIODE MODE Switch except TURN ON.

Current Switching Tube

Resistors R5940 and R5941 form a voltage divider from —150 volts to ground which holds the grid of V5934B fixed at approximately —51 volts. The voltage at the other grid of the switching tube is controlled by operation of the mercury switch. The tube characteristics and the voltage changes produced by the mercury switch insure that only one of the two sections conducts at any one time. When one of the sections conducts, the voltage on the common cathode holds the other section cutoff.

The amount of current carried by V5934A when it conducts is relatively unimportant since this current is conducted to ground. However when V5934B conducts, the amount of current flowing through the tube is of prime importance since the plate current must be the sum of the forward and reverse currents for the diode.

When V5934B conducts, the cathode current sets the common cathode voltage for the tube. The total cathode resistance is determined by the settings of the FORWARD CURRENT and DIODE MODE Switches. Since the cathode resistances are quite large, the resistance effectively controls the cathode current of V5934B. The amount of cathode current is determined by how much current passing through the cathode resistance is required to raise the cathode voltage near that of the grid. Since the grid voltage is at approximately —51 volts, it can be seen that approximately a 100-volt drop is required across the cathode resistance.

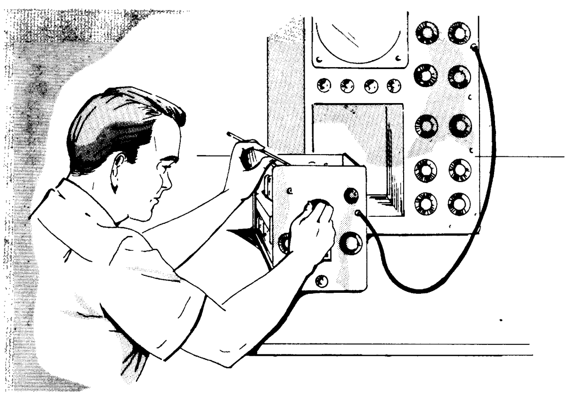
In the cathode circuit of V5934, the forward current setting resistors and the reverse current setting resistors are in parallel. The value of each resistor is selected either by the FORWARD CURRENT or the DIODE MODE Switch, as applicable. The value of the reverse current setting resistor in the 2 ma position of the DIODE MODE switch is 50 k. Since there is approximately a 100-volt drop across this resistor, it is evident that 2 ma of current must flow through the resistor in order to obtain the required drop. Similarly in the 1 ma position of the FORWARD CURRENT Switch, 100 k resistor R5942A is used. Again, the 100-volt drop across the cathode resistance requires that 1 ma of current flow through the resistor. It can thus be seen that the total cathode and plate current is the sum of the individual forward and reverse currents.

As the cathode resistance is made quite small, the value of the cathode resistance does not completely control the amount of cathode current. To compensate for this effect it is necessary to decrease the value of the current setting resistors on the 5, 10, and 20 ma positions of the FORWARD CURRENT Switch from the values which would be expected. This decrease in resistance is necessary to insure that the proper amount of cathode current is obtained.

When the DIODE MODE Switch is in the TURN ON position, V5934A is normally conducting and V5934B is cut off. However when the mercury switch closes, V5934A is rapidly cut off causing V5934B to conduct. The resulting plate current of V5934B, for the duration of the pulse, is the sum of the forward and reverse diode currents.

In all positons of the DIODE MODE Switch except TURN ON, V5934B is normally conducting and V5934A is cut off. When the mercury switch closes, V5934B is cut off and V5934A conducts. The plate current of V5934B drops to zero as all of the current is switched through V5934A. The circuit is such that when the diode is to be switched on, V5934B is brought into conduction by the closure of the mercury switch; when the diode is to be switched off, V5934B is cut off by the closure of the mercury switch.

It is necessary for the switching operation to occur as rapidly as possible upon closure of the mercury switch. Therefore, to increase the switching speed, a portion of the pulse is coupled through C5923 to the cathode circuit of



SECTION 5

MAINTENANCE

PREVENTIVE MAINTENANCE

Calibration

The Type S Plug-In will require complete calibration very infrequently. However, to insure that the unit is operating properly at all times, we suggest that you check the calibration of the instrument after each 500-hour period of operation (or every six months if the unit is used intermittently). A complete step-by-step procedure for calibrating the unit and checking its operation is given in the Calibration Procedure Section of this manual.

The accuracy of measurements made with the S Unit depend not only on the accuracy of the S-Unit calibration, but on the calibration of the associated oscilloscope as well. It is essential that the calibration of the oscilloscope is checked frequently.

Visual Inspection

Many potential and existent troubles can be detected by a visual inspection of the unit. For this reason, you should perform a complete visual check each time the instrument is calibrated or repaired. Apparent defects may include loose or broken connections, damaged connectors, improperly seated tubes, scorched or burned parts, broken terminal strips, as well as many others. The remedy for these troubles is readily apparent except in the case of the heat-damaged parts. Damage of parts due to heat is often the result of other less apparent troubles in the unit. It is essential that you determine the cause of overheating before replacing the damaged parts.

COMPONENT REPLACEMENT

General

The procedures for replacing most parts in the Type S Unit are obvious. Detailed instructions for their removal are therefore not required. In some cases, however, additional information will aid in the replacement of parts. This information is given in the following paragraphs. Because of the nature of the unit, replacement of certain parts will require that you calibrate the instrument to insure proper operation. Refer to the Calibration Procedure Section of this manual.

Switches

Methods for removal of defective switches are, for the most part, obvious and only a normal amount of care is required. Single wafers are normally not replaced on the switches; if one wafer is defective, the entire switch should be replaced. Switches may be ordered from Tektronix either unwired or with the parts wired in place, as desired.

Soldering Precautions

In the production of Tektronix instruments, a special silver-bearing solder is used to establish a bond to the ceramic terminal strips. This bond may be broken by the repeated use of ordinary tin-lead solder, or by the application of too much heat. Occasional use of ordinary solder will not break the bond, however, if too much heat is not applied.

If you frequently perform work on Tektronix instruments, it is advisable that you have a stock of solder containing about 3% silver. This type of solder is used quite often for etched circuit boards and should be readily available. It may also be purchased directly from Tektronix in one-pound rolls (part number 251-514).

Because of the shape of the terminals on the ceramic terminal strips, you will probably want to use a wedge-shaped tip on your soldering iron. A tip such as this allows you to apply heat directly to the solder in the terminals and reduces the amount of heat required. It is important to use as little heat as is possible.

Mercury Switch

Special care is required to replace the mercury switch. This switch consists of a glass envelope containing the contacts, the mercury reservoir, and gas under high pressure. If the glass is cracked or broken during removal or replacement of the switch, the envelope will likely explode. This could produce serious injury due to flying glass and mercury. It is recommended that safety glasses be worn when you are working with the switch.

The mercury switch and adhesive shield can be removed quite easily by unsoldering five connections, three at the top and two at the bottom. The shield is an adhesive-coated copper sheet which is wrapped around the switch and stuck to it. The shield can be removed from the defective switch and wrapped around the new one if another piece of the shielding material is not available. To replace the switch,

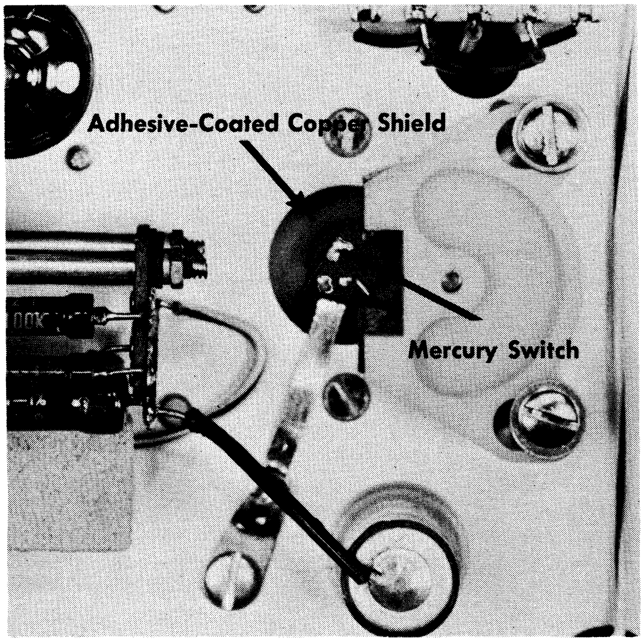


Fig. 5-1. Top view of the Type S Unit showing the location of the mercury switch.

the procedure for removal is reversed. If the mercury switch is replaced, it will be necessary for you to readjust the bias magnet to obtain proper operation of the switch.

Ceramic Terminal Strips

Damaged ceramic terminal strips are most easily removed by unsoldering all connections, then using a plastic or hard rubber mallet to knock the yokes out of the chassis. This can be done by pounding on the ends of the yoke protruding through the chassis. This removes both the strip and the yoke assembly.

When the damaged strip and yoke assembly has been removed, place the spacers for the new strip into the holes in the chassis. Snap the ceramic strip into the yokes and place the tip of the yoke pins into the spacers. Using a plastic or hard rubber mallet, tap the ceramic strip lightly above the yokes to drive the yoke pins down through the spacers. Be certain that the yoke pins are driven completely through. Using a pair of diagonal cutters, cut off the excess length of the yoke pin protruding through the chassis. Fig. 5-2 illustrates the way that the parts fit together.

REPLACEMENT PARTS

Standard Parts

Replacements for all parts used in the Type S Unit can be purchased directly from Tektronix at current net prices. However, since most of the components are standard electronic parts, they can generally be obtained locally in less time than is required to obtain them from the factory. Before purchasing a part, be sure to consult the parts list to determine the tolerances and ratings required. The parts list gives the values, tolerances, ratings, and Tektronix part numbers of all components used in the instrument.

Special Parts

In addition to the standard electronic components mentioned in the previous paragraph, special parts are also used. These parts are manufactured or selected by Tektronix to satisfy particular requirements, or are manufactured specially for Tektronix by other companies. These parts and most mechanical parts should be ordered directly from Tektronix since they are normally difficult or impossible to obtain from other sources. All parts may be obtained either directly from the factory or through the local Tektronix Field Engineering Office.

Parts Ordering Information

Each part in the Type S Unit has a 6-digit Tektronix part number. This number and a description of the part will be found in the parts list. When ordering parts, be sure to include a description of the part, the number, and the serial number of the unit. For example, if the serial number of your unit is 1145, a certain resistor would be ordered as follows: R6034, 100 k, $\frac{1}{2}$-watt, fixed, precision, 1%, part number 309-045, for Type S plug-in Unit, Serial Number 1145. When parts are ordered in this manner, we are able to fill your orders promptly and delays that might result from transposed digits in the part number are avoided.

Since the production of your unit, some of the parts may have been superseded by new or improved components. In such cases, the part numbers of these new components will not be listed in the parts list accompanying this manual. However, if you order a part from Tektronix and it has been superseded by a new component, the new part will be shipped in place of the part ordered. Your local Tektronix Field Engineering Office knows of these changes and may call you if a change in your purchase order is necessary.

Replacement information sometimes accompanies the improved components to aid in their installation.

NOTE

Always include the instrument type and serial number in any correspondence concerning this or any other Tektronix Instrument.

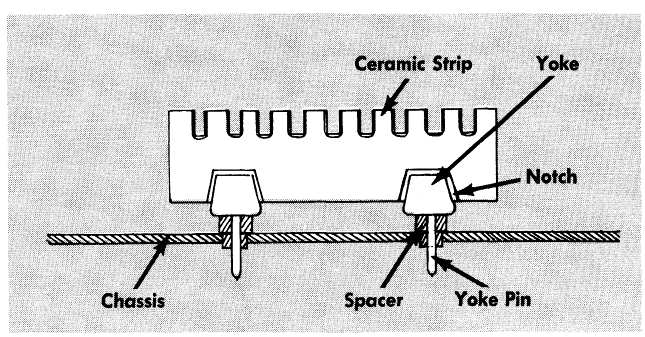


Fig. 5-2. Installation of ceramic terminal strips.

TROUBLESHOOTING

General Information

This section is included to provide you with information that will enable you to more efficiently troubleshoot the Type S Unit in the event that a trouble develops. During troubleshooting work, you should correlate information contained in this section with information obtained from other sections of the manual. We have not attempted to give step-by-step procedures for finding the cause of specific troubles. We have, instead, attempted to outline a general troubleshooting guide which can be used to locate any trouble which might occur. This guide provides a means for determining the cause of a trouble from symptoms observed rather than from detailed voltage or resistance measurements.

In general, a troubleshooting procedure can be thought of as consisting of two parts; circuit isolation and circuit troubleshooting. The first step involves isolating a trouble to a definite circuit. When the trouble has been isolated, detailed checks will then allow you to determine the exact cause of the trouble. Both circuit isolation and circuit troubleshooting are covered in detail in the following paragraphs.

In the following troubleshooting procedures, it is assumed that the oscilloscope used with the Type S Unit is operating correctly. This is not always the case. If you are in doubt, you should check the operation of the oscilloscope before attempting to troubleshoot the Type S Unit. Troubles occuring in the oscilloscope can usually be detected by substituting another plug-in unit and checking for proper operation.

A schematic diagram of the Type S Unit is contained in a special pocket at the rear of this manual. The reference designation of each component is shown on the circuit diagrams in addition to important voltages and waveforms. These voltages and waveforms should be used as troubleshooting aids.

All wiring used in the Type S Unit is color coded to facilitate circuit tracing. In addition, filament and power-supply leads are distinguishable by specific color codes. All power supply leads follow the standard JETEC (formerly RETMA) code. For example, the —150-volt lead is coded brown-green-brown. The widest strip identifies the first color of the code.

Troubleshooting Procedure

Before attempting any troubleshooting work, you should check all front panel controls for proper settings. If you are in doubt as to the settings of controls, refer to the Operating Instructions and Applications Sections.

A defective test diode may produce symptoms of trouble in the Type S Unit. To eliminate this possible trouble, replace the test diode with a 100-ohm resistor during troubleshooting work. An accurate low-inductance resistor should be used.

A good procedure to follow when troubles occur in the Type S Unit is to make a careful visual check of the unit and external connections. Many troubles can be detected most easily by visual means. If a visual check of the unit does not indicate the cause of trouble, reinsert the unit in the oscilloscope and adjust the front-panel controls to see the effect of each. The normal or abnormal operation of each control will allow you to firmly establish the trouble symptoms in your mind. Once the symptoms are clearly established, the faulty circuit can usually be detected without much difficulty.

To isolate the trouble to a circuit, first look for the obvious indications. Check to see that the trace is on the screen of the oscilloscope, feel for any irregularities in the operation of controls, listen for the sound of the mercury switch in operation, and check to see that the tubes are heating. The type of trouble will generally indicate the checks to make.

No Trace on the Screen of the Oscilloscope

If there is no trace on the oscilloscope, this indicates a trouble which can be caused either by a lack of triggering signals to the oscilloscope or by deflection of the trace off the screen. Check the vertical beam position indicators of the oscilloscope while operating the VERTICAL POSITION Control. If the beam can not be positioned on the screen, as indicated by the beam position indicators, the trouble is probably in the vertical preamplifier of the plug-in unit.

If you suspect that triggering signals are not being applied to the oscilloscope, adjust the oscilloscope for internal triggers. If the oscilloscope then triggers properly, connect the triggering cable to the input of a test oscilloscope and check for the triggering signals. If no triggering signals are present, listen for the buzzing sound produced by the operation of the mercury switch. If the mercury switch is operating, check the pulse divider network by observing the voltage waveforms at various points in the divider on a test oscilloscope. If the proper waveforms are present, then the trouble is probably in the trigger amplifier, Q5904. If the mercury switch does not operate, refer to the information contained under "Mercury Switch Not Operating".

When the beam cannot be positioned on the screen of the oscilloscope, place the SENSITIVITY Switch at ZERO REFERENCE and check again to see whether the VERTICAL POSITION or VERT. POS. RANGE Controls will bring the beam onto the screen. If the beam still cannot be positioned onto the screen, or if there is an abnormal positioning range, the vertical preamplifier is unbalanced. Since this type of trouble is most often caused by tubes, check the preamplifier tubes by substitution. Then, if necessary, determine which stage is producing the unbalance by using a short wire jumper to short between corresponding points on opposite sides of the preamplifier. Center the VERTICAL POSITION and VERT. POS. RANGE Controls. Start at the output of the preamplifier and short between first the cathodes and then the grids of V6943A and V6943B. Then proceed backwards through the remainder of the preamplifier shorting corresponding points in succession. As each point is shorted, the trace should return to the screen. When a point in the circuit is reached where the trace does not return to the screen, the stage immediately following that point is unbalanced. Leave the jumper connected, and connect a voltmeter at the output of the unbalanced stage. Measure the amount of unbalance. If the unbalance is slight, (a few tenths of a volt) this stage is probably not causing the trace to be off the screen. Proceed then until the defective stage is found. Use voltage and resistance measurements to locate the defective part or parts in the stage.

No Pulse Displayed on the Oscilloscope

If no pulses are displayed on the oscilloscope, listen for the buzzing of the mercury switch. If the mercury switch is not operating, refer to the information under "Mercury Switch Not Operating". If the switch is buzzing, check all tubes by substitution. Then if necessary, use a test oscilloscope to check the waveform at the grid of V5934A (pin 7). The voltage at the grid of V5934A should change between approximately —42 and —60 volts in all positions of the DIODE MODE Switch. If the voltage is not normal, check the pulse divider network.

If the voltage range at the grid of V5934A is normal, check the waveform across the 100-ohm test resistor. The amplitude of this waveform should vary as the FORWARD CURRENT and DIODE MODE Switches are rotated. If no waveform is present across the 100-ohm test resistor, check the grid voltage of V5934B and the cathode circuit of V5934. The voltage at the grid of V5934B should be approximately —51 volts.

If a normal waveform appears across the 100-ohm test resistor, use the test oscilloscope to trace the signal stage-by-stage through the vertical preamplifier. When the defective stage has been determined, use voltage and resistance measurements to find the exact cause of the trouble.

Mercury Switch Not Operating

A lack of buzzing sound from the Type S Unit indicates that the mercury switch is not operating. To determine the cause of this trouble, first use a test oscilloscope to observe the waveform at the collectors of Q5945 and Q5955. A normal waveform here indicates that the switching multivibrator is operating. If there is no waveform at these points the multivibrator is not operating.

The switching multivibrator obtains its power from the series filament string. Consequently, if the filament of one of the tubes is open, no power is applied to the multivibrator and the circuit cannot operate. Therefore, if the multivibrator is not operating, first check tubes for an open filament.

If the filaments of all the tubes are normal and the multivibrator still does not operate, check the voltage at the emitters of Q5945 and Q5955. Then, if necessary, check the windings of T5955. Finally, try replacing Q5945 and Q5955.

If the multivibrator operates but the mercury switch does not run, rotate the FREQ. ADJ. Control to the lowest frequency setting to see if the switch will operate correctly at this frequency. If it does not, the probable trouble is a misadjustment of the bias magnet. The correct procedure for adjusting the bias magnet is given in the Calibration Procedure Section of this manual.

Pulse Distortion

If pulse distortion occurs, first check all tubes by substitution. If the tubes are not at fault, then determine whether the distortion occurs in the pulse applied to the current switching tube, the pulse applied to the vertical preamplifier, or is introduced in the vertical preamplifier. This can be determined by using a wide-band test oscilloscope to observe the pulse at various points in the unit. The first place to check is at the grid of V5934A. If the pulse appears to be distorted at this point, the distortion is probably due to improper compensation of the pulse divider network or to a defective mercury switch. Repeat the compensation adjustments outlined in the Calibration Procedure Section. This should eliminate any distortion, but if it doesn't, it may be necessary to replace the mercury switch.

If the waveform at the grid of V5934A appears normal, check the waveform across the 100-ohm test resistor with the test oscilloscope. If this waveform is distorted, recheck the setting of C5923. If necessary, also check T5936.

If the distortion is introduced in the vertical preamplifier, check to see if the distortion occurs in both the 0.5 V/CM and .05 V/CM positions of the SENSITIVITY Switch. If the trouble only occurs in the 0.5 V/CM position, check the setting of C5972. Troubles occuring in both positions of the SENSITIVITY Switch can be isolated to a stage in the preamplifier by using a test oscilloscope to trace the signal through the preamplifier. When the defective stage has been found, use voltage and resistance measurements to determine the exact cause of the trouble.

Incorrect Forward or Reverse Currents

This trouble will not be apparent from normal operation of the Type S Unit. It will be necessary for you to specifically check for any improper currents. To make this check, remove the 100-ohm test resistor and V5934 and set the DIODE MODE Switch at .1. Set the SENSITIVITY Control to 0.5 V/CM and connect 1 volt of signal from the calibrator of the oscilloscope to the upper terminal of the test diode connector. Adjust the oscilloscope for internal triggering, and set the GAIN ADJUST Control for exactly 2 centimeters of vertical deflection on the oscilloscope. This correctly sets the gain of the preamplifier. Reduce the calibrator signal to .1 volt, set the SENSITIVITY Control at .05 V/CM, and again check for exactly 2 centimeters of vertical deflection on the oscilloscope. If the deflection is not correct, check R5971 and R5972. Disconnect the calibrator signal.

Next, replace the 100-ohm test resistor and V5934. Adjust for external triggering and set the DIODE MODE Switch at TURN ON. Check each setting of the FORWARD CURRENT Switch and the resulting vertical deflection against the values in Table 5-1.

TABLE 5-1

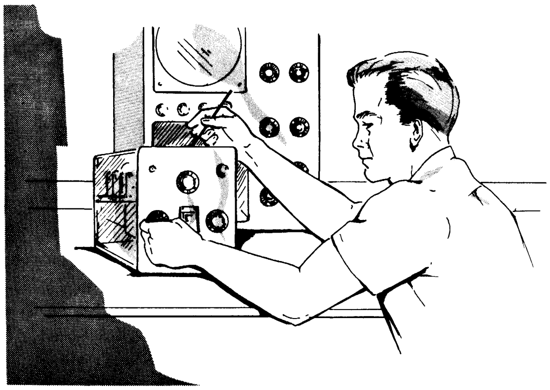
Forward Current Checks		
FORWARD CURRENT	SENSITIVITY	Deflection
20 mAMPS	0.5 V/CM	4 cm.
10 mAMPS	0.5 V/CM	2 cm.
5 mAMPS	0.5 V/CM	1 cm.
2 mAMPS	.05 V/CM	4 cm.
1 mAMPS	.05 V/CM	2 cm.

Set the FORWARD CURRENT Switch at 1, the DIODE MODE Switch at 0, and the SENSITIVITY Switch at ZERO REFERENCE. Using the VERTICAL POSITION Control, set the trace at the bottom line of the graticule (bottom of the usable area of the screen.) Now set the SENSITIVITY Switch at .05 V/CM and check each setting of the DIODE MODE Switch and the resulting vertical deflection against the values in Table 5-2.

Any deviations from the deflections shown in Tables 5-1 and 5-2 indicate an incorrect forward or reverse current. If an incorrect current is obtained, check the cathode and plate resistors of V5934.

TABLE 5-2

Reverse Current Checks		
DIODE MODE	SENSITIVITY	Deflection Above Bottom Graticule Line
0 mAMPS	.05 V/CM	0 cm
.1 mAMPS	.05 V/CM	0.2 cm
.2 mAMPS	.05 V/CM	0.4 cm
.5 mAMPS	.05 V/CM	1 cm
1 mAMPS	.05 V/CM	2 cm
2 mAMPS	.05 V/CM	4 cm



SECTION 6

CALIBRATION PROCEDURE

General Information

Normally, it will not be necessary to make all of the adjustments given in these instructions at any one time. Adjustments in the field will consist of merely touching up some of the adjustments, all of which are accessible when the unit is partially extended out of the oscilloscope by means of plug-in extension.

The calibration steps are arranged in proper sequence for a complete calibration of the instrument. Most of the numbered steps contain information required to make one check or one adjustment. The steps are arranged so that unnecessary repetition of certain checks is avoided.

In each calibration step only the required information is given. Detailed instructions pertaining to the normal operation of the instrument are not included. If you are in doubt as to the proper operation of the front-panel controls, refer to the Operating Instructions.

Controls not mentioned in a particular calibration step are assumed to be in the positions they were in during the previous step. The test resistor used in step 2 remains connected in the diode holder until the last step has been completed.

If a single control requires adjustment, it can be adjusted as described in the applicable step of this procedure without performing additional steps. It may be necessary, however, for you to refer to the preceding steps to determine the proper settings for the controls not mentioned in that step.

EQUIPMENT REQUIRED

The following equipment, or its equivalent, is necessary to completely calibrate the Type S Plug-In Unit.

(1) Test oscilloscope, Tektronix Type 541A or equivalent having the following specifications: Main vertical amplifier risetime—10 nsec; calibrated sweep rates—1 millisec/cm to 0.02 μsec/cm.

In this calibration procedure, the Type S Unit is assumed to be installed in a Type 541A Oscilloscope. If you are using an equivalent oscilloscope, adapt the control settings used here to suit the settings for corresponding controls on your instrument.

(2) Tektronix Type EP54 Plug-In Extension (Tektronix part number 013-019).

(3) Test resistor—100 ohms, 1%, low capacitance and inductance; e.g., deposited-carbon type.

(4) Tools:

3" screwdriver.

6" plastic dowel, 3/16" diameter, wedge tip.

Low-capacitance, insulated screwdriver (Tektronix part number 003-000; refer to the Accessories Section) or equivalent.

ADJUSTMENT PROCEDURE

Remove the left panel and bottom panel from the oscilloscope. Leave the oscilloscope in the upright position. Insert the Type EP54 Plug-In Extension between the Type S Unit and the oscilloscope plug-in connector. Connect the +TRIGGER OUT cable to the oscilloscope TRIGGER INPUT connector. Turn on the power and wait about five minutes for the initial warmup drift to cease.

1. Vertical Position Range Adjustment

Need for adjustment of the VERT. POS. RANGE Control (R5991) is indicated if the trace is not centered on the graticule when the VERTICAL POSITION Control is at midrange.

To make this adjustment, and to prepare the Type S Unit for the succeeding calibration steps, preset the oscilloscope and plug-in front-panel as follows:

Type 541A:

STABILITY	Fully clockwise
TRIGGERING LEVEL	centered
TRIGGERING MODE	AC
TRIGGER SLOPE	+EXT
TIME/CM	1 MILLISEC
VARIABLE (TIME/CM)	CALIBRATED
HORIZONTAL DISPLAY	NORM.
HORIZONTAL POSITIONING	centered

Type S:

FORWARD CURRENT	10
VERTICAL POSITION	centered
SENSITIVITY	ZERO REFERENCE
DIODE MODE	TURN ON

Next, adjust the VERT. POS. RANGE Control (see Fig. 6-1) so that the trace is positioned behind the horizontal centerline of the graticule.

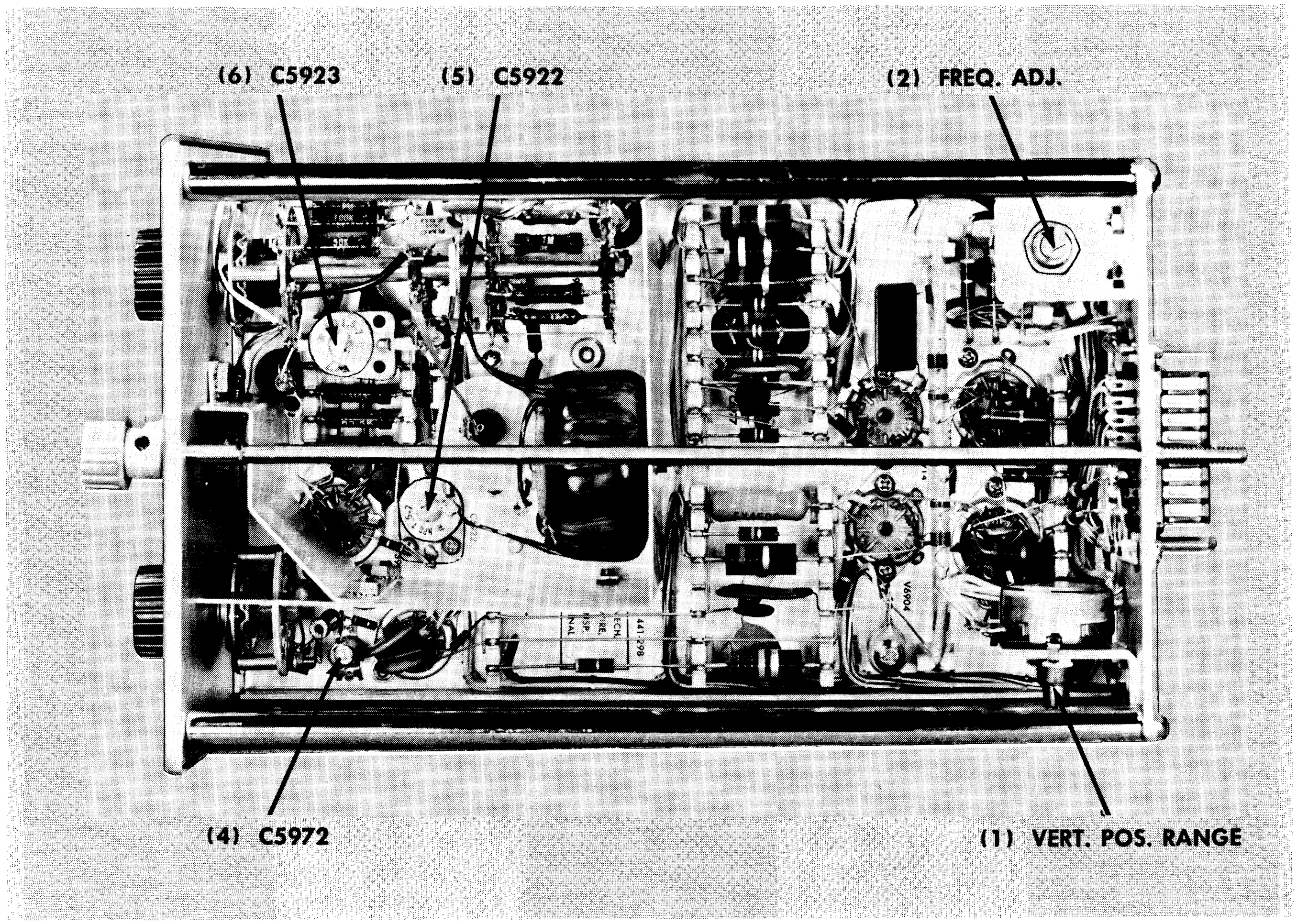


Fig. 6-1. Bottom view of the plug-in unit showing the location of the internal adjustments. Numbers in parenthesis refer to the calibration step number.

2. Mercury Switch Magnet Positioning

The magnet, in conjunction with the switching multivibrator, controls the movement of the mercury switch reed. The two-part procedure that follows describes a method for positioning the magnet and adjusting the multivibrator frequency when all circuits are operating normally.

(a) Preliminary Positioning

Insert the 100-ohm test resistor into the diode holder. Pull the oscilloscope forward until it extends about two inches past the edge of the workbench. Place the SENSITIVITY Switch at 0.5 V/CM. Place the oscilloscope STABILITY Control at PRESET and rotate the TRIGGERING LEVEL Control for stable triggering of the sweep. Square waves, similar to those shown in Fig. 6-2 (a), should be displayed if the reed is vibrating and if an output signal is being produced. The reed should vibrate easily, and square waves should be produced even though the magnet may not be in a location for best mercury switch operation. If the magnet is close to its best location, the square waves will be nearly symmetrical. Ignore the horizontal jittering caused by changes in reed phasing.

WARNING

—150 volts is present at the contact terminals of the FORWARD CURRENT Switch and at the top of capacitor C5943. Stay clear of this potential when positioning the magnet.

To position the magnet loosen the magnet mounting screws (see Fig. 6-3). Then carefully move the magnet closer to or away from the mercury switch, at the same time shifting the magnet from side to side. The magnet should be positioned to a place where the reed vibrates freely. While the reed is vibrating freely, move the magnet around in this vicinity until the reed produces a loud, steady buzzing sound. Observe the waveform on the screen to determine whether or not nearly symmetrical square waves are being displayed, as mentioned earlier in this step. Adjust the oscilloscope TRIGGERING LEVEL Control, if necessary, so that the waveform begins at the start of a negative-going pulse. To make a complete check on the operation of the mercury switch and the position of the magnet, proceed to part (b).

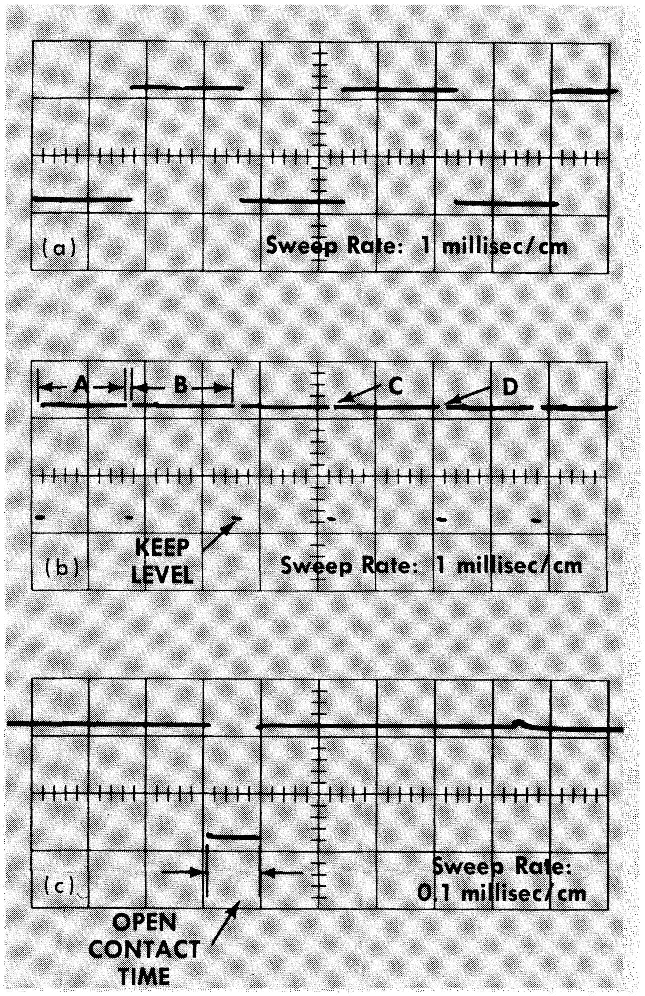


Fig. 6-2. Output waveform (a) obtained when the DIODE MODE switch is set to TURN ON. Typical output waveforms (b) and (c) obtained when the DIODE MODE switch is placed at the 0 position.

(b) Final Positioning and Frequency Adjustment

Place the DIODE MODE Switch at the 0 position. Closely-spaced positive pulses should be displayed at twice the repetition rate obtained in part (a). The positive pulse dimensions [A and B, shown in Fig. 6-2 (b)] do not have to be equal. The narrow space between positive pulses indicates the time that the contacts are open. The magnet should be positioned to cause the negative portion of the displayed waveform to be level, while at the same time causing the time between positive pulses [C and D, shown in Fig. 6-2 (b)] to be approximately the same. Do not try to eliminate all the horizontal jittering from the waveform. The jittering can be reduced to a certain extent if you rotate the FREQ. ADJ. Control (R6977) slowly clockwise or counterclockwise a few degrees while watching for more stable operation. By reducing the jitter, you can more easily check the waveform. When you check the waveform, keep in mind that the level of the negative portion of the waveform is also affected by the adjustment of C5972 (step 4). If C5972 is not correctly adjusted, you will notice the presence of either a rolloff or an overshoot at the leading corners. Since either aberration, if present, will be corrected later on, ignore it for the present.

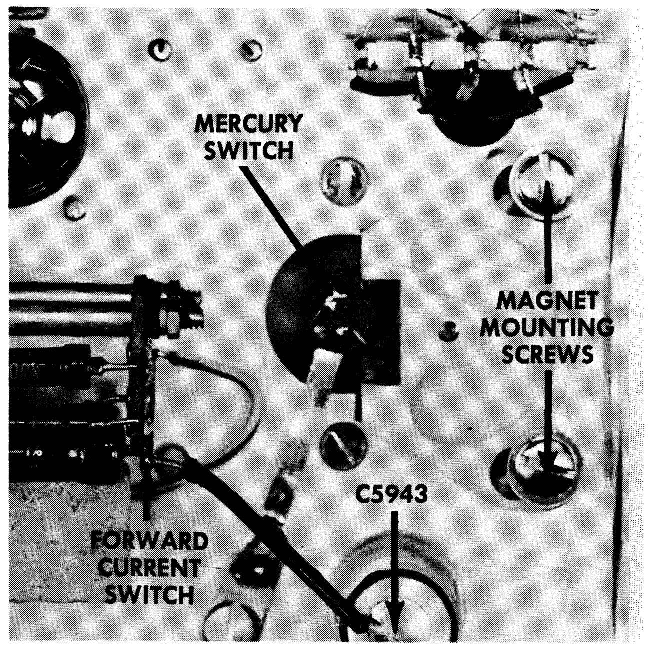


Fig. 6-3. Partial top view of the plug-in unit showing the location of magnet mounting screws and the mercury switch.

The amount of time that the contacts are open varies with different mercury switches. The open time may be anywhere from 25 to 200 microseconds. The time interval to be obtained must be longer than the turn-on time required for the diodes you are testing. To measure the time interval, set the oscilloscope TIME/CM Switch to .5 MILLISEC and the HORIZONTAL DISPLAY Switch to 5X MAG. Horizontally position each negative portion of the waveform onto the screen and measure the time interval [see Fig. 6-2 (c)]. While you are making the measurements, a closer examination of the negative portion of the waveform can be made to see that it is level.

After completing this step, push the oscilloscope back so that only the plug-in itself extends over the edge of the workbench about five inches.

3. Gain Adjustment

The gain adjustment should be checked periodically because aging of the tubes will affect the gain of the plug-in unit.

To check the gain or to adjust the GAIN ADJUST Control (R6907) for the correct amount of vertical deflection, set the oscilloscope TIME/CM Switch to 1 MILLISEC and the HORIZONTAL DISPLAY Switch to NORM. Set the FORWARD CURRENT Switch to 20. Place the DIODE MODE Switch to the TURN ON position. Adjust the GAIN ADJUST Control (located on the front panel) for exactly four centimeters of vertical deflection.

4. Attenuator Frequency Compensation

The adjustment procedure that follows describes a method for adjusting the 10X attenuator at the input of the preamplifier. This adjustment is made to insure optimum square-wave response when the signal passes through the attenuator network.

To make the adjustment, place the FORWARD CURRENT Switch at 10. Adjust C5972 (see Fig. 6-1) for a square corner with minimum rolloff or overshoot (use the plastic dowel).

5. Pulse Divider Network Compensation

This adjustment is made to compensate the divider network connected between the output of the mercury switch and the input of V5934.

Set the oscilloscope TIME/CM Switch to .5 μSEC. Adjust the TRIGGER LEVEL Control for a stable presentation of the negative-going portion of the switching waveform. Adjust C5922 (see Fig. 6-1) so that the lower portion of the switching waveform becomes level. Overlook minor aberrations, if they appear, because these will be compensated for in the next step.

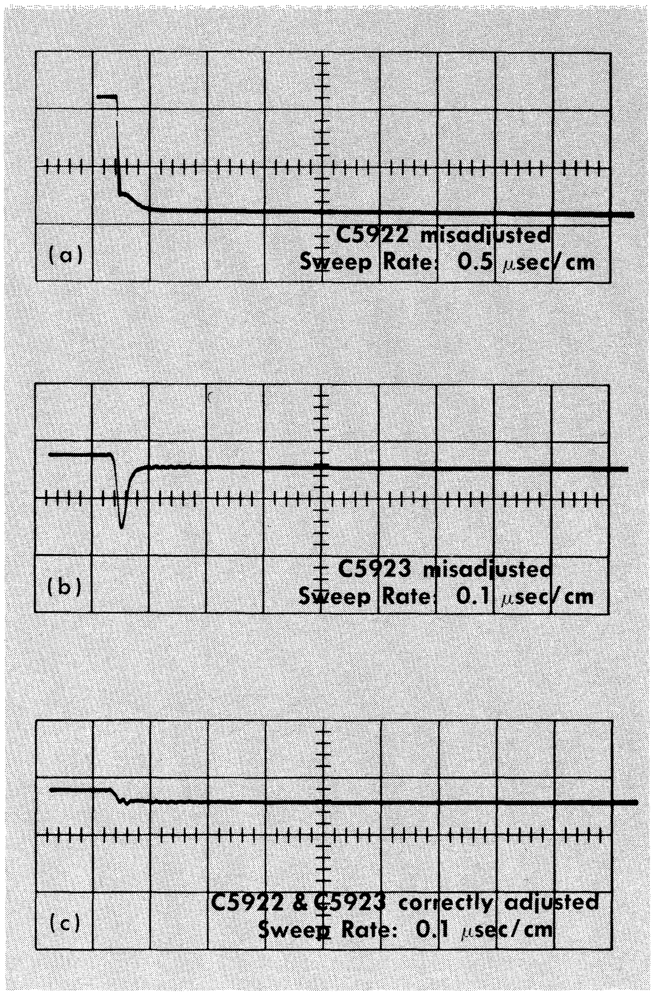


Fig. 6-4. Output waveforms displayed on a 540-Series Oscilloscope. Waveform (a) and (b) are typical of what you may expect when C5922 and C5923 are misadjusted. Waveform (c) is a display obtained from a properly adjusted plug-in unit.

6. Switching-Tube Cathode Compensation

The purpose of this adjustment is to improve the transient response of the switching circuit.

Place the oscilloscope TIME/CM Switch at the .1 μSEC position. Set the FORWARD CURRENT Switch to 1. Adjust C5923 (see Fig. 6-1) for a square corner at the lower leading edge of the waveform. Place the SENSITIVITY Switch at the .05 V/CM position to check the appearance of the waveform. An aberration of 3 or 4 minor divisions is permissible. The tip of the aberration should be even with the bottom level of the waveform. If it is not, readjust C5923 slightly to move the tip to the proper level. Repeat steps 5 and 6 because the adjustments in these steps interact with each other. Typical output waveforms to be expected when you adjust C5922 and C5923 (with the SENSITIVITY Switch at the 0.5 V/CM position) are shown in Fig. 6-4.

7. Risetime Measurements

The overall performance of the Type S Plug-In Unit and a Type 540-Series Oscilloscope combined is based on risetime measurements. Two risetime checks are made—one when the DIODE MODE Switch is at TURN ON, and the other when the Switch is at 0.

(a) To make the first risetime check, place the oscilloscope HORIZONTAL DISPLAY Switch at 5X MAG. Set the FORWARD CURRENT Switch to 10 and place the SENSITIVITY Switch at the 0.5 V/CM position. Adjust the oscilloscope TRIGGERING LEVEL Control for maximum delay time of the negative-going pulse and yet obtain a stable display. That is, the waveform should shift to the right as far as possible with the sweep starting at the first graticule line. The risetime of the pulse should be approximately .012 microseconds (12 nsec). (Risetime is defined as the time it takes the pulse to rise from 10% to 90% of its maximum amplitude.) The time can be checked by using the graticule lines to measure the distance. To do this, rotate the HORIZONTAL POSITION and the VERTICAL POSITION Controls to position the display where the center vertical graticule line passes through the 10% amplitude portion of the waveform as shown in Fig. 6-5. Measure the horizontal distance between the 10% and 90% points as illustrated. The product of the distance measured and the sweep rate (.02 μsec/cm or 20 nsec/cm) is the actual risetime.

(b) To make the second risetime measurement, place the DIODE MODE switch to the 0 position. Measure the risetime of the positive pulse in the same manner as described for measuring the negative-going pulse. The time measurement should be about the same (12 nsec).

Remove the plug-in extension and insert the Type S Unit directly into the oscilloscope vertical amplifier compartment. Remove the test resistor from the diode holder. Attach the bottom and side panels on the oscilloscope.

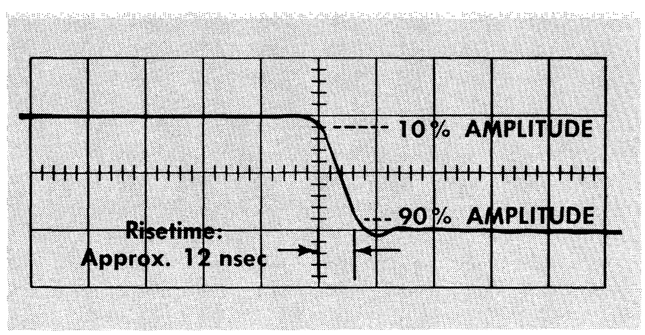
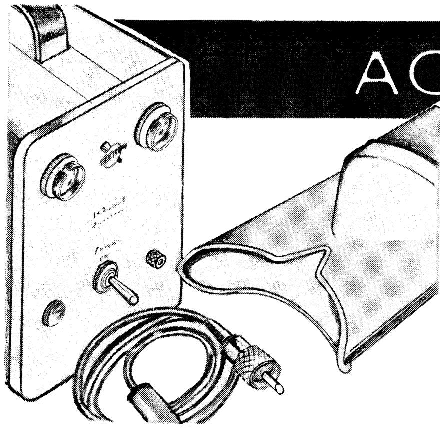
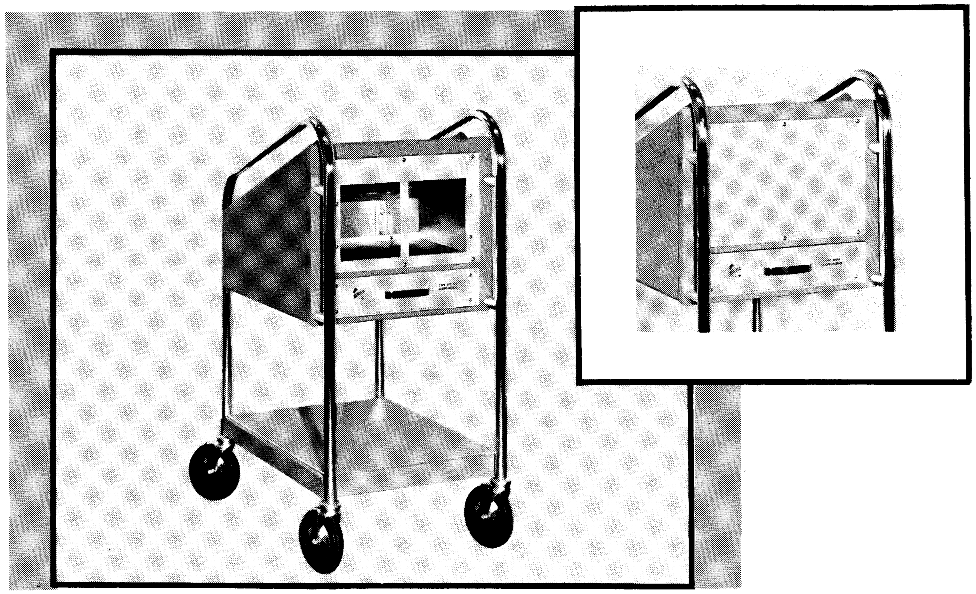


Fig. 6-5. Risetime measurement of a negative-going pulse at a sweep rate of .02 μsec/cm (20 nsec/cm). The DIODE MODE switch is set at the TURN ON position.

ACCESSORIES SECTION





SCOPE - MOBILES

The Tektronix Type 500/53A Scope-Mobile is a sturdy, mobile support for Tektronix 5" Oscilloscopes. Convenient observation of the crt face is achieved by a 20-degree backward tilt of the top surface. The front panel has two supporting cradles to accommodate plug-in units. A drawer, felt-lined and operating on rollor bearings, provides handy storage for probes, cables, manuals, etc. An open shelf, topped with tough linoleum, is located at the bottom. Power input and three convenience outlets are mounted at the rear.

The Type 500/53A Scope-Mobile weighs 35 pounds. The outside dimensions are 18½" wide, 39" high and 30" deep.
Type 500/53A $110.00

Type 53A Scope-Mobile Panel. For Type 500A Scope-Mobiles. Converts the Type 500A to a Type 500/53A by replacing the standard blank panel.
Part No. 014-005 .... $10.50

Scope-Mobile Wheel Locks. The Type 500/53A Scope-Mobile may be ordered with two wheel locks by specifying Mod. 741A. The additional cost for this is $15.00. Four wheel locks may be ordered for the Scope-Mobiles by specifying Mod. 741B. The additional charge for this is $30.00.

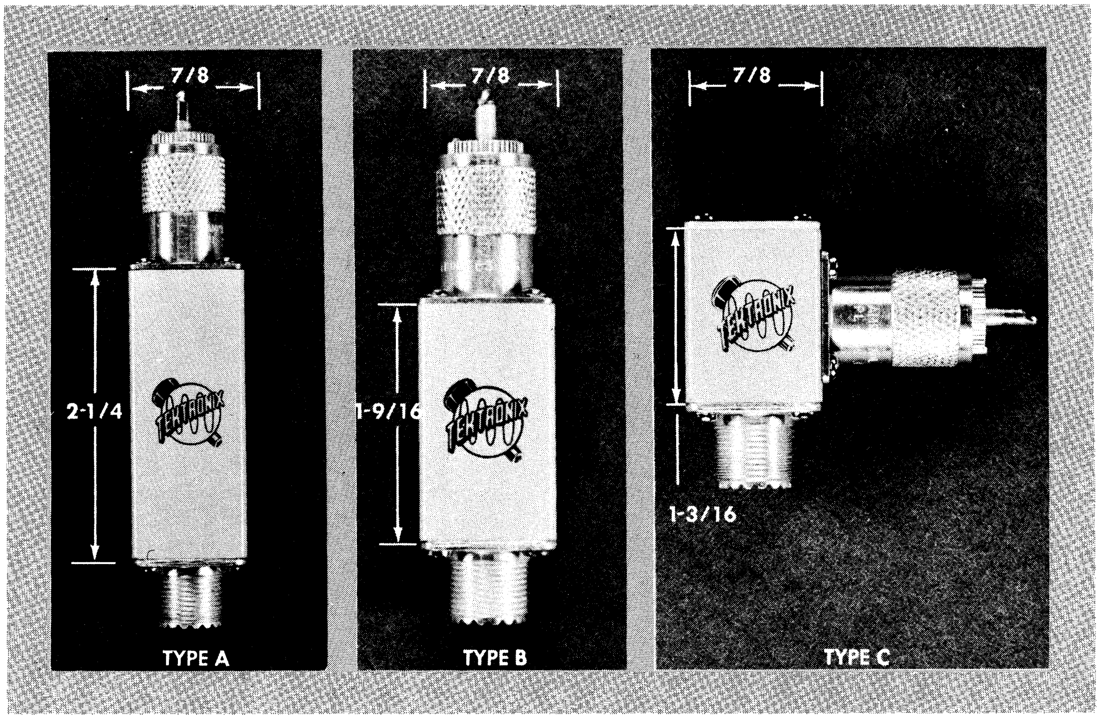
Scope-Mobile Fan Kit. For forced-air ventilation of the equipment compartment of the Type 500A Scope-Mobile. Contains motor, 5"-blade, filter, and mounting hardware.
Part No. 040-161 .... $15.00

Scope-Mobile three-wire power receptacle. Installation of this kit allows a three-wire receptable assembly to be added to the 500 or 500/53 scope-mobile.
Part No. 040-186 .... $8.50

The Tektronix Type 500A Scope-Mobile is identical to the Type 500/53A, except for the front panel. Auxiliary equipment can be mounted behind the blank front panel, but it will usually be necessary to provide forced-air ventilation for the equipment compartment. A fan kit, 040-161, is recommended for this purpose.
Type 500A $100.00

2

CABLE TERMINATORS



Type B52-R 52-ohm terminating resistor, 1.5 w, Type A case.
Part No. 011-001 .... $8.50

Type B52-L5 52-ohm 'L' pad, 5 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-002 .... $8.50

Type B52-L10 52-ohm 'L' pad, 10 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-003 .... $8.50

Type B52-75L Minimum-loss pad, 52 ohms to 75 ohms, Type A case.
Part No. 011-004 .... $11.50

Type B52-170L Minimum-loss pad, 52 ohms to 170 ohms, Type A case.
Part No. 011-005 .... $11.50

Type B52-T10 52-ohm 'T' pad, 10 to 1 voltage ratio, 1.5 w, Type B case.
Part No. 011-006 .... $11.50

Type B75-R 75-ohm terminating resistor, 1.5 w, Type A case.
Part No. 011-007 .... $8.50

Type B75-L5 75-ohm 'L' pad, 50 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-008 .... $8.50

Type B75-L10 75-ohm 'L' pad, 10 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-009 .... $8.50

Type B75-T10 75-ohm 'T' pad, 10 to 1 voltage ratio, 1.5 w, Type B case.
Part No 011-011 .... $11.50

Type B93-R 93-ohm terminating resistor, 1.5 w, Type A case.
Part No. 011-011 .... $8.50

Type B93-L5 93-ohm 'L' pad, 5 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-012 .... $8.50

Type B93-L10 93-ohm 'L' pad, 10 to 1 voltage ratio, 1.5 w, Type A case.
Part No. 011-013 .... $8.50

Type B93-52L Minimum-loss pad, 93-ohms to 52 ohms, 1.5 w, Type A case.
Part No. 011-014 .... $11.50

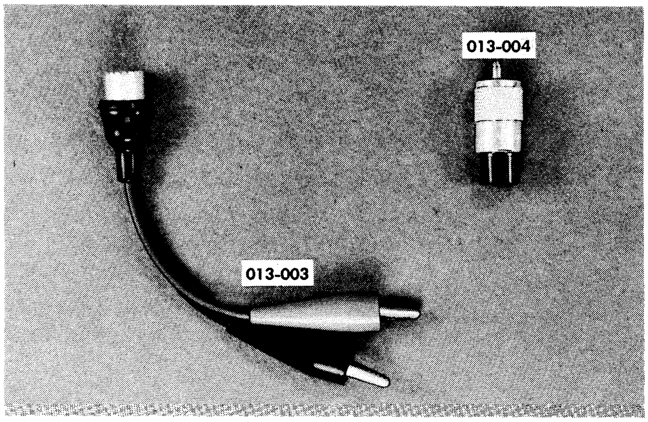
Type B93-T10 93-ohm 'T' pad, 10 to 1 voltage ratio, 1.5 w, Type B case.
Part No. 011-015 .... $11.50

Type B170-R 170-ohm terminating resistor, 1.5 w, Type C case.
Part No. 011-016 .... $8.50

Type B170-A 170-ohm pi-attenuator, using 2% precision resistors, 1 to 64 db in 1-db steps, 0.25 w, not shown in photograph.
Part No. 011-017 .... $45.00

Type B52-170T10, 52-ohm to 170-ohm 'T' pad, 10 to 1 voltage ratio. Type A case.
Part No. 011-026 .... $11.50

COAXIAL ADAPTERS

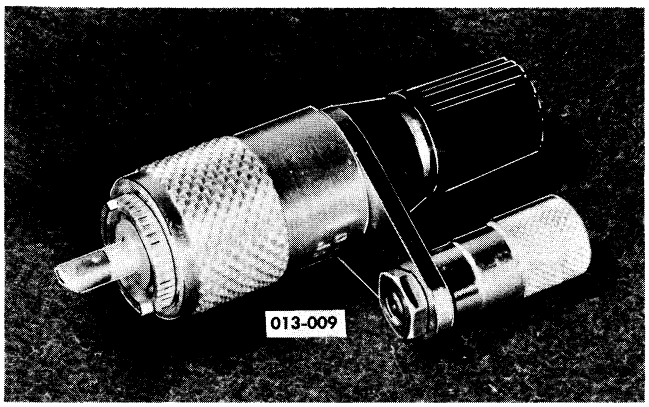


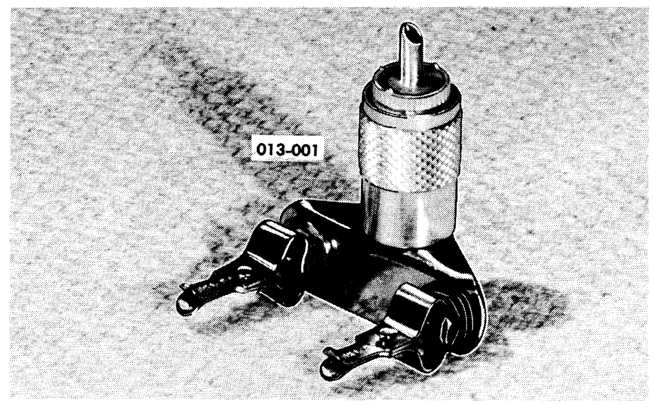
Type A100 Clip-Lead Adapter. Provides clip lead connections for a coaxial cable.
Part No. 013-003 .... $2.00

Type A510 Binding-Post Adapter. Provides permanent connection for a single wire to the center conductor of a coaxial connector.
Part No. 013-004 .... $2.00

Binding-Post Adapter. Similar to Type A510 binding post adapter, but includes ground terminal. 3/4" spacing between connector centers.
Part No. 013-009 .... $3.00

Type F30 Production Test Fixture. This fixture was designed for use with the Type 130 L, C Meter in production line sorting and testing. It may be used to terminate the output of any standard coaxial connector.
Part No. 013-001 .... $3.00





INTERCONNECTING LEADS

Type W130B Black, 30" flexible output lead with banana-type connector at one end and alligator clip at other.
Part No. 012-014 .... $1.00

Type W130R Same as Type W130B except colored red.
Part No. 012-015 .... $1.00

Type PC-6B Black, 6" flexible cord terminated in combination male and female banana-type connectors. The combination type connectors permit "stacking."
Part No. 012-023 .... $1.25

Type PC-6R Similar to Type PC-6B except colored red.
Part No. 012-024 .... $1.25

Type PC-18R Similar to Type PC-6B except 18"long and colored red.
Part No. 012-031 .... $1.50

Type W531B Black, 6" flexible cord terminated in male banana-type connectors.
Part No. 012-028 .... $1.00

Type W531R Similar to Type W531B except colored red.
Part No. 012-029 .... $1.00

Suppressor cord for Type 570. Similar to Type W531 cords but includes 100 Ω resistor.
Part No. 012-025 .... $1.50

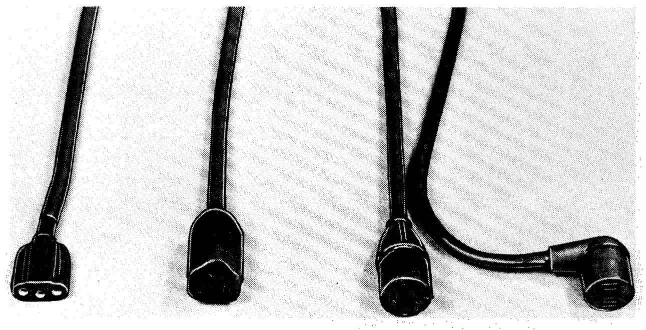
Suppressor cord for Type 570. Similar to type W531 cords except includes 300 Ω resistor.
Part No. 012-026 .... $1.50

Suppressor cord for Type 570. Similar to Type W531 cords except includes 1 k resistor.
Part No. 012-027 .... $1.50

Flexible plug-in extension, 30" for Tektronix Plug-In Preamplifiers.
Part No. 012-038 .... Price on request

4

POWER CORDS



TYPE A   TYPE B   TYPE C   TYPE D

2-conductor, 8′ rubber-covered power cord with Type C connector. No. 18 wire.
Part No. 161-001 .... $1.25

2-conductor 8′ rubber-covered power cord with no female connector. (For permanent connection to instrument).
Part No. 161-002 .... $1.10

2-conductor, 1′ rubber-covered power cord with Type C connector. No. 18 wire.
Part No. 161-003 .... $ .85

2-conductor, 8′ rubber-covered power cord with Type C connector. No. 16 wire.
Part No. 161-004 .... $1.75

3-conductor, 8′ rubber-covered power cord with Type A connector. No 16 wire.
Part No. 161-005 .... $2.00

3-conductor, 10′ rubber-covered power cord with no female connector. (For permanent connection to instrument). No. 16 wire.
Part No. 161-006 .... $3.00

2-conductor, 8′ rubber-covered power cord with Type D connector. No 18 wire.
Part No. 161-007 .... $1.25

3-conductor, 8′ rubber-covered power cord with Type B connector. No. 18 wire.
Part No. 161-008 .... $1.50

3-conductor, 8′ rubber-covered power cord with Type B connector. No. 18 wire.
Part No. 161-010 .... $1.75

3-conductor, 8′ rubber-covered power cord with Type B connector. No. 18 wire.
Part No. 161-011 .... $1.25

3-conductor, 8′ rubber-covered power cord with no female connector to instrument. No. 18 wire.
Part No. 161-012 .... $1.25

Power-cord adapter for connecting a 3-wire power cord to a 2-wire receptacle.
Part No. 103-013 .... $ .65

3-conductor, 20″ rubber-covered power cord.
Part No. 161-014 .... Price on request

COAXIAL CABLES

Type P75 Coaxial cable, 75 ohms nominal impedance, 42″ long.
Part No. 012-002 .... $4.00

Type P93 Coaxial cable, 93 ohms nominal impedance, 42″ long.
Part No. 012-003 .... $4.00

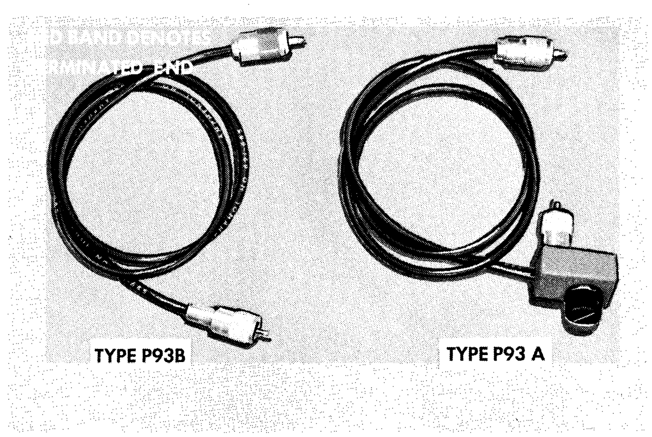
Type P93A Coaxial output cable, 93 ohms, terminated with variable attenuator, 42″ long. (See photo).
Part No. 012-004 .... $13.50

Type P93B Coaxial output cable, 93 ohms, terminated with ½-watt 93-ohm resistor, 42″ long. (See photo).
Part No. 012-005 .... $5.00

Type P170 Coaxial cable, 170 ohms nominal impedance, 42″ long.
Part No. 012-006 .... $9.50

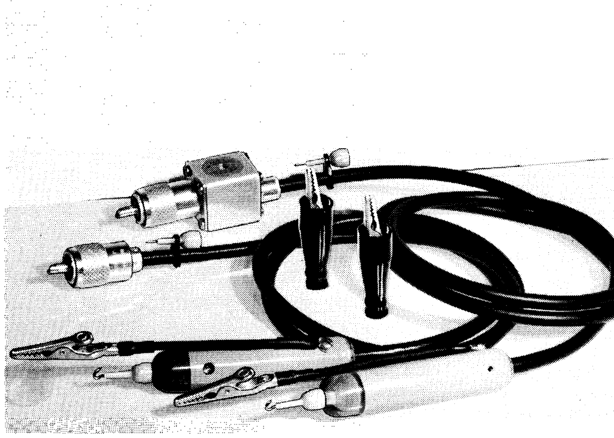
Coaxial cable, 170 ohms nominal impedance, 5′ long.
Part No. 012-034 .... $4.00

Type P52 Coaxial cable, 52 ohms nominal impedance, 42″ long.
Part No. 012-001 .... $4.00



Ⓐ

P400-SERIES PROBES



P400-Series Low-Capacitance Probes. This series of low-capacitance probes preserves the transient response of Tektronix fast-rise instruments. The P400-Series probes are free of overshoot and ringing and have relatively uniform high-frequency response. Input capacitance and insertion loss are affected by cable length. With cables up to 12′ in length, insertion loss is less than 3 db at 20 mc, and overshoot is less than 1%. With exception of the P450-L, these probes can be used on those instruments having input capacitances from 20 to 50 μμf.

General physical characteristics of the P400-Series probes are identical to the P510A probe. Color-coding of the plastic nose indicates attenuation ratio. Two interchangeable Tektips—a straight tip and a hooked tip—each adding less than 0.5 μμf to the input capacitance, and an alligator clip assembly are supplied with each probe.

PROBE	CABLE LENGTH	PART NO.	PRICE
P405 (green nose)	42″ 8′	010-006 010-013	$10.50 12.50
P410 (brown nose)	42″ 8′	010-007 010-014	10.50 12.50
P420 (red nose)	42″ 8′	010-008 010-015	10.50 12.50
P450 (clear nose, green inside)	42″ 8′	010-009 010-016	12.50 14.50
P450-L (clear nose, green inside)	42″ 8′	010-010 010-017	12.50 14.50
P4100 (clear nose)	42″ 8′	010-002 010-018	12.50 14.50

P400-SERIES PROBE SPECIFICATIONS

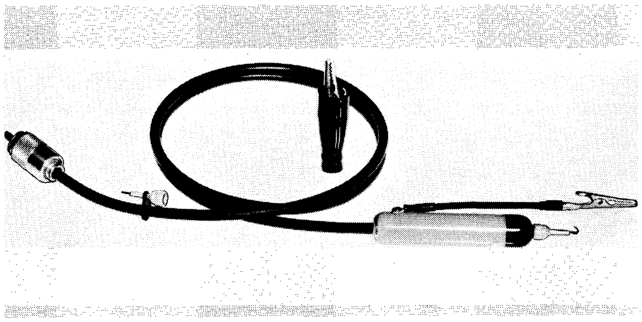
PROBE TYPE	ATTEN. RATIO	INPUT CHARACTERISTICS			DB Loss at 30 MC	Maximum Voltage Rating
		Resist. (Meg Ω)	Capacitance Minimum*	Capacitance Maximum †		
P405	5:1	5	12 μμf 21 μμf**	19 μμf 30 μμf**	1-2	600
P410	10:1	10	8 μμf 12 μμf**	11 μμf 15 μμf**	1	600
P420	20:1	10	5.5 μμf 8 μμf**	7 μμf 9 μμf	1	600
P450	50:1	10	3.5 μμf 4 μμf**	3.5 μμf 4 μμf**	1	1000
P450-L	50:1	10	2.5 μμf 3 μμf**		1	1000
P4100	100:1	10	2.5 μμf 3 μμf**	2.5 μμf 3 μμf**	1	1000

***When connected to instruments with 20-μμf input capacitance.**

† When connected to instruments with input capacitances up to 50 μμf.

****With 8-foot cable.**

P510A PROBES



P510A Attenuator Probe provides an attenuation of ten times when used with Tektronix oscilloscopes and amplifiers. The P510A is small and streamlined, and presents an input impedance of 10 megohms paralleled by 14 $\mu\mu$f. The probe is completely insulated—made of high-impact-strength fiber-glass-reinforced alkyd—and has an internal brass shield. Two interchangeable Tektips—a straight tip and a hooked tip—and an alligator clip assembly are furnished. Probe has a 42" cable with coaxial connector, and is rated at 600 v maximum.

Part No. 010-001 .... $8.50

P510A PROBES WITH LONG CABLES

P510A probe cables ring at a period that depends on the cable length and, to a lesser degree, on the input capacitance of the oscilloscope used. Each particular cable length will be satisfactory only when zero transmission of the oscilloscope does not extend to a frequency that includes the resonant frequency of the probe. This difficulty has been eliminated in the P400-Series Probes.

P510A with 6' cable, Part No. 010-004 .... $9.00

P510A with 8' cable, Part No. 010-005 .... $9.50

Prices for P510A Probes with other cable lengths available on request.

PROBE TIPS

Tek tip, Hook Shank, Part No. 206-008 .... $ .25

Tek tip, Straight Shank, Part No. 206-009 .... $ .25

Pin Jack Probe Tip, Bent Shank (fits 0.082" jacks)
Part No. 206-011 .... .25

Alligator Clip Assembly. Part No. 344-005 .... $ .40

CF PROBES

TYPE P170CF

The P170CF Cathode Follower Probe was developed for use with the Type 517 Oscilloscope. The cathode-follower is a 5718 triode with the 170-ohm termination of the pre-amplifier grid line in the Type 517 as a cathode load. Plate and heater voltages for this tube are provided at a four-terminal socket on the panel of the oscilloscope. The signal is attenuated by 2 times when using the P170CF. The input impedance of the probe will depend on the attenuator head being used, and because of the transit time in the cathode-follower, it will decrease appreciably at the higher frequencies. When the probe is used without on attenuator head, the input characteristic is 12 megohms shunted by 5 $\mu\mu$f. The probe cable is 42" long. Probe comes complete with 3 attenuator heads.

Part No. 010-101 .... $86.00

PAX-I Attenuator Head. Attenuation can be varied between 4 times and 40 times.

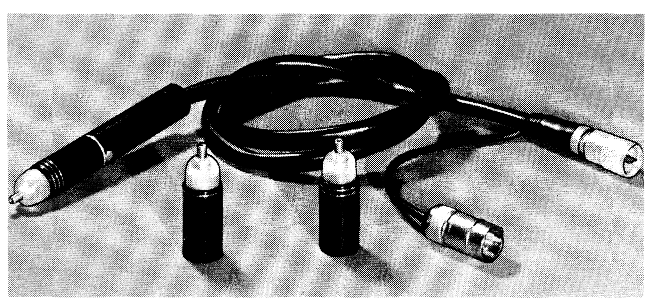
Part No. 010-301 .... $11.00

PAX-II Attenuator Head. Attenuation can be varied between 20 times and 200 times.

Part No. 010-302 .... $11.00

PAX-III Attenuator Head. Attenuation can be varied between 200 times and 2000 times.

Part No. 010-303 .... $11.00



CF PROBES

TYPE P500CF

Type P500CF Cathode-Follower Probe. For use with Type 524AD Oscilloscope. Presents low capacitance with minimum attenuation. Input characteristic is 40 megohms paralleled by 4 $\mu\mu$f. The gain is 0.8 to 0.85. Input to probe is ac-coupled, limiting its low-frequency response to 5 cycles. Amplitude distortion is less than 3% on unidirectional signals exceeding a few volts to minimize amplitude distortion. With the attenuator head attached, the probe input characteristic is approximately 10 megohms paralleled by 2 $\mu\mu$f. Probe output level is 11-v positive, making it necessary to use the AC-coupled position of the oscilloscope AC-DC switch. Probe cable is 42" long.

Part No. 010-105 .... $64.00

PROBE POWER SUPPLY

The Type 128 Probe Power Supply. The Type 128 supplies the necessary plate and filament voltages for one or two probes, making it possible to use the Type P500CF and Type P170CF cathode-follower probes with oscilloscopes not equipped with a probe-power outlet.

DC Output Voltages:

+120 v regulated, at 25 ma
+6.3 v unregulated, at 150 ma
+6.3 v unregulated, at 150 ma

When a P170CF probe is to be used with an instrument other than the Tektronix Type 517, a 170-ohm terminating resistor is required. The Type B170-R Terminating Resistor is recommended for this purpose.

Ripple—Ripple on the 120 v supply is not more than 5 mv peak-to-peak, and not more than 75 mv peak-to-peak on the 6.3 v supplies.

Power Requirements—105 to 125 v or 210 to 250 v, 50 to 60 cycles, 25 watts using two P500CF probes.

Dimensions—4¾" wide, 7¾" high, 9" overall depth.

Weight—6 lbs.

Part No. 015-006 .... $100.00

CATHODE-RAY-TUBES

The catalog description of each oscilloscope gives the kind of phosphor that is normally provided in the crt. In general, your oscilloscope can be provided, on order, with any commercially available phosphor.

Phosphors, other than those of short persistence may display an intitial fluorescence of one color, followed by a phosphorescence of the same or another color. The following table describes some of the phosphors we can provide in your crt. Other phosphors are available. We welcome your inquires.

PHOSPHOR CHARACTERISTICS

PHOSPHOR	FLOURESCENCE	PHOSPHORESCENCE	PERSISTENCE
P1	Green	Green	Medium
P2	Blue-green	Green	Long
P7*	Blue-white	Yellow	Long
P11	Blue		Short
P16	Violet and near ultra-violet		Extremely short
P24	Blue		Extremely short

***Double-layer type.**

CATHODE-RAY-TUBES

PRICE LIST

Types 515A and RM15.

5CBP1	154-125	$60.00
5CBP2	154-120	60.00
5CBP7	154-126	60.00
5CBP11	154-127	60.00
5CBP16	154-161	60.00
5CBP24	154-177	60.00

Type 536.

T536P1	154-140	$60.00
T536P2	154-133	60.00
T536P7	154-135	60.00
T536P11	154-136	60.00
T536P16	154-169	60.00

Type 551.

T551P1	154-186	$150.00
T551P2	154-160	150.00
T551P7	154-189	150.00
T551P11	154-143	150.00

Type 502.

T502P1	154-172	$150.00
T502P2	154-144	150.00
T502P7	154-170	150.00
T502P11	154-173	150.00

Type 524AD.

5ABP1	154-068	$31.00
5ABP7	154-069	35.00
5ABP11	154-070	35.25

Types 581 and 585.

T581P1	154-228	Price on request
T581P2	164-224	Price on request
T581P7	154-229	Price on request
T581P11	154-230	Price on request

Types 531A, RM31A, 533, RM33, 535A and RM35A.

T533P1	154-178	$90.00
T533P2	154-165	90.00
T533P7	154-179	90.00
T533P11	154-180	90.00

Types 525, 532, RM32, 570 and 575.

5CAP1	154-093	$50.00
5CAP2	154-097	50.00
5CAP7	154-102	50.00
5CAP11	154-103	50.00
5CAP16	154-162	50.00

Type 517A.

T517P1H	154-107	$110.00
T517P2H	154-109	110.00
T517P7H	154-108	110.00
T517P11H	154-105	110.00
T517P16H	154-128	110.00

Types 541, RM41A, 543, RM43, 545 and RM45A.

T543P1	154-181	$110.00
T543P2	154-175	110.00
T543P7	154-182	110.00
T543P11	154-183	110.00

Type 555.

T555P1	154-219	Price on request
T555P2	154-199	Price on request
T555P7	154-220	Price on request
T555P11	154-221	Price on request

GRATICULES

Type 532 graticule. Centimeter ruling, 8 cm vertically, 10 cm horizontally.

Part No. 331-026 .... $1.50

Types 507, 531, 531A, 535 and 535A graticule. Centimeter ruling, 6 cm vertically, 10 cm horizontally.

Part No. 331-016 .... 1.50

Types 541, 541A, 543, 545 , 545A, 581 and 585 graticule. Centimeter ruling, 4 cm verically, 10 horizontally.

Part No. 331-034 .... 1.50

Types 536, 570 and 575 graticule. Division ruling, 10 divisions vertically, 10 horizontally.

Part No. 331-028 .... 1.50

Types 551 and 555 graticule. Centimeter ruling, 6 cm vertically, 10 cm horizontally.

Part No. 331-045 .... 1.50

CATHODE-RAY TUBE LIGHT FILTERS

Types 502, 507, 525AD, 531, 531A, 532, 535, 535A, 536, 570 and 575.

Amber. Part No. 378-501 .... .90

Yellow. Part No. 378-502 .... .90

Green. Part No. 378-503 .... .90

Blue. Part No. 378-504 .... .90

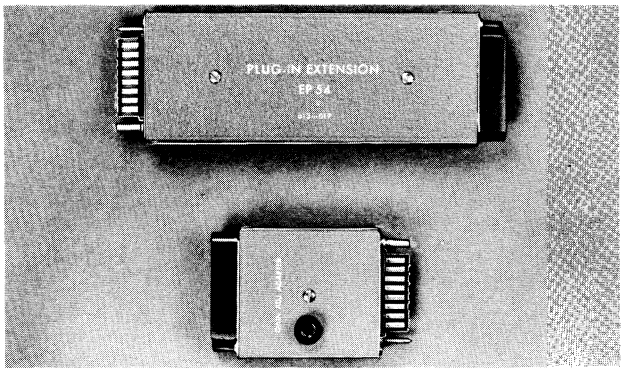
Types 515A, 517A, 533, 541; 541A, 543, 545, 545A, 551, 555, 581 and 585.

Green. Part No. 378-514 .... .90

Blue. Part No. 378-515 .... .90

Amber. Part No. 378-516 .... .90

AUXILIARY DEVICES



TYPE EP54 PLUG-IN EXTENSION

Permits the operation of the plug-in unit partially extended out of its housing in a 530-, 540-, or 550-Series Oscolloscope.

Part No. 013-002 .... $5.00

TYPE EP53A GAIN ADJ. ADAPTER

Permits the introduction of an external calibrating signal directly to the oscilloscope vertical amplifier input, by-passing the plug-in preamplifier. Useful for adjusting oscilloscope vertical amplifier gain in 530-, 540-, and 550-Series Oscilloscopes.

Part No. 013-005 .... $5.00

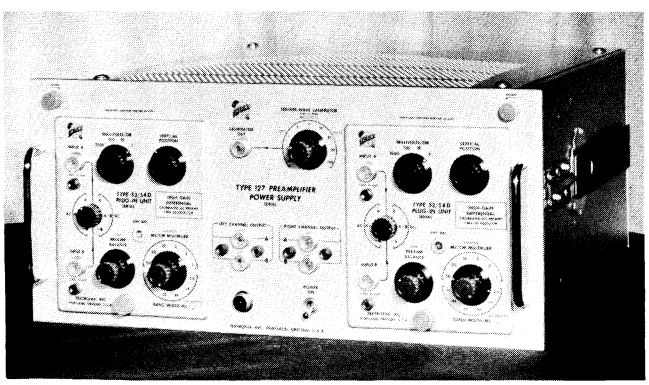
AIR FILTERS

Type 530-, 540-, 550-, and 580- Series Instruments. Disposable 10 x 10 x ¾ spun -glass filter with back-up screens.

Part No. 378-009 .... $1.75

Type 530- 540-, 550- and 580- Series Instruments. Disposable 10 x 10 x ¾ spun-glass filter.

Part No. 378-012 .... $1.00



PLUG-IN POWER SUPPLY

The Tektronix Type 127 Preamplifier Power Supply supplies proper operating power to one or two Tektronix plug-in preamplifiers. Any plug-in units powered by the Type 127, can be used to further increase the signal-handling versatility of Tektronix oscilloscopes employing plug-in preamplifiers. Double-differential dual-trace display may be obtained by employing 2 Type D, E, or G Differential Plug-In Preamplifier Units, in the Type 127 in conjunction with an oscilloscope using a Type CA Dual-Trace Plug-In Unit. The Type 127 also facilitates the use of plug-in units in other applications.

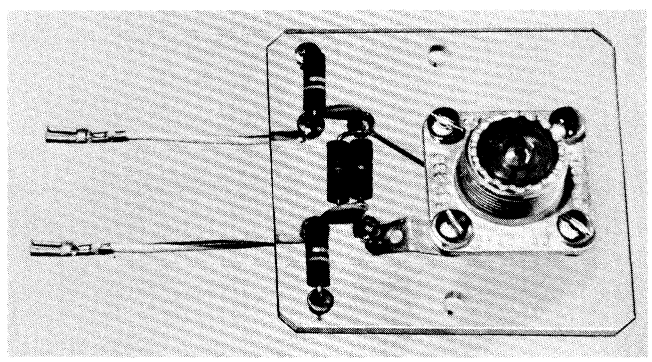
The outputs of plug-in units powered by the Type 127 are fed through dc-coupled differential amplifier stages and cathode followers to provide a push-pull signal at the output terminals. Risetime of the unit is 0.018 μsec, permitting maximum utilization of the response of Tektronix 530-Series Oscilloscopes. Output swing is linear $\pm 3\%$ over a range of ± 0.3 volt. Output dc operating levels are adjustable to ground potential.

The Type 127 has a gain of one, push-pull. With single-ended output, gain is one half.

Each channel has four output terminals, two on the front and two at the rear. Terminated 170-ohm output cables are furnished.

Price $525.00

DEFLECTION-PLATE CONNECTOR



The Type DP-52 Deflection-Plate Connector provides a convenient means for making direct connections to the CRT vertical-deflection plates in the 530- and 540-Series Oscilloscopes. With this device, front-panel control of the CRT beam position is retained. The connector is designed for use with a 52-ohm cable. For 530- and 540-Series Instruments with serial numbers 5001 and above order Part No. 013-007.

Price $5.00

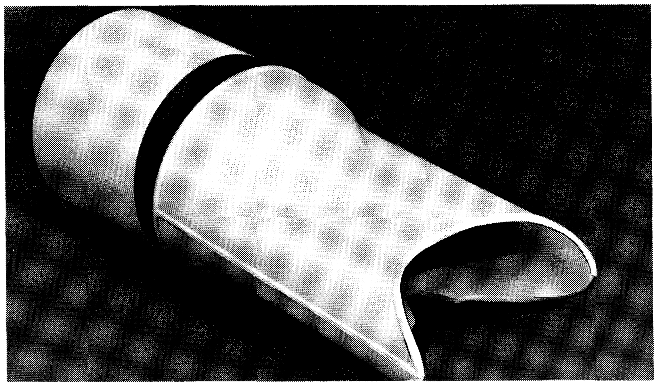
PROBE POWER-CABLE EXTENSION

A 24" 3-conductor power-cable extension for Tektronix cathode-follower probes. Permits wider separation of the probe power source from the instrument signal input.

Part No. 012 030 .... $5.00

AUXILIARY DEVICES

H510 VIEWING HOOD



Type H510 Viewing Hood for Tektronix 5" Oscilloscopes. Includes molded rubber eye-piece and aluminum light shield.

Part No. 016-001 .... $4.50

Molded rubber eye-piece.

Part No. 337-002 .... $3.35

Aluminum light shield.

Part No. 354-004 .... $1.15

UNIVERSAL PROBE REPAIR KIT

This repair kit includes all of the necessary electrical and mechanical parts to repair badly damaged Type P410 and P510 Probes. Includes repair and assembly instructions.

Part No. 040-180 .... $8.50

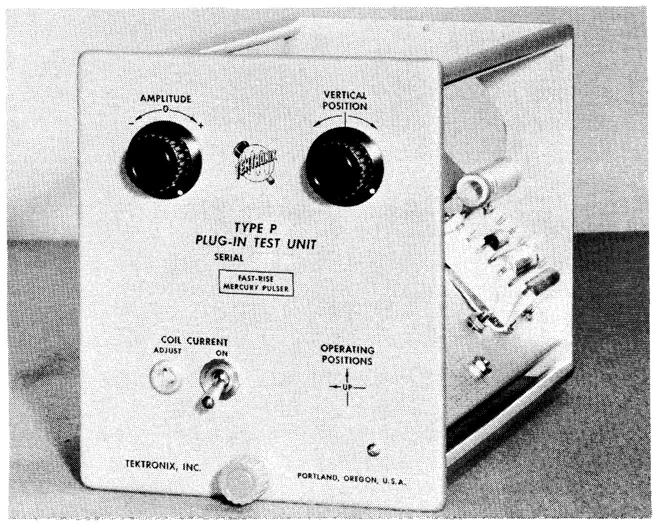
CAPACITANCE STANDARDIZERS

Type CS47 Input Capacitance Standardizer. This device is used for standardizing the input capacitance of those plug-in units having a 47 $\mu\mu f$ input capacitance. Standardization of plug-in input capacity permits interchanging probes from one plug-in to the other without the need for probe readjustment. The Type CS 47 case is similar to the Type A attenuator case on Page A-2.

Part No. 011-021 .... $11.50

Type CS20 Input Capacitance Standardizer. Similar to the Type CS47 above but for standardizing 20 $\mu\mu f$ input capacitances.

Part No. 011-022 .... $11.50

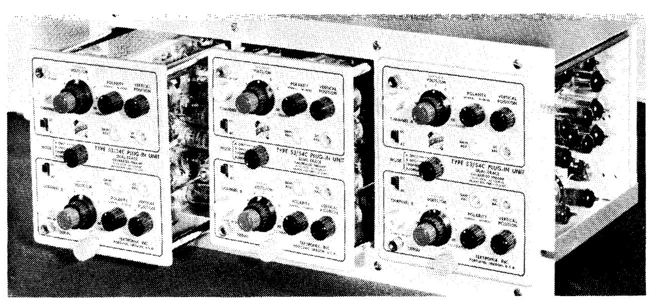


The Type P is a special-purpose test unit for Tektronix convertible oscilloscopes. You can use the step function generated by the Type P Unit to adjust an oscilloscope vertical amplifier and delay-line. By this procedure you can standardize the transient response of a number of like oscilloscopes. A plug-in preamplifier will exhibit identical transient-response characteristics in like oscilloscopes that have been standardized with the Type P.

Risetime of the step function generated by the Type P is less than 4 millimicroseconds. Polarity can be either positive or negative, and amplitude is continuously adjustable from 0 to 3 major graticule divisions. Repetition rate is 240/sec.

Price $60.00

PLUG-IN STORAGE CABINET

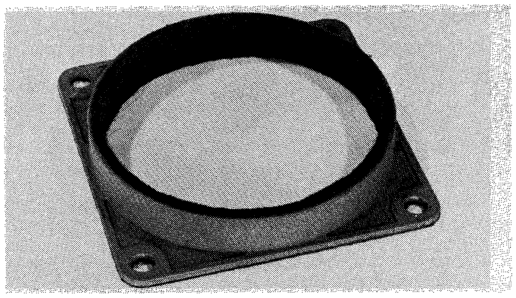


Plug-In Storage Cabinet. Mounts in standard rack, holds three Plug-In Units. Dimensions: 19" wide, 8¾" high, 9⅜" deep. Price without Plug-In Units.

Part No. 437-031 .... $25.00

AUXILIARY DEVICES

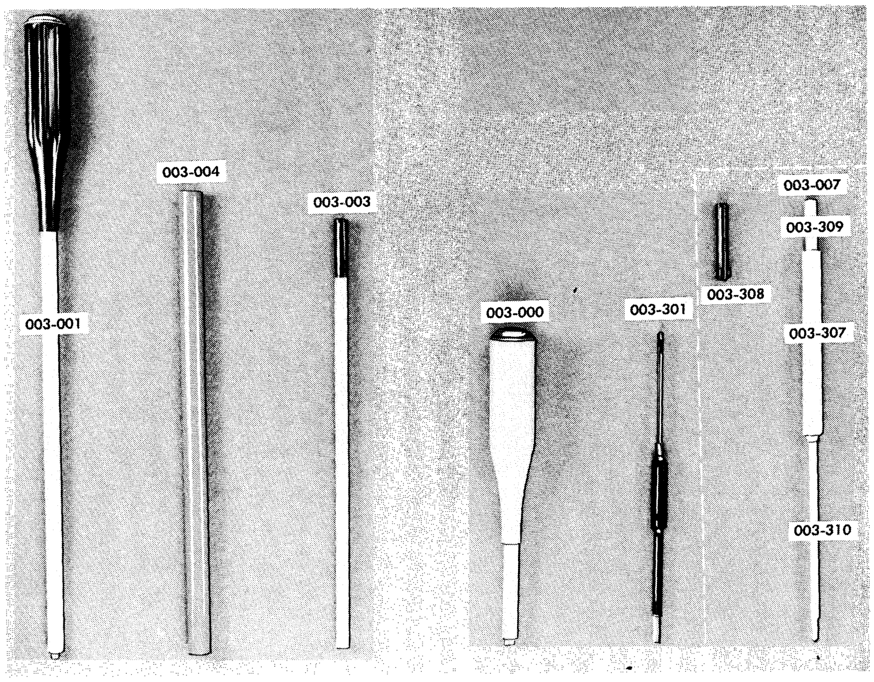
TYPE BE510 BEZEL



Type BE510 Bezel for mounting camera on Tektronix 5" oscilloscopes. Dimensions: $5\frac{7}{8}$" square; ring $\frac{7}{8}$" deep, diameter $5\frac{5}{8}$" outside, $5\frac{1}{8}$" inside. Die-cast construction, wrinkle finish, felt lined.

Part No. 014-001 .... $4.50

RECALIBRATION TOOLS



003-007 Tektronix recalibration tool assembly. This 4-unit tool assembly provides most of the necessary tools for adjusting variable inductors in Tektronix instruments. The price of this entire assembly is $2.50

Individual unit prices are as follows:

003-307 Handle .... $ .75

003-308 Red nylon insert with wire pin .... .50

003-309 White cymac insert with wire pin .... .50

003-310 Hexagonal core insert . .75

The tools shown above are handy—and in some cases, necessary—tools for the recalibration of Tektronix instruments. All of the tools except the assembly at the right (003-007) are available through most radio parts suppliers.

003-001 Jaco No. 125 insulated screw driver with 7" shank and metal bit. This tool is useful for adjusting hard-to-reach adjustments on oscilloscopes $1.25

003-000 Jaco No. 125 insluated screw driver. This tool is similar to 003-001 but has a $1\frac{1}{2}$" shank .... $ .75

003-003 Walsco No. 2519 insulated alignment tool. This double-ended tool is useful for adjusting variable inductors in Tektronix Instruments $1.25

003-004 Walsco No. 2503 $\frac{1}{4}$" insulated hexagonal wrench. This tool is useful for tightening variable inductor lock nuts on older Tektronix Instruments. Current production instruments do not have lock nuts on coil assemblies ...... $ .60

003-006 (Not pictured) Insulated alignment tool suitable for adjusting small capacitors $1.25

003-301 Walsco No. 2543 double-ended 0.1" hexagonal wrench. This tool is useful for adjusting variable inductors with hexagonal cores $1.00

Alignment tool kit. Contains the following alignment tools.

003-001	003-004	003-308
003-000	003-006	003-309
003-003	003-307	003-310

Part No. for kit 003-500 .... $7.50

Tektronix, Inc., P. O. Box 831, Portland 7, Oregon

Telephone: CYpress 2-2611 TWX—PD 311 Cable: TEKTRONIX

AN OREGON CORPORATION

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Printed in USA

PARTS LIST *and* DIAGRAMS

ABBREVIATIONS

Cer.	Ceramic	n	Nano or 10^{-9}
Comp.	Composition	Ω	ohm
EMC	Electrolytic, metal cased	p	Pico or 10^{-12}
f	Farad	PTB	Paper, "Bathtub"
G	Giga, or 10^{9}	PMC	Paper, metal cased
GMV	Guaranteed minmum value	Poly.	Polystyrene
h	Henry	Prec.	Precision
K or k	Kilohms or kilo (10^{3})	PT	Paper Tubular
M/Cer.	Mica or Ceramic	T	Terra or 10^{12}
M or meg	Megohms or mega (10^{6})	v	Working volts DC
μ	Micro. or 10^{-6}	Var.	Variable
$\mu\mu$	Micromicro or 10^{-12}	w	Watt
m	milli or 10^{-3}	WW	Wire-wound

SPECIAL NOTES AND SYMBOLS

+ and up

† Approximate serial number.

X000 Part first added at this serial number.

000X Part removed after this serial number.

* 000-000 Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, also reworked or checked components.

(Mod. w/) Simple replacement not recommended. Modify to value for later instruments and change other parts to match.

TEKTRONIX MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

HOW TO ORDER PARTS

Replacement parts may be purchased at current net prices from your local Tektronix Field Office or from the factory. Most of the parts can be obtained locally. All of the structural parts, and those parts noted in the parts list "Manufactured by Tektronix", should be ordered from Tektronix.

When ordering from Tektronix include a complete description of the part, and its 6-digit part number. Give the type, serial number, and modification number (if any) of the instrument for which it is ordered.

Structural parts are not listed in the parts list. Their part numbers are usually stamped directly on the metal. If not, a complete physical description of the part will suffice.

If the part which you have ordered has been replaced by a new or improved part, the new part will be shipped instead. Tektronix Field Engineers are informed of such changes. Where necessary replacement information comes with new parts.

TYPE S MOD. 3245

EFFECTIVE SN 380

CAPACITORS

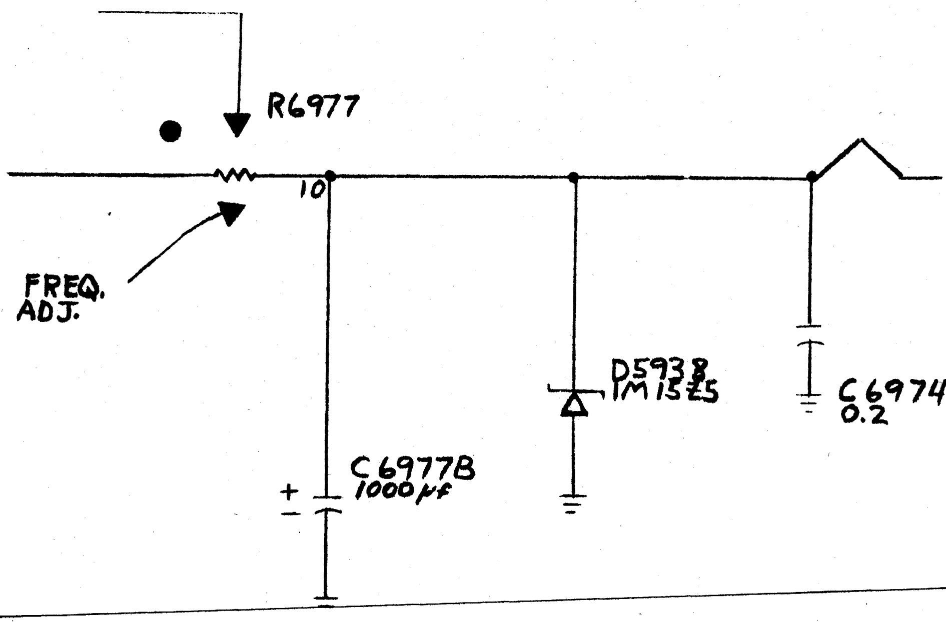
C6975	Add	Ceramic	Discap	.1 μfd	100 v			283-012

DIODES

D5938	Change to Zener Diode, 1M15Z5	1 w	15 v	5%		152-024

RESISTORS

R5954	Change to	Comp.	1/2 w	10%	82 Ω	302-820
R5993	Change to	Comp.	1/2 w	10%	100 k	302-104



TYPE S MOD. 3174 effective s/n 376
TYPE S MOD. 3126 effective s/n 171

Mod. 3174

Q5904	change to	2N1631 Transistor	151-047

Mod. 3126

D5937	change to	T12G Germanium Diode	152-008

DIODE TEST
TYPE S PLUG-IN UNIT

TYPE S MOD. 3245

EFFECTIVE SN 380

CAPACITORS

C6975	Add	Ceramic	Discap	.1 µfd	100 v		283-012

DIODES

D5938	Change to Zener Diode, 1M15Z5	1 w	15 v	5%		152-024

RESISTORS

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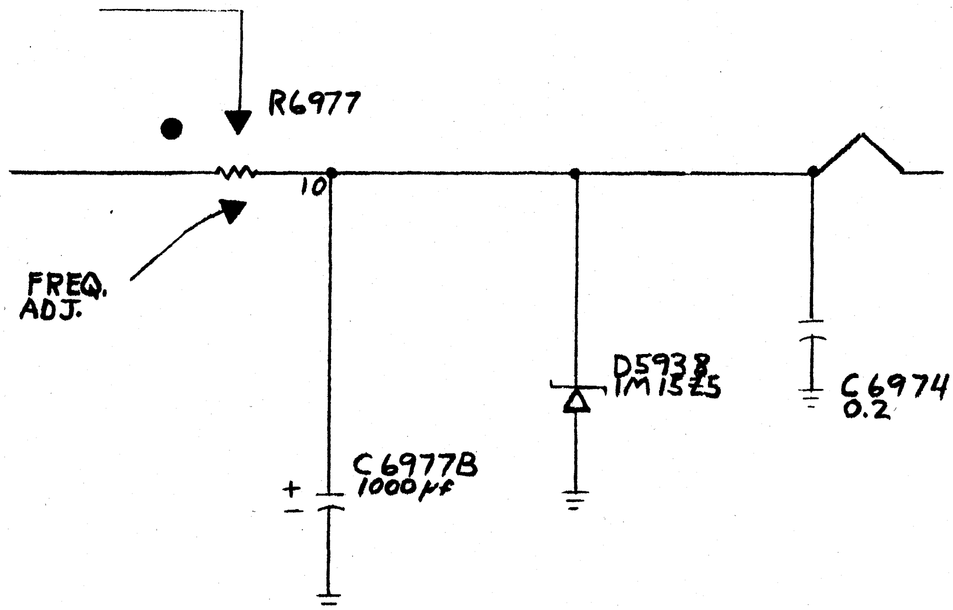
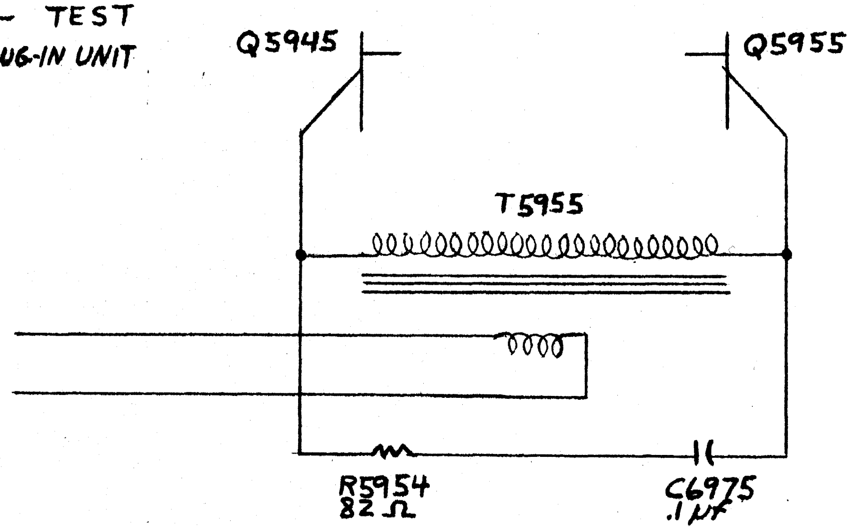


DIODE - TEST
TYPE S PLUG-IN UNIT



DIODE TEST
TYPE S PLUG-IN UNIT

PARTS LIST

Values fixed unless marked Variable.
Tolerance ±20% unless otherwise indicated.

Capacitors

Ckt. No.			Description				Tektronix Part Number
C5911		470 pf	Cer.				281-525
C5913		330 pf	Cer.			10%	281-546
C5918		2.2 pf	Cer.				281-500
C5919	X132-up	.01 μf	Discap				283-002
C5920		27 pf	Cer.				281-513
C5921		6.8 pf	Cer.			10%	281-541
C5922		1.5-7 pf	Cer.	Var.			281-005
C5923		1.5-7 pf	Cer.	Var.			281-005
C5933		.01 μf	Discap		500 v		283-002
C5934		.01 μf	Discap		250 v		283-005
C5937		.01 μf	Discap		250 v		283-005
C5940		.01 μf	Discap		150 v		283-003
C5942		3.3 pf	Cer.			±0.25 pf	281-534
C5943		20 μf	EMT		150 v		290-110
C5971		.68 pf	Cer.				281-537
C5972		.5-5 pf	Tub.	Var.			281-001
C5975		.01 μf	Discap		150 v		283-003
C5976		.005 μf	Discap		500 v		283-001
C5979		.01 μf	Discap		500 v		283-002
C5980		.01 μf	Discap		500 v		283-002
C5981		.01 μf	Discap		500 v		283-002
C5991		.01 μf	Discap		500 v		283-002
C5994		.01 μf	Discap		500 v		283-002
C6903		0.1 μf	Discap		500 v		283-008
C6904		0.68 pf	Cer.				281-537
C6911		0.2 μf	Discap		25 v		283-026
C6914		0.68 pf	Cer.				281-537
C6944		.001 μf	Discap		500 v		283-000
C6954		.001 μf	Discap		500 v		283-000
C6961		.01 μf	Discap		500 v		283-002
C6963		.01 μf	Discap		500 v		283-002
C6966		.01 μf	Discap		500 v		283-002
C6967		.01 μf	Discap		500 v		283-002
C6968		.01 μf	Discap		150 v		283-003
C6969		.01 μf	Discap		150 v		283-003
C6970		.02 μf	Discap		600 v		283-006
C6973		.01 μf	Discap		500 v		283-002
C6974		0.2 μf	Discap		25 v		283-026
C6977A,B		2 x 1000 μf	EMC		15 v		290-050

Inductors

		Tektronix Part Number
L5915	Ferramic Suppressor	276-507
L5916	Ferramic Suppressor	276-507
L5955	Mercury Switch Driving Coil	*108-201
L6905A,B	4-section Plate Line	*108-097
L6941	0.45 μh	*108-062
L6944	0.18 μh	*108-009
L6951	0.45 μh	*108-062
L6954	0.18 μh	*108-009

Resistors

R5903	4.7 k	½ w	Comp.	10%	302-472
R5904	150 k	½ w	Comp.	10%	302-154
R5911	10 k	½ w	Comp.	10%	302-103
R5913	1 k	½ w	Comp.	10%	302-102
R5915	180 Ω	½ w	Comp.	10%	302-181
R5916	180 Ω	½ w	Comp.	10%	302-181
R5917	69.5 k	½ w	Prec.	1%	309-264
R5918	78 k	½ w	Prec.	1%	309-168
R5920	6.5 k	½ w	Prec.	1%	309-262
R5921	50 k	½ w	Prec.	1%	309-090
R5922	43.4 k	½ w	Prec.	1%	309-176
R5925	100 k	½ w	Prec.	1%	309-045
R5930	47 Ω	¼ w	Comp.	10%	316-470
R5932A	1 meg	½ w	Prec.	1%	309-014
R5932C	500 k	½ w	Prec.	1%	309-003
R5932E	200 k	½ w	Prec.	1%	309-051
R5932G	100 k	½ w	Prec.	1%	309-045
R5932J	50 k	½ w	Prec.	1%	309-090
R5933A	2.15 meg	½ w	Prec.	1%	309-275
R5933C	1 meg	½ w	Prec.	1%	309-014
R5933E	333 k	½ w	Prec.	1%	309-053
R5933G	111 k	½ w	Prec.	1%	309-138
R5934	111 k	½ w	Prec.	1%	309-138
R5936	390 Ω	¼ w	Comp.	10%	316-391
R5940	25.6 k	½ w	Prec.	1%	309-136
R5941	50 k	½ w	Prec.	1%	309-090
R5942A	100 k	½ w	Prec.	1%	309-045
R5942C	50 k	½ w	Prec.	1%	309-090
R5942E	19.6 k	1 w	Prec.	1%	310-132
R5942G	9.76 k	2 w	Mica Plate	1%	*310-564
R5942J	4.64 k	4 w	Mica Plate	1%	*310-563
R5953	27 Ω	½ w	Comp.	10%	302-270
R5957	1 k	½ w	Comp.	10%	302-102
R5971	9 meg	½ w	Prec.	1%	309-157
R5972	1 meg	½ w	Prec.	1%	309-014

Resistors *(continued)*

						Tektronix Part Number
R5974	47 Ω	1/4 w		Comp.	10%	316-470
R5976	47 Ω	1/4 w		Comp.	10%	316-470
R5978	22 k	2 w		Comp.	10%	306-223
R5979	47 Ω	1/2 w		Comp.	10%	302-470
R5981	50 k		Var.	Comp.	Vert. Pos.	311-023
R5983	180 k	1/2 w		Comp.	10%	302-184
R5984	1.2 k	1/2 w		Comp.	10%	302-122
R5985	120 k	1/2 w		Comp.	10%	302-124
R5986	150 k	1/2 w		Comp.	10%	302-154
R5991	50 k		Var.		Vert. Pos. Change	311-023
R5993	180 k	1/2 w		Comp.	10%	302-184
R5995	100 k	1/2 w		Comp.	10%	302-104
R6901	27 Ω	1/2 w		Comp.	10%	302-270
R6903	2 k	5 w		WW	5%	308-091
R6904	515 Ω	1/2 w		Mica Plate	2%	*310-551
R6906	5.5 k	5 w		WW	5%	308-101
R6907	5 k		Var.	Comp.	Gain Adj.	311-011
R6911	27 Ω	1/2 w		Comp.	10%	302-270
R6914	515 Ω	1/2 w		Mica Plate	2%	*310-551
R6916	5.6 k	2 w		Comp.	10%	306-562
R6917	10 k	1/2 w		Comp.	10%	302-103
R6921	47 Ω	1/4 w		Comp.	10%	316-470
R6923	27 Ω	1/2 w		Comp.	10%	302-270
R6926	8.2 k	1 w		Comp.	5%	303-822
R6931	47 Ω	1/4 w		Comp.	10%	316-470
R6933	27 Ω	1/2 w		Comp.	10%	302-270
R6936	8.2 k	1 w		Comp.	5%	303-822
R6943	3.9 k	2 w		Comp.	10%	306-392
R6944	8.2 k	1 w		Comp.	5%	303-822
R6946	8.2 k	1 w		Comp.	5%	303-822
R6954	8.2 k	1 w		Comp.	5%	303-822
R6956	8.2 k	1 w		Comp.	5%	303-822
R6961	100 Ω	1/2 w		Comp.	10%	302-101
R6963	47 Ω	1/2 w		Comp.	10%	302-470
R6966	100 Ω	1/2 w		Comp.	10%	302-101
R6967	47 Ω	1/2 w		Comp.	10%	302-470
R6971	39 Ω	2 w		Comp.	10%	306-390
R6977	10 Ω		Var.	WW	Freq. Adj.	311-001
R6978	70 Ω	5 w		WW	5%	308-078
R6979	15 Ω	2 w		Comp.	10%	306-150

Switches

		Wired	Unwired
SW5930	Diode Mode	*262-280	*260-304
SW5942	Forward Current Milliamps	*262-281	*260-305
SW5955	Mercury		*260-308
SW5970	Sensitivity	*262-282	*260-306

Transformers

		Tektronix Part Number
T5936	Toroid, TD16	*120-175
T5955	Pulser	*120-165

Diodes

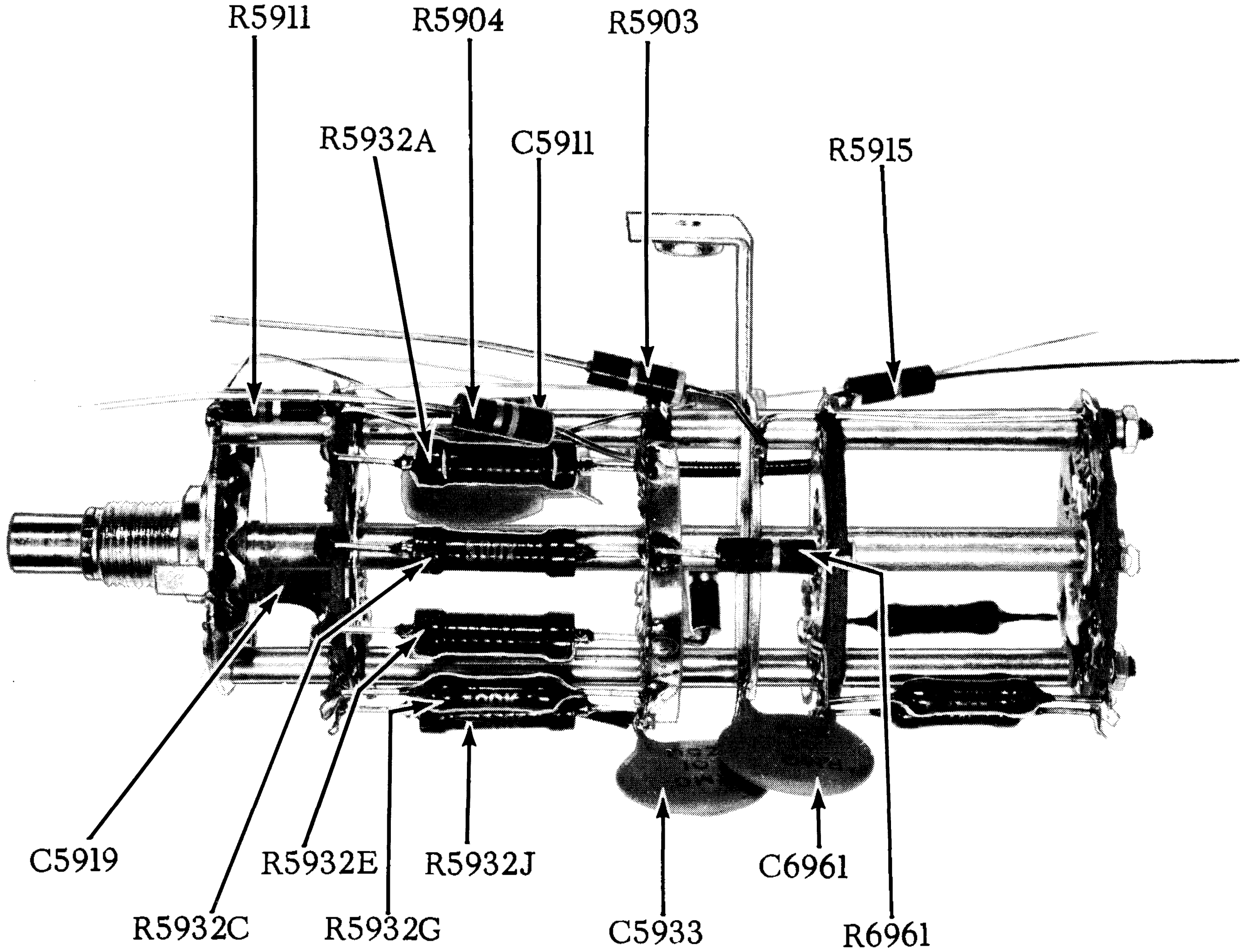
D5937	T13G	152-005

Transistors

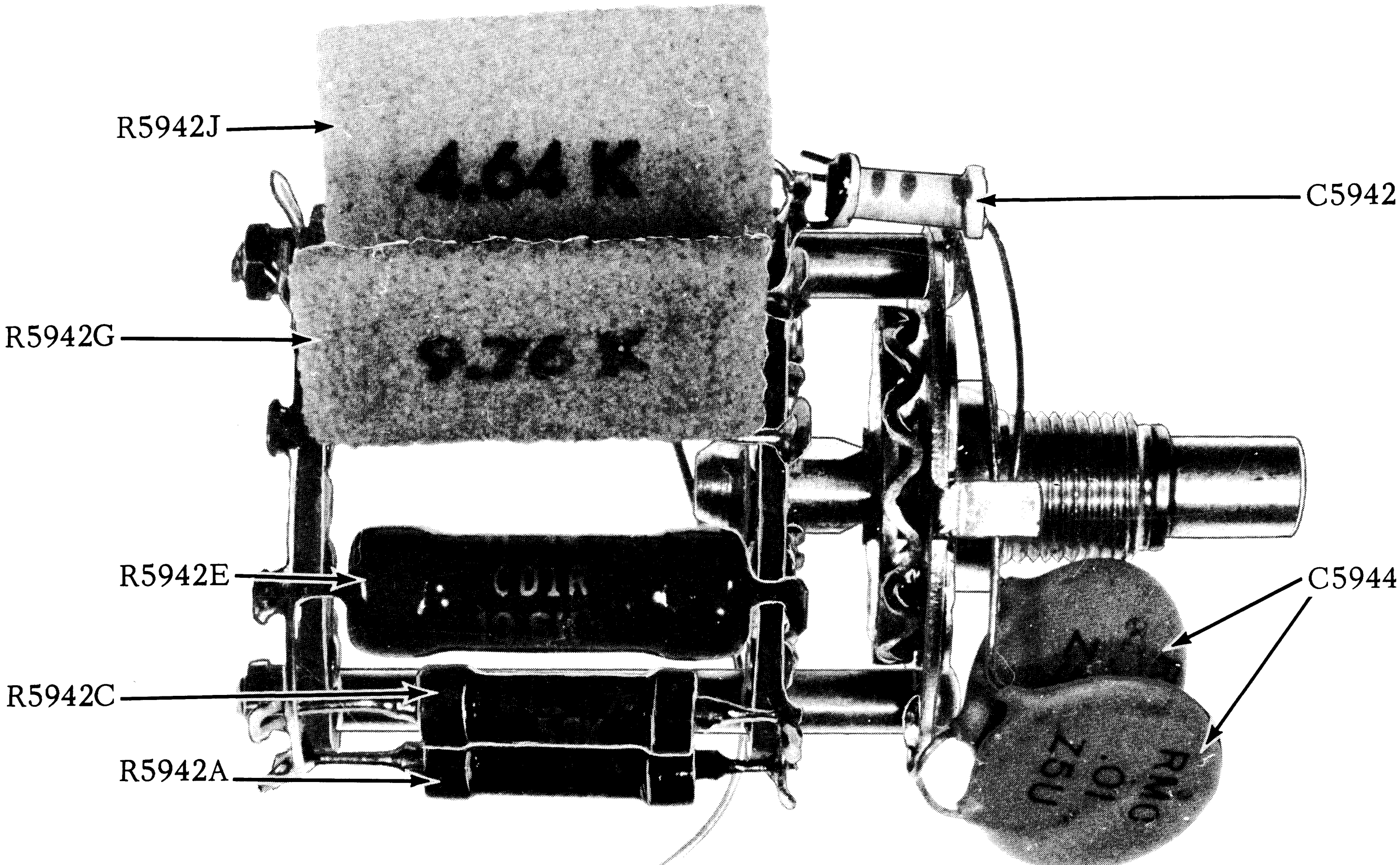
Q5904	2N544	151-008
Q5945	2N226	151-025
Q5955	2N226	151-025
Q5993	2N270	151-007

Electron Tubes

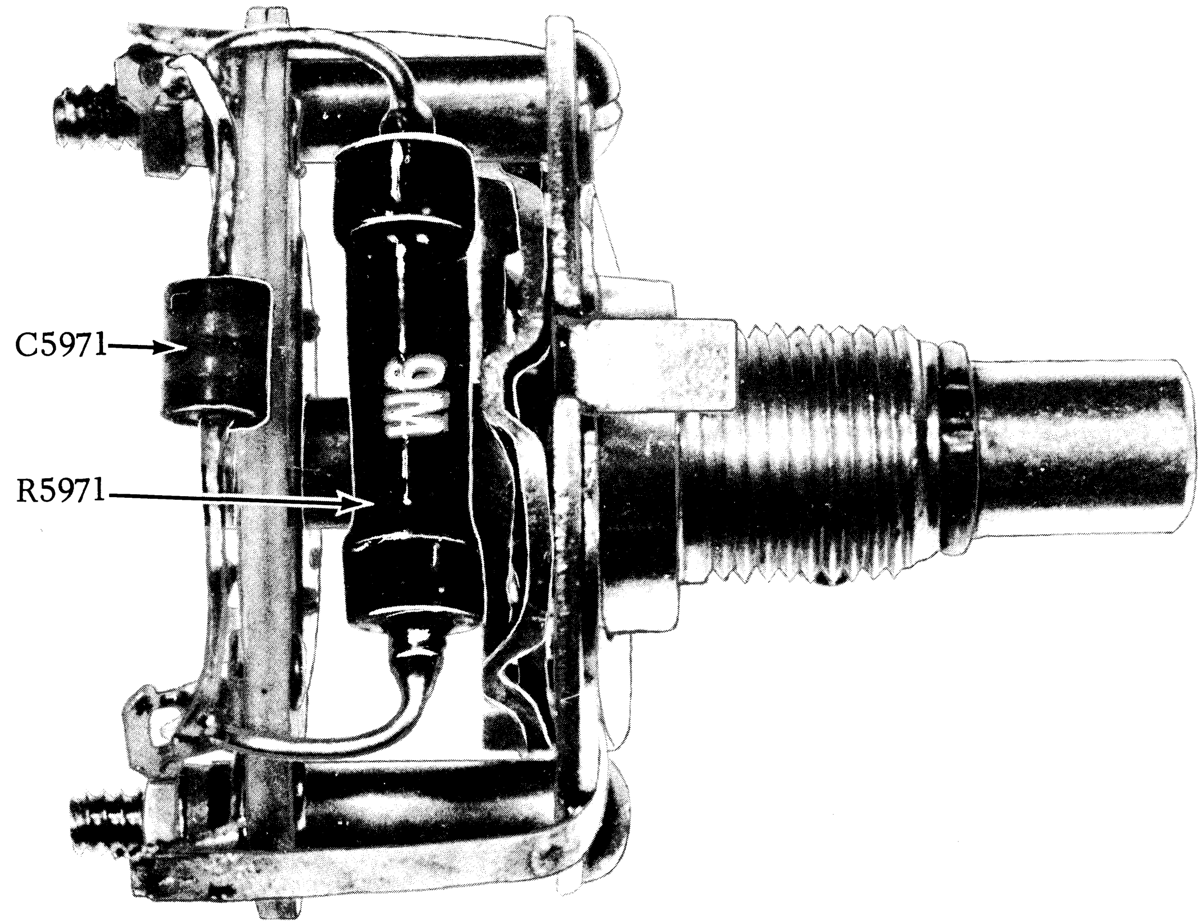
V5934	6GM8/ECC86	154-259
V5973	6AK5	154-014
V6904	12AU6	154-040
V6914	12AU6	154-040
V6923	12AT7	154-039
V6943	12AT7	154-039



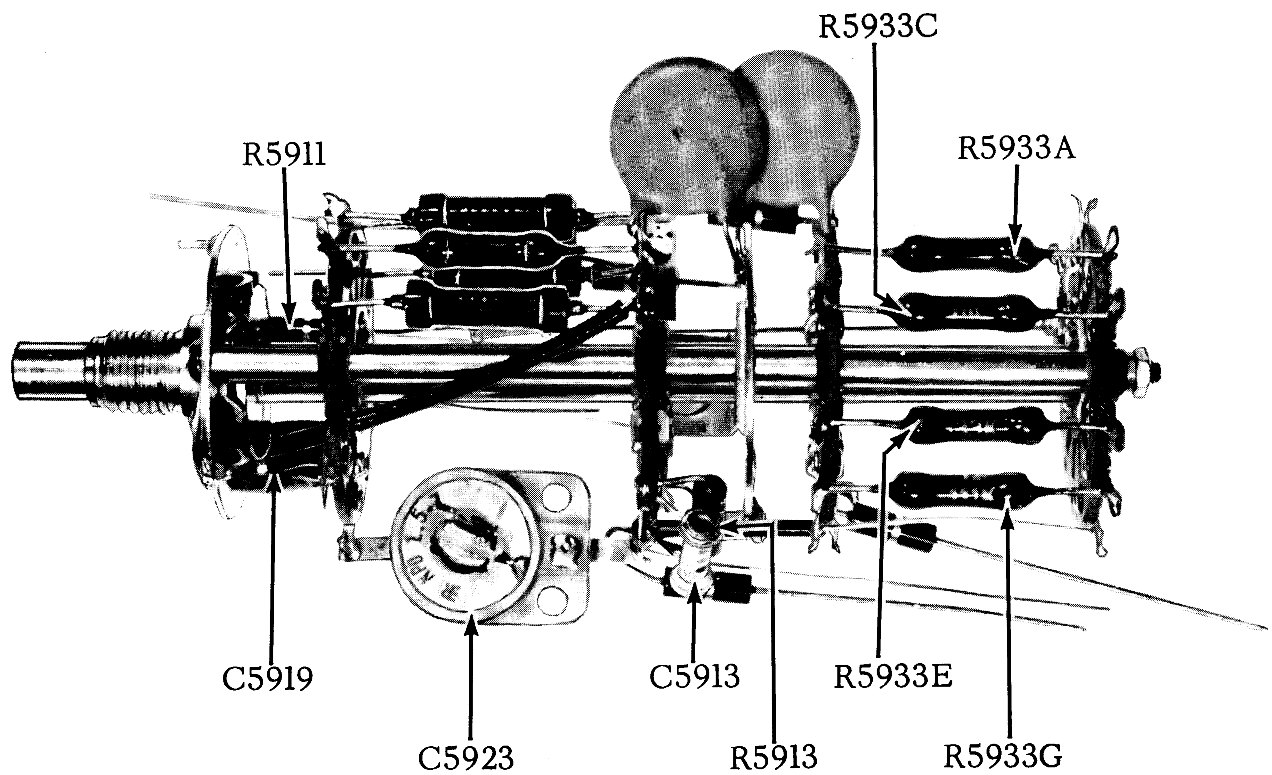
Type S **INSIDE VIEW DIODE MODE** A



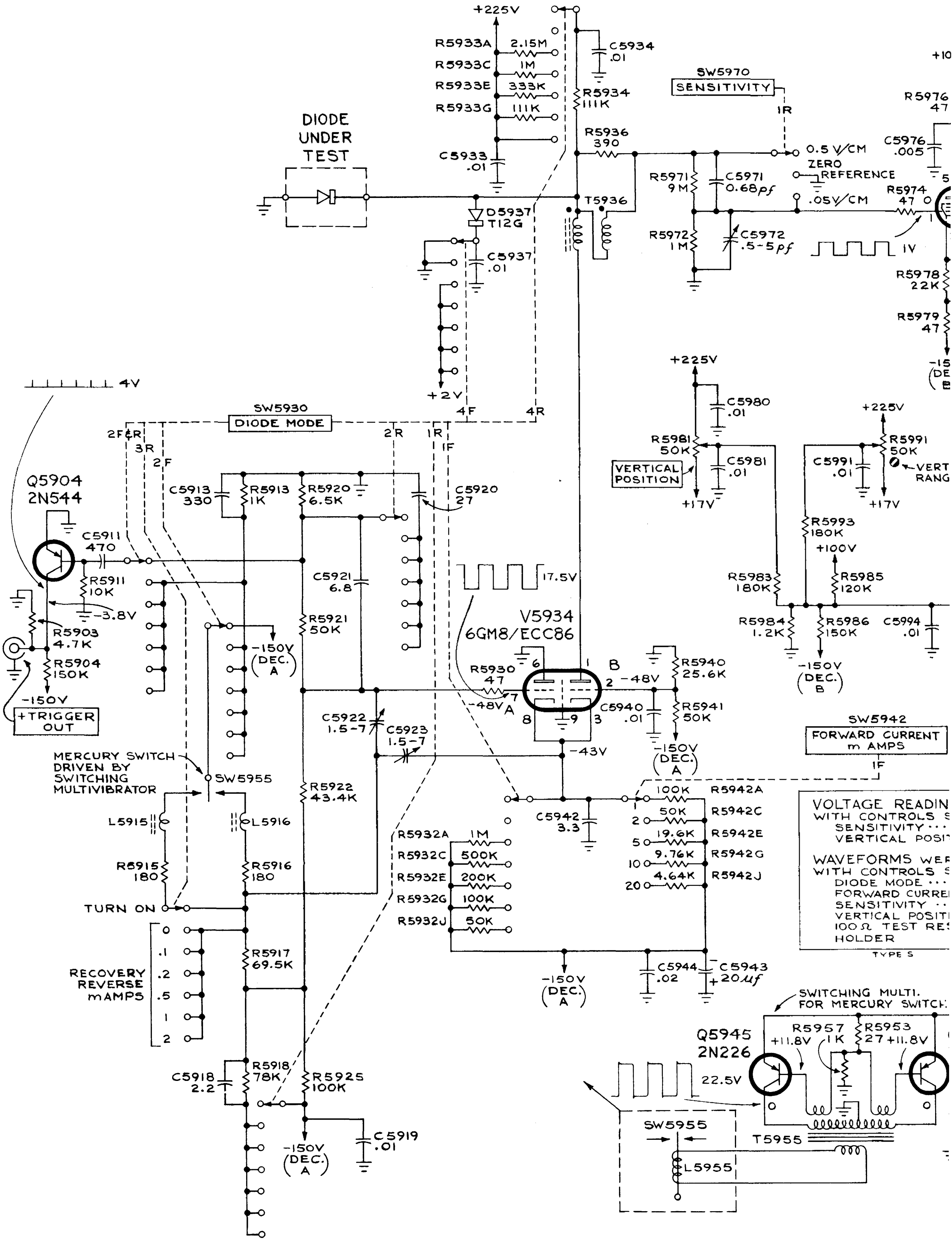
Type S **FORWARD CURRENT MILLIAMPS** A

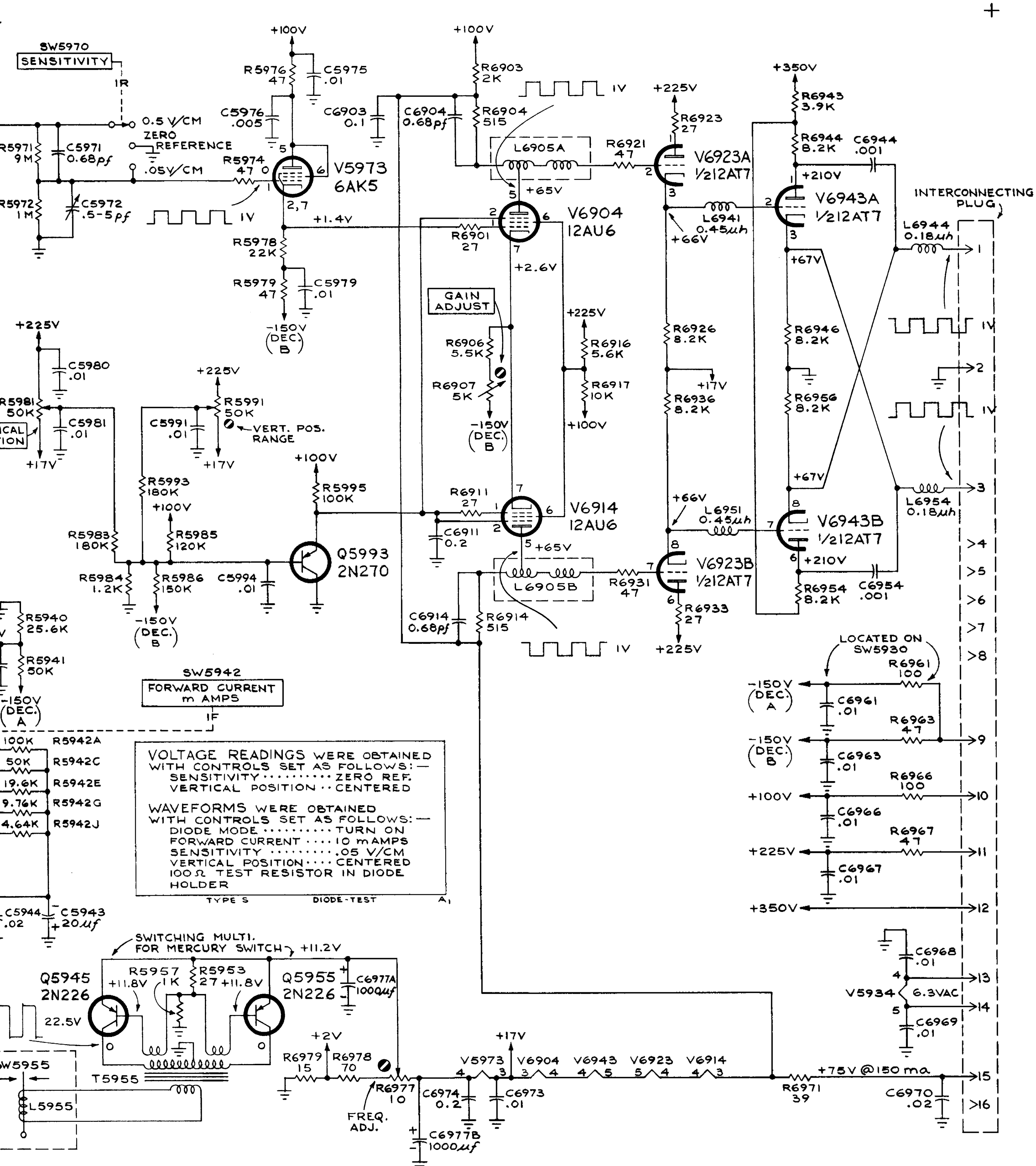


Type S **SENSITIVITY** A



Type S **OUTSIDE VIEW DIODE MODE** A

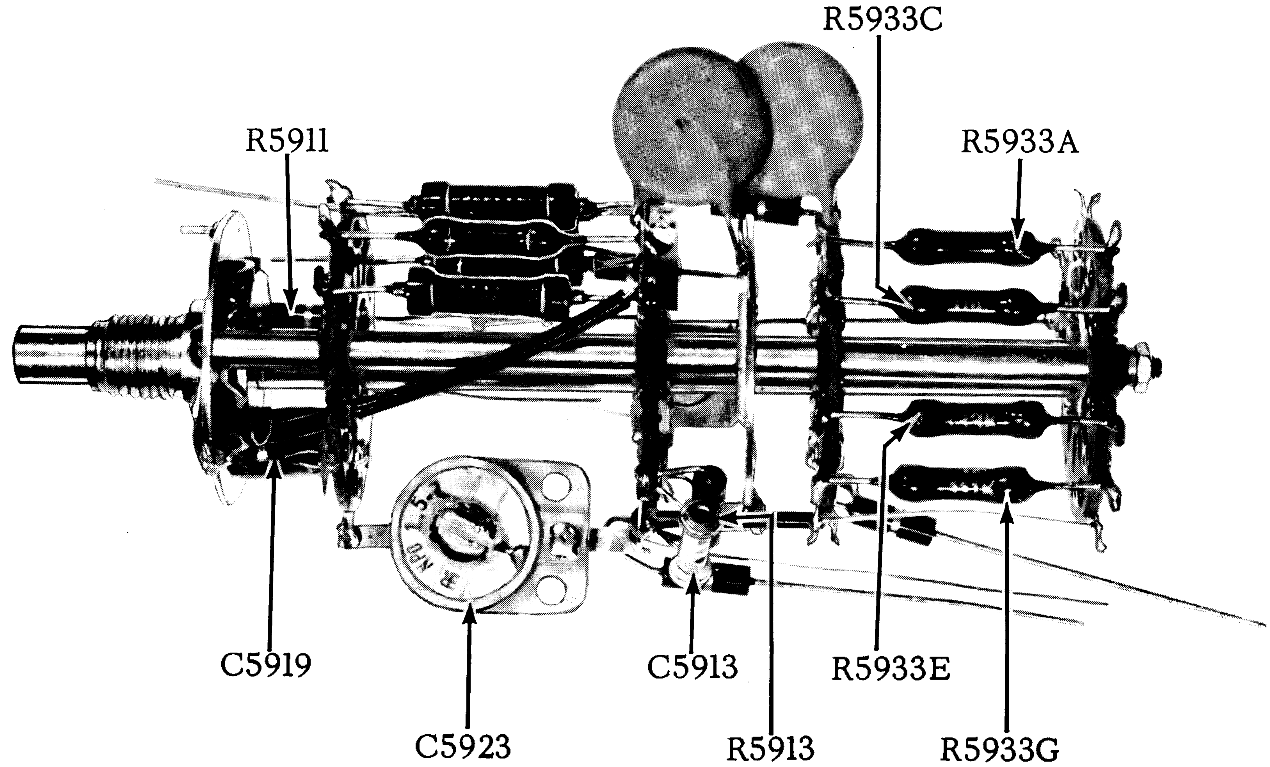

DIODE UNDER TEST
+225V
R5933A 2.15M
R5933C 1M
R5933E 333K
R5933G 111K
C5933 .01
C5934 .01
R5934 111K
R5936 390
D5937 T12G
C5937 .01
T5936
+2V
SW5970
SENSITIVITY
0.5 V/CM
ZERO REFERENCE
.05V/CM
R5971 9M
C5971 0.68pf
R5972 1M
C5972 .5-5pf
R5974 47
R5976 47
C5976 .005
R5978 22K
R5979 47
SW5930
DIODE MODE
4V
Q5904 2N544
C5911 470
R5911 10K
-3.8V
R5903 4.7K
R5904 150K
-150V
+TRIGGER OUT
C5913 330
R5913 1K
R5920 6.5K
C5920 27
C5921 6.8
R5921 50K
-150V (DEC. A)
C5922 1.5-7
C5923 1.5-7
R5922 43.4K
MERCURY SWITCH DRIVEN BY SWITCHING MULTIVIBRATOR
SW5955
L5915
L5916
R5915 180
R5916 180
TURN ON
RECOVERY REVERSE mAMPS
R5917 69.5K
C5918 2.2
R5918 78K
R5925 100K
C5919 .01
17.5V
V5934
6GM8/ECC86
R5930 47
-48V
-43V
C5940 .01
R5940 25.6K
R5941 50K
C5942 3.3
R5932A 1M
R5932C 500K
R5932E 200K
R5932G 100K
R5932J 50K
R5942A 100K
R5942C 50K
R5942E 19.6K
R5942G 9.76K
R5942J 4.64K
C5944 .02
C5943 20uf
+225V
C5980 .01
R5981 50K
VERTICAL POSITION
C5981 .01
+17V
R5991 50K
C5991 .01
R5993 180K
+100V
R5983 180K
R5985 120K
R5984 1.2K
R5986 150K
C5994 .01
-150V (DEC. B)
SW5942
FORWARD CURRENT m AMPS
SWITCHING MULTI. FOR MERCURY SWITCH
Q5945 2N226
R5957 1K
R5953 27
+11.8V
22.5V
SW5955
L5955
T5955



A

MRH
3-17-60
DIODE-TEST

TYPE S DIODE-TEST



Type S **OUTSIDE VIEW DIODE MODE** A