



THE CATHODE FOLLOWER

A continuation of the discussion on the cathode-follower circuit. Part 1 of this discussion, which appeared in the August, 1964, issue of Service Scope, covered the need for a device having a small input capacitance and a device having a small internal output impedance—two prime characteristics of the cathode-follower circuit. Also covered, were the polarity of the output signal and the voltage gain of the circuit.

Part 2

Input capacitance. The input capacitance of a cathode follower consists essentially of the effects of (1) the grid-to-cathode capacitance of the tube and (2) the grid-to-plate capacitance of the tube (see Fig. 9).

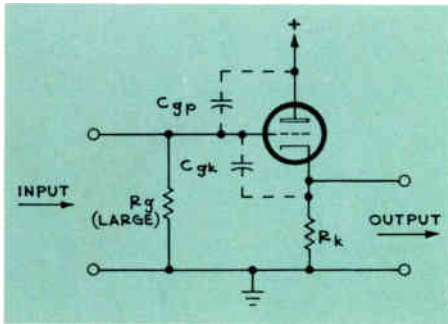


Fig. 9—Illustrating that the input capacitance of a cathode-follower stage is small. If we apply a given grid-input voltage change, this input signal causes the cathode output voltage to change in the same direction. Since the voltage gain of the stage is commonly between 0.5 and 0.99, the new grid-to-cathode voltage (with the input signal applied) isn't much different from the original grid-to-cathode bias voltage that existed before we applied the signal. Since we haven't changed the voltage across the grid-to-cathode capacitance C_{gk} very much, this capacitance hasn't required much charging current. And therefore C_{gk} causes relatively little loading effect on the source. (As far as the grid-to-plate capacitance C_{gp} is concerned, C_{gp} acts simply as a shunting grid-to-ground capacitance since the positive power supply acts as a short circuit to signal variations.) The resulting total input capacitance is considerably less than for a plate-loaded amplifier using a similar tube.

To observe the effect of the grid-to-cathode capacitance C_{gk} , suppose that C_{gk}

is 2 picofarads, and that the voltage gain of the stage is 0.9. If we apply an input signal-voltage change of +1 volt to the grid of the tube, then the cathode output voltage changes by +0.9 volt. Thus we change the voltage across C_{gk} by 0.1 volt—thereby changing the charge stored in C_{gk} . But this 0.1 volt change across the 2-picofarad capacitance C_{gp} alters the charge in coulombs exactly as much as a 1-volt change (the actual input signal) across a capacitance of only 0.2 picofarad. Therefore the actual grid-to-cathode capacitance (2 picofarads) loads the source only as much as if C_{gk} were a grid-to-ground capacitance of only 0.2 picofarad.

The grid-to-plate capacitance C_{gp} in Fig. 9 presents a simple shunt capacitance across the input terminals, since the power supply is a short circuit to signal variations.

Thus, as far as the signal source is concerned, the input terminals of the cathode follower represent a capacitance equal to a fraction of the rated grid-to-cathode capacitance of the tube—plus the rated grid-to-plate capacitance. The input capacitance of a plate-loaded amplifier is ordinarily considerably greater than the input capacitance of the cathode follower. We can make the effective input capacitance of the cathode follower even smaller by increasing R_k so that the voltage gain of the stage approaches unity.

Cathode-follower probes. Suppose we are using an oscilloscope to look at a waveform

developed by a certain source. The vertical-input circuit of the oscilloscope causes a certain amount of resistive and capacitive loading on the source. Unless the internal impedance of the source is low, this loading might (1) distort the waveform, or (2) reduce the amplitude of the waveform, or both.

We can use a voltage-divider probe to reduce the loading and thus reduce the waveform distortion. But the voltage-divider probe also attenuates the signal we want to display. Consequently, if the signal is already small, the voltage-divider probe can attenuate the signal to a point where it no longer produces a useful display. Therefore the voltage-divider probe might not fill the bill when we need to look at a small waveform from a high-impedance source.

What we need for such purposes is a probe that (1) loads the source only lightly, but still (2) has a voltage gain as close as possible to unity. We can make such a probe by placing a cathode follower inside the probe body. The small input capacitance of the cathode follower puts only a light load on the source. But the voltage gain in the cathode follower can readily be between 0.5 and unity.

In Table 1, we compare the loading effects and the voltage gains that we might get (1) when we use a typical voltage-divider probe, and (2) when we use a typical cathode-follower probe.

TABLE 1

	Loading effect	Voltage gain
Typical voltage-divider probe	10 megohms 11.5 picofarads	0.1 (10X attenuation)
Typical cathode follower probe	40 megohms 4 picofarads	0.8 - 0.85

From this comparison, we might at first imagine that we should forget about the voltage-divider probe and simply use the cathode-follower probe for all our waveform observations. But there are some other considerations, including these:

1. A cathode-follower probe can readily be overloaded by large input signals. This overloading causes waveform distortion. (For example, one type of cathode-follower probe introduces about 3 percent amplitude distortion when the input voltage exceeds about 5 volts. Some other cathode-follower probes can accommodate only much smaller input voltages.)

2. Attenuators are available that can be attached to the nose of the cathode-follower probe, for signals larger than those the probe can handle directly. (These attenuators affect both the input impedance and the frequency response of the probe.)

3. If an uninformed worker uses a cathode-follower probe in such a way that the probe is overloaded—as discussed above—he can get readings or waveforms that are very misleading.

4. Suppose we connect the cathode-follower-probe input to a waveform source whose internal impedance is inductive at some frequency. Then the cathode-follower-probe input impedance drops—perhaps sufficiently to change the amplitude or shape of the displayed waveform. If the Q of the source-and-probe circuit is high, the probe-input impedance can actually become negative at some frequency so that the cathode-follower-probe circuit oscillates.

5. The cathode-follower probe costs significantly more than the voltage-divider probe. Furthermore, the cathode-follower probe requires a stable, low-ripple power supply that is external to the probe. (Probe power supplies are available. Some oscilloscope types include probe-power connections.)

6. If the tube needs replacing in a cathode-follower probe, the new tube should be carefully selected and installed at the factory or by a technician trained in such work.

If you think a cathode-follower probe will help you, ask your Tektronix Field Engineer or Representative to help you select the probe and apply it to your work.

A method of increasing apparent input resistance. In order to reduce the loading on the signal source, we often want to make the resistive component of the input impedance of a stage very large. To accomplish this result, we might make the grid resistor R_g very large. But tube manufacturers often specify a maximum value of R_g that we should not exceed. This maximum value of R_g is based principally on grid-current considerations. A typical recommended maximum value for R_g is 1 megohm.

When we use a cathode resistor to obtain the negative grid-to-cathode bias voltage—as in the case of cathode followers and of many plate-loaded amplifiers—the upper limit for R_g is not so critical. (The tendency for grid current in R_g to make the dc plate current unstable is largely balanced out, since a change in plate current causes a change of bias voltage developed across the cathode resistor—and this bias-voltage change is in a direction that tends to bring the plate current back to its original value.) However, even with cathode-resistor bias, we cannot expect the tube to operate reliably in every case when we use indiscriminately large values of grid resistance R_g .

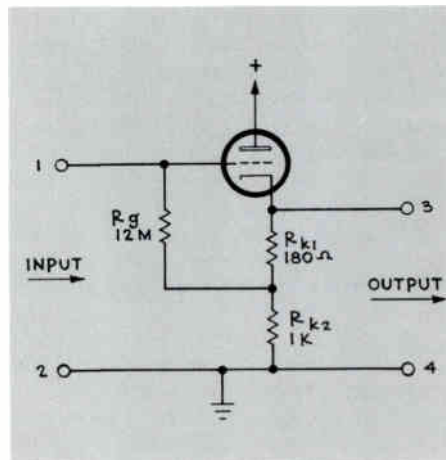


Fig. 10—Means of increasing the apparent value of the grid resistor R_g in a cathode follower, to reduce the shunt loading effect on the signal source. R_{k1} and R_{k2} act as a voltage divider, applying most of the output-signal voltage to the lower terminal of the grid-return resistor R_g . Since the output-signal voltage at the cathode terminal is nearly as great as the input-signal voltage, only a small part of the signal voltage appears across R_g . In Fig. 10, the resulting signal current in R_g is so small that this 12-megohm resistor appears to the input-signal source as if it were a 40-ohm resistance between the input terminals.

A circuit like that of Fig. 10 can make the apparent grid-input-circuit resistance of a cathode follower very large—considerably larger than the actual value of R_g . In the figure, the actual value of R_g is 12 megohms. But the apparent resistance seen by a source that drives the grid circuit is about

40 megohms. Let us see how the circuit of Fig. 10 accomplishes this increase in apparent input resistance.

Suppose, for example, that we apply an input signal voltage of +1 volt to terminals 1 and 2 of the circuit of Fig. 10. Assume that the gain of the cathode follower is, say, 0.83. Then the output signal voltage that appears across terminals 3 and 4 will be 0.83 volt. Because of the voltage-divider action of the series cathode resistors R_{k1} and R_{k2} , only a part of this output-signal voltage will appear at the junction of R_{k1} and R_{k2} . In fact, since $R_{k1} = 180$ ohms and $R_{k2} = 1,000$ ohms, the signal voltage at the junction of these two resistors will be $1,000/1,180$ times the output-signal voltage of 0.83 volt. Thus the signal voltage at the junction of R_{k1} and R_{k2} is about 0.7 volt.

Since the signal voltage at the lower end of R_g is 0.7 volt, and the signal voltage at the upper end of R_g is 1 volt, the signal voltage across R_g is only 0.3 volt. The resulting signal current in R_g is, by Ohm's law, equal to $0.3/12,000,000$ ampere, or 0.025 microampere.

Thus the input circuit takes a signal current of 0.025 microampere when the source signal voltage is 1 volt. By Ohm's law, the apparent resistance of the input circuit is $1/0.000,000,025$ ohms or 40 megohms. This increase in apparent grid-input-circuit resistance occurs simply because we connected the lower end of R_g to the junction of the two series cathode resistors rather than to ground. We should note, however, that there is a certain sacrifice in the voltage gain as compared to the gain we would get with the lower end of R_g grounded.

The circuit of Fig. 10 is actually used in some cathode-follower probes.

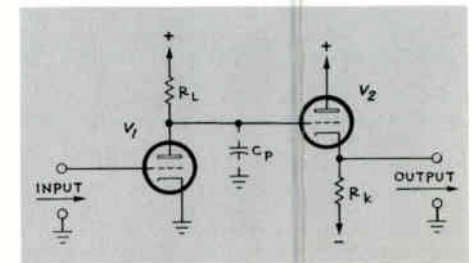


Fig. 11—Here a plate-loaded amplifier V_1 drives the input of a cathode follower V_2 . The plate-to-ground capacitance of V_1 (plus the small input capacitance of V_2) is represented by C_p . The risetime of the coupling circuit between V_1 and V_2 is determined by the time constant $R_k C_p$.

Bootstrap capacitor. Fig. 11 shows a plate-loaded amplifier V_1 that supplies a varying signal voltage to the grid-input circuit of a cathode-follower tube V_2 . There

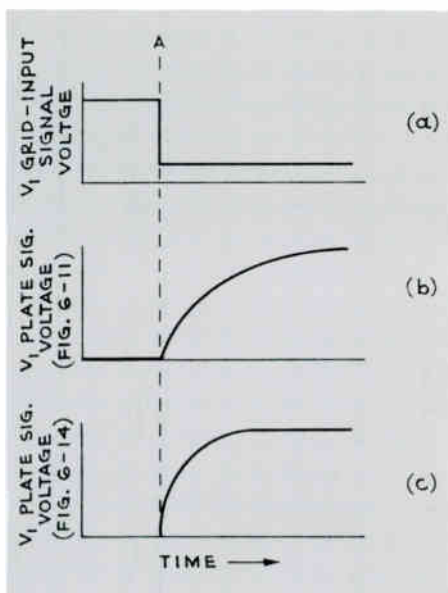


Fig. 12 — (a) An example of a grid-input signal voltage that we can apply to V_1 in Fig. 11 to observe the effect upon the output signal of the time constant $R_L C_p$ in Fig. 11.

(b) V_1 plate signal voltage applied to the grid of V_2 in Fig. 11 when we apply to the grid of V_1 the waveform of diagram (a).

(c) Faster response of the coupling circuit between V_1 and V_2 to the input signal of diagram (a), achieved by the hypothetical method of Fig. 13 or by the practical method of Fig. 14.

will exist an unavoidable shunt capacitance C_p at the plate of the amplifier tube V_1 . And the RC circuit composed of the plate-load resistor R_L and the shunt capacitance C_p might cause the risetime of the circuit to be longer than we can tolerate.

If, for example, we apply a negative-going input-voltage step (instant A, Fig. 12) to the grid of V_1 , the plate current will be abruptly reduced. And the signal voltage at the plate of V_1 will rise according to a curve like Fig. 12b.

We can use peaking or compensating circuits to shorten the risetime. But another approach to shortening the risetime is shown

in Fig. 13. Here the upper end of the plate-load resistor R_L is connected to the movable contact of a variable voltage divider R . Suppose we could provide some way by which the movable contact would automatically move toward the positive end of R when the signal voltage at the plate of V_1 tended to rise. If we could make this provision, then the stored charge in C_p would be more quickly removed so that the signal voltage at the plate of V_1 could rise more rapidly.

We cannot, of course, provide the mechanical arrangement just suggested—except possibly for signals that change quite slowly. But a system that operates in somewhat the same way can be arranged electronically, as follows:

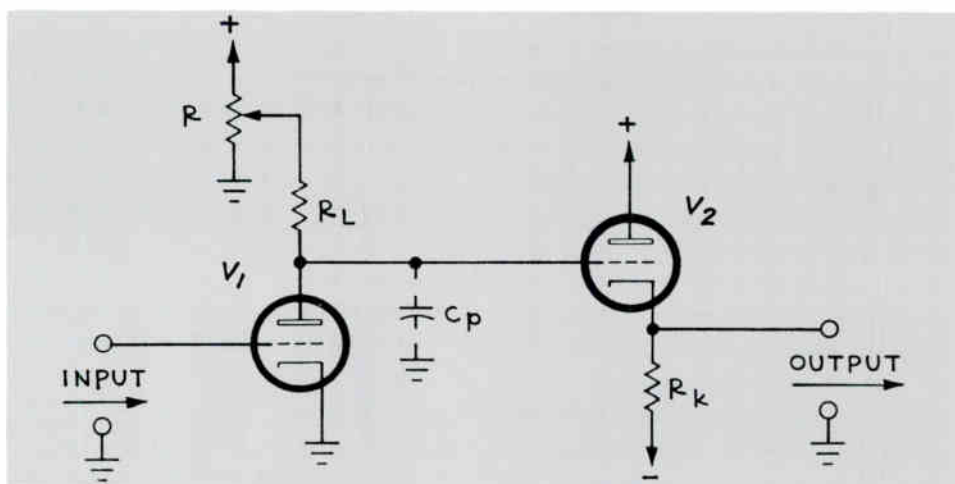


Fig. 13 — A hypothetical way to improve the speed of the response of the coupling circuit between V_1 and V_2 in Fig. 11. Here we apply the waveform of Fig. 12a to the grid of V_1 . And we assume that we can provide some way by which a voltage rise at the plate of V_1 moves the variable contact on R upward. The resulting voltage rise at the upper end of R_L helps to charge C_p while the input waveform changes. Thus the voltage at the plate of V_1 can change more rapidly, as indicated in Fig. 12c.

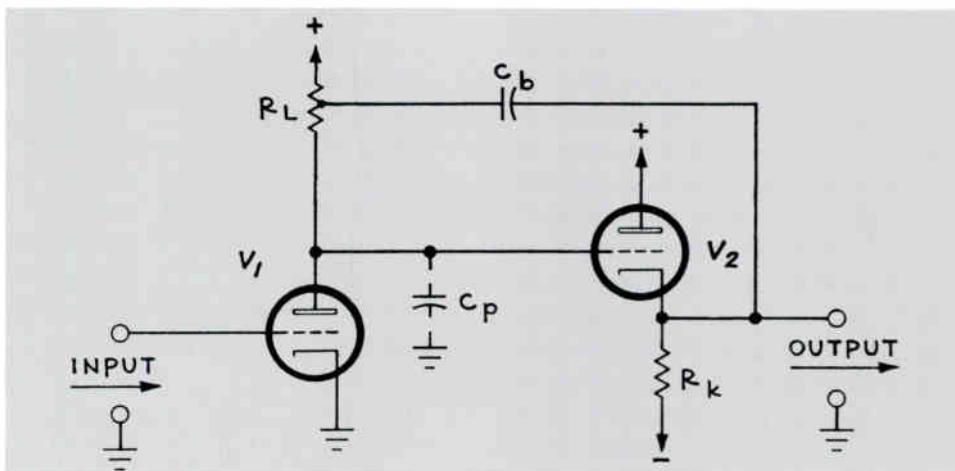


Fig. 14 — A practical way to achieve the result we considered in Fig. 13. Here the V_1 grid-input signal of Fig. 12a makes the voltage at the plate of V_1 rise. By cathode-follower action, V_2 couples this voltage rise to the cathode of V_2 . The bootstrap capacitor C_b applies this voltage rise to the tap on the plate-load resistor R_L , helping to change C_p more rapidly. Therefore, in response to the input waveform of Fig. 12a, the voltage at the plate of V_1 can change relatively rapidly as indicated in Fig. 12c.

Fig. 14 shows a small capacitance C_b connected between the cathode output terminal of the cathode follower V_2 and a tap on the plate-load resistor R_L . When the signal output voltage at the plate of V_1 begins to rise, this voltage rise is applied to the grid of V_2 . And the signal-voltage rise appears only slightly diminished at the cathode output terminal of V_2 . The same signal-voltage rise is coupled through C_b to the tap on R_L , so that the voltage at the tap rises more rapidly than it would if the circuit through C_b were absent. Thus electrons are drawn away from C_b more rapidly than they would if C_b were absent. The action continues during the plate-voltage rise of V_1 —each increase in plate voltage causing a corresponding rise in voltage at the tap on R_L , so that electrons can be drawn rapidly away from C_b . The corresponding output-voltage waveform at the plate of V_1 is therefore like that of Fig. 12c.

In thus improving the risetime of the response to a step-voltage input, we have also made the circuit of Fig. 14 capable of responding to other rapidly changing waveforms. Inasmuch as this improvement is actually intended to affect only waveforms that change rapidly, we make C_b small enough that its coupling action is negligible for slowly changing waveforms. We can refer to C_b as a *bootstrap* capacitor. It is, in general, necessary to select the value of C_b and the tap point on R_L so that optimum results are obtained.

The End

The material for this article was taken from the book "Typical Oscilloscope Circuitry", published by Tektronix, Inc. The complete text is available from your Tektronix Field Engineer or Representative. The price in the U.S.A. is \$5.00.



TYPE 1A1 DUAL-TRACE PLUG-IN UNIT — OUTPUT-AMPLIFIER CARD IMPROVEMENTS

Depending upon the model of Output-Amplifier card in your Type 1A1, there are up to five improvements you can incorporate into the instrument. The Output-Amplifier cards affected by the improvements are models 2, 3 and 4. Cards with model numbers 5 and up have all the improvements installed at the factory. Model numbers are silk screened on the cards near the tube socket for the V464 NU-Vistor.

Installation of the improvements require the removal of the Output-Amplifier card. These are of the plug-in type and easily removed by first removing the securing rod. Next, un-plug the ground lead and the leads which individually plug into the card. Now un-plug the card itself from the Bendix connector.

Page 5-6 of the Type 1A1 Instruction Manual features a large photograph of the component side of the Output-Amplifier. Each component on this card is identified with its circuit number. Consulting this photo will aid you in physically locating the components replaced, changed or removed in making the improvements.

The first improvement is applicable to Output-Amplifier cards with model numbers 2, 3, and 4. It reduces the failure rate of the diodes D454, D453, D452, D451, D424, D423, D422 and D421 by replacing the original GaAs point-contact diodes with the Type 6153 Silicon Diodes (Tektronix Part Number 152-153). To do this, remove the original diodes from the card by lifting them from their clips. Next, using a 15 or 25 watt soldering iron heat each clip and lift it from the card. This will expose four soldering points (two per clip) for each diode position. Install a 6153 replace-

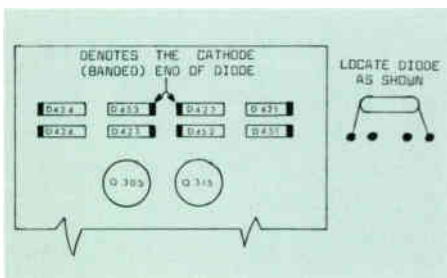


Figure 1. Showing orientation of replacement diodes and location of diode leads on Type 1A1 Output Amplifier Cards Models 2, 3 and 4.

ment diode in each position orienting the diode and soldering the axial leads in their locations as shown in Figure 1.

The second improvement is applicable to models 2 and 3 Output-Amplifier cards. It prevents the alternate-trace blocking oscillator from intermittently running twice on a sync pulse. The improvement adds a Type 6075 Germanium Diode (Tektronix Part Number 152-075) across the collector winding of T330. Circuit designation of this new diode is D330, see Figure 2. Figure 3 shows

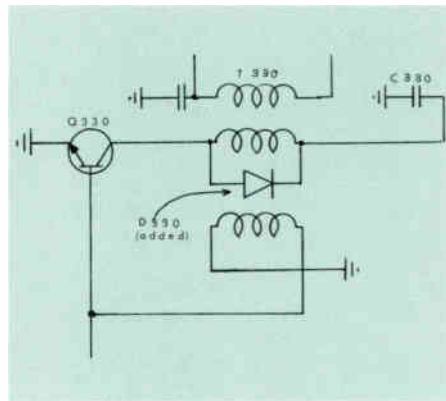


Figure 2. Partial schematic showing circuit location of the added Type 6075 Germanium diode (D330) across the collector windings of T330.

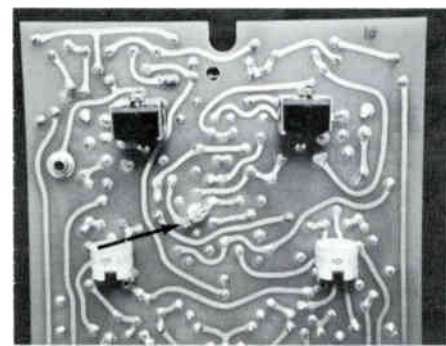


Figure 3. Partial view of Output Amplifier Card (rear or soldered side.) Arrow shows the physical location of the added Type 6075 Germanium diode (D330) and points to the anode end of the diode.

the physical location of D330 on the rear (soldered) side of the Output-Amplifier card.

The third, fourth, and fifth improvements are applicable to the model 2 Output-Amplifier card. These improvements reduce aberrations on the Chopped waveform, reduce

field failure of Q353 an assure ALTERNATE trace operation in all units.

To Reduce Aberrations on Chopped Waveform install a new 150 pf ceramic capacitor (Tektronix Part Number 281-524) in parallel with R343. Designate this new capacitor C344. Replace C491, a 0.001 μ f capacitor located from pin 10 of V243 to ground, with a 0.1 μ f ceramic capacitor (Tektronix Part Number 283-057) and add a 3/8 inch piece of #18 varglas to the lead at pin 10. V243 is located on a bracket directly behind the front sub-panel on the Channel 2 side of the Type 1A1. Install a new 0.1 μ f ceramic capacitor (Tektronix Part Number 283-057) from pin 21 of the Output Amplifier card's Bendix connector to the ground lug under R495, a 470 ohm, wire wound resistor, located on the rear frame plate of the Type 1A1. Designate this new capacitor C494. Remove and discard C260*, a 0.001 μ f capacitor, located between pin X of the Channel 2 Input-Amplifier card's Bendix connector and a solder lug on the bracket supporting the rear end of this Bendix connector.

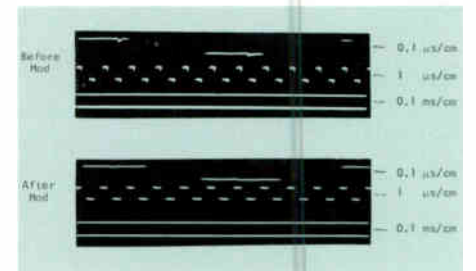


Figure 4 shows waveforms from a Type 1A1 in Chopped Mode before and after the improvement.

To Reduce Field Failure of Q353

On the rear wafer of the MODE switch locate a contact with a green-on-white wire and a second contact with a red-on-white wire. Install a 2.7 megohm*, 1/2 w, 10% resistor (Tektronix Part Number 302-275) between these two contacts. Designate this resistor R360.

To Insure ALTERNATE trace operation in all units

Replace C303 and C304, 0.001 μ f capacitors, with 0.05 μ f ceramic capacitors (Tektronix Part Number 283-010). Replace C306 and C316, 22 pf capacitors, with 47 pf, ceramic capacitors (Tektronix Part Number

281-518). Replace D303, a 6075 diode, with a 1N3605 diode (Tektronix Part Number 152-141). Replace Q305 and Q315, 2N964 transistors, with a pair of selected 2N964 transistors (Tektronix Part Number 153-530). These last two transistors are selected for a minimum Beta of 80 at 10 ma I_c .

Correct the schematics and parts list in your Type 1A1 Instruction Manual to conform to the improvements you have just made.

*Some Type 1A1 instruments in the field may have had these starred components removed or installed at the factory. If your instrument falls in this category, ignore these portions of the improvement procedure.

TYPE 180A FREQUENCY DOUBLER—MARKING TURN-AROUND

The Type 180A Frequency Doubler (Tektronix Part Number 015-013) — used for obtaining 100 Mc from the 50 Mc output of the Type 180A Time-Mark Generator — is intended to be coupled directly to the Type 180A, not at the end of a cable. The schematic on the case of the Frequency Doubler has confused some operators. The schematic markings implied that the female UHF connector was the input and the male connector the output. This interpretation is wrong. The *male connector* is the *input*. It connects directly to the 50 Mc Sine Wave output (a female UHF connector) of the Type 180A Time-Mark Generator.

TYPE 4S1, 4S2 and 4S3 DUAL-TRACE SAMPLING UNITS — “SLASH”-REDUCTION MODIFICATION INFORMATION

Here is a very simple solution to a problem that a few operators find troublesome. The problem occurs when using a Type 4S1, Type 4S2 or Type 4S3 to look at fast signals recurring at a very low rep rate. In this situation, there is such a long waiting period between samples that the Miller Memory usually drifts away from the level it was set to by the preceding sample before

it is reset by a new sample. This creates vertically elongated “slashes” instead of dots. The addition of a 25 k potentiometer (Tektronix Part Number 311-390) in series with the plate of V1133A in the Memory circuit of these plug-ins will give you an adjustment with which you can virtually eliminate the tendency to drift and slash. Figure 5 shows a schematic of the new circuit.

Please note that the Types 4S1, 4S2 and 4S3 are dual-trace instruments. As such they have two input channels and each channel has its own Memory card. For single trace operation you need modify only the Memory card of the input channel you intend to use. For dual-trace operation you should modify the Memory cards of both channels.

The potentiometer may be installed on the lip of the Memory card chassis alongside the Smoothing Balance potentiometer. It will require the drilling of a $\frac{1}{4}$ -inch hole. A nearby vacant slot in a ceramic strip simplifies rerouting the +100-volt supply lead through the new potentiometer before connecting it to the plate (pin 6) of V1133A via the 100- Ω suppressor resistor.

To adjust the pot, first be sure the DC-offset control for the channel used is set to zero volts. Monitor the voltage with a voltmeter at the monitoring jacks. Observe that adjustment of the potentiometer can reverse the direction of the spot (up or down) as well as the rate at which it drifts each time a free-running sweep is stopped. Set it so the spot remains in the same position as the trace each time the sweep is stopped from free-running.

There is some interaction with the Smoothing Balance Control so you may have to work back and forth between these controls a couple of times.

NE-23 NEONS RADIOACTIVE MATERIAL — A CORRECTION

In this column of the April, 1964, Service Scope we stated that the new NE-23 Neon lamps contained a tiny bit of radioactive material added to the glass envelope during manufacture. Mr. Charles Dougherty, Applications Engineer with the Miniature Lamp Department of General Electric Company, tells us that radioactive material is *not* added to the glass envelope. They do, however, add a radioactive gas with the neon mixture. This accomplishes the purpose which we cited as the reason for adding radioactive material to the glass — that of assuring immediate ionization of the neon gas. In addition, it minimizes dark effect in these neons.

To answer any question that you may have in regard to danger from this radioactive gas, Mr. Dougherty assures us that it offers no hazard to service people or users of equipment containing NE-23 neons.

TYPE 541, 545, RM41 and RM45 OSCILLOSCOPES — MODIFICATION TO PERMIT THE USE OF TYPE T543 CRT

A simple modification will permit the use of either the Type T54 (original equipment) crt or the Type T543 (used in Type 543 Oscilloscopes) in all Type 541, 545, RM41 and RM45 Oscilloscopes. Both the T54 and the T543 crt employ etched deflection plates. There are, however, two possible advantages in converting to the Type T543 crt. One is, facilities that use both the Type 543 instrument and other instruments in the older Type 540 Series (541, 545, RM41 and RM45) will need stock only one type of replacement crt — the Type T543. The other advantage is that the Type T543 crt reduces the effect of intensity change as a result of Astigmatism control changes.

Please note that this modification does not apply to the recently announced Type 544, Type 546 and Type 547, or to the Type 540A Series and Type 540B Series Oscilloscopes.

To make the modification:

1. Remove the crt from the instrument.
2. Disassemble the crt socket by removing the two screws.
3. Short pins 11 and 12 of the crt socket together. One method is to notch the rib between the ribs and short them with a piece of #22 bare wire; another, to use an external loop.

Steps 4, 6 and 7 apply to the following instruments only:

Type 541, s/n 101 - 6928, inclusive
 545, s/n 101 - 11328, inclusive
 RM41, s/n 101 - 135, inclusive
 RM45, s/n 101 - 192, inclusive

4. Run a lead through hole #8 in the crt socket insert and solder it to pin #8. We suggest using a 9-inch length of #22 stranded wire, color-coded: white-orange-green-brown, which denotes the supply voltage to which the lead will be connected.

5. Re-assembly the crt socket.

6. Remove the high-voltage shield on the top left side of the instrument.

7. Run the free end of lead (Step 4) through a vacant hole in the high-voltage chassis (just above the crt socket) and solder it to the +350 volt point (white-orange-green-brown lead) on the rear ceramic strip.

8. Replace the high-voltage shield and install the crt.

Correct your Instruction Manual parts list and schematic as required.

Refer to your Instruction Manual and recalibrate your instrument as required.

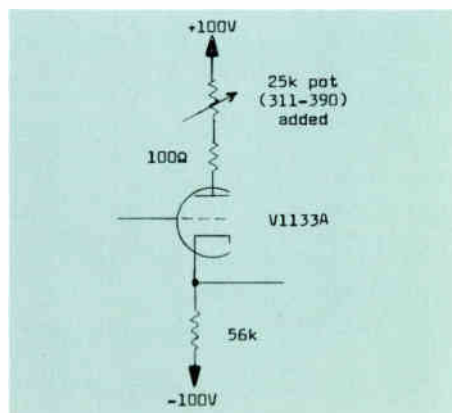


Figure 5. Partial schematic showing the addition of the 25 k potentiometer to the plate circuit of V1133A.

SCOPE PADS BY ENSCA, INC. — ADDRESS INFORMATION

In the February, 1964, issue of Service Scope we told our readers about a product called "Scope Pad" distributed by Ensca, Inc., P.O. Box 253, New York, New York 10023 (Zip Code).

We are now informed that the address should include "Ansonia Station" following the P.O. box number.

Several of our readers complained to us that inquiries to Ensca using the address as originally given were returned to them as undeliverable. Using the corrected ad-

dress should solve these readers' problem. This Editor has contacted Ensca several times using the correct address.

Mr. Sidney, Sales Manager for Ensca, Inc., stresses the need to include the Zip Code in the address. New York postal people are becoming very emphatic about the inclusion of Zip Code Numbers.

NEW FIELD MODIFICATION KITS

TYPE 3T77 SAMPLING PLUG-IN UNIT — IMPROVED SINE-WAVE TRIGGERING

This modification improves the display stability when triggering on high-frequency sine waves.

A change in the trigger circuit supplies a means of switching to a "lock-on" type of triggered operation when displaying high-frequency sine waves. This eliminates the drift in recovery time and the subsequent display break-up.

A new front-panel RECOVERY control with a push-pull switch replaces the old RECOVERY control. Pulling the switch to the ON position activates the RECOVERY control to synchronize the circuit on sine waves above approximately 30 Mc. Pushed in, the RECOVERY control activates the circuit to trigger on signals below 30 Mc.

This modification is applicable to Type 3T77 Sampling Units with serial numbers 126 through 839.

Order through your local Tektronix Field Engineer, Representative or Field Office. Specify Tektronix Part Number 040-372. Price: \$38.00.

TYPE 6R1 DIGITAL PLUG-IN UNIT — PEAK-TO-PEAK MEMORY AND IMPROVED COMPARATOR CARDS

This modification replaces the original Memory and Signal Comparator cards with new and improved cards. The new cards offer switch selection of Peak-to-Peak or Average Memory, switch selection of Fast or Slow charging rate, increased 100%-Zone adjustment and improved long term stability.

This modification also decouples the -12.2 volt supply to the Comparator Card. Installation requires changing some of the associated circuitry and includes some changes in the Vertical Input circuits to the Timing Start and Timing Stop switches.

This modification is applicable to Type 6R1 instruments with serial numbers 126 through 994. Please note, however, that instruments below serial number 695 must have the Series M Master Gate Card Modification (Tektronix Part Number 040-342) installed before this modification is performed.

Tektronix part number for the Peak-To-Peak Memory and Improved Comparator Card Modification Kit is 040-369. Order through your local Tektronix Field Engineer, Representative or Field Office. Price: \$398.00.

TYPE 581 AND TYPE 585 OSCILLOSCOPES — SILICON RECTIFIER

This modification replaces the original selenium rectifier assembly with a silicon diode rectifier assembly. This new rectifier offers better reliability and longer life.

The modification also adds a fuse in series with one of the AC leads for protection from damage caused by an overload or component short.

This modification is applicable to Type 581 instruments with serial numbers 101 through 1300 and Type 585 instruments with serial numbers 101 through 3762*. Please note that this modification does not apply to instruments that have had the modification kit "Regulated DC Filaments in the Vertical Amplifier" installed.

Order through your local Tektronix Field Engineer, Representative or Field Office. Specify Tektronix Part Number 040-387. Price \$5.85.

*Some instruments within this serial number range were factory modified. A visual check of your instrument will determine if it is one of these.

TYPE 321 OSCILLOSCOPE — VERTICAL LINEARITY IMPROVEMENT

This modification gives the Type 321 improved vertical linearity, minimum AC-DC gain change and reduced DC shift.

The improvement in the vertical linearity is accomplished by electrically relocating the POSITION control to the Input Amplifier emitter circuit, by reducing post accelerator voltage and by thermally balancing the Input Amplifier. The input protection neon is moved from the +45-volt supply to ground. This reduces the small "dark current" in the neon that tends to introduce dc shift.

The modification is applicable to Type 321 Oscilloscopes with serial numbers 101 through 4267. However, instruments in the serial number range 101 through 719 should have the Nuvistor Modification Kit (Tek-

tronix Part Number 040-309) installed before the Vertical Linearity Improvement Modification Kit (Tektronix Part Number 040-377) is installed.

Order through your local Tektronix Field Engineer, Representative or Field Office. Specify Tektronix Part Number 040-377. Price: \$12.60.

RELAY RACK CRADLE ASSEMBLY

This modification provides a rear support cradle for mounting the listed instruments in a backless relay rack by means of slide-out tracks. The slide-out tracks, which must be ordered separately, allow the instrument to be pulled out of the rack like a drawer and locked in one of seven positions; horizontal, or 45°, 90°, or 105° above and below horizontal.

The modification is applicable to instruments in the following list. The list also gives the slide-out tracks required for mounting the instrument in a backless relay rack.

Instrument	Serial Number	Slide-out Track Tek. Part No.
Type 127	309-up	351-006 (1 each)
Type RM15	101-up	351-006 (1 each)
Type 526	101-up	351-010 (1 each)
		and
		351-011 (1 each)
Type RM561	101-up	351-050 (1 each)
Type RM561A	101 to 105	351-050 (1 each)
Type RM561A	5001-up	351-050 (1 each)
Type RM564	100-up	351-050 (1 each)
Type RM647	100-up	351-006 (1 each)

Order through your local Tektronix Field Engineer, Representative or Field Office. Specify Tektronix Part Number 040-344. Price: \$12.00.

TYPE 121 PREAMPLIFIERS — SILICON RECTIFIER

This modification replaces the original selenium rectifier with a silicon-diode rectifier. The silicon-diode rectifier offers better reliability and longer life.

The modification applies to Type 121 instruments with serial numbers 101 and up.

Order through your local Tektronix Field Engineer, Representative or Field Office. Specify Tektronix Part Number 040-381. Price: \$3.65.

TYPE 502 AND TYPE 502A OSCILLOSCOPES — SAWTOOTH AND +GATE OUT

This modification installs two UHF output connectors (one for the direct coupled Sawtooth and one for the +Gate Out waveforms) on the rear panel of the Type 502 or Type 502A Oscilloscopes. The +Gate Out waveform is 40 volts and of the same duration as the +150-volt Sawtooth waveform. The waveforms are dc coupled to the connector via a dual cathode-follower assembly which mounts on the Time/CM switch bracket.

Order through your local Tektronix Field Engineer, Field Office or Representative. Specify Tektronix Part Number 040-312. Price is \$11.25.

TYPE 502 OSCILLOSCOPE — SILICON RECTIFIER

This modification replaces the selenium rectifier (SR642) used in the Type 502 with silicon rectifiers which offer more reliability and longer life. Order through your local Tektronix Field Engineer, Field Office or Representative. Specify Tektronix Part Number 040-383. Price is \$2.75.

USED INSTRUMENTS WANTED

A used Tektronix Plug-In oscilloscope in good condition. Type 531A, 533, or 541 preferred. Must have at least 10 Mc frequency response and a plug-in vertical preamplifier. Contact: H. E. Schauwecker, 8820 Sepulveda Boulevard, Los Angeles, California 90045. Telephone: Area Code 213 SP 6-3829.

A used 5 megacycle Tektronix Oscilloscope. Contact: Mike Talbot, 1C West Way, Greenbelt, Maryland.

A used Type 105 Square-Wave Generator. Contact: A. B. Robert, 4040 Goodland Avenue, North Hollywood, California. Telephone: PO 1-5984.

A used Type 502 or Type 502A Oscilloscope. Contact: Chester Shaw, Shaw Electronics, 2033 South Granville, Los Angeles 25, California. Telephone: Area Code 213 GR 7-1643.

A used Type 121 Wideband Amplifier in any repairable condition. Price must be in accord with condition but not over \$80.00. Also want a Scopemobile and a Type 124 Television Adapter. Contact: H. R. Greenlee, 430 Island Beach Boulevard, Merritt Island, Florida.

A used Type 502 Oscilloscope. Contact Ronald Leask, Springfield Army, Aircraft Weapons Systems Lab., Springfield, Massachusetts.

A used Type 503 or Type 504 Oscilloscope. Contact: Engineering Associates, 434 Patterson Road, Dayton, Ohio 45419.

USED INSTRUMENTS FOR SALE

1 Type 545A Oscilloscope, s/n 029483, with a Type CA Dual-Trace Plug-In Unit, s/n 31173. Both instruments recently factory reconditioned. Price: \$750.00. Contact: Carl G. Sontheimer, Anzac Electronics, Inc., Moody's Lane, Norwalk, Connecticut. Telephone: Area Code 203 838-8451.

1 Type 513D Oscilloscope, like new. Contact: Engineering Associates, 434 Patterson Road, Dayton, Ohio 45419.

1 Type 585A Oscilloscope. Brand new. Has never been unpacked. Price \$1400.00. Contact: Mr. Lubkin, Lubkin Associates, 33 Lewis Lane, Port Washington, New York.

1 Type 511AD Oscilloscope, s/n 3010. Best offer. Contact: J. L. Peters, 114 Dikeman Street, Hempstead, Long Island, New York.

1 Type 503 Oscilloscope, s/n 1473 in A-1 condition. Price: \$540.00. Contact: Carl Helmer, Repair Center Supervisor, Tektronix, Inc., 16930 Sherman Way, Van Nuys, California 91460 who will act as intermediary for the seller. Telephone: 987-2600 or 873-6868.

3 Type 2A63 Differential Amplifier Plug-In Units, 1 to 1½ years old. Price: \$100.00 each. Contact: Bill Gower, Zeltex, Inc., 2350 Willow Pass Road, Concord, California.

1 Type 502 Dual-Beam Oscilloscope, 2 Type 122 Preamplifiers, 1 Type 125 Power Supply, 1 Type 161 Generator, 1 Type 160A Power Supply, 2 Type 162 Generators. This equipment is modified and interconnected to provide a triggered delay sweep and gating XY loops for EKG studies. Contact: Dr. Julian Isaacs, 9735 Wilshire Boulevard, Beverly Hills, California. Telephone: CR 6-4155.

1 Type 3A72 Dual-Trace, DC-to-650 kc Plug-In Unit, s/n 003213, purchased in February, 1964, and has seen very little usage. Asking price: \$195.00. Contact: Max W. Scholfield, Chief Engineer, International Radio and Electronics Corporation, 1718 West Mishawaka Road, Elkhart, Indiana. Telephone: JA 3-4919.

1 Type 535A Oscilloscope, s/n 28640. Approximately two years old, recently factory reconditioned. Contact: Ralph Sellers, Heliodyne Corporation, 2365 Westwood Boulevard, Suite 201, Los Angeles 64, California. Telephone: 879-0170.

1 Type CA Dual-Trace Plug-In Unit, s/n 13443. Not used since new and has been in air-conditioned storage. Asking price: \$150.00. Contact: Dr. V. J. Wulff, Masonic Research Lab., Utica 2, New York.

The following instruments are offered for sale by the Information Storage Systems:

1 Type 543	s/n 2097	\$ 950.00
1 Type 531A	s/n 21997	750.00
1 Type 661	s/n 821	} 2500.00
1 Type 5T1A	s/n 1006	
1 Type 4S1	s/n 708	} 2500.00
1 Type 661	s/n 465	
1 Type 5T1A	s/n 461	} 2500.00
1 Type 4S1	s/n 455	

Contact: Paul Margolin, Information Storage Systems, 222 Wanaque Avenue, Pompton Lakes, New Jersey. Telephone: 839-0001.

1 Type 515 Oscilloscope, s/n 897, in good condition. Contact: Decisional Controls, 1590 Monrovia Avenue, Newport Beach, California, Attention: John Flood.

1 Type 53C Dual-Trace Plug-In Unit, s/n 2855. Price: \$75.00. Contact: Egon Donner, IBM Corporation, Monterey and Cottle Roads, San Jose, California. Telephone: 227-7100, xtn 3354.

1 Type RM35 Oscilloscope, s/n 258, with a Type 53/54C Dual-Trace Plug-In Unit, s/n 21216. Both instruments in very good condition. Total price: \$975.00. Contact: Robert Desormeaux, Box 9, Williamstown, Massachusetts.

1 Type 512 Oscilloscope, s/n 1006 with new crt. Also, will trade a Type 517 Oscilloscope, s/n 504, for a low-frequency laboratory oscilloscope. Contact: Al Herman, Surface-Air Electronics, 138 Nevada Street, El Segundo, California. Telephone: SP 2-1469 or EA 2-5571.

The Denro Labs offer the following instruments for sale or will consider a trade on a Type 585 Oscilloscope or a Type 575 Transistor-Curve-Tracer Oscilloscope:

1 Type 122	s/n 967	\$ 65.00
1 Type 121	s/n 1856	175.00
1 Type 517		695.00
Extra power supply for Type 517		100.00
1 Type 513D	s/n 999	275.00
1 Type 513	s/n 1003	225.00

Contact: Dennis Roveti, Denro Labs, 1643 Forest Drive, Annapolis, Maryland. Telephone: CO 8-0456.



The Nassua Messenger Service reports the loss of a Type 1A1 Wide-Band Dual-Trace Plug-In Unit, s/n 569, from one of their carriers. The instrument was in transit to the Columbia Radiation Laboratory at the time of disappearance. Information regarding the whereabouts of this instrument should be reported to the Nassua Messenger Service, Mineola, New York.

The following instruments have been missing from the Consolidated Electrodynamics of Pasadena, California for some time. They may have been stolen:

1 Type 515 Oscilloscope	s/n 642
1 Type 531 Oscilloscope	s/n 7184
1 Type 321 Oscilloscope	s/n 1108
1 Type D Plug-In Unit	s/n 11168
1 Type CA Plug-In Unit	s/n 9501
1 Type R Plug-In Unit	s/n 482

Please contact the Consolidated Electrodynamics people if you have any information on any of these instruments.

Missing and presumed stolen is a Type 310 Oscilloscope, s/n 576. This instrument belongs to the IBM Corporation and disappeared from one of their local accounts in Olympia, Washington.

Our readers are asked to report any information on this scope to A. A. Russel, IBM CE Manager, 106 Maple Park, Olympia, Washington.

Control Data, Inc., of 1254 Winston Plaza in Melrose Park, Illinois, reports the loss of a Type 310A Oscilloscope, s/n 100998. This instrument is also presumed to be stolen. Mr. Dennis Farrell is the man to contact at Control Data, Inc., if you have any information on this instrument.



Tektronix, Inc.
P. O. Box 500
Beaverton, Oregon

Service Scope

USEFUL INFORMATION FOR
USERS OF TEKTRONIX INSTRUMENTS

BULK RATE
U. S. POSTAGE
PAID
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Mr. Ed. Harding
5325 Colfax Ave., S.
Minneapolis, Minn.