8th Comm BN

L.E. EUGLE

DEPARTMENT OF THE NAVY
HEADQUARTERS UNITED STATES MARINE CORPS
WASHINGTON, D. C. 20380

NORMAL

TI-10510-35/3A
13 Jun 1973

U.S. MARINE CORPS TECHNICAL INSTRUCTION

TROUBLESHOOTING PRINTED CIRCUIT BOARDS

ELECTRONIC EQUIPMENT

1. Purpose. To provide technical information and instructions for an improved method of troubleshooting PCB's (printed circuit boards) on electronic equipment.

NOTE

This TI is based on information provided in NAVSHIPS E1B815.

2. Cancellation. TI-10510-35/3.

3. Information

a. Disadvantages of Troubleshooting PCB's With an Ohmmeter. Troubleshooting PCB's with an ohmmeter has these disadvantages:

(1) It requires that all but one lead of the component under test be disconnected from the circuit.

(2) Removal of the leads involves time-consuming and expensive labor in soldering and resoldering leads.

(3) The soldering techniques themselves have been rendered obsolete by the miniaturization and microminiaturization of electronic components and by the density of their placement.

(4) Heat from a soldering iron is particularly hazardous when components are tiny and close together.

PCN 168 100200 00

Further, inadvertent use of a soldering gun can induce a destructive current in solid state devices.

(5) Some ohmmeters, even at low range, generate enough current to damage solid state components whose current-handling capacities decrease as their sizes decrease.

(6) Unsoldering and soldering components may result in damage to previously good components.

(7) Ohmmeters cannot normally detect shorted inductors or open capacitors.

b. Advantages of "In-Circuit" Troubleshooting. "In-circuit" troubleshooting, as its name implies, is troubleshooting without disconnecting components from the PCB or equipment. This method is possible with an "octopus," an assembly which, with its power cord, oscilloscope leads, and protruding probe cables, looks like an "octopus." In addition to saving the equipment from the ravages of soldering heat, in circuit troubleshooting with the octopus will:

(1) Reduce maintenance time.

(2) Reduce material damage due to present techniques.

(3) Improve maintenance techniques.

(4) Increase operational readiness of units by decreasing downtime of essential equipment.

(5) Simplify localization of faulty components for corrective maintenance.

(6) Provide visual display of component condition.

(7) Test components under dynamic energized conditions.

4. Octopus Assembly. Assemble the octopus in either of the following three ways:

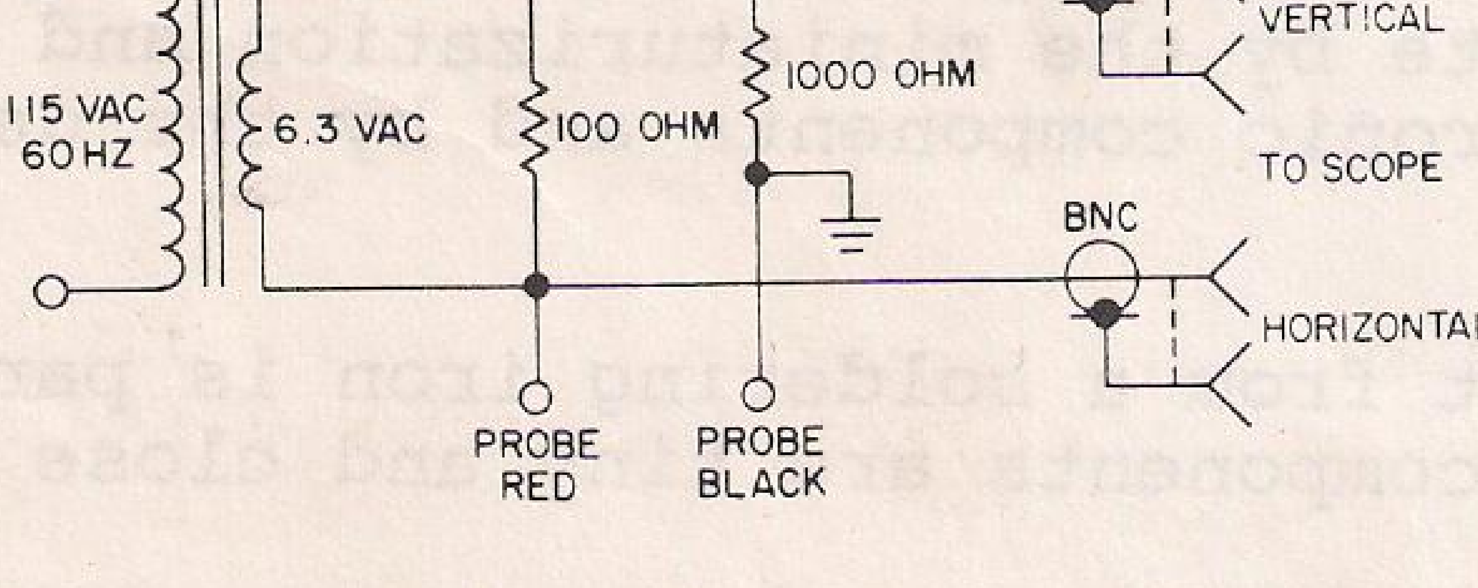

Figure 1. Tester With 6.3-Volt Filament Transformer

a. Tester With 6.3-Volt Filament Transformer. Assemble the tester as shown in figure 1, using:

(1) One filament transformer, 115 to 6.3 volts (the 6.3-volt size is commonly used; the 6.3 volts are dropped by resistors to 1.0 volt).

(2) Three resistors; one each at 1,000 ohms, 560 ohms, and 100 ohms (the 1,000-ohm resistor placed across the 1.0 voltage assures a safe current of 1.0 milliampere).

(3) Two test lead probes, color-coded (black for the ground and red for the hot lead). If leads are not needle-tipped, file the leads to a sharp point so they will penetrate the plastic and moisture/fungus proof coating frequently found on PCB's. Attach leads to the octopus permanently.

(4) Two BNC female connectors (used for vertical and horizontal outputs).

NOTE

Cables may be permanently fastened, if desired. Also, if desired, an on-off switch and an indicating neon lamp may be added to the primary output circuit.

b. Tester Using 1.0-Volt Source. Assemble the tester as shown in figure 2, substituting a variable frequency audio oscillator as the test voltage source.

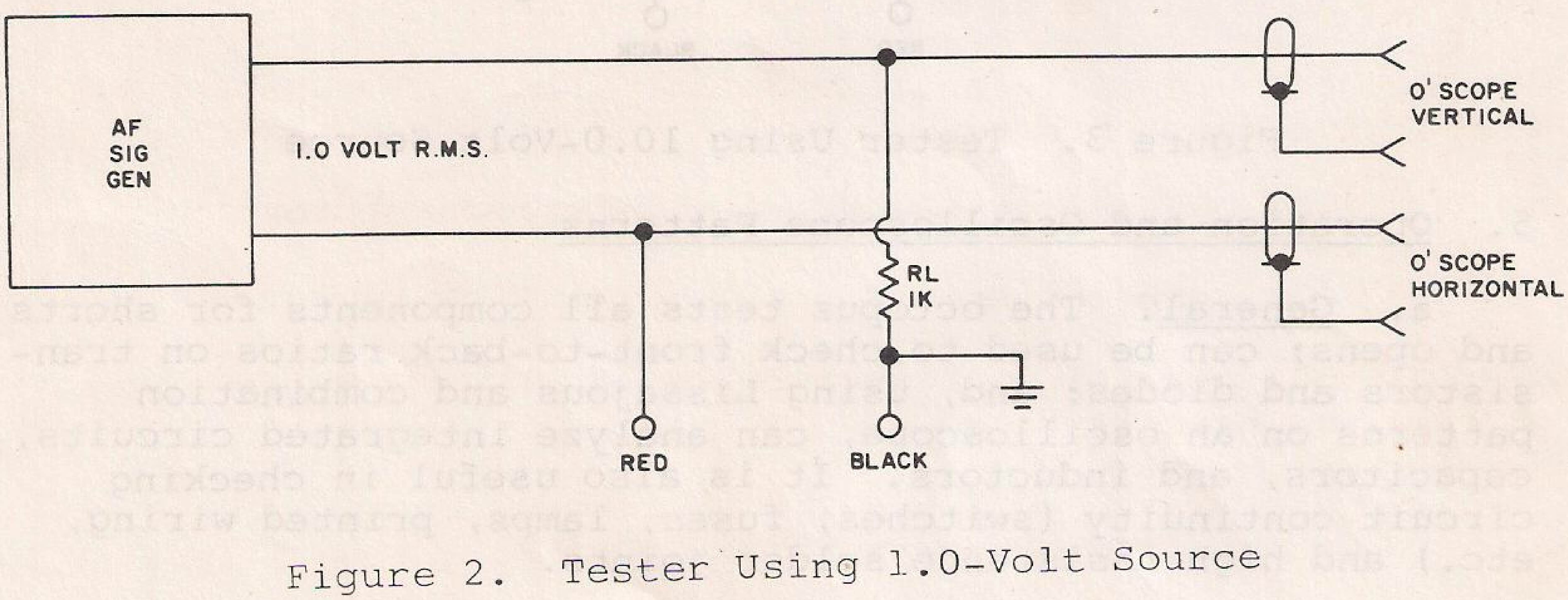

Figure 2. Tester Using 1.0-Volt Source

NOTE

The 560-ohm and 100-ohm voltage divider resistors shown in figure 1 may be eliminated if the audio oscillator output can be fixed at 1.0-volt rms.

c. Tester With 10.0-Volt Source. Assemble the tester as shown in figure 3, which shows a 10.0-volt variable frequency audio oscillator source with proper values of resistance necessary to reduce the output to 1.0 volt.

NOTE

The use of a variable frequency test voltage source allows the tester to extract meaningful information from components that are either too large or too small in value to be tested with 60 Hz alone. Experience proves that while a large capacitor appears to be shorted when tested with 60 Hz, it can be made to show an oval pattern when the frequency is decreased and a small capacitor which appears open at 60 Hz can be checked by increasing the test frequency.

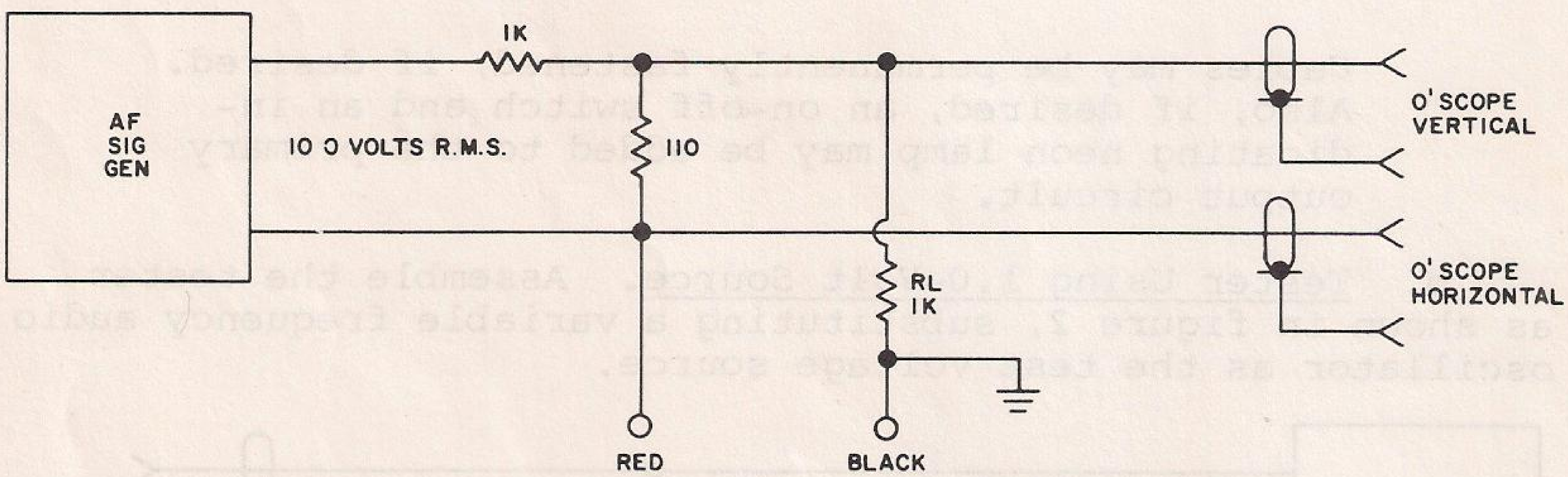

Figure 3. Tester Using 10.0-Volt Source

5. Operation and Oscilloscope Patterns

a. General. The octopus tests all components for shorts and opens; can be used to check front-to-back ratios on transistors and diodes; and, using Lissajous and combination patterns on an oscilloscope, can analyze integrated circuits, capacitors, and inductors. It is also useful in checking circuit continuity (switches, fuses, lamps, printed wiring, etc.) and high resistance solder joints.

b. Operation

(1) Connect the vertical output of the octopus to the oscilloscope vertical input and its horizontal output to the oscilloscope horizontal input. The oscilloscope vertical and horizontal gain controls should be adjusted to prevent trace

L.E. GUGLE

ends from going-off screen. Remove power from the PCB when testing for shorts. If the PCB or chassis under test is grounded, the black lead should be attached to the ground end of the components.

(2) Because the octopus is an ac device, the technician is able to observe reactive components, Lissajous patterns, and front-to-back ratios of junction components. Reversal of the test leads is unnecessary.

(3) When testing transistors, check first from the base to one side and then from the base to the other side. A collector-to-emitter test would have to pass through two junctions in series and will not, therefore, produce a usable pattern. For a technician to become proficient in testing components in-circuit, it is necessary for him to recognize the basic patterns when they appear singly and in combination. Subsequent paragraphs discuss common patterns that may be observed. Use of the octopus is limited only by the ability of the technician to interpret observed patterns and is not limited to the circuits discussed in subsequent paragraphs.

c. Basic Patterns. Figure 4 illustrates basic oscilloscope displays. Capacitors of very small value will appear open rather than reactive, and inductors will appear shorted rather than reactive. In most cases, however, it is still possible to detect a shorted capacitor or an open inductor by increasing the gain adjustments on the oscilloscope to the desired amplification.

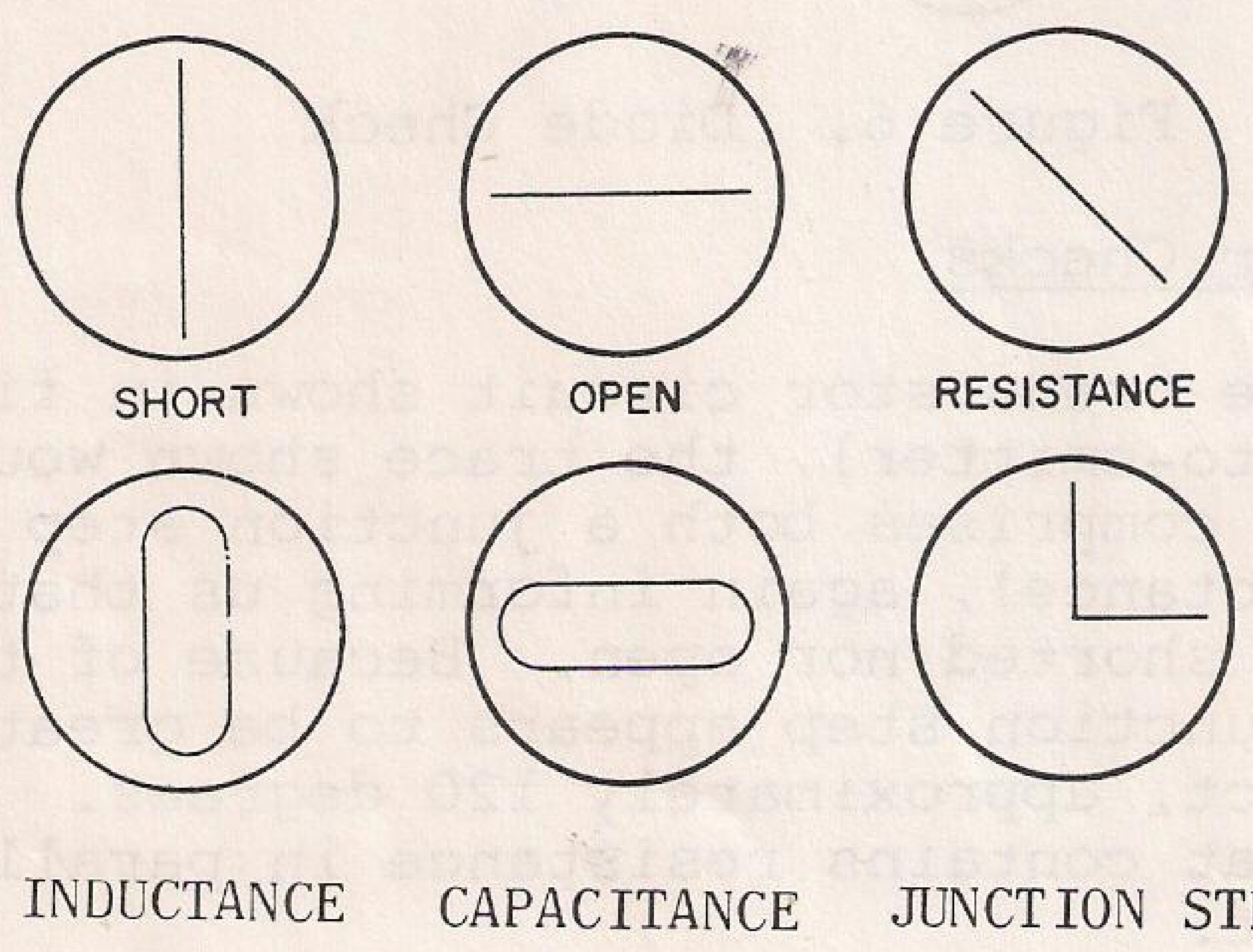

Figure 4. Typical Oscilloscope Displays

d. Transistor/Diode Check-Single Junction. (See figure 5.) An ideal single-junction check will produce a 90-degree step display, indicating a very high front-to-back ratio. This means an open in the reverse direction and a short in the forward direction. A display that is open more than 90-degrees is something less than perfect; the wider the angle, the less the merit of the junction.

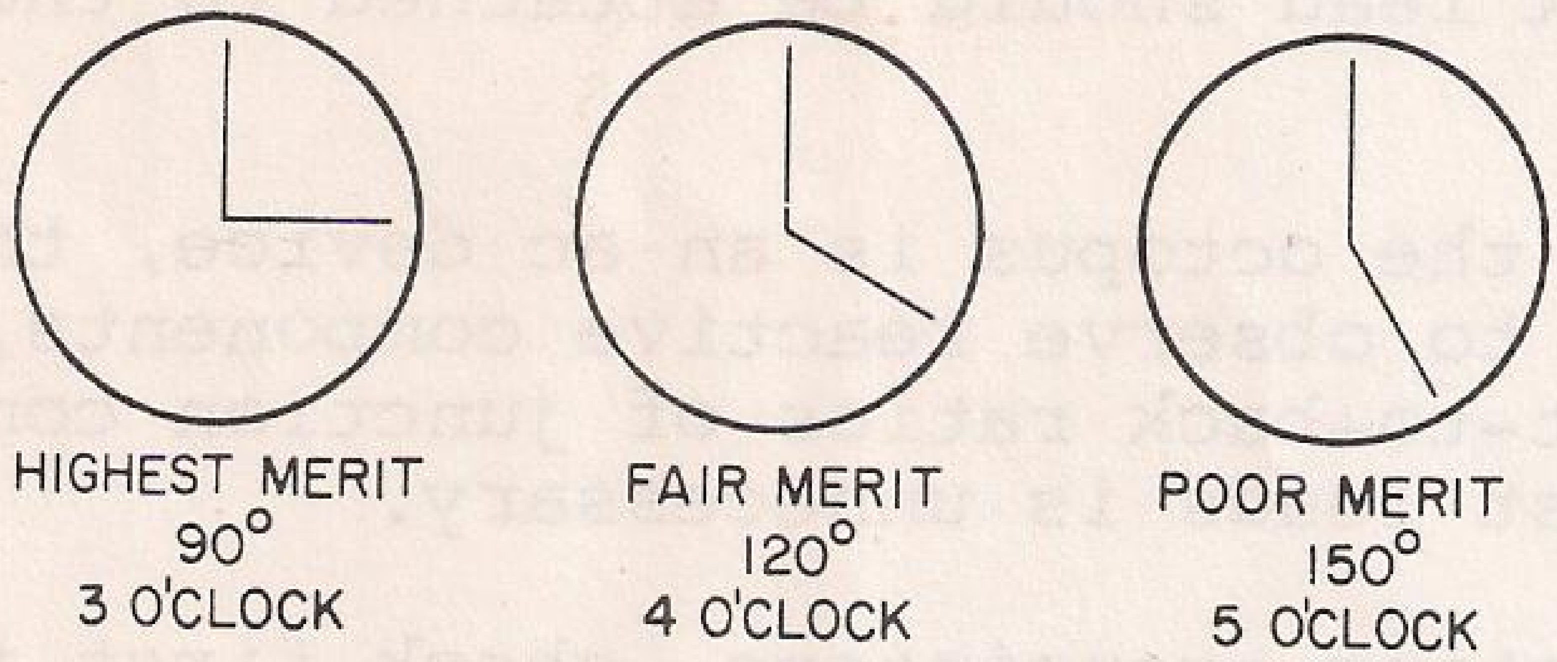

Figure 5. Transistor Check-Single Junction

e. Diode Check. If the diode and capacitor pictured in figure 6 were under test, the display shown in that figure would be the result. The oscilloscope presents both a Lissajous (Xc reactance) and a 90-degree junction step, informing that the components are neither shorted nor open.

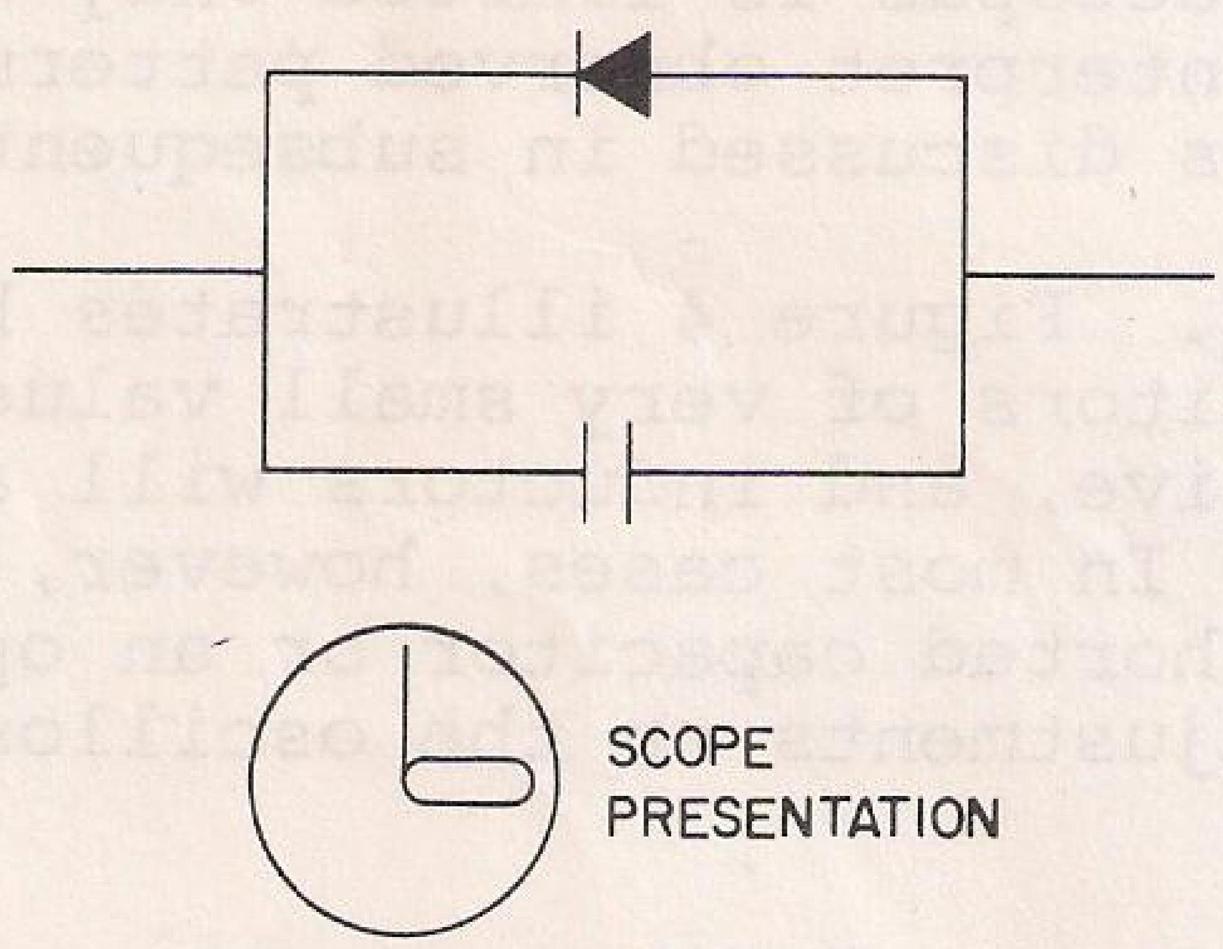

Figure 6. Diode Check

f. Transistor Checks

(1) If the transistor circuit shown in figure 7 were under test (base-to-emitter), the trace shown would result. The scope pattern comprises both a junction step and Lissajous (Xl reactance), again informing us that the components are neither shorted nor open. Because of the coil resistance, the junction step appears to be greater than 90 degrees--in fact, approximately 120 degrees. This is common in any circuit that contains resistance in parallel with a junction component.

L.E. GUGLE

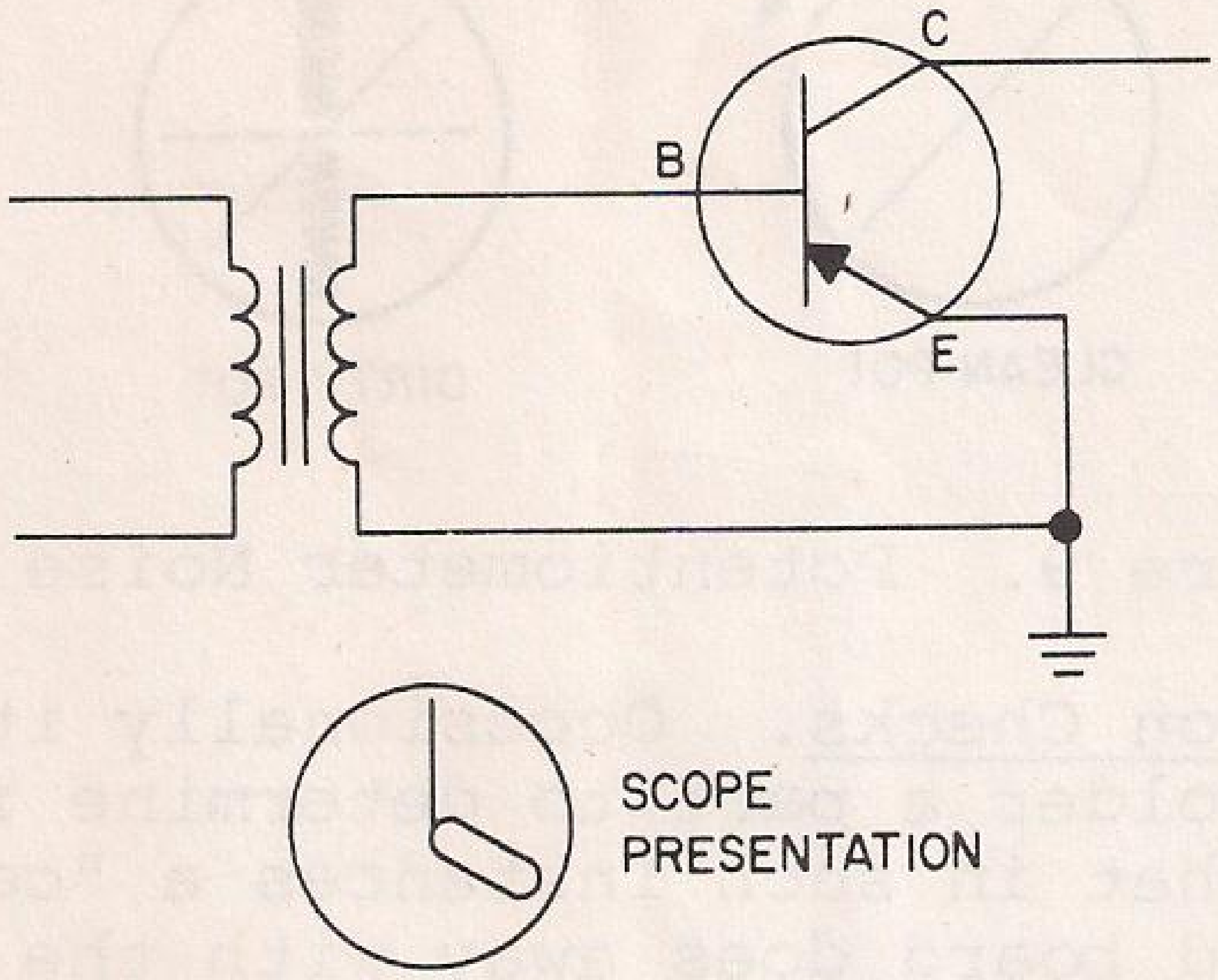

Figure 7. Transistor Check-Base to Emitter

(2) If the transistor pictured in figure 8 contained an electrical short between the base and the collector, the display shown would result during testing from the base to the collector.

(3) To distinguish NPN from PNP transistors, move the red probe to the transistor base and the black (grounded) lead to either the emitter or collector. If the step pattern opens downward, the transistor is NPN (emitter arrow pointing downward); if the pattern opens upward, the transistor is PNP (emitter arrow pointing upward). The same technique can also be used to determine diode direction.

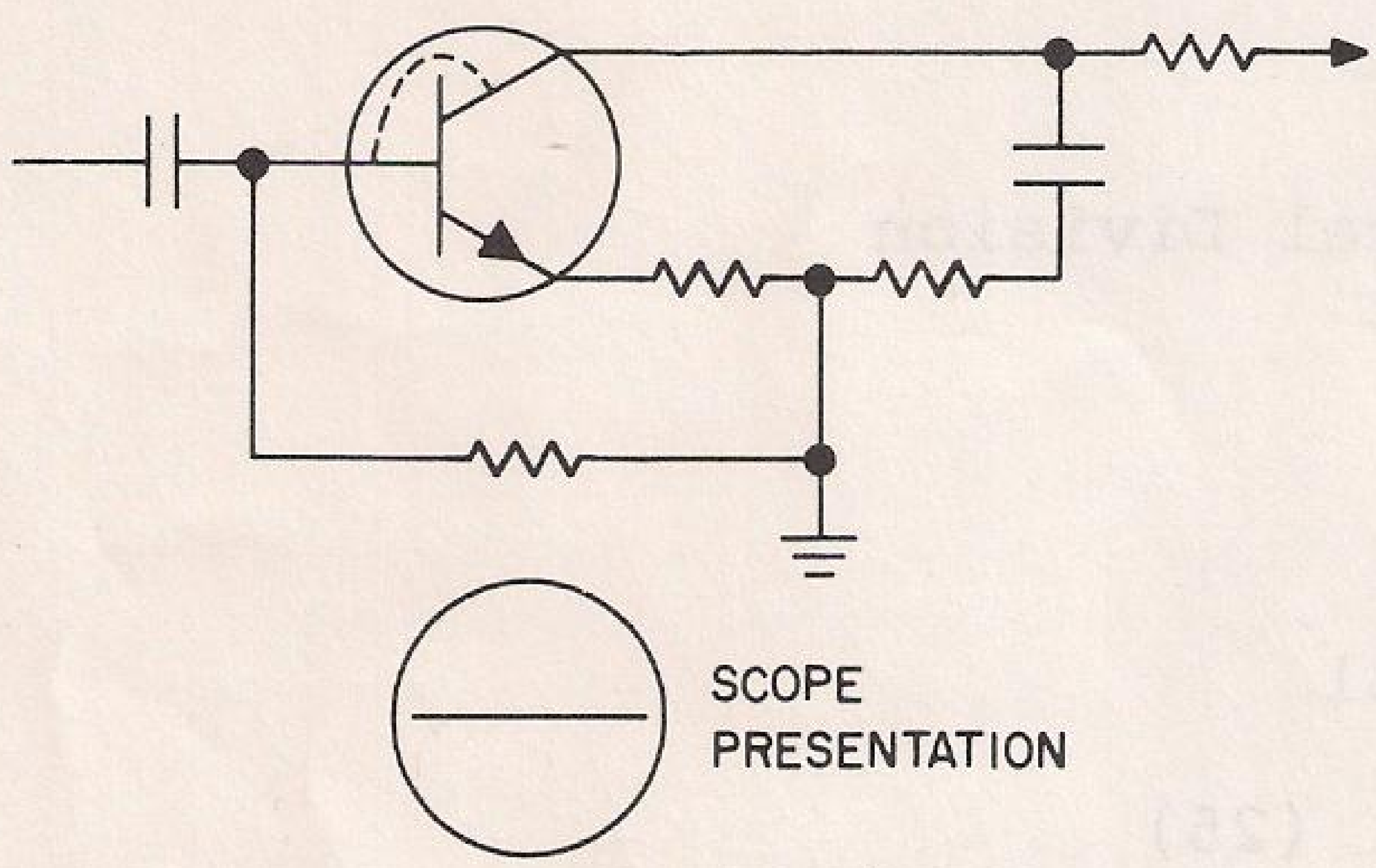

Figure 8. Transistor Check-Base to Collector

g. <u>Potentiometer Noise Check</u>. (See figure 9.) To check a potentiometer for noise or dirt, connect one probe to the potentiometer arm and the other probe to either end, then manipulate the potentiometer through its range while observing the oscilloscope pattern.

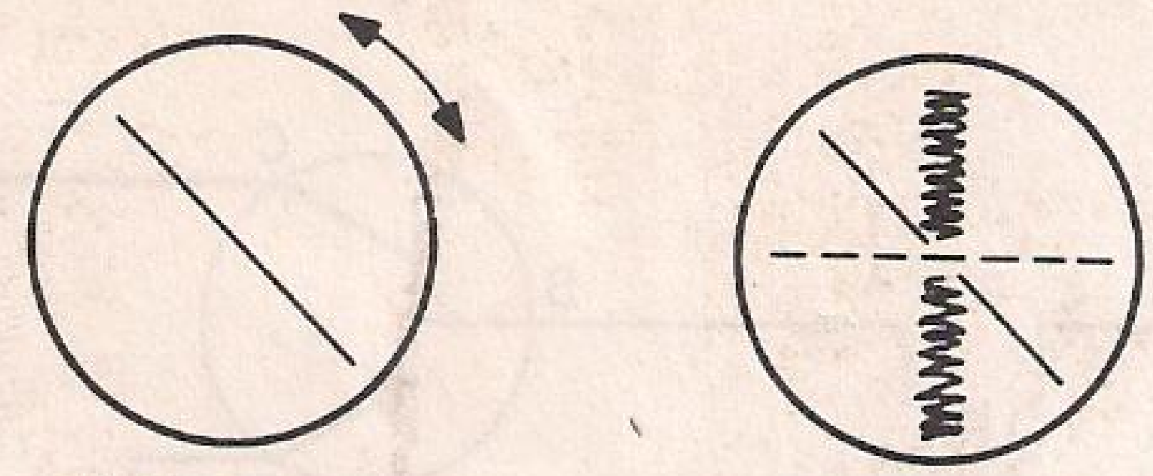

Figure 9. Potentiometer Noise Check

h. Comparison Checks. Occasionally it may appear necessary to unsolder a part to determine its condition. It has been found that in such instances a "comparison" check with a known good board does away with the need to unsolder the suspect component. This comparison method, which gives conclusive results, is recommended whenever there is any question regarding a component's operating condition.

BY DIRECTION OF THE COMMANDANT OF THE MARINE CORPS

OFFICIAL

P. T. Lanham
P. T. LANHAM
Director, Technical Division
Supply Department

DISTRIBUTION: BL1

Copy to: 7000161 (25)