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(ADDENDUM to BULLETIN NO. 5)

Recommended Test Procedure for Semiconductor Thermal Dissipating Devices

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SUPPLEMENT TO COMPONENTS BULLETIN NO. 5

RECOMMENDED TEST PROCEDURE FOR THERMAL DISSIPATING DEVICES

SCOPE

The scope of this supplement to EIA Components Bulletin No. 5 is to present methods of instrumentation for plastic case semiconductors and integrated circuits for evaluation of thermal dissipating devices.

DISCUSSION

The need for this addendum arises from the increasing use of "plastic" or "economy" type devices. Components Bulletin No. 5 as it now exists, discusses devices with metal studs or flanges only.

The procedures and methods described in this supplement have been developed for and used in "laboratory" testing of heat dissipating components. Where correlation between laboratory data and systems evaluation is desired, additional instrumentation is required. The exact location of the additional thermocouples or other sensors depends on the type of heat dissipator under test. Therefore, instrumentation other than that recommended for laboratory conditions are not specified.

It is proposed that the "case" temperature measuring thermocouple no longer be attached to the case or outside shell of the device, as instrumented on the metal case semiconductors. Instead, it is proposed that it be attached to the metal substrate upon which the semiconductor chip is mounted.

The use of the metal chip supporting member as the location for the measuring thermocouple was selected for several reasons. The plastic material commonly used as the encapsulant has, generally, a very low thermal conductivity. Therefore, the ability of the heat to reach all areas of their transistor case is greatly reduced. To specify any location on the case as representative of the actual junction temperature under operation is misleading at best.

Investigation into the area of plastic semiconductor construction determined that most units have a metal platform on which the dice or chip is secured. The platform or dice pad is located where it is comparatively easy to attach a thermocouple to it without disturbing the chip. Mounting the thermocouple as close as possible to the chip insures optimum accuracy.

The size relation between the chip and its pad is usually not greater than four of five to one. Measuring the temperature of this area indicates an approximate junction temperature. The difference between actual junction temperature and the metal pad temperature is a function of the thermal resistance (θ) of the bonding technique used. In many instances, this is on the order of 1°C per watt or less.

Obtaining a temperature closer to the chip allows a more accurate indication of the effect that a heat dissipator/sink has upon the semiconductor junction temperature. In this manner, a majority of the guesswork involving conduction path gradients is eliminated. This procedure provides an easily obtained, repeatable, and accurate temperature measuring point to get accurate data on the effects of a dissipator.

In system thermal evaluation, it is sometimes necessary to mount the case thermocouple to an easily accessible point, i,e,,on a flange mounted device, under the screw head.

A case temperature comparison may be made by performing an additional test on a similar device mounting thermocouples in both places (under the screw head and close to the chip) to obtain correlation. But, for non-flange mounted devices, thermocouples should be attached to other places such as the tab, collector lead, or to the platform close to the chip.

With these points in mind, the following is then proposed as a supplement/ addendum to EIA Component Bulletin No. 5.

It is proposed that the following paragraph and figures be added to EIA Components Bulletin No. 5. The purpose is to describe instrumentation techniques for plastic case transistors and integrated circuits.

1. GENERAL DISCUSSION

Relative information: Paragraph 1.1 through 6 and 8.1 through 10.3 of EIA Components Bulletin No. 5 are considered applicable to this Supplement.

The following information is for laboratory tests only. System thermal evaluations must be correlated to these procedures by additional specific case temperature measurements. This temperature data should be obtained using infrared equipment or thermocouples measuring the case surface temperature in a simulation of the system configuration. This data can be then used as correlation to identical measurements on actual equipment.

2. CASE CONFIGURATION

The plastic transistor can generally be classified into separate groups of similar case configuration. Each has its own shape, yet each has a supporting structure for leads and chips. It is this structure which is used to obtain mounting locations for the principle thermocouple. This thermocouple is attached as close as possible to the semiconductor chip or hot-spot.

2.1 Non-metallic Case Type

2.1.1 Plastic Case Type

Figures 1, 2 and 7 show the locations of the holes for these configurations. Any appropriate method of attaching a thermocouple may be used. If one of the device surfaces is to be used as a conduction plane, it must be kept free of thermocouple wires. This may be accomplished as shown in Figure 3 by inserting them in a small groove, cementing them in place with a suitable epoxy and sanding the epoxy to conform to the original surface.

2.1.2 Ceramic Cases

Where the case is of a material that is too hard for drilling without special equipment or a non-conductive material to prohibit welding, a bonding technique must be used.

If one of the device surfaces is to be used as a conduction plane, it must be kept free of thermocouple wires. This is shown in Figure 5.

3. CLEARING THERMOCOUPLE LEADS FROM TEST SPECIMENS

3.1 Dissipators

When mounting the thermocouple to the chip pad, it may become necessary to route the leads between the dissipator and the semiconductor. Whenever possible the dissipator should be relieved to allow the thermocouple leads to pass.

There are times when this would reduce the effectiveness of the dissipators' mechanical function. The relief should be then considered on the semiconductor case.

3.2 Semiconductors

With semiconductors care should be taken to insure that the area of thermal flow from transistor to dissipator is not impaired. Alternate instrumentation should be considered if either of these cannot be used.

4. HIGH POWER PRESSURE MOUNTED SEMICONDUCTORS

The new high power pressure mounted semiconductors require another technique for mounting the thermocouple than those already described.

Because the largest heat flow is through the flat areas of the anode and the cathode, this is the best area to mount the thermocouple. There can be no distortion in this area, however, as good contact is required for both electrical and therma interfaces.

4.1 Thermocouple Location

To place the thermocouple in this plane, it is necessary to cut a shallow groove, just wide and deep enough to allow the thermocouple to lay in it without extending above the surface. The thermocouple junction should be located approximately one half the distance from the edge of the center. The junction can be spark welded or soldered to the case and the groove, filled with a ceramic, low temperature solder, or other thermally conductive material. (Figure 6).

5. DISSIPATOR INSTRUMENTATION

5.1 Interface

When required, the heat dissipator instrumentation shall be placed at such a point as to accurately measure the semiconductor/dissipator thermal interface temperature.

5.2 Thermal Resistance Case to Dissipator

The dissipator thermocouple in conjunction with the device case temperature will indicate case to dissipator thermal resistance. This is illustrated in Figure 7.

6. SEMICONDUCTOR THERMOCOUPLE MOUNTING

6.1 Semiconductors

Because the "plastic" of the case is non-conductive, relatively brittle and often very thin, the technique described in Paragraphs 7.1 through 7.3 of Bulletin No. 5 cannot be effectively used to mount a thermocouple. Therefore, the following alternate methods are proposed.

6.1.1 Welding - Internal

In this technique, a very small hole is drilled (to just clear the thermocouple wire) through the case to a point close to the chip on its mounting substrate or frame. The thermocouple lead or leads are then placed down the hole and electrically welded to the frame. The hole is then sealed with a suitable epoxy resin to seal the hole against moisture. This technique is illustrated in Figure 1.

6.1.2 Welding - External

In devices where the case has a metal and ceramic sandwich construction it is often possible to place the thermocouple as near as possible to the chip by electrically welding the thermocouple to the natural plate on the bottom of the device. After the weld is made, it should be covered with a small amount of epoxy resin to act as a strain relief to protect the weld. This technique is described in Figure 4.

6.1.3 Bonding

After location of point closest to hot spot, a material of similar characteristics as the case is used to bond the thermocouple junction to the surface of the device under test. A very small amount is used to initially affix the thermocouple junction to the surface; a larger amount is then overlayed to act as strain relief. This is indicated on Figure 5.

6.2 Dissipator

Any method described in Paragraphs 7.1 to 7.4 of EIA Components Bulletin No. 5 may be used.

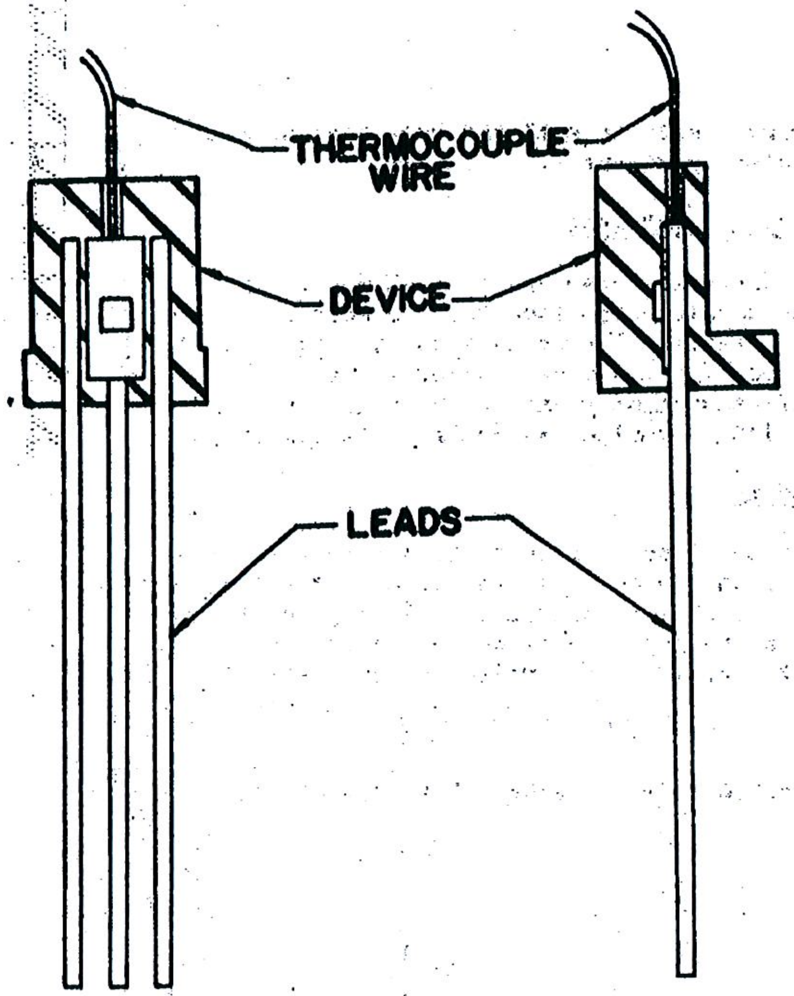


FIGURE 1

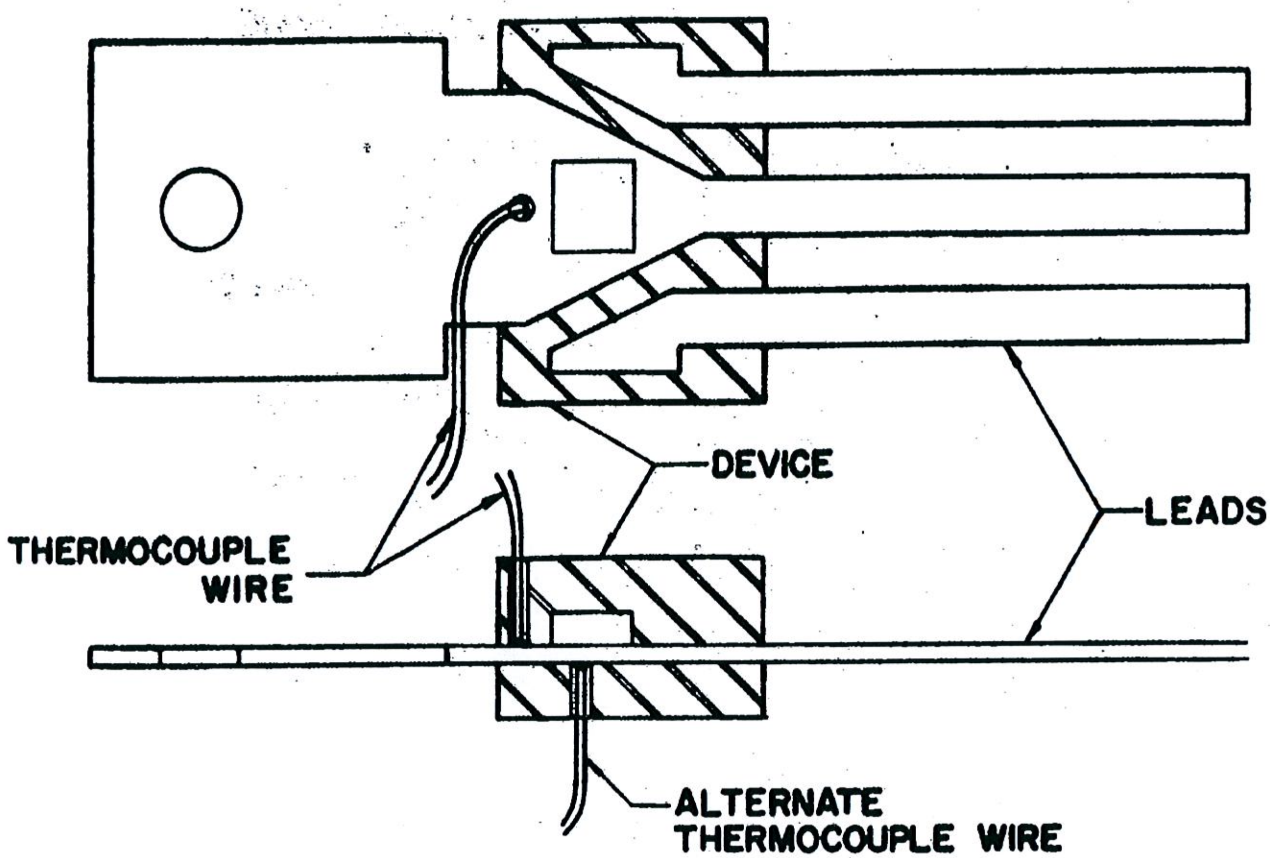
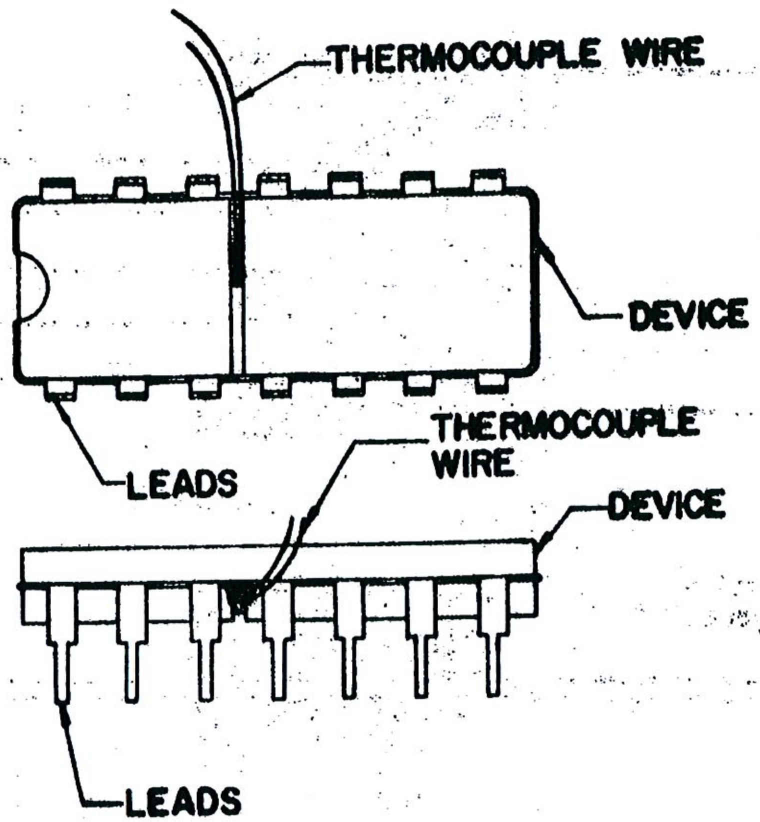

DEVICE
LEADS
THERMOCOUPLE WIRE
ALTERNATE THERMOCOUPLE WIRE

FIGURE 2


THERMOCOUPLE WIRE
DEVICE
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THERMOCOUPLE WIRE
DEVICE
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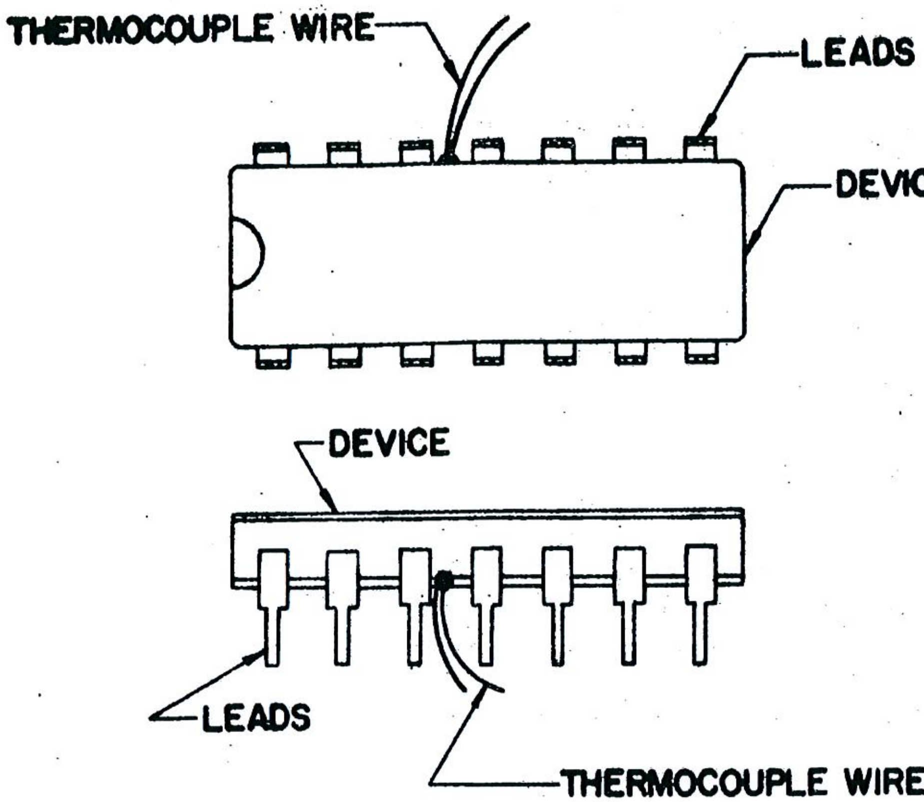
FIGURE 3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THERMOCOUPLE WIRE

FIGURE 4

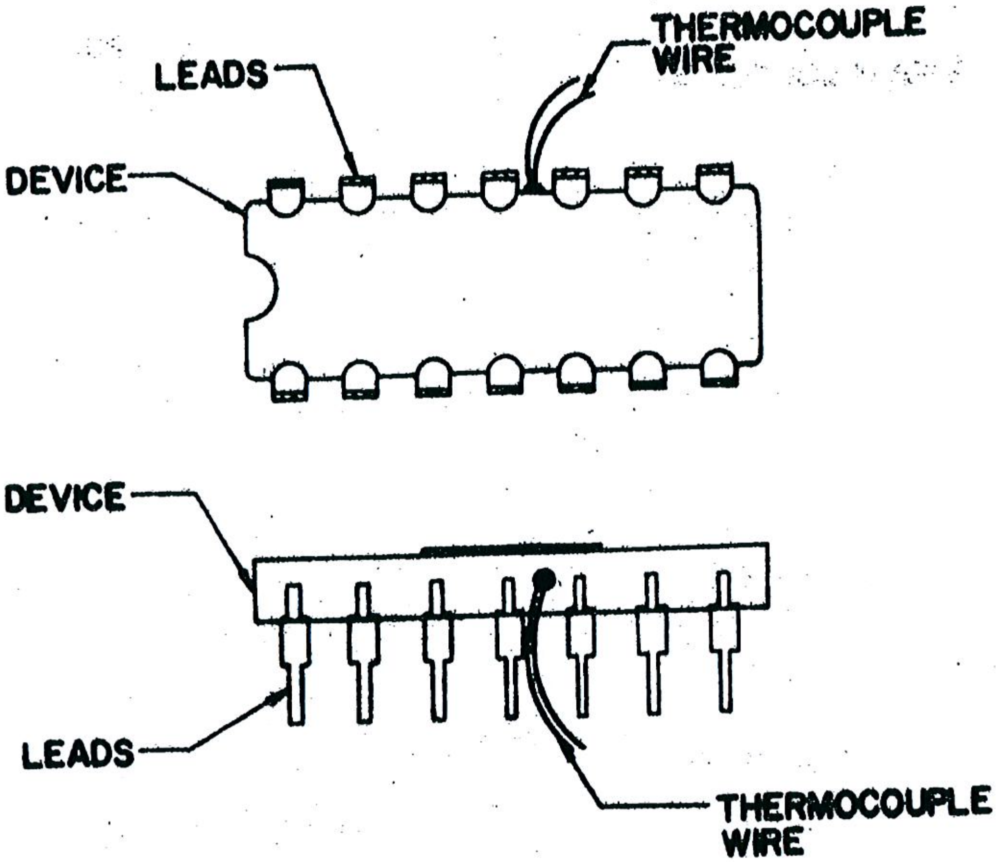
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FIGURE 5

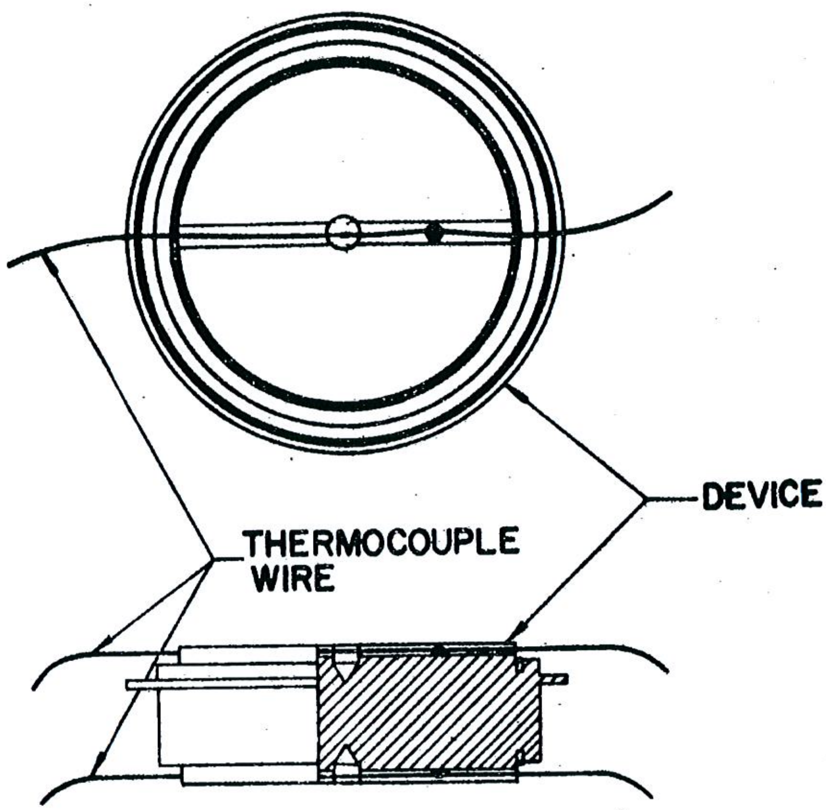

FIGURE 6

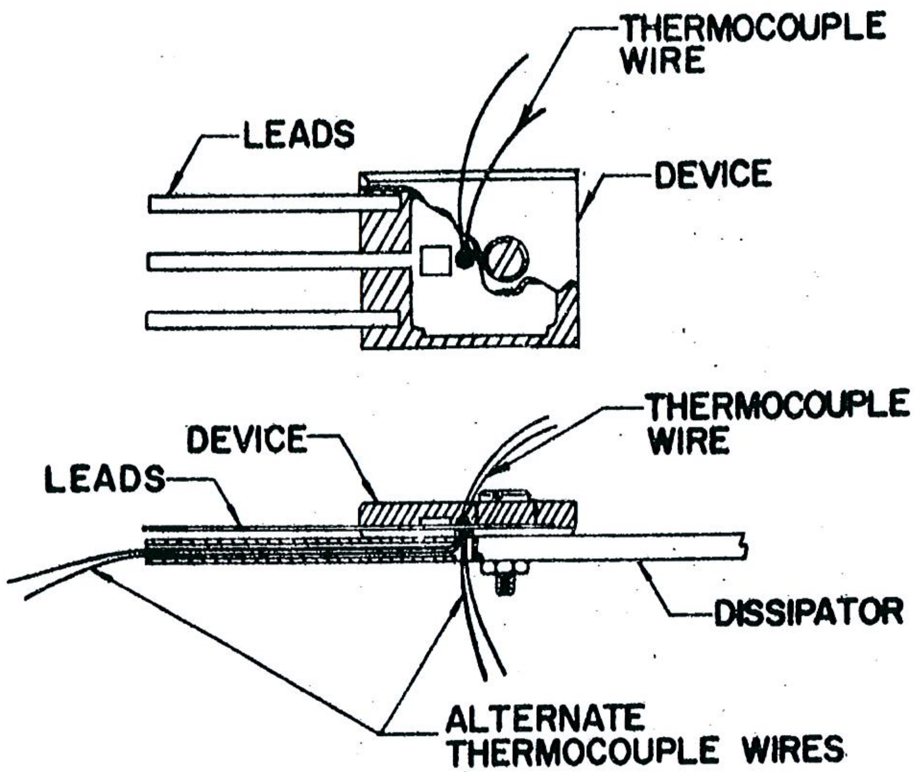
THERMOCOUPLE WIRE
LEADS
DEVICE
THERMOCOUPLE WIRE
DEVICE
LEADS
DISSIPATOR
ALTERNATE THERMOCOUPLE WIRES

FIGURE 7