RCA Quicktracer Transistor Checker

Type WC-528B

The RCA WC-528B Quicktracer may be used with any general purpose oscilloscope to make rapid point-to-point checks of transistors (excluding FETs), zener diodes and other diodes, capacitors, and resistors. Distinctive Quicktrace waveforms indicate at a glance whether the component under test is functioning properly.

Special "stick-on" fastening material is provided on the Quicktracer so that it can be mounted on the side of an oscilloscope, workbench, wall, or other convenient, smooth surface. The unit can be installed and removed as often as desired. An extra fastening piece is provided, so that you can place the Quicktracer in your choice of two locations.

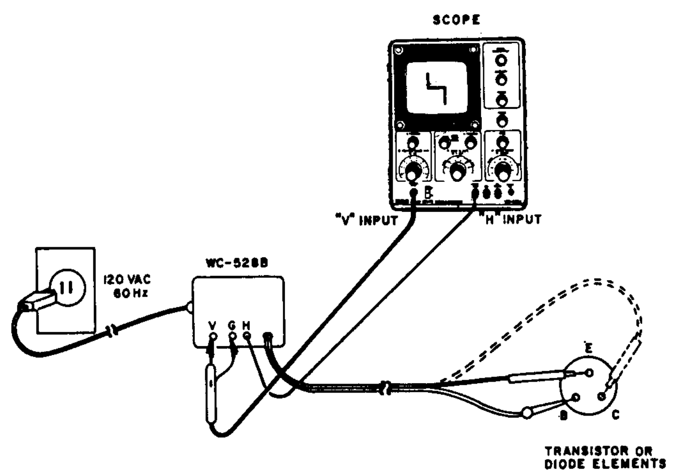
Instructions for operating the Quicktracer are provided below. Detailed application information is contained in the special booklet that is also supplied.

WC-528B Quicktracer

Equipment Hookup

1. Plug the Quicktracer into a 120 volt, 60 Hz outlet. Connect the oscilloscope vertical probe to terminal "V" and the ground lead to "GND" on the Quicktracer. Connect a lead from the scope horizontal input jack to terminal "H" on the Quicktracer.
2. Set Scope horizontal sweep selector to "external". Adjust the horizontal gain to produce a horizontal line with almost full-scale deflection.
3. Short together the Quicktracer test leads, and adjust the vertical gain for a vertical line with almost full-scale deflection.

Note: When making in-circuit tests, turn off equipment under test. If it is an AC/DC chassis, unplug the power cord, or use an isolation transformer such as the RCA WP-25A or WP-26A Isotap.



Equipment Hookup

Transistor Test (In-or-Out of Circuit)

Connect the black test lead to the transistor base. Connect the probe to the collector, then to the emitter.

A straight vertical line indicates a shorted junction.

A straight horizontal line indicates an open junction.

For further test data and waveform analysis, refer to "Service Tips" booklet supplied with the Quicktracer.

Diode Test

Connect the Quicktracer test leads across the diode elements. Interpret results in a similar manner as for transistor junctions, described above.

Out-of-Circuit UHF Diode Tests

The Quicktracer limits the maximum power applied to the device under test to 100 milliwatts. However, certain types of small UHF diodes, "Schottky" diodes, and point-junction diodes can be damaged in an out-of-circuit test, or even by static discharge in handling.

If you are not sure if the diode will withstand the 100 milliwatt level, connect a 10 K ohm resistor in series with the Quicktracer probe. This will provide enough additional current limiting to protect the type of diodes noted above.

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RCA

The Quicktracer System

for

Transistor, Diode, Zener Testing

Routine testing of transistors as a troubleshooting technique has been advocated by many authorities in the servicing industry, often with little or no consideration given to the practical aspects of the technique. Several methods of testing a transistor have been proposed, and each has certain advantages and disadvantages. These are summarized here:

Out-of-circuit curve tracing is used almost exclusively in design and development work. Of the methods described here, this testing procedure yields the greatest amount of information. However, from the point of view of the servicing technician, the time required to remove the device from the circuit, test it, and reinstall it is excessive; **often the value of the time expended exceeds the value of the device being tested.** Further, the service technician often lacks the specifications or tolerance limits of the device, which makes much of the test data superfluous.

Out-of-circuit testing with a transistor tester which uses a meter as an indicating device requires less capital outlay, but it shares with the curve tracer the other disadvantages. It is not intended to imply that either of these techniques is basically faulty, (quite the contrary is true); the undesirability lies in the fact that the procedure is time-consuming and more data is obtained than is actually needed.

A number of transistor testers are available which allow both out-of-circuit and in-circuit testing. The in-circuit test greatly reduces the time required for the test; however, the data obtained are often misleading because of the loading effects of the circuitry to which the transistor is connected. This problem would be alleviated if in-circuit test data could be made available for transistors when they are connected in their circuits; however, the tremendous number of transistors, circuits, and testers in use today makes a compilation of this information a practical impossibility.

Performance testing of a transistor while it is in operation in its circuit is an excellent method of transistor testing. This, of course, requires either substitution of the device in question, or rather complicated signal-tracing procedures, either of which is time-consuming. Voltage measurements of the transistor elements are indicative of transistor performance in some circuits, but not in others—particularly if the transistor is normally biased into cutoff.

Diode testing of the transistor, using only an ohmmeter, is adequate in most troubleshooting applications. Electrons will flow from base to emitter and from base to collector in a PNP device, and in the opposite direction in an NPN transistor. If either junction conducts in both directions—or fails to conduct at all—the transistor is defective. A second mode of failure, leakage current through either junction, also can be detected with an ohmmeter—if the maximum allowable leakage current is known. This method of testing is surprisingly valid, since the usual modes of transistor failure are open junctions, shorted junctions, or excessive leakage current; however, in-circuit testing is subject to many errors because of the shunt effect of the circuitry to which the transistor is connected.

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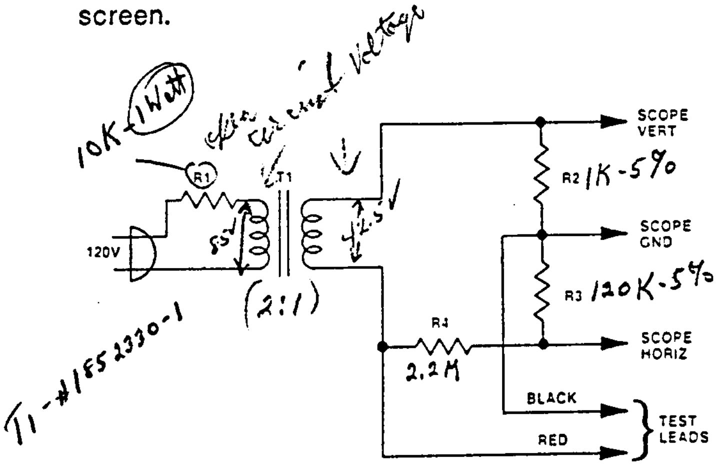
The transistor testing method used by the WC528 Quicktracer combines features of curve tracing and diode checking as described in the preceding paragraphs. Hence, it has some of the advantages, and suffers from some of the disadvantages, of both. These will be considered in the explanation of its circuitry and use which follow.

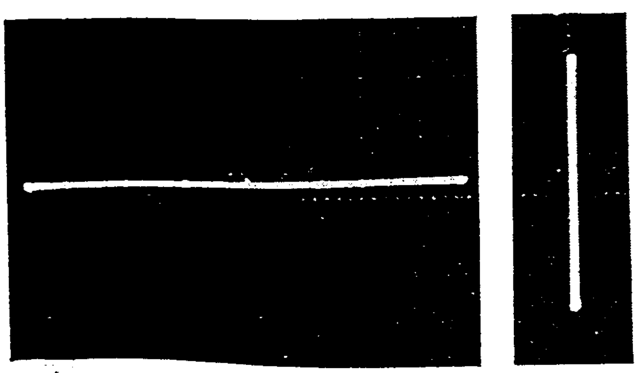
Circuit Description

Figure 1 shows the complete schematic of the WC528 Quicktracer. With the instrument connected to a scope and with the test leads not connected, the entire output of the transformer is applied to the horizontal input of the scope. A horizontal line results. If the test leads are connected together, the output of the transformer is applied to the vertical input of the scope, and a vertical line results. It is desirable to adjust the scope gain so that the lines approximately cover the CRT screen.

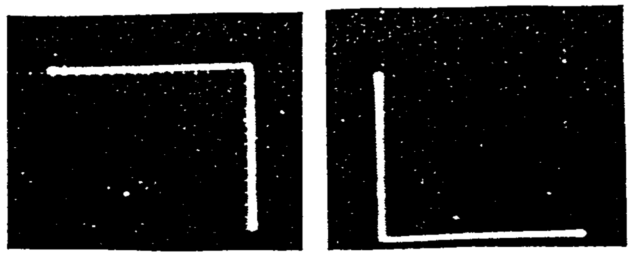


WC528 Quicktracer

Discounting barrier potential, if a diode is connected between the test leads, the scope will indicate a short circuit (vertical line) whenever the diode is forwarded biased, and an open circuit (horizontal line) whenever the diode is reverse biased. If the diode is open, a horizontal line is produced; a shorted diode produces a vertical line. If the cathode is always connected to the black (ground) test lead, vertical deflection always will be downwards and will occur at the right end of the scope trace. (It is assumed that the scope has normal phasing so that a positive-going voltage produces upward vertical deflection and horizontal deflection towards the right.) If the test leads are reversed, vertical deflection will be upward and will occur at the left end of the horizontal trace.



The horizontal line is produced when there is an open between the test leads; a short produces a vertical line. The scope may be adjusted to produce the desired lengths.



Waveforms generated when a diode is connected to the test leads. The one at the left results when the black test lead is connected to the diode cathode. Reversing the diode connections produces the waveform at the right.

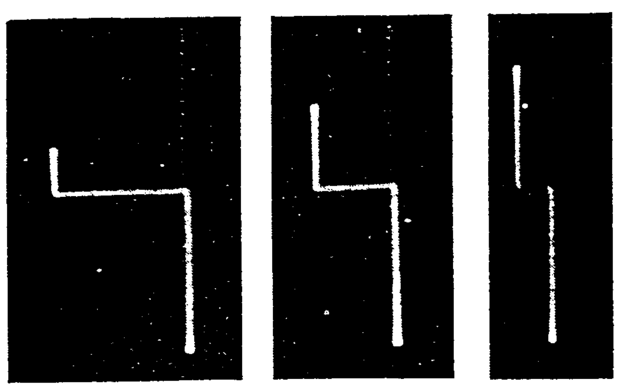
Diodes will conduct in either direction if sufficient voltage is applied. This is not destructive if the inverse current is limited so that the power dissipation within the device is held below the maximum rating. **In the WC528, power dissipation within any device is held below 75 milliwatts.** Few, if any, junctions will be damaged below 100 milliwatts; but some of certain types of UHF tuner diodes may be damaged. When testing these, connect a 10,000-ohm resistor in series with the diode.

Power is limited by R1 in the primary of T1, since this causes the output voltage to decrease radically when load current flows. The same result could have been realized by using a transformer with high flux leakage.

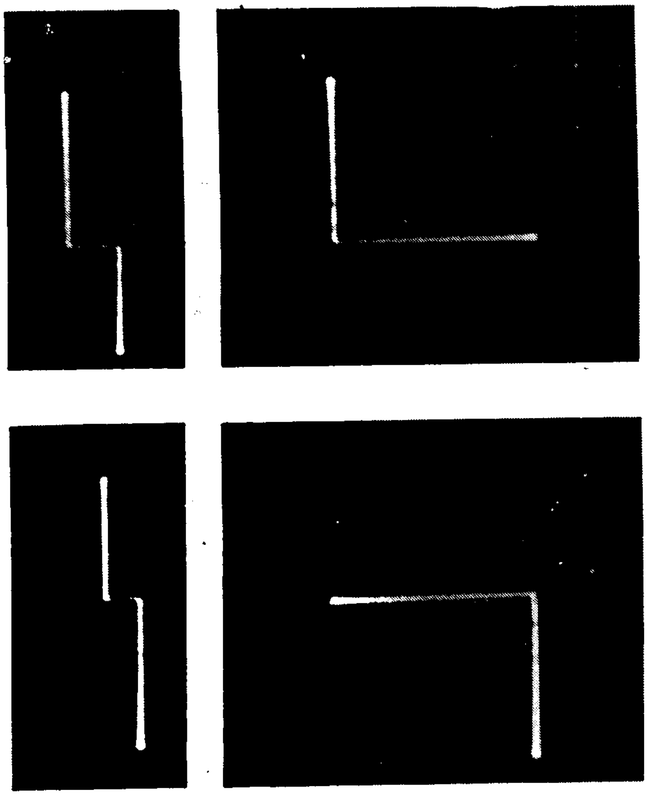
The photographs below show the waveforms produced when zener diodes are tested. The downward deflection at the right is the result of normal diode conduction. The upward deflection at the left occurs when the applied voltage exceeds the zener voltage of the diode.

Description of Test

For purposes of testing, a transistor may be considered as two diodes connected in series with opposing polarities. If the transistor is PNP, the base material serves as a cathode; the emitter and collector are the two anodes. Therefore, if the black test lead from the WC528 is connected to



Waveforms produced by zener diodes. The length of the horizontal section indicates zener voltage. From left to right, 30, 15, and 7-volt zeners were tested. Scope horizontal sensitivity in this series of waveforms is about 12.5 volts/cm.



Typical waveforms ***produced*** *by good transistors. The base-emitter waveforms are at the left and the NPN waveforms are at the top.*

The waveform photographs below show the waveforms produced by various resistances shunted across the base-collector junction of a good transistor.

Because of the shunting effects of the external circuitry, the **Quicktracer** is most effective when the waveforms produced by a transistor in a specific circuit are known. When these data are available, the technician needs only to compare these with the waveforms he obtains to find a fault. **In many instances, this will be much more productive than attempting to find the fault by more conventional methods.**

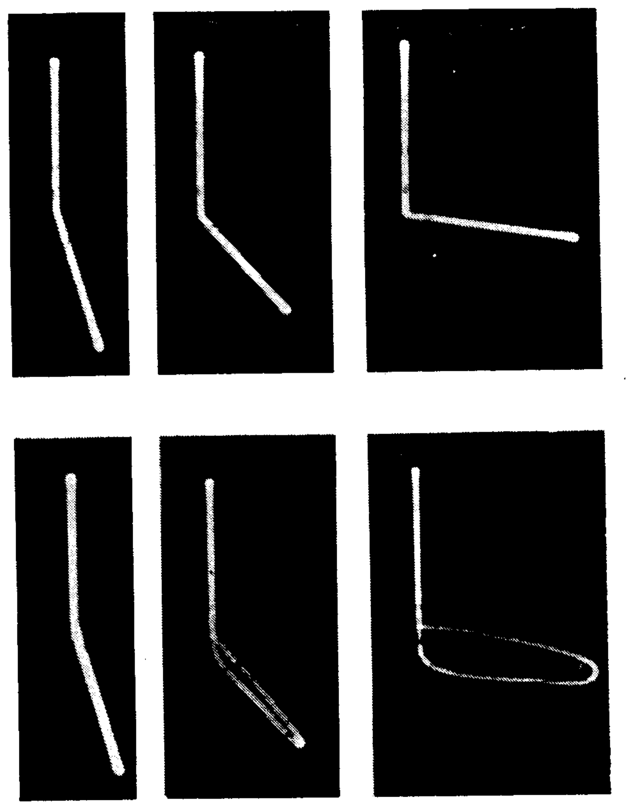
If waveform data are not at hand, the technician may proceed on the assumption that any transistor or diode waveform having only right angles indicates a good device. Any straight horizontal waveform indicates an open junction and a bad transistor, since no external circuit can affect the waveform in this way. In nearly every instance, a vertical-line waveform indicates a defective device (shorted junction), since few circuits except power supplies have less than a few hundred ohms shunted across the junction.

When waveforms other than those described above are observed, the quality of the device is in question. This may be resolved either by disconnecting the device for further tests, or more conveniently, by comparing the observed waveform with the

the base of the transistor, connecting the other test lead to either the emitter or collector will produce downward deflection at the right end of the trace. If an NPN transistor is tested, deflection will be upwards at the left, because the base serves as an anode, rather than a cathode.

The output voltage of the WC528 Quicktracer was designed to exceed the PIV of most emitter-base junctions. (R1 in the primary of T1 limits current so no damage is done.) Because of this, the waveform produced when the emitter-base junction is tested has vertical excursions at both ends of the horizontal trace. In all cases, the PIV of the emitter-base junction is greater than its forward barrier potential, so the vertical deflection representing reverse (zener) conduction will be shorter than deflection caused by forward conduction. **The output voltage of the WC528 is normally less than the PIV of the base-collector junction,** hence vertical deflection occurs at only one end of the trace. This allows the base-emitter junction of most transistors to be identified.

Transistor leakage current appears to the tester as a resistor shunted across the junction under test. When the transistor is forward biased and conducting, the junction resistance is practically nil and the shunt resistance has no effect on the waveform. When the junction is reverse biased the effect of the shunt resistance is noticeable because it is much lower than the back resistance of a normal junction.



The effect of shunt impedance across a junction is illustrated in the waveforms above. From left to right in the top row, the shunt resistances were 470, 1000, and 10K ohms. To produce the lower row of waveforms, a .22-μF capacitor was connected across the resistor.

known, normal waveform. A number of data sheets are included in this publication, additional sheets will be published as they become necesary.

It is suggested that technicians sketch the normal waveforms on various schematics adjacent to the transistors and diodes. This will provide a ready reference for future troubleshooting of the same chassis type. To save time, any transistor which exhibits no loading effects may be marked "normal," rather than being marked with waveform sketches.

Operating Instructions

Any oscilloscope suitable for general television servicing, and many which are not, may be used in conjunction with the WC528. The output of the Quicktracer that is connected to the scope vertical input (test leads shorted together) is about 30 volts peak-to-peak; horizontal drive to the scope is approximately 4 volts peak-to-peak. The scope should have sufficient sensitivity to produce full-screen deflection with these inputs.

If the scope to be used has insufficient horizontal sensitivity, additional drive may be obtained by connecting a shunt resistor between the red test lead and the horizontal output lead of the Quicktracer. A 1-megohm resistor will increase the drive to about 12 volts; 470K ohms will produce a drive of about 17 volts. **Use the highest possible value of shunt resistance, since the horizontal amplifiers of many scopes saturate very easily with excessive drive and severe waveform distortion will result.**

To set up the WC528 for testing, proceed as follows:

1. Turn on the scope and set the horizontal-input selector to "external."
2. Adjust the scope to produce a dot at the center of the CRT screen.
3. Connect the horizontal, ground, and vertical outputs of the WC528 to the corresponding scope terminals, and plug in the WC528.
4. Adjust the scope horizontal gain to produce about full-screen horizontal deflection.
5. Short together the test leads of the WC528 and adjust the scope vertical gain for approximately full-screen vertical deflection.

Test Procedure for Diodes

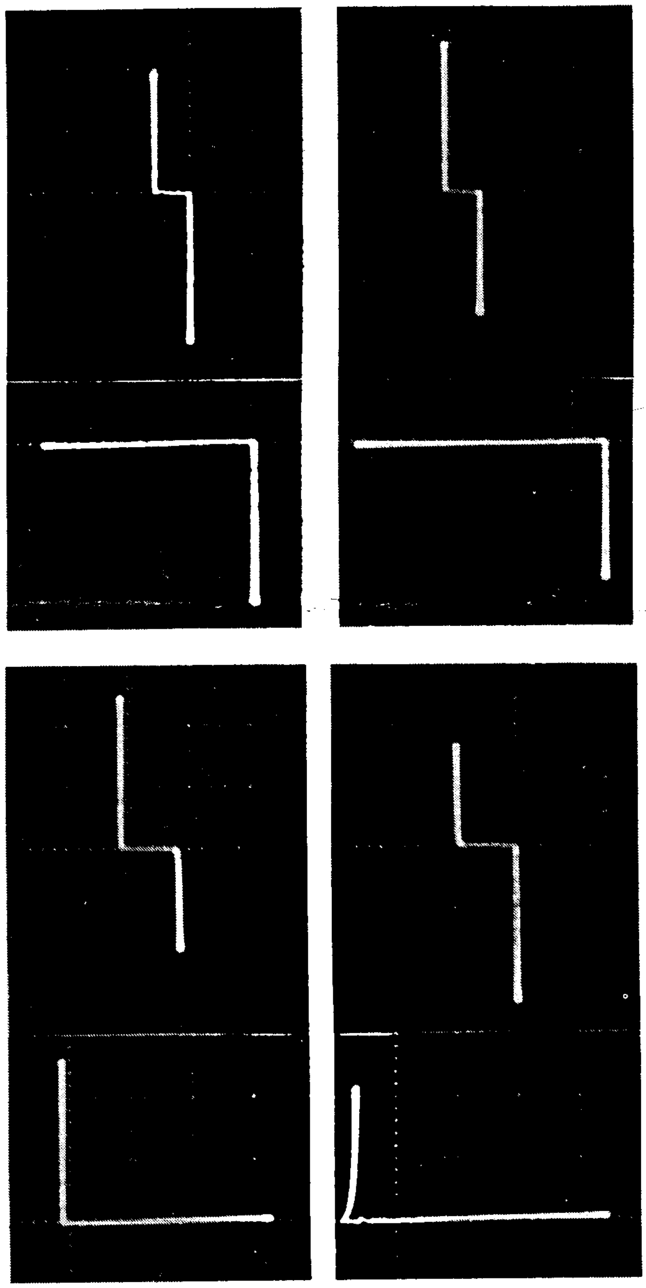
Connect the test leads to the diode and observe the waveform. If the trace deflects downwards at the right, the cathode is connected to the black test lead. No vertical deflection indicates an open diode.

A straight vertical line indicates a shorted device, except in power supplies where the shunt current through the filter capacitors causes an apparent short. If leakage is indicated, slanted "horizontal" deflection, it may be determined if this is a diode fault or a shunt circuit by disconnecting one end of the diode and checking it out of the circuit, or by comparison of the waveform with a standard.

Out-Of-Circuit Transistor Test

The elements of most transistors and their types (PNP or NPN) can be identified by the following procedure:

1. Connect the test leads at random to the transistor; when the waveform approximates any of the ones specified below, the leads are connected across the base-emitter junction.



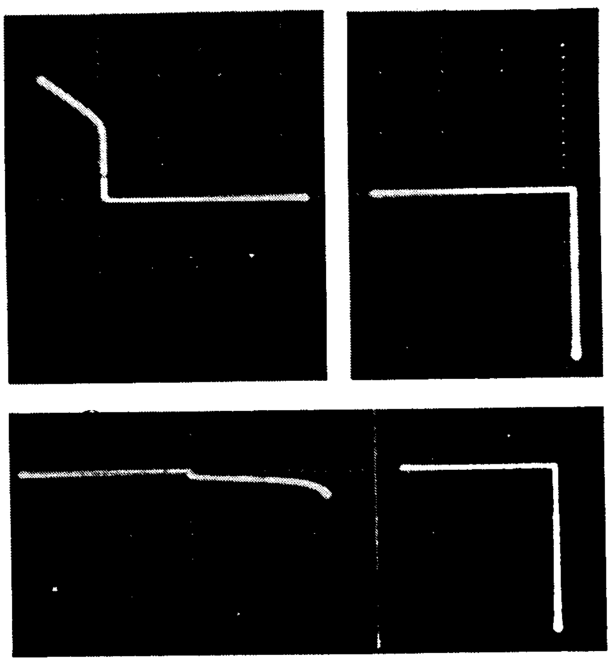
Waveforms produced by the base-emitter junction are shown in the top pair in each set. The remaining transistor lead is the collector. With the red test lead connected to the collector, greater vetical deflection results when the black test lead is connected to the base (lower left waveform of each set). The lower right waveform in each set results when the black lead is connected to the emitter. The top set of waveforms is typical for a PNP transistor; the bottom for an NPN device.

2. Connect the red test lead to the collector.
3. Connect the black lead alternately to the two remaining leads. The vertical deflection in the waveform will be greater when the lead is connected to the base.
4. When the black test lead is connected to the base, vertical deflection will be downwards at the right for PNP transistors and upwards at the left for NPN transistors.

A few transistors may not exhibit zener conduction through the base-emitter junction. In this case, Step 1 is impossible, and the following procedure should be used:

1. Connect the leads at random to the transistor; when an open circuit is indicated, the leads are connected to the collector and emitter. (Some conduction may occur near voltage crossover).
2. Connect the black test lead to the base.
3. When the black test is connected to the base, vertical deflection will be downwards at the right for PNP transistors and upwards at the left for NPN transistors.

Transistor leakage will be indicated by angular displacement of the horizontal segment of the test waveform. Any leakage in a silicon transistor should be considered a fault. In some germanium power transistors some "tilt" of the horizontal segment of the waveform may be acceptable. An angle of 10° from horizontal indicates about 5700 ohms of leakage resistance.



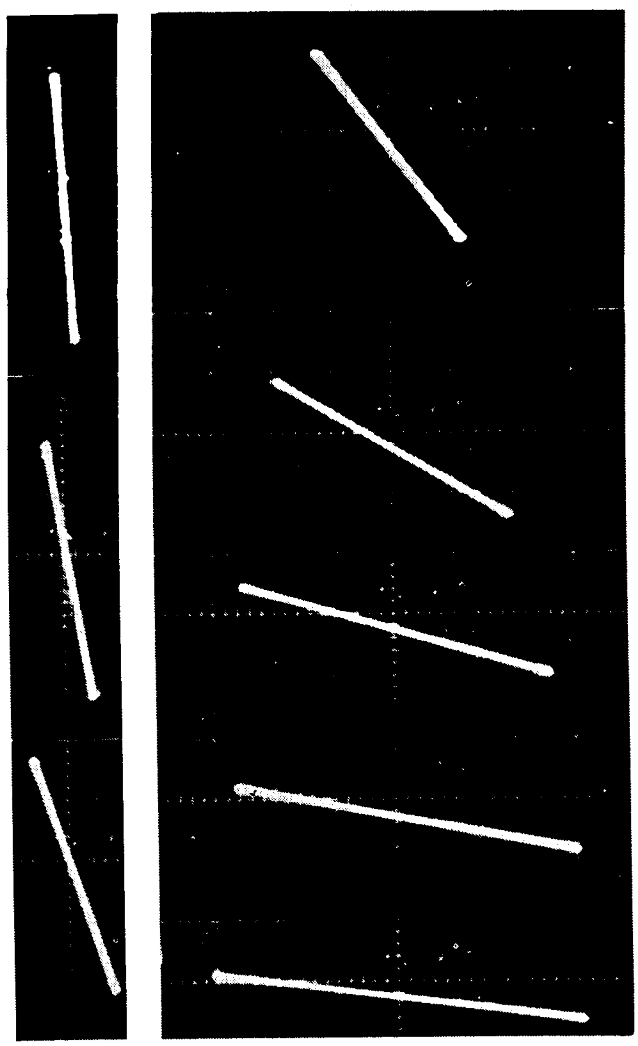
Examples of waveforms produced when there is no reverse conduction through the base-emitter junction (right). Waveforms at the left were produced by connecting to the emitters and collectors. The base-collector waveforms are identical to the base-emitter waveforms.

In-Circuit Transistor Tests

If no reference data are available, the same techniques may be used to test transistors and identify their terminals, either in-circuit or out-of-circuit. However, the WC528 Quicktracer cannot distinguish between transistor leakage resistance and shunt resistance of the circuit into which the transistor is connected.

The tilt of the waveform is a function of the total resistance across a junction. The correlation between the angle of displacement of the horizontal portion of the waveform and shunt resistance across the junction is shown approximately by the waveforms given in the resistance measurement procedure. **If the vertical section of the waveform is tilted, the transistor is bad,** since no external circuit can increase the zero resistance of a forward-biased junction.

If reference data are available, comparison of the test waveform with these data is the most reliable testing technique. If the transistor terminals can-



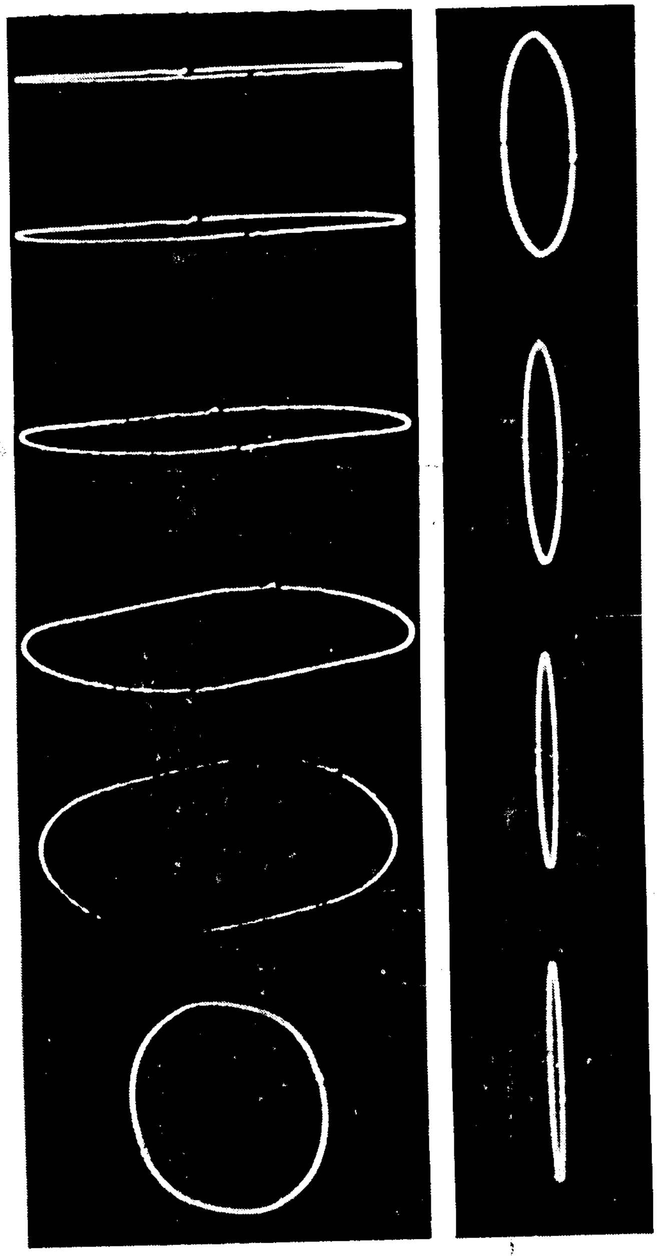
The "slant" of the baseline indicates the resistance between the test leads of the Quicktracer. A short producs a vertical line and an open produces a horizontal line. The resistances used to produce the waveforms above were 100 ohms (upper left), 220, 470, 1000, 2.2K, 4.7K 6.8K, and 10K (lower right).

not be identified by inspection, make random connections of the WC528 until the test waveform correlates with one of the reference waveforms.

If the test waveforms are not very nearly the same as the ones given in the reference, a fault is presumed to exist. An open-circuit indication (straight horizontal line) always indicates a defective junction (open). Other abnormal waveforms can be caused by either a fault in the transistor or in the surrounding circuitry.

Other Tests

The WC528 may be used conveniently as a **continuity tester,** since a horizontal line indicates an open and a vertical line indicates continuity. Approximate resistance measurements are possible by observing the slant of the base line.



Capitance may be approximated by comparison with these wavefoms. From top to bottom in the left column the capacitors used were .047μF, .1μF, .22μF. .47μF, 1μF, and 2μF. To produce the waveforms in the right column, capacitances of 5, 10, 20, and 30μF were used.

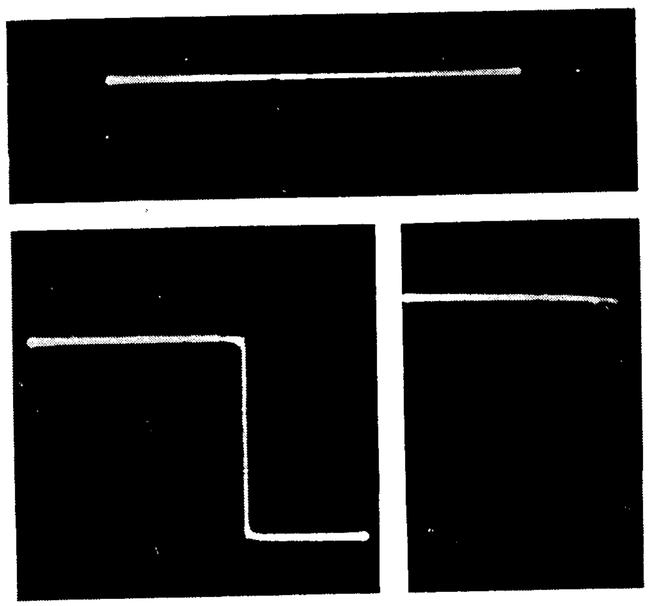
Approximations of capacitance also are possible within the range of about 0.2μF to 20μF. The photographs below show the waveforms produced by various capacitors. Naturally, any shunt impedance across the capacitor being tested will change the waveform.

If an oscilloscope having a direct-coupled vertical amplifier is used, the **voltage characteristics** (below 40 volts) of zener diodes may be accurately measured by the following procedure:

1. Connect the vertical output of the WC528 to the horizontal input of the scope and connect ground to ground.
2. Connect the vertical scope input to the red test lead of the Quicktracer.
3. Short the test leads together and position the horizontal line on the scope to a zero-voltage reference line.
4. Connect the zener to the test leads (cathode to black lead).
5. Downward deflection indicates zener voltage.
6. Upward deflection indicates junction barrier potential.

The same techniques may be used to determine the forward and reverse voltage/current characteristics of transistor junctions.

Junction FET's may be tested for integrity of the junctions. Little useful information will be gained by attemtping to test MOSFET's and they may be damaged by the Quicktester.



Pertinent waveforms for checking junction voltages. Top, test leads shorted to establish zero-voltage baseline; lower left, 5-volt/cm scale indicates zener voltage; lower right, 1-volt/cm scale indicates barrier potential.