NWC TP 5822

No-Voltage Meter

by

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Naval Weapons Center
CHINA LAKE, CALIFORNIA 93555

Naval Weapons Center

AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

R. G. Freeman, III, RAdm., USN .... Commander
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FOREWORD

This report describes the development of a special instrument. The program was accomplished in-house from October 1973 through January 1975 using internal funding.

This report is released for information only. Equipment described herein was designed for highly specialized and limited application and for use by NWC personnel. NWC assumes no responsibility or liability for any action or incident resulting from use of the equipment by other than NWC personnel.

This report was reviewed for technical accuracy by Gordon Greene.

Released by
G. W. LEONARD, *Head*
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(U) *No-Voltage Meter*, by Michael R. Osburn. China Lake, Calif., Naval Weapons Center, February 1976. 8 pp. (NWC TP 5822, publication UNCLASSIFIED.)

(U) A meter with no power source was designed to make voltage checks on firing lines. The meter will detect 50 millivolts, both AC and DC voltages, and cannot result in voltage transfer to the firing line.

ACKNOWLEDGEMENT

This instrument was developed through the efforts of an ad hoc committee organized by the NWC Safety Department. The committee consisted of:

J. D. DeSanto	Code 146
K. S. Skarr	Code 22
P. A. Donaldson	Code 222
G. C. Pritchard	Code 222
A. R. Blackman	Code 3722
R. M. Pullen	Code 3723
M. R. Osburn	Code 4504
R. B. Johanboeke	Code 4531
R. C. Meade	Code 4531
G. A. Greene	Code 4541

Mr. Meade deserves special recognition for his actual design work.

DEDICATION

The result of the overall program is dedicated to the late James D. DeSanto, who was one of the key people responsible for the development of this No-Voltage Meter. For many years Mr. DeSanto was instrumental in the safe conduct of range operations and his vast knowledge and experience is reflected in the design of this meter.

INTRODUCTION

As a step in upgrading the safety program at the Naval Weapons Center (NWC), China Lake, California, it was decided to make mandatory voltage checks on firing lines before connecting any electro-explosive device (EED). This requirement was written into NAVWPNCENINST 5100.6B, *General Safety and Industrial Hygiene Manual*, Change 12, 21 January 1974 (page 119). The requirement also stated that only meters approved by the technical department involved and the Safety Department could be used in making the "no-voltage" check. The approval of meters was mainly intended to eliminate use of battery-operated meters, such as a VOM, that could pose a hazard in test site operations. The Safety Department enlisted the assistance of the technical departments to form an ad hoc committee that would determine what meters would be approved.

DESIGN

The ad hoc committee generated a list of required characteristics for the no-voltage meter.

1. No power source which, through fault or mechanical failure, could result in a voltage being present on the test leads.

2. Must measure both AC and DC voltages.

3. Provision for internal check to ensure meter is functioning properly. Voltage source must be current-limited.

4. Must be portable and rugged.

5. Shall detect 0.1 volt with an internal impedance of 1000 ohms per volt.

6. Must have sufficient voltage range to prevent meter destruction if put across 120 volts AC.

The committee was unable to locate a commercially available meter that would meet these requirements. Therefore, it was decided to design a special meter and fabricate a sufficient quantity for the entire Center. The meter is shown in Figures 1 and 2. It will clearly indicate the presence of 50 millivolts AC or DC (about one division deflection of the needle is obtained) and 120 volts AC or DC will be on scale. The meter was specifically designed with a low internal impedance so that only low-impedance voltage sources would be detected. In this way, voltages coupled by high impedances, which present no hazard, are not detected and subsequent confusion is eliminated. There are no range selections required and polarity does not matter. A built-in voltage source, current limited to less than 1 milliampere, can be probed to

FIGURE 1. Overall View of No-Voltage Meter.

FIGURE 2. Closeup of Front Panel.

check the meter. These features make this no-voltage meter ideally suited for use by non-technical personnel; the need to interpret readings or select meter ranges is eliminated. Since the normal reading is zero, the built-in check feature ensures that the user has a no-voltage reading.

The schematic of the meter is shown in Figure 3. The input signal is limited by the silicon diodes, D_1 and D_2, regardless of polarity. This signal is then full-wave rectified by the diode-connected Germanium transistor bridge, T_1, T_2, T_3, and T_4. Transistor T_5 acts as a second current limiter. Resistor R_2 was selected to give 90% of full-scale meter deflection with an input signal of 115 volts. The internal voltage source consists of an AA-size alkaline battery with the two current-limiting resistors, R_3 and R_4. (Two current-limiting resistors are used so that if one is shorted, current-limiting protection is still provided.) The meter movement is a taut-band suspension type chosen because of the absence of pivot friction and resistance to damage.

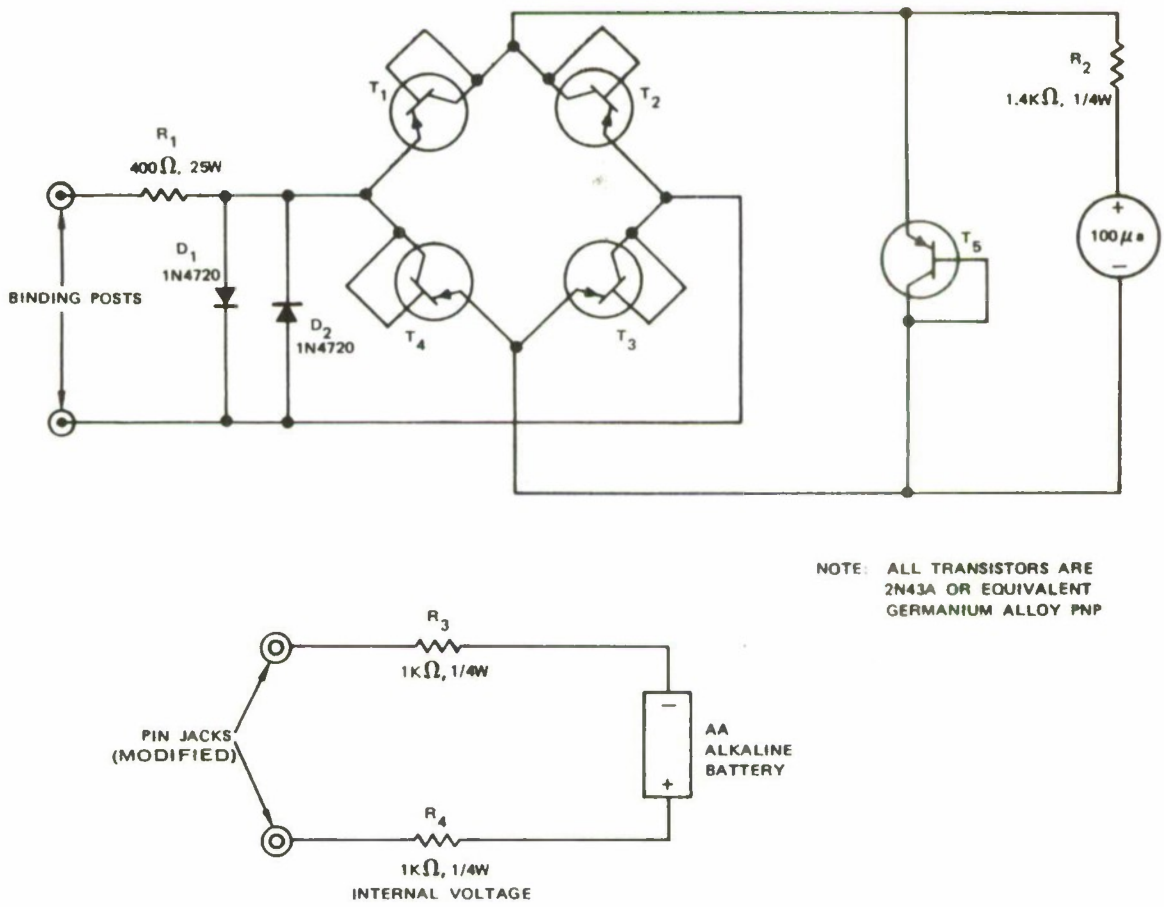

FIGURE 3. No-Voltage Meter Schematic.

Figure 4 shows the physical arrangement. The following features guarantee that mechanical failure will not result in a voltage on the test leads. A plate separates the check voltage source from the meter circuit to prevent a loose or broken wire from one circuit making contact in the other. Plastic screws hold the circuit board to this plate; a piece of mylar covers the underside of the circuit board. Locknuts and adhesive on nuts and screws are used to prevent loosening during the rough handling to which these meters are exposed. The high-wattage resistor is mounted on a heat sink, held away from the circuit board by standoffs to increase heat dissipation. (Even so, this meter cannot take 120 volts indefinitely.) The "Meter Check" test points (see Figure 1) are actually recessed screw heads to prevent test leads from being inadvertently attached to the internal voltage source.

The attachments (e.g., pins, clips, probes, etc.) to both ends of the test leads should be solidly soldered instead of using screw-in or mechanically-attached types. This will ensure that positive electrical contact is always made, preventing intermittent contact that can occur with mechanical attachments. The test leads should also be of the same color to eliminate any polarity confusion since this meter is not polarity sensitive. Test leads were not included because the configuration of individual firing line terminations vary from site to site. The most versatile test leads, of which several sets were made, can be seen in Figure 2. These test leads have a pin soldered to one end which is inserted under the binding posts. These were used rather than banana plugs so that the leads could be left attached when the lid is closed. On the other ends, one lead has a clip soldered to it and the other lead is soldered to a test probe.

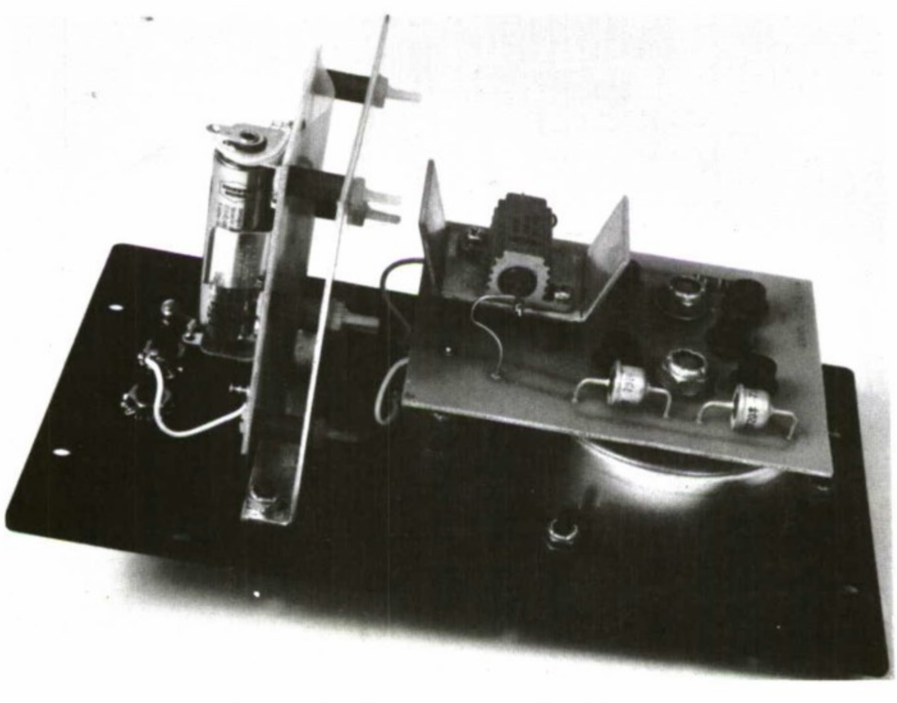

FIGURE 4. Physical Arrangement of Components.

Typical meter readings versus input voltage are plotted in Figure 5. It may be noted that the curves are similar to those plotted for collector current versus collector-to-emitter voltage for transistors. Frequency response is down 50% at 2 megahertz for a 0.05-volt RMS signal.

USE OF NO-VOLTAGE METER

Proper use of the no-voltage meter ensures the user there is no continuous voltage on the firing line or between the firing line and the ordnance item. A check for voltage is made between the two conductors of a firing line and from each conductor to the ordnance ground. By definition, the ordnance ground is whatever the ordnance item is electrically tied to. Since a zero reading is the norm, the internal voltage check is probed both before and after a firing line check to ensure the meter is working properly. Instructions for use of the meter are attached inside the meter lid (Figure 6).

No-voltage meter checks enable the user to detect abnormalities which have been responsible for accidents such as (1) direct power on the firing line, (2) electrical shorts in instrumentation resulting in voltage on the ordnance item itself, and (3) ground loops.

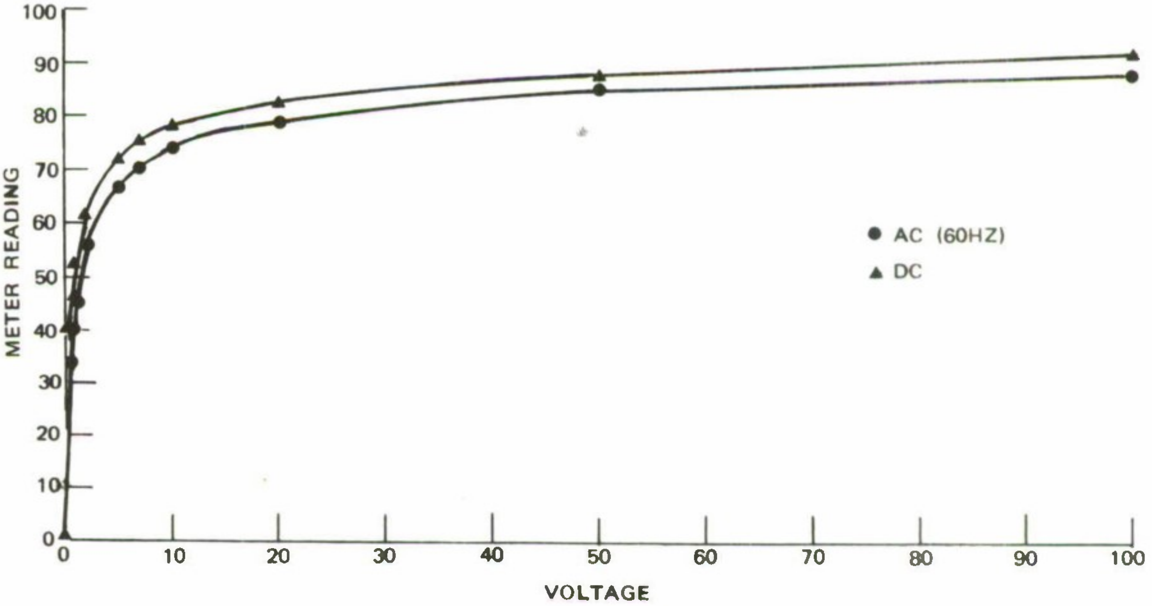

FIGURE 5. Typical No-Voltage Meter Response to Voltage from 0-100 Volts.

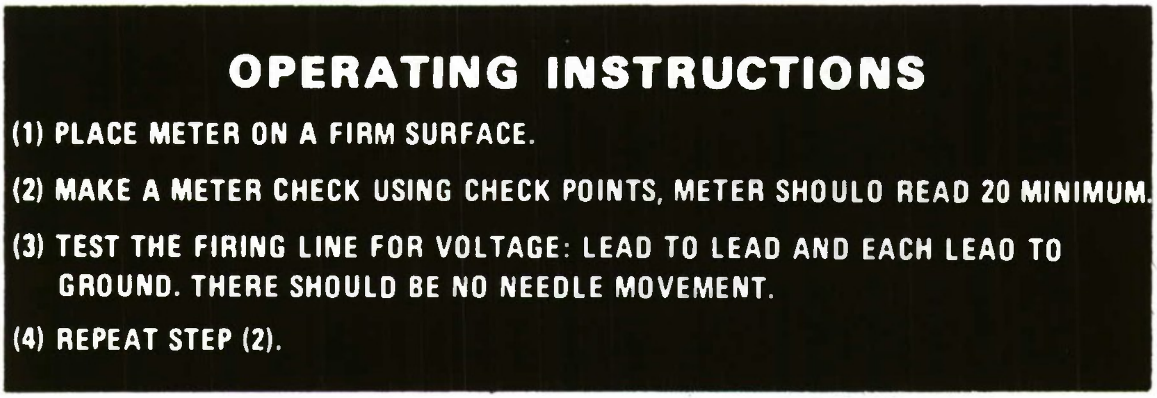

FIGURE 6. Operating Instructions.

The user is warned that this voltage check will only show the absence or presence of a continuous voltage source. It will not guarantee the absence of static electricity, or the possibility of its subsequent generation.

CONCLUSION

The meter functions well for its intended purpose—no-voltage measurement of firing lines prior to hook-up of an electro-explosive device. It is highly sensitive, was not designed as an accurate voltmeter, and should not be used for any other purpose. Static electricity may not be detected by this meter; therefore facility firing circuits must be designed to prevent the build-up of electrostatic charges.

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