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Recommended Test Procedure for Semiconductor Thermal Dissipating Devices

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RECOMMENDED TEST PROCEDURE FOR SEMICONDUCTOR THERMAL DISSIPATING DEVICES

1. SCOPE

This test procedure provides standard methods for the evaluation of semiconductor thermal dissipators.

1.1 Purpose:

The purpose of this Bulletin is to establish standard procedures for the evaluation, calibration, and presentation of test data for semiconductor thermal dissipators. Since semiconductor and thermal dissipator temperature measurements are meaningless when test conditions are not uniform or controlled, this test procedure will define the methods for testing and presenting data on temperature measurements of semiconductor junction, semiconductor case, chassis, thermal dissipator, and ambient under both natural and forced convection environments.

1.2 Nomenclature:

The commonly used and incorrect term "heat sink" refers in practice to "heat" or "thermal" dissipators used to reduce the operating case temperature of a semiconductor by transferring heat to an ambient fluid.

2. JUNCTION TEMPERATURE MEASUREMENTS

When required, junction temperature measurements shall be determined by generally accepted test methods such as Vebo or Vcbo measurements. Schematics for the required test equipment are shown in Figures 1 and 2 of this Bulletin. Procedures as outlined in EIA and NEMA Standards RS-313 and SK 508-1965, respectively, will be used.

3. CASE TEMPERATURE MEASUREMENTS

This procedure covers four basic classifications of semiconductor case types and suggested thermocouple mounting methods.

3.1 Stud Type:

Figure 3 shows the location of a hole drilled in the stud of the semiconductor, and a means of retaining the thermocouple in this drilled hole.

3.2 Non-Stud Type with Metal Base over .060" Thick:

Figures 4 and 5 show locations of the hole drilled in the base plate of the semiconductor, and the method for retaining the thermocouple wire.

3.3 Non-Stud Type with Metal Base Less Than .060" Thick or Non-Metal Base:

Figures 6 and 7 show the method of attaching the thermocouple to the case of these semiconductors.

3.4 High Power Flat Base Devices:

Figure 8 shows the method of attaching the thermocouple to the case of these semiconductors

4. DISSIPATOR TEMPERATURE MEASUREMENTS

Methods are shown in Figures 3, 4, 5, 6, and 8 for attaching the thermocouple to the hottest point in the dissipator. The method selected shall be determined by the mounting position of the semiconductor and the type of dissipator.

5. CHASSIS TEMPERATURE MEASUREMENTS

5.1 Aluminum plates of the sizes shown in Table 1 shall be instrumented with thermocouples as shown in Figures 3, 4, 5, 6, 7, and 8.

5.2 Non-Metallic Chassis:

When a test is to be conducted on a thermally insulative surface a 6" x 6" x 1/8" (maximum) epoxy chassis should be used. The test load or semiconductor and the dissipating device shall be placed in the center of the chassis.

5.3 Metallic Chassis:

When the test is to be conducted on a thermally conductive chassis, the test chassis dimensions to be used are shown in Table 1.

TABLE 1

Aluminum Chassis	CHASSIS all dimensions maximum		
Max. heat dissipation	Length	Width	Thickness
3 Watts	2"	2"	1/8"
30 Watts	4"	4"	1/8"
50 Watts and above	6"	6"	1/8"

The chassis should be mill rolled finish, natural color, aluminum. The test load or semiconductor and the dissipating device shall be placed in the center of the chassis.

6. CONSTANT TEMPERATURE HEAT SINK

When thermal link devices (a device designed to attach the semiconductor's case to a heat sink) are being tested, a constant temperature heat sink, such as shown in Figure 9 or equivalent, will be used and shall be instrumented as indicated.

7. THERMOCOUPLE MOUNTING

The thermocouples can be of the open or closed junction type, depending upon the discretion of the testing facility, and will be stated in the test data. The thermocouple wires shall have a minimum gauge of 36 AWG for fractional to 5-watt applications and 30 AWG for high power work in order to minimize errors due to hear loss through the wires. The junction or leads shall be connected to the test device by one (1) of the following methods:

7.1 Insert the junction of leads into a small hole and jam a metal or wooden pin into the hole. See Figures 3, 4, 5, 7, 8, and 9.

7.2 Insert the junction or leads into a small hole and stake the metal around the hole. See Figures 3 and 4.

7.3 Solder or weld the junction or leads to the case. See Figure 6.

7.4 Care shall be taken that the junction or leads are in metal-to-metal contact with the object being tested. The two thermocouple wires shall not be allowed to touch electrically, except at their junction.

8. AMBIENT CONDITIONS

8.1 Natural Cooling:

External sources of moving air passing over the test setup shall be minimized by placing an enclosure over the mounted specimen. The enclosure shall contain a sufficient volume of air to prevent a significant temperature rise of the air due to heat from the transistor. The enclosure shall be made from clear plastic and closed at the bottom. It may have a small opening at top. A volume of one (1) cubic foot is adequate unless a very large wattage is being dissipated. The test temperature should not be accepted until stabilization occurs. This can be determined by noting the range of fluctuation of the test temperature. When the variation is less than 1°C in 10 minutes, it can be assumed to be stabilized.

8.2 Forced Air Conditions:

The heat dissipator shall be tested in an air duct with a fan mounted on one (1) end. The ratio of the air duct cross-sectional area to the cross-sectional area of the dissipator shall be not less than two (2). The air duct shall be equipped with suitable bends, baffles, or air straighteners to assure that the velocity gradient across the duct in the test area shall not deviate more than 10 percent from the average velocity. This gradient shall be measured with no dissipator in the duct. The dissipator shall be placed near the exhaust end of the duct, but wholly within the duct. It shall be located centrally within the cross-section of the duct. Suitable air velocity and temperature measuring probes shall be installed in the duct at least six (6) inches upstream from the dissipator. Figure 10 illustrates a setup for forced air measurement. The unit of measure of air velocity shall be in feet per minute. This test shall be performed with either the semiconductor, semiconductor and dissipator, or test load and dissipator mounted to an epoxy chassis (5.2) with standard mounting hardware. Test data will be presented in either tabular or graph form and will indicate the case temperature, air temperature, air velocity, and junction temperature, if required. The head loss in inches of water of the dissipator will be shown at the various air flows. All duct dimensions and instrumentation points are to be called out.

9. SEMICONDUCTOR WITH DISSIPATOR TESTS

These tests shall be specified under four different conditions.

9.0.1 Semiconductor, with no dissipator mounted by normal means to an epoxy chassis (5.2).

9.0.2 Semiconductor and dissipator mounted by normal means to an epoxy chassis (5.2).

9.0.3 Semiconductor and dissipator mounted to a metal chassis (5.1).

9.0.4 Semiconductor and dissipator mounted in an air duct (8.2).

9.0.5 Semiconductor and dissipator on constant temperature sink, when applicable.

9.1 Evaluation of Dissipator Performance by Means of Simulated Loads:

For the calibration of high power dissipators, test loads can be used in place of semiconductors. When any simulated load is used to test a dissipator, the simulated load must be certified as to similar shape, mounting procedure, and dissipation in all test conditions as the semiconductor it simulates. See Figure 11 for suggested test circuits.

10. PRESENTATION OF TEST DATA

All test conditions shall be noted, such as (1) the type of thermal grease, if used, and the degree of flatness and finish of the surface on which the semiconductor load was mounted (i.e., machined, sanded, anodized, clear aluminum, etc.); (2), insulating washers, mica, anodize, etc., if used; (3), transistor types number or test load case configuration; (4), semiconductor or test load mounting torque; (5), position of dissipator during test; (6), amount of air used for forced convection tests (i.e., feet per minute); (7), duct size, and (8), location and mounting method of instrumentation.

10.1 Temperature Data and Heat Dissipating Information may be Presented in Three Different Forms:

10.1.1 Tabular Form: A table showing all temperatures taken, such as: Junction, Case, Dissipator mounting surface, Ambient Temperatures, and the power levels at which the temperature was measured. The temperature is to be expressed in degrees Centigrade and the power in watts.

10.1.2 Graphical or Curve Form: The information contained in the Tables of 10.1.1 can readily be converted to Graphical form, such as: Heat sink mounting surface temperature rise above ambient versus power dissipated; case temperature rise above ambient versus power dissipated; thermal resistance (°C/W) rise above ambient versus air flow velocity in feet per minutes.

10.1.3 Thermal Resistance Form: Thermal resistance is defined as the temperature difference (ΔT) between two points divided by the heat energy (W) passing between the two points.

$$\text{Thermal Resistance} = \frac{\Delta T - {}^{o}\text{Centigrade}}{W - \text{Watts}}$$

The unit of thermal resistance is °C/Watt.

The information derived and listed in 10 and 10.1.1 can be easily converted to thermal resistance. The total thermal resistance to the flow of heat from the junction to the ambient is the sum of the individual thermal resistances such as: (1) thermal resistance from junction to case, (2), thermal resistance from case to dissipator and (3), thermal resistance from dissipator to ambient. The thermal resistance from junction to case may be obtained from the semiconductor's Manufacturer's Specifications or Test Data per paragraph 2. The thermal resistance from case to dissipator is obtained through test data and varies with type of semiconductor case, mounting torque, finish or mating surfaces, degree of flatness, and whether thermal conductive compounds or electrical insulations are used. This value is obtained by dividing the differential in temperature obtained at the semiconductor or load case and a point directly below it on the dissipator mounting surface by the power dissipated. This value is a sum of all thermal resistances between the case and dissipator. The thermal resistance between the dissipator and ambient is the value received by dividing the differential in temperature between the dissipator mounting surface and the ambient by the power dissipated through the dissipator. The presentation of thermal resistance data requires that all conditions of test be presented due to the number of variations involved. Test equipment should be able to maintain a 5% accuracy of thermal resistance data.

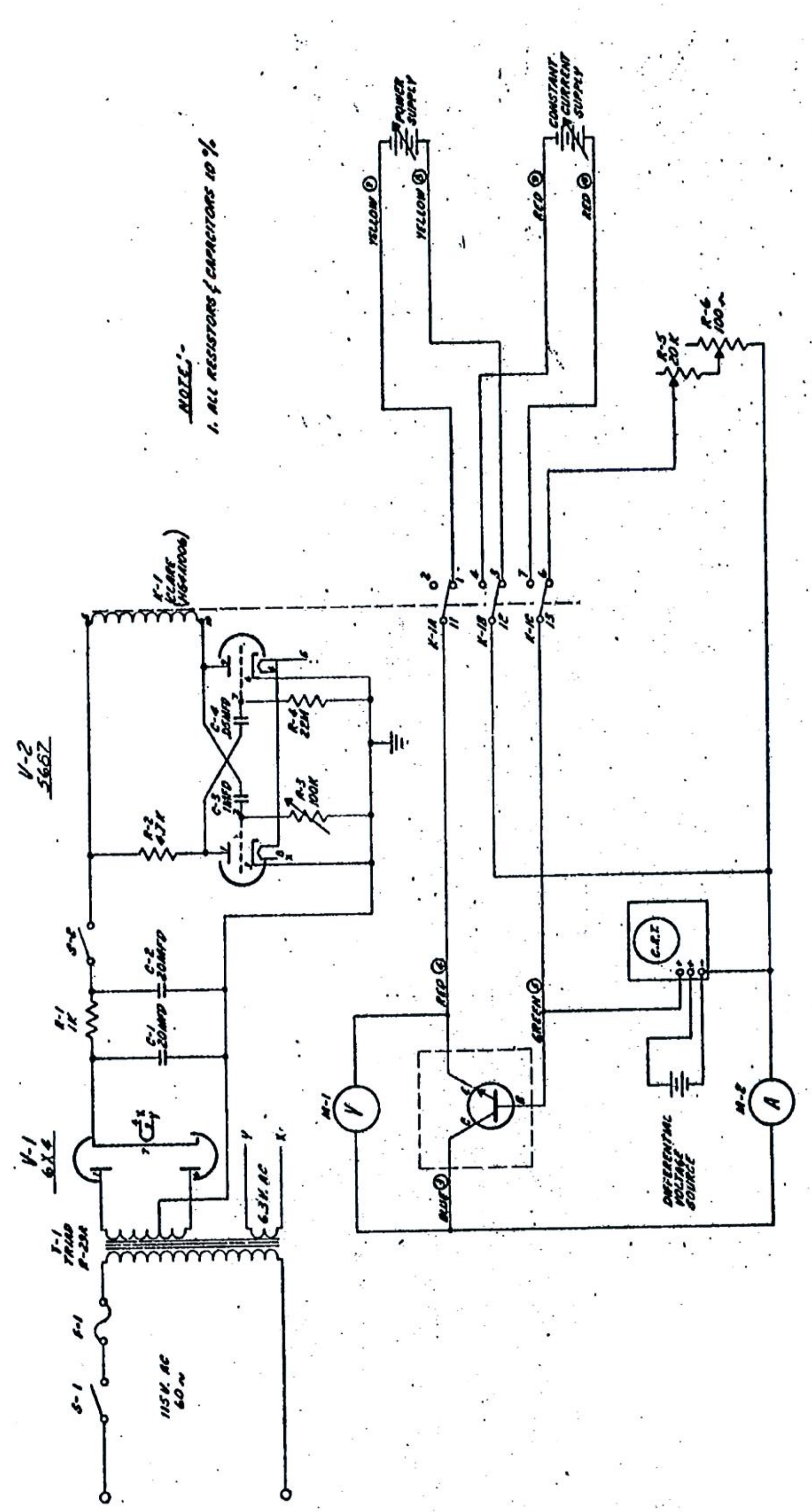


FIGURE 1
JUNCTION TEMPERATURE TEST CIRCUIT
Vcbo Method

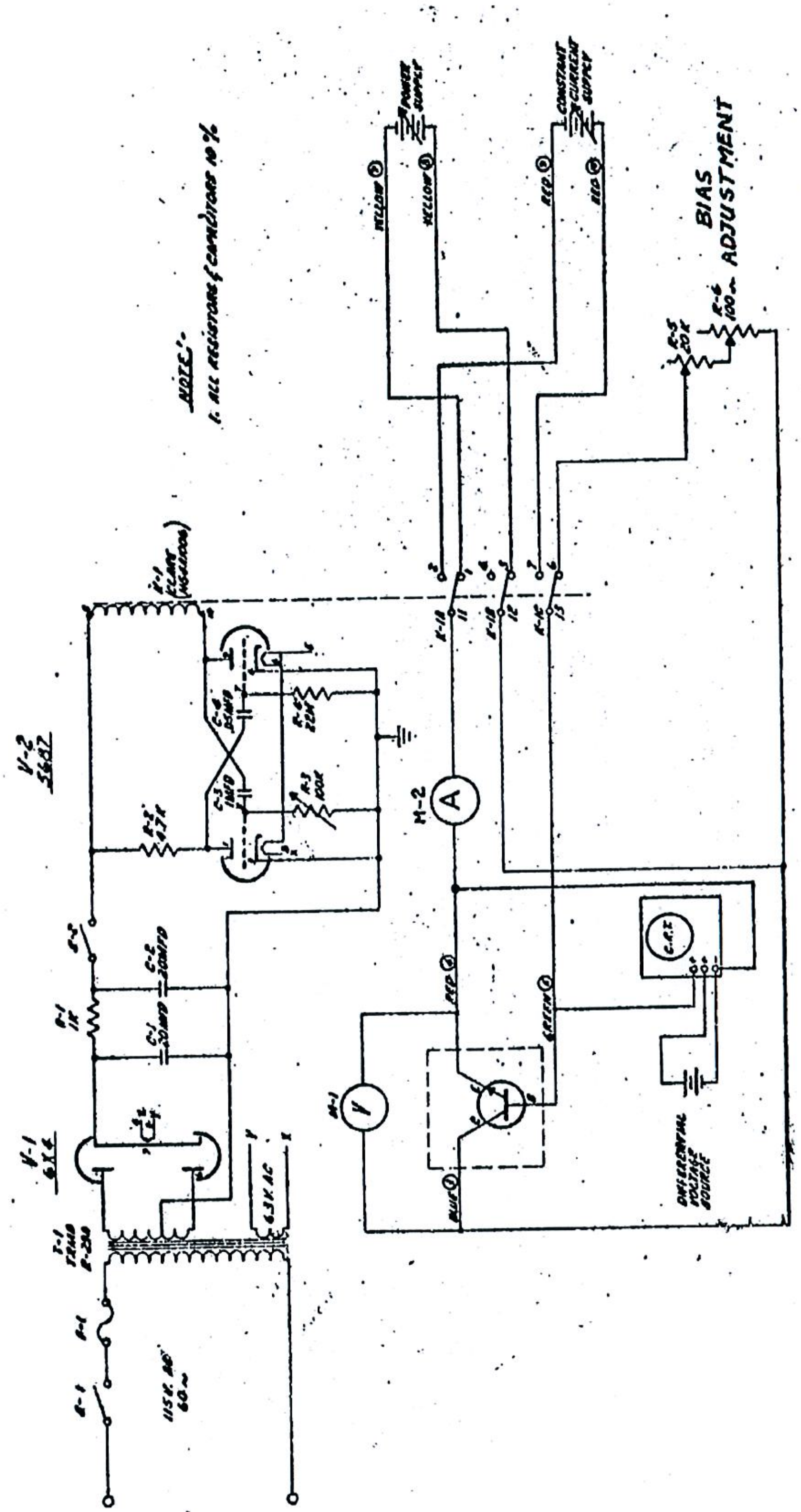


FIGURE 2

JUNCTION TEMPERATURE TEST CIRCUIT
Vebo Method

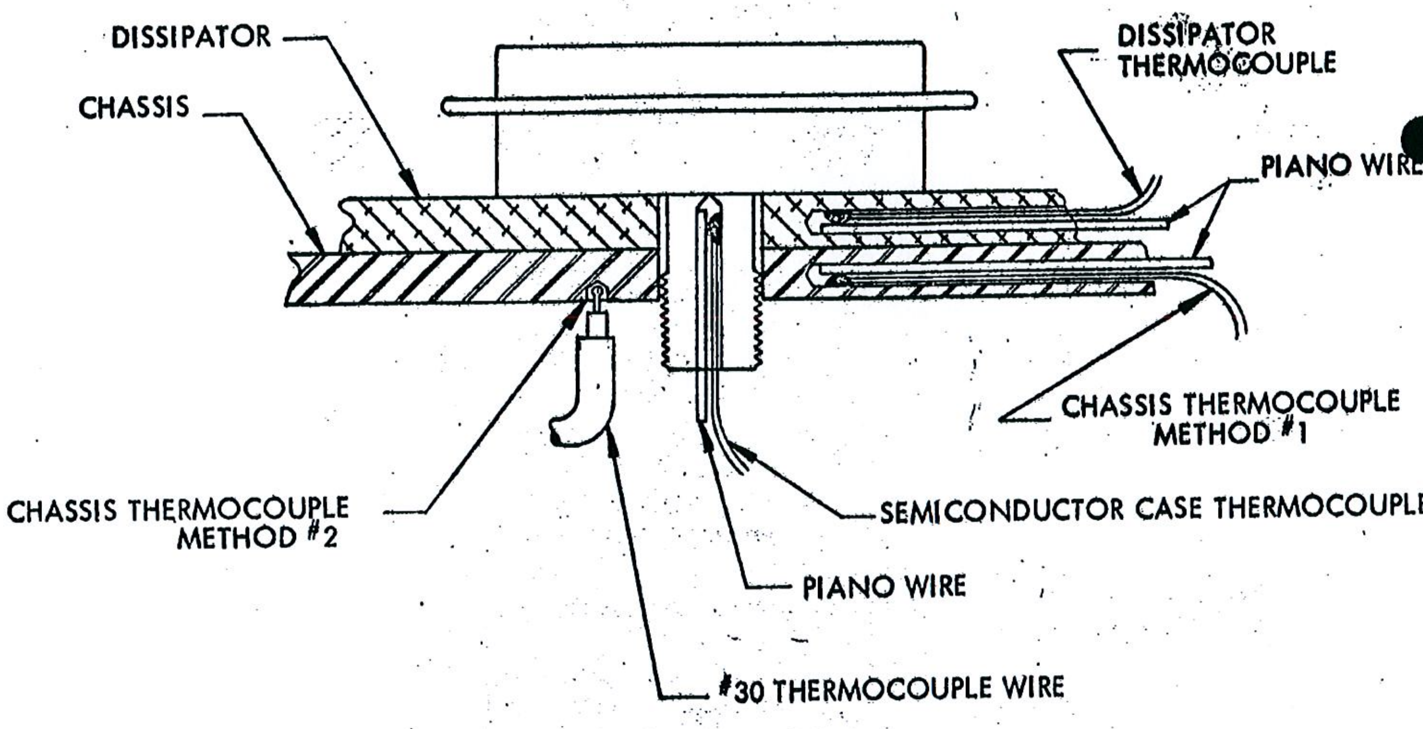


FIGURE 3

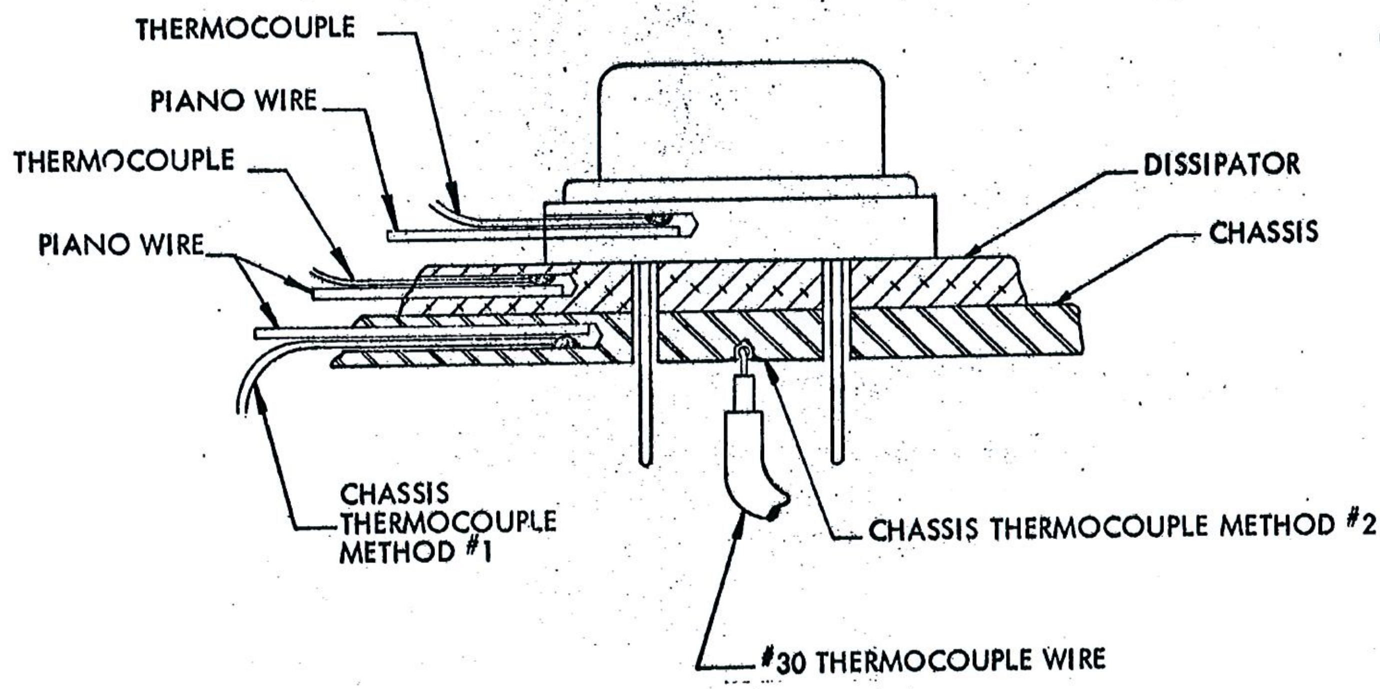


FIGURE 4

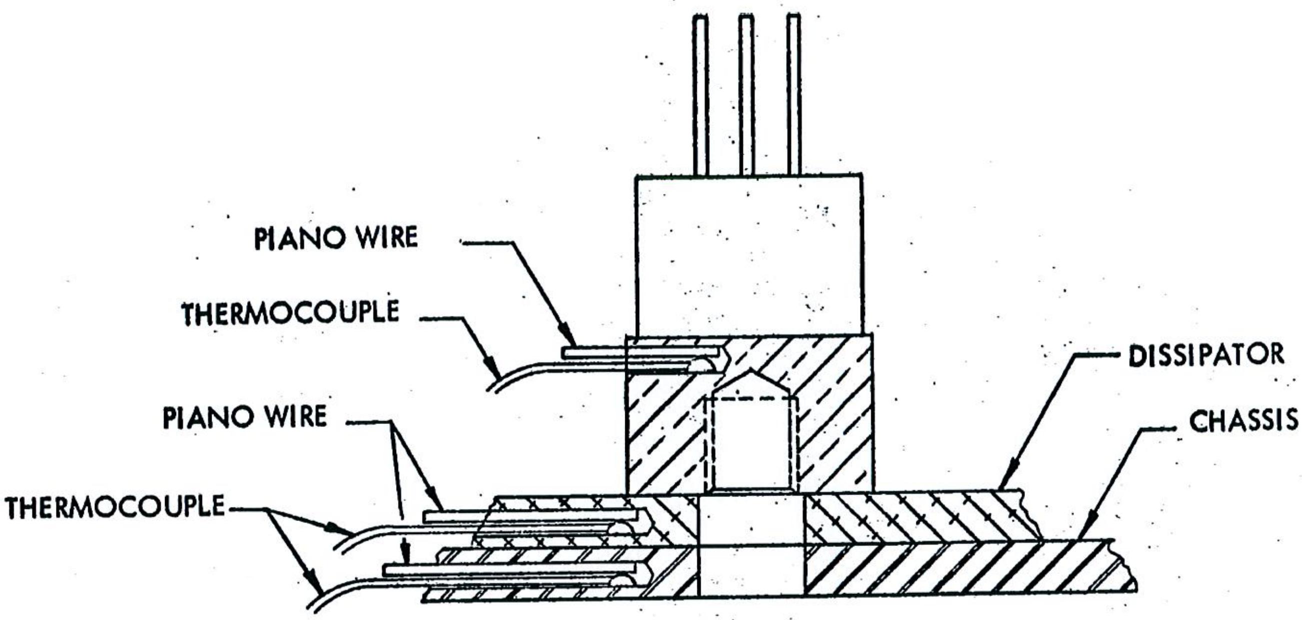
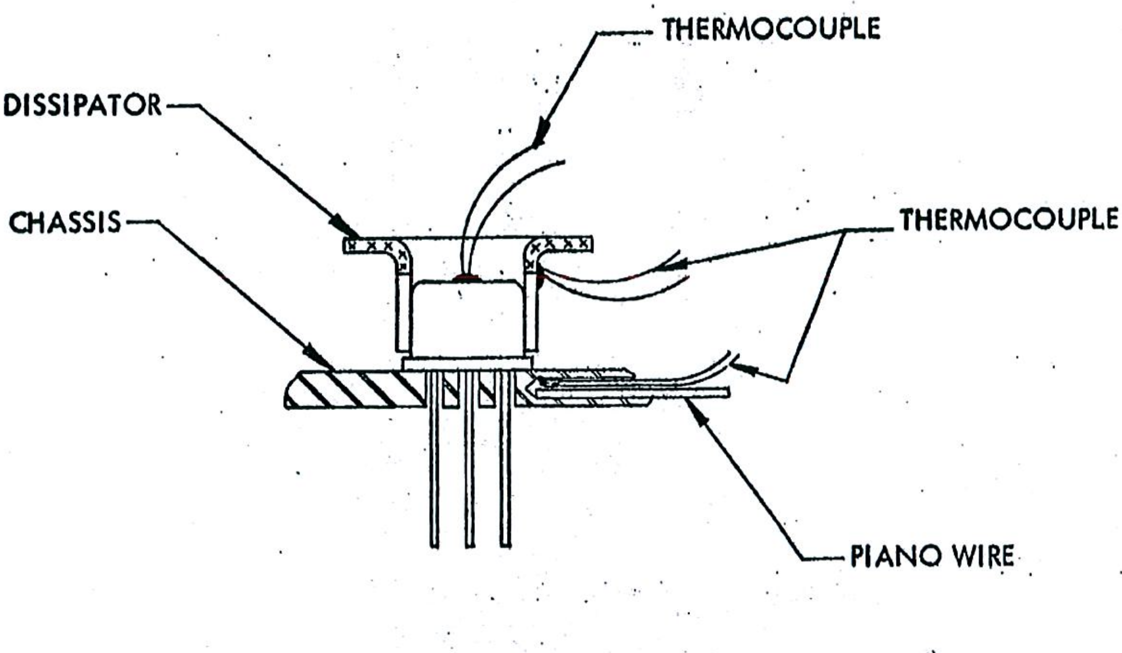
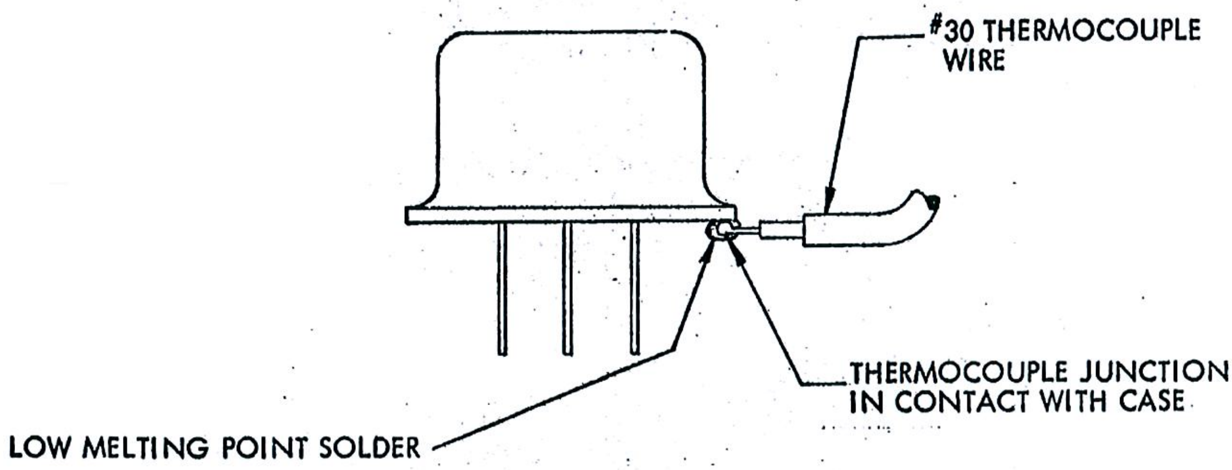

PIANO WIRE
THERMOCOUPLE
PIANO WIRE
THERMOCOUPLE
DISSIPATOR
CHASSIS

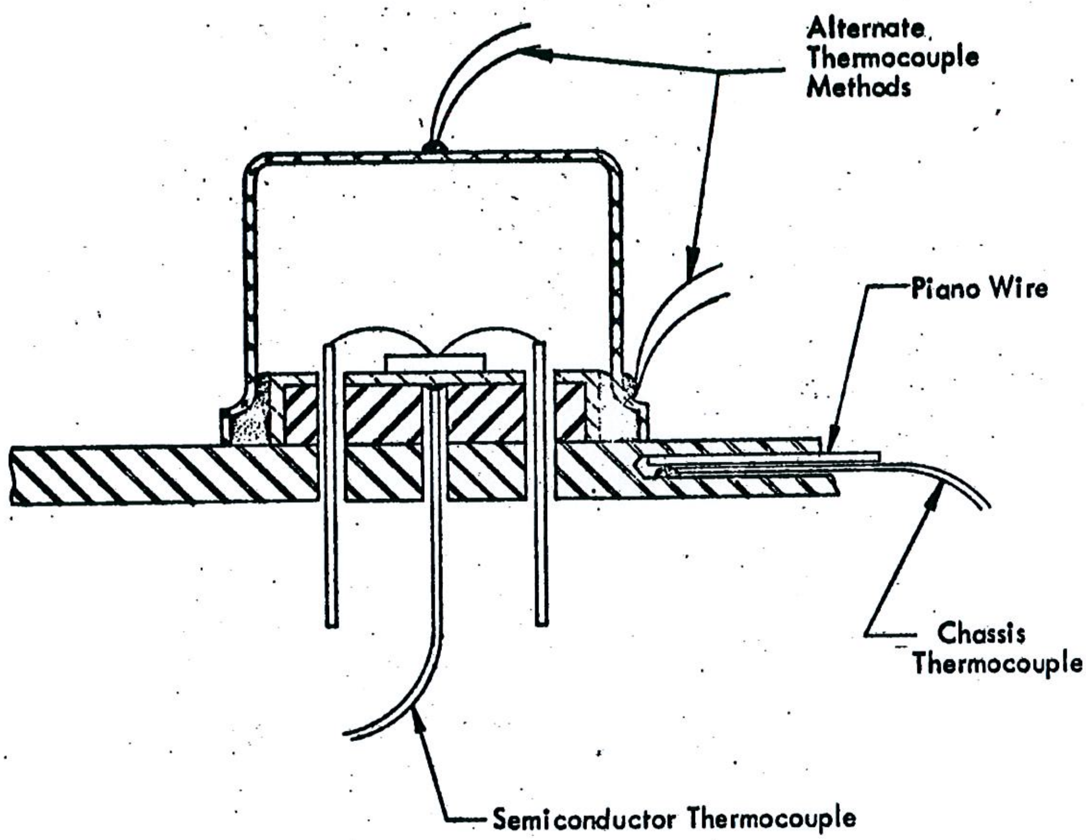
FIGURE 5





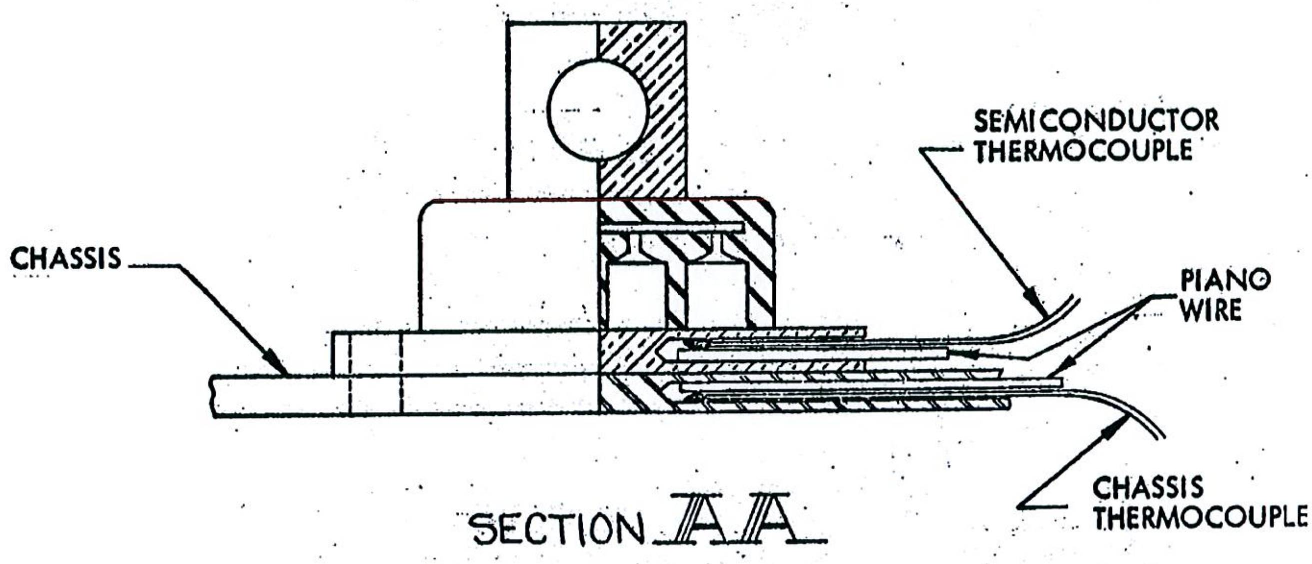
THERMOCOUPLE ATTACHMENT FOR NON-STUD TYPE TRANSISTOR WITH METAL BASE TOO THIN FOR MOUNTING IN FLANGE

FIGURE 6



THERMOCOUPLE MOUNTING IN NON-METAL BASE SEMICONDUCTORS

FIGURE 7


SEMICONDUCTOR THERMOCOUPLE
CHASSIS
PIANO WIRE
CHASSIS THERMOCOUPLE
SECTION AA

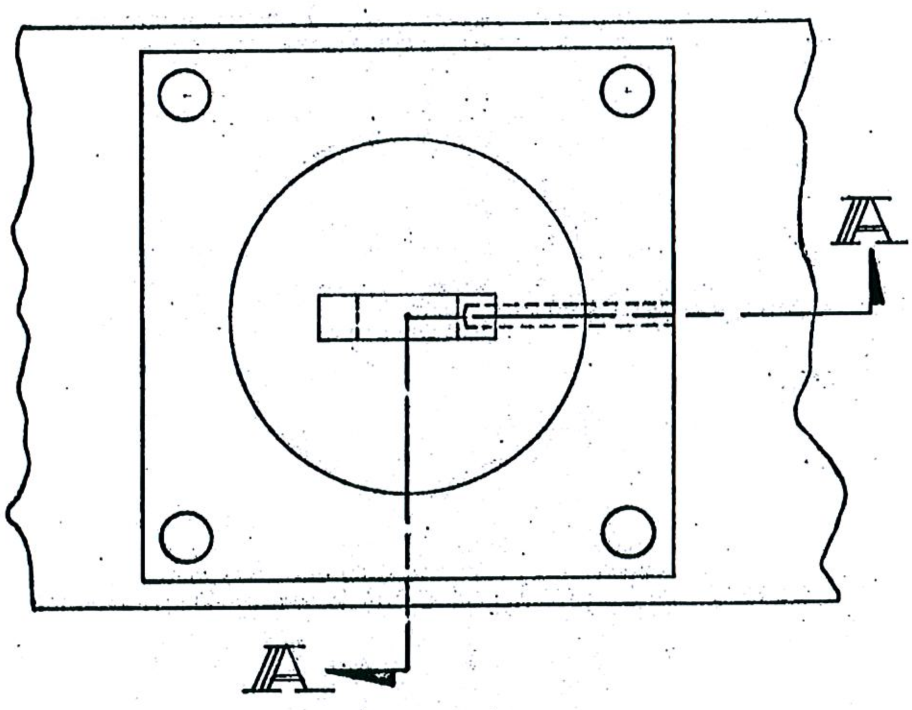
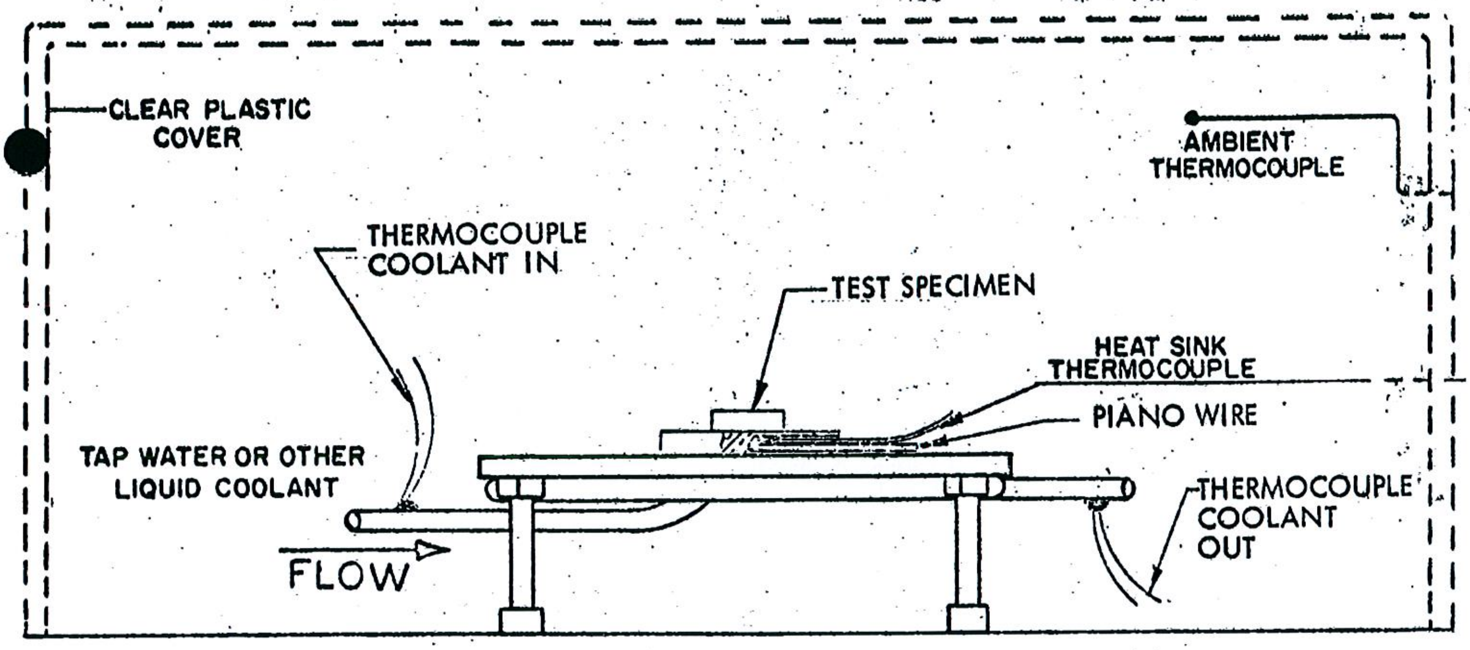

A
A

FIGURE 8



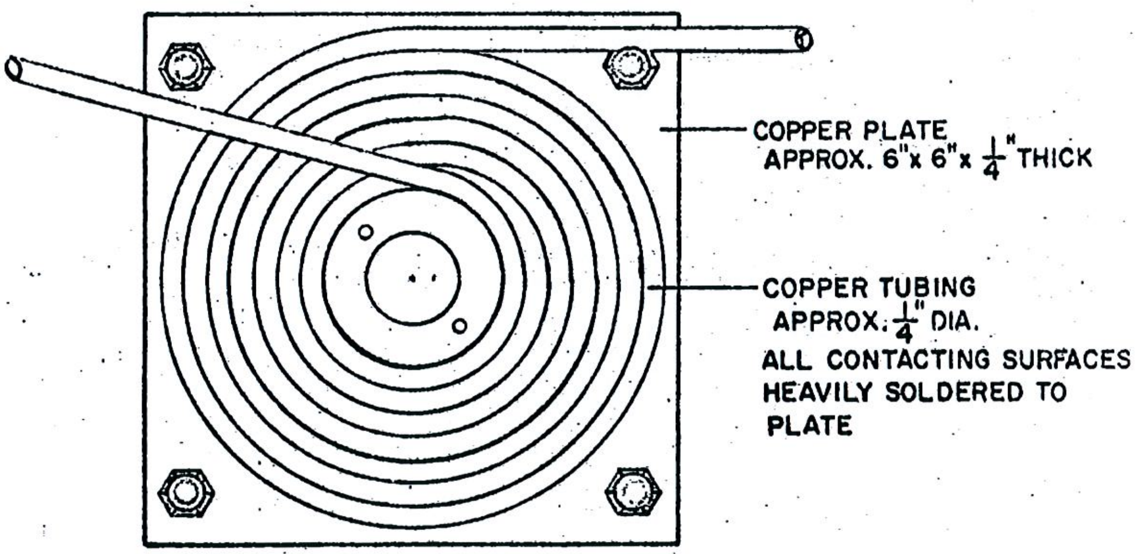


FIGURE 9

CONSTANT TEMPERATURE HEAT SINK

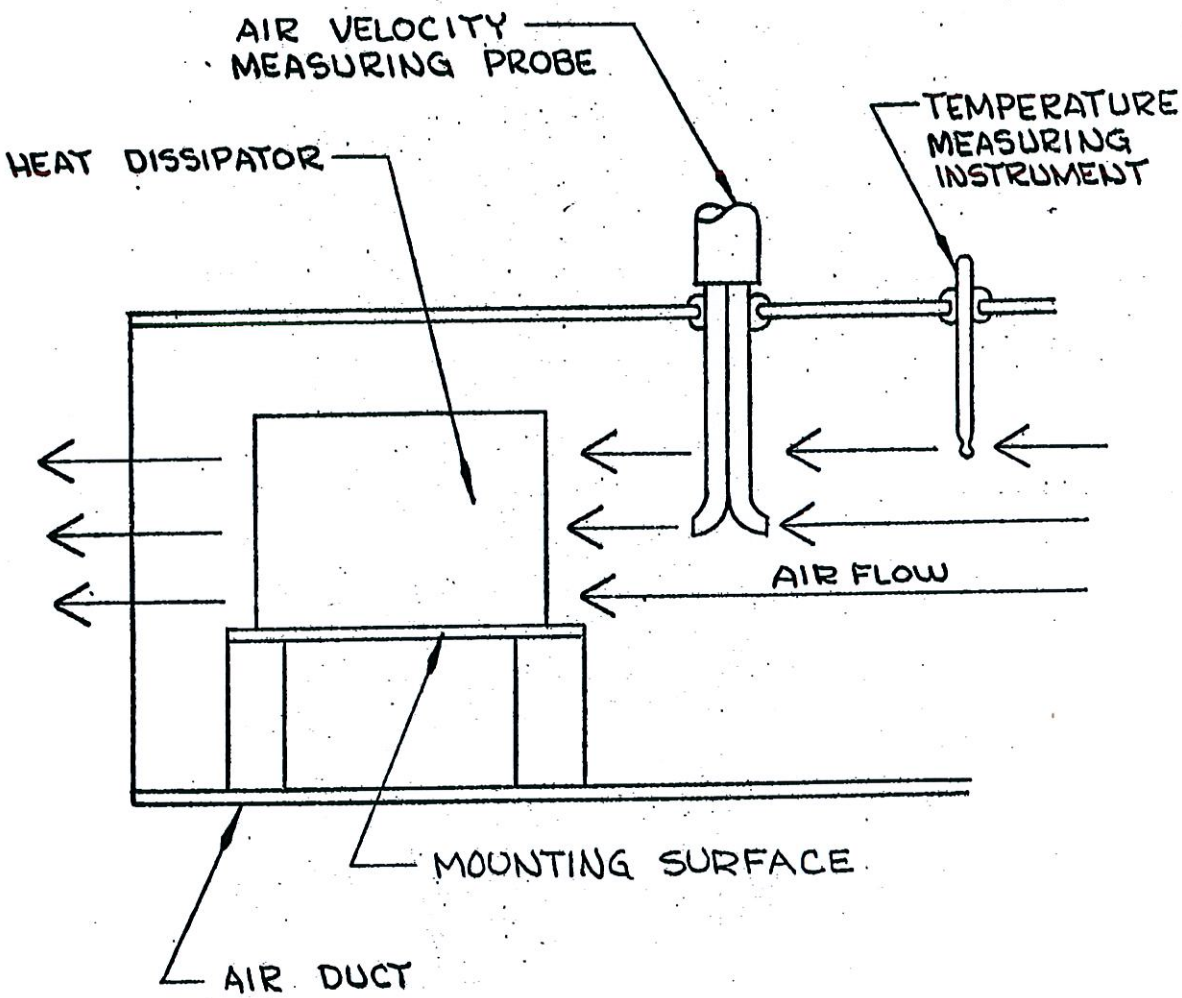


FIGURE 10

FORCED AIR MEASUREMENT, LINEAR

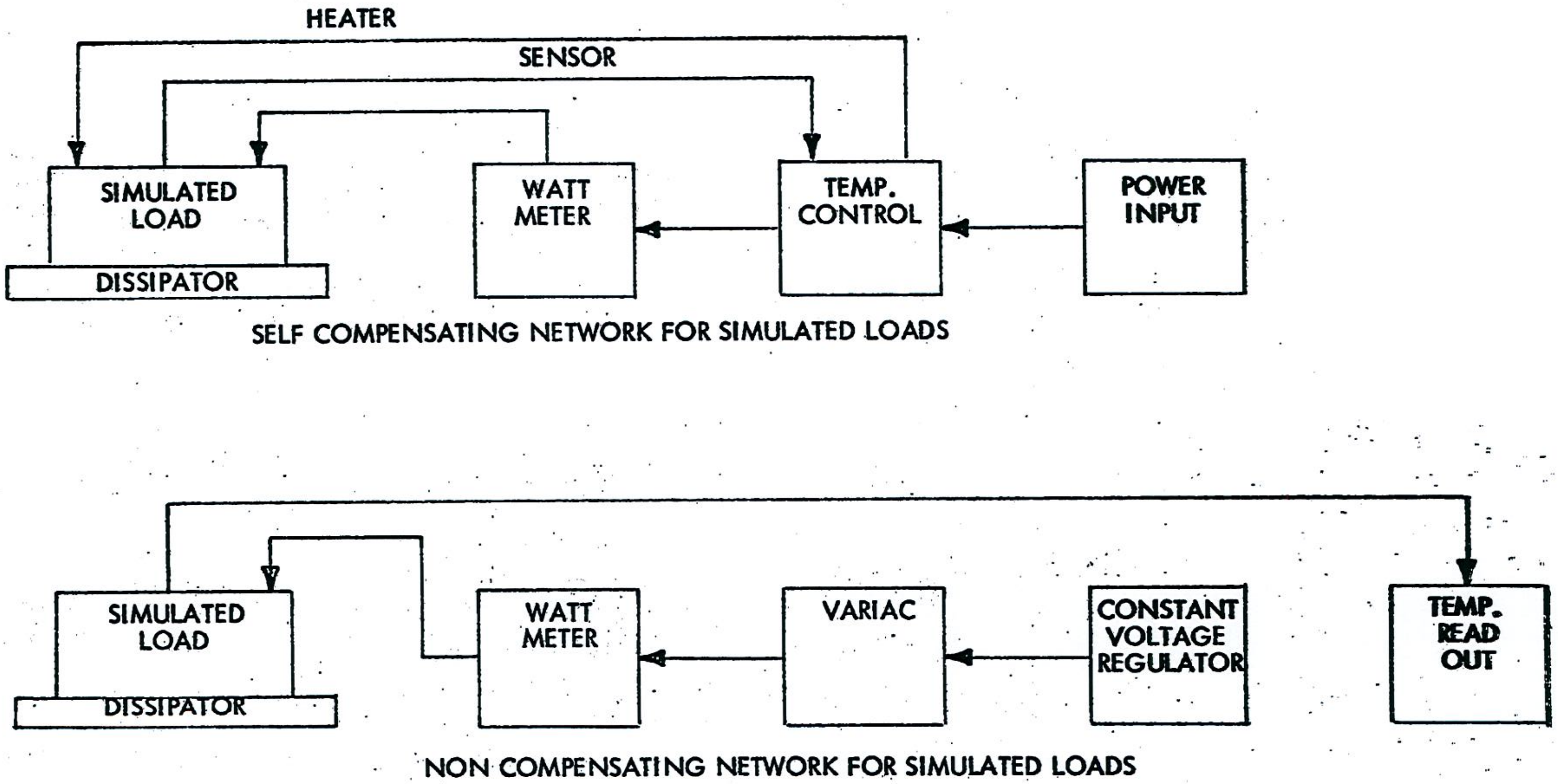

HEATER
SENSOR
SIMULATED LOAD
DISSIPATOR
WATT METER
TEMP. CONTROL
POWER INPUT
SELF COMPENSATING NETWORK FOR SIMULATED LOADS
SIMULATED LOAD
DISSIPATOR
WATT METER
VARIAC
CONSTANT VOLTAGE REGULATOR
TEMP. READ OUT
NON COMPENSATING NETWORK FOR SIMULATED LOADS

FIGURE 11