INSTRUCTION BOOK FOR

BIRD

SERIES 8655/56-600A
MODULOAD® RF CALORIMETER/ LOAD RESISTOR

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50kW MODELS COVERED IN THIS INSTRUCTION BOOK

MODELS*	VOLTS	MODELS**	VOLTS
8655-601A	115	8655-631A	115
8655-602A	230	8655-632A	230
8656-601A	115	8656-631A	115
8656-602A	230	8656-632A	230

*Without Ethylene Glycol
**With Ethylene Glycol

INSTRUCTION BOOK

FOR

SERIES 8655/56-600A

DIGITAL RF CALORIMETER/

LOAD RESISTOR

Bird Electronic Corporation
30303 Aurora Road, Cleveland (Solon), Ohio 44139-2794

SAFETY PRECAUTIONS

The following are general safety precautions that are not necessarily related to any specific part or procedure and do not necessarily appear elsewhere in the publication.

Keep away from live circuits.

Operating personnel must at all times observe normal safety regulations. Do not attempt to replace parts or disconnect an RF transmission or any other high voltage line while power is applied. When working with high voltage always have someone present who is capable of rendering aid if necessary. Personnel working with or near high voltage should be familiary with modern methods of resuscitation.

The following will appear in the text of this publication and is shown here for emphasis.

****
* C A U T I O N *
* *
* Do not use any sealants, leak-stopping material, or *
* automotive antifreeze in the coolant. Use only potable *
* water and pure ethylene glycol. Do not use deionized *
* water. *
****

****
* C A U T I O N *
* *
* The pump/motor must not be operated without sufficient *
* coolant in the system or damage to its working parts *
* will result. *
****

****
* C A U T I O N *
* *
* Do not use any drain plug other than that provided *
* by Bird. Use of a substitute plug could cause equip- *
* ment overheating by crossflow in the drain tubes. *
****

Continued

****

W A R N I N G

Before any RF operation whatever of the load/sensor unit is attempted the transmitter interlock and ac line attachment to the equipment must be made. Attach the transmitter interlock connections first to the two binding posts on the panel.

****

****

C A U T I O N

Do not operate the RF load/sensor unit without connecting interlock. This is very important. Even momentary application of power to the load while the cooling circulation is off or possibly functioning improperly will cause immediate destruction of the resistor element.

****

****

C A U T I O N

Be sure flow control switch is in proper position for power level.

Do not apply more than the rated RF power to the load used.

Do not block air flow. Air enters housing through perforated grilles on each side and exhausts at top.

****

****

C A U T I O N

RF power input over 10kW in the LO position will cause resistor burnout.

****

****

C A U T I O N

Do not exceed the power rating of the calorimetric load unit. Damage to the load resistor will result.

****

Continued

****

W A R N I N G

The following sections of this procedure involve the application of high power to the load. The following precautions must be observed to insure operator safety. Severe electrical burn or possibly death may result.

1. Make sure that the coaxial power cable connector is securely fastened to the load and that the water is flowing before turning on the ac power source.

2. Ensure that all Y.E.W. meter connections are tight before turning on ac power.

3. High voltage is present at the terminals of the Y.E.W. meters when the ac power source is on. Keep clear of these terminals.

4. Completely shut down the ac power source before changing the Y.E.W. meter connections, turning off the low voltage ac power source or removing the power cable from the load input connector.

****

****

W A R N I N G

The resistor used in this load consists of a resistive film on a special substrate. If the substrate is broken, there will probably be sharp pieces or splinters inside the load housing. Caution should be exercised to avoid possible injury.

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SERIES 8655/56-600A DIGITAL RF CALORIMETER/LOAD RESISTOR

INTRODUCTION

PURPOSE AND FUNCTION

The Bird Series 8655/56-600A Calorimeters are instruments realized by the marriage of the popular Bird Model 6080A Calorimeter and the Series 8600 MODULOAD® RF Load Resistor. This idea was destined to evolve into an auspicious combination very useful to any type of transmitting station.

The Series 8655/56-600A Calorimeters are space saving units that are easily installed and have a serviceability similar to a MODULOAD® RF Load Resistor, yet display measured RF power very precisely, without resorting to any calculations. These units are also independent of frequency within the frequency band of the load.

The load section is designed as a unique self-cooling, low reflection and nonradiating termination for high power RF transmitting equipment. It is capable of continuous power dissipation of up to 50kW with a VSWR of less than 1.10 to 1 from 1kHz to 900MHz (see Specifications). The Series 8655/56-600A are designed for use on CW, AM, FM, SSB and TV modulation envelopes, and within certain limits on radar or pulse modes.

The Series 8655/56-600A Calorimeters are another unique innovation by Bird Electronic Corporation in calorimetric measurement. The need for interpolation of the flow rates, temperature differences, and system constants by the user has been eliminated. Calibration is performed by one simple adjustment before power is applied (see Section III - Operating Instructions). The power is directly displayed in kilowatts on a digital meter. Because measurement has ±3% accuracy or better and is not frequency dependent, measuring energy transferred into a water medium, the calorimeter is ideal for use as a standard for other wattmeters.

Lightweight and versatile, the control unit can be moved within a ten foot radius of the load/sensor unit. Combining this with a bright display permits easy to read power measurements.

DESCRIPTION

The calorimeter is comprised of the two units as described above: the Calorimeter Control Unit and the Load Sensor Unit. These two units are connected by a ten foot sensor cable. A portion of the Model 6080A Calorimeter's measurement system has been conveniently installed into the Series 8655/56 Load Resistor. This has been done to ease operator installation and use.

Continued

The calorimetric load/sensor unit consists of four basic systems:

1. The RF assembly - contains the resistive load element with its water system for cooling.

2. Sensor unit - contains two temperature sensors, input and output water temperature, and another sensor to monitor water flow rate.

3. Heat exchanger - consists of a pump/motor unit, collector tank, a finned heat exchanger unit and blower fans..

4. Interlock control system - includes the electrical interlock circuitry required to prevent damage to the transmitter or load in the event of malfunction.

SPECIFICATIONS FOR SERIES 8655/56-600A

Impedance	50 ohms nominal
VSWR	1.10 maximum 1000Hz to 900MHz
Connectors	
Model 8655-( )*	3-1/8 EIA flanged
Model 8656-( )*	3-1/8 EIA flanged (Flush Center Conductor)
Power Range**	
LO Range	1-10kW continuous duty
HI Range	10-50kW continuous duty
Frequency Range	1kHz to 900MHz
Accuracy	
1 to 10kW	±3% of indicated power
10 to 50kW	±2.5% of indicated power, 50 ohms**
Dimensions	
Control Unit	4-3/64"H x 10-1/8"W x 10-5/16"L (102.6 x 257.4 x 262mm)
Calorimetric Load/Sensor Unit	19-1/32"H x 19-9/16"W x 45-1/2"L (483 x 497 x 1181mm)
Modes	CW, AM, SSB, TV & certain pulse types
Ambient Temperature	
50kW Continuous	
Water	+5°C to 30°C
35% Ethylene Glycol Mixture	0°C to +25°C
40kW Continous	
Water	+5°C to +40°C
35% Ethylene Glycol Mixture	0°C to +35°C
Nonoperating (Storage)	
Water	0°C minimum
35% Ethylene Glycol Mixture	-20°C minimum

Continued

Cooling Method.....	4 U.S. Gallons (15.14 liters) potable water or 2/3 water and 1/3 technical grade Ethylene Glycol
Weight	
Load/Sensor Unit Without Water.....	246 lbs. (111.6kg)
Load/Sensor Unit With Water.....	279 lbs. (126.6kg)
Calorimeter Control Unit.....	6 lbs. 2 oz. (2.78kg)
AC Power Required for Calorimetric Load/Sensor Unit.....	115Vac, 60Hz, 1 phase 14 amps 230Vac, 50Hz, 1 phase 7 amps
AC Power Required for Control Unit.....	115/230Vac, 50/60Hz, 1 amp

* -601A for 115V models without ethylene glycol
  -631A for 115V models with ethylene glycol
  -602A for 230V models without ethylene glycol
  -632A for 230V models with ethylene glycol

**Although the 6080A Digital Calorimeter is capable of power up to 80kW its capabilities will be limited by the maximum power rating of the RF load supplied or used with the system.

SECTION I - INSTALLATION

1-1. GENERAL

1-2. The purpose of this section is to assist the user with the initial steps that should be performed when receiving and preparing the RF Calorimeter for service. Refer to Figure 1-1 throughout this section.

1-3. UNPACKING

1-4. The Model 6080A Calorimeter Control Unit and Series 8650 Load/Sensor Unit are shipped in separate containers. Included in these containers are:

- 1 6080A Calorimeter Control Unit
- 1 8650 Series Calorimetric Load/Sensor Unit
- 2 ac line cords
- 1 Sensor cable
- 1 instruction manual

1-5. The 6080A Calorimeter Control Unit is shipped in a separate box. The unit is protected by foam inserts and is easily removed by lifting unit straight up out of the box.

1-6. INITIAL INSPECTION

1-7. All packages are carefully wrapped and inspected by Bird prior to shipment. If the package shows any sign of damage, open and inspect the contents. If any damage is visible, notify the carrier immediately. Retain the shipping container for inspection.

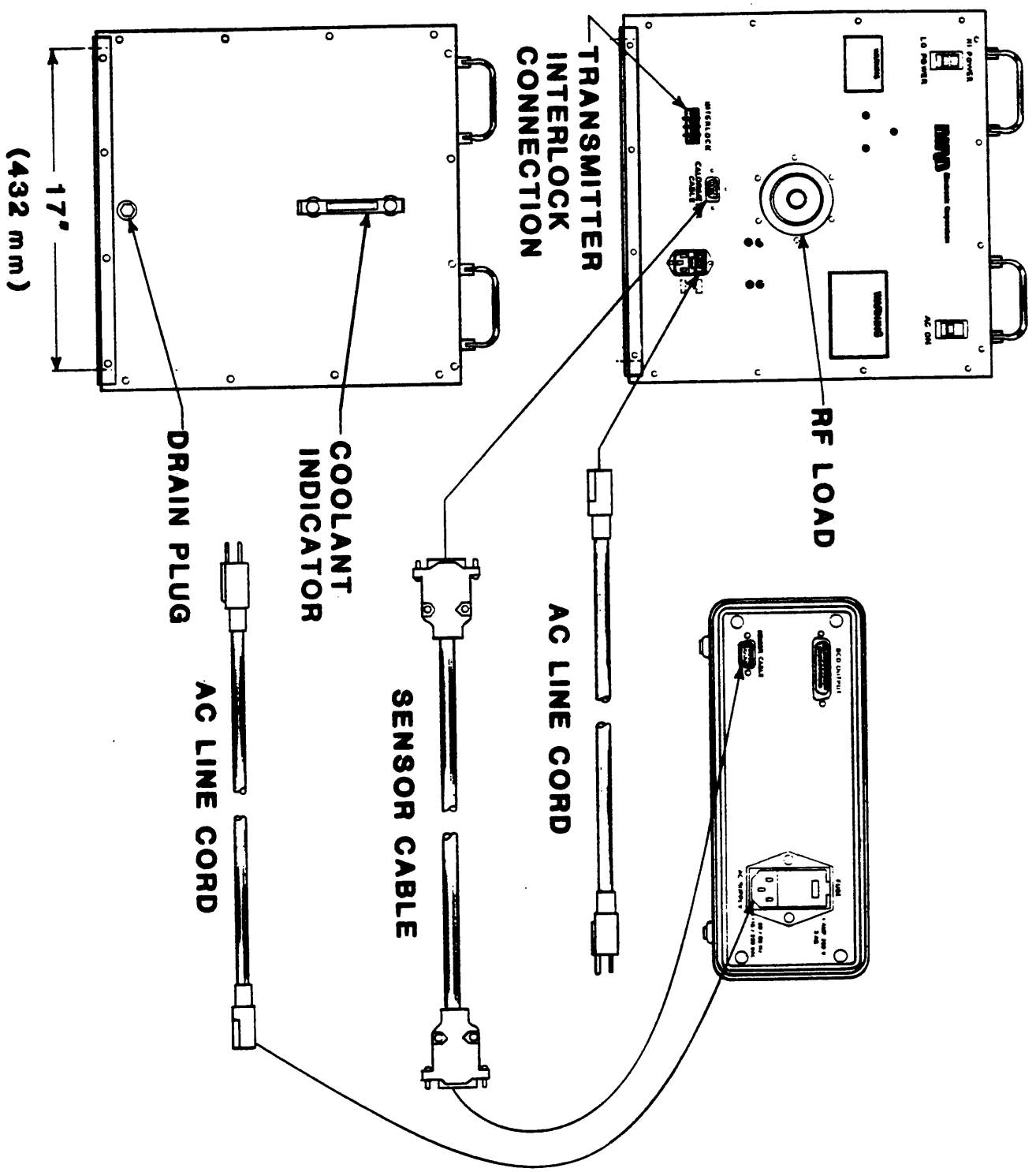
1-8. MOUNTING AND LOCATION

1-9. The Series 8655/56-600A Calorimetric Load/Sensor unit must be installed and operated only in its original horizontal position, as the unit is shipped and as it normally stands on its base brackets. Operation in any other manner will radically hamper the cooling system and almost certainly result in immediate burnout of the load resistor.

1-10. For convenience in installation of the equipment, angle brackets for mounting are attached to the front and back base edges of the enclosure. They may be removed by unscrewing the four 8-32 pan head screws holding each bracket. These brackets have two slots each on 17 inch centers and spaced 45-1/2 inches (432 x 1156mm) apart to accommodate four 1/4 screws that may be used for mounting the unit. The main control unit may be placed conveniently within the ten foot radius of the control cable reach.

1-11. The calorimetric load/sensor may be operated anywhere that adequate ac line power and air supply are available, and ambient temperatures do not exceed those given, 40°C maximum at 40kW or 30°C maximum at 50kW continuous, with water, see Specifications, Page x. Note - Since 50kW is equivalent to 170,740 Btu/h, a sufficient quantity of air must be provided. Allow room for unobstructed air intake over the entire surface of the perforated grilles on both sides of the equipment and a clearance of at least three feet over the top of the unit.

FIGURE 1-1. INSTALLATION.



```
************************************************************
*                        W A R N I N G                     *
*  Before any RF operation whatever of the load/sensor     *
*  unit is attempted, the transmitter interlock and ac     *
*  line attachment to the equipment must be made. Attach   *
*  the transmitter interlock connections first to the two  *
*  binding posts on the panel.                             *
*                                                          *
************************************************************
```

1-12. AC LINE CONNECTION

1-13. Model 6080A Calorimeter Control Unit contains an ac line module located on the rear panel for input of ac power. This module is voltage selectable for either 115 Vac or 230 Vac and contains an ac line fuse. The following steps explain voltage selectability and fuse accessibility:

Step 1: Determine the voltage level of the ac line. This may be 115/230 Vac.

Step 2: Compare this voltage level with the number that appears in the ac line select window.

Step 3: The control unit is factory-shipped for 115 Vac operation. Change to 230 Vac if necessary. Open cover door and remove voltage selector drum (see Figure 1-2).

Step 4: Rotate voltage selector drum to desired voltage and reinsert.

Step 5: AC line fuse is accessible by pulling out fuse drawer.

Step 6: Close cover door.

Step 7: Locate the ac cord. Connect one end to the control unit's ac line module the other end at the ac outlet. Refer to paragraph 1-15 when connecting to European style sockets.

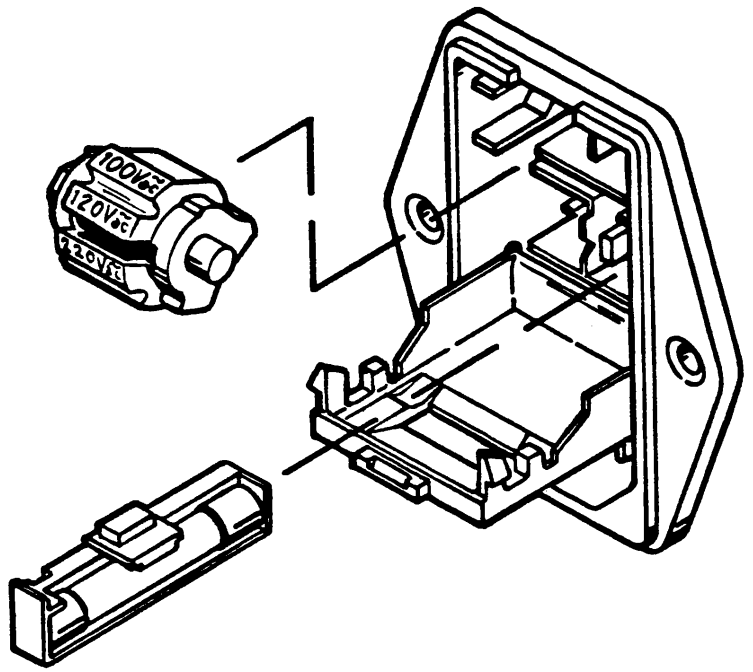
1-14. The calorimetric load/sensor unit also contains an ac line module located on the front panel. This module is wired for either 115 Vac or 230 Vac and does not have voltage selectability. The module does contain an ac line fuse which is accessible as described in the preceding steps. Locate the power cord. Plug one end into the load/sensor ac line module and the other end to an ac power outlet. Refer to paragraph 1-15 when connecting to European style sockets.

For safety, the third wire in the ac line cord (the green wire) is the ground wire and must be connected to an earth ground. If a three wire system is not used, this wire must be properly attached to an earth ground.

1-15. EUROPEAN STYLE CONNECTORS

1-16. In order to make the ac line cord compatible with European style sockets, users must replace the connector at the end of the power cord. Then set the operating voltage selection drum for 230 Vac.

FIGURE 1-2. AC LINE MODULE.



1-17. 6080A CONTROL UNIT INSTALLATION

1-18. Locate the calorimetric control unit on a clean flat surface within the radius of the sensor cable. For longer distance remote monitoring, various lengths of sensor cables are available. See Section VII Replacement Parts.

With ac line already connected, the control unit requires only one other connection, the sensor cable. Connect the sensor cable to the control unit as follows:

Step 1: A 9-pin D-shell sensor cable connector is located on the rear panel of the calorimeter control unit. Correctly align the sensor cable with the sensor cable connector and mate the two parts. (The design does not permit incorrect connection.)

Step 2: Secure the provided screws, but do not overtighten them.

1-19. LOAD/SENSOR UNIT INSTALLATION

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* Do not operate the RF load/sensor without connecting     *
* interlock. This is very important. Even momentary        *
* application of power to the load while the cooling       *
* circulation is off or possibly functioning improperly    *
* will cause immediate destruction of the resistor         *
* element.                                                 *
************************************************************
```

1-20. Connect the unterminated end of sensor cable to the load/sensor unit's cable connector located on the rear panel. Follow the preceding steps for connection.

Connect the transmitter's interlock cable (not provided) to the two binding posts located on the front panel.

1-21. COOLANT

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* Do not use any sealants, leak-stopping material, or      *
* automotive antifreeze in the coolant. Use only potable   *
* water and pure ethylene glycol. Do not use deionized     *
* water.                                                   *
************************************************************
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1-22. The unit operates with 16 quarts (15.14 liters) of coolant. The coolant may be potable water for ambient temperatures of +5°C to +40°C

(+41°F to +104°F), or 2/3 water and 1/3 ethylene glycol for temperatures from 0°C to +35°F (+32°F to +95°F). Temperature ranges must be stated when an order is placed. Use only potable water and industrially pure ethylene glycol. Standards for potable water have been established by the U.S. Public Health Service at a maximum of 500 ppm of total dissolved solids (ppm - parts per million or 1 mg. per liter). Hardness of water (content of calcium and magnesium salts) is also an essential factor, and should be less than 75 ppm. If the quality of the available water supply is doubtful or the mineral content is questionable, it is advisable to use only distilled water or, as the case may be, distilled water and ethylene glycol mixture. Note - Do not, under any circumstances, use deionized water in the system. It will have a detrimental action on the internal parts. Do not use any antifreeze preparations. Note - When ethylene glycol is used, special calibration of the calorimeter is necessary. Any change in the concentration of the factory supplied coolant will require recalibration.

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* The pump/motor must not be operated without sufficient   *
* coolant in the system or damage to its working parts     *
* will result.                                             *
************************************************************
```

1-23. Check the coolant level daily when the unit is in prolonged use or when starting after a period of inaction. The coolant gauge is in the upper left side of the rear panel of the load/sensor unit. Whether the pump is on or off, when properly filled, the coolant indicator in the glass tube should show the liquid level at the upper level of the gauge. The level may also be checked by removing the filler plug at the top. It should be filled to a level about 4-5/8 inches (117mm) below the top surface of the filler tube opening. Add coolant, if necessary, to bring to the required level.

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* Do not use any drain plug other than that provided       *
* by Bird. Use of a substitute plug could cause equip-     *
* ment overheating by crossflow in the drain tubes.        *
************************************************************
```

1-24. DRAINAGE AND FILLING

NOTE: All units are flushed with ethylene glycol before leaving the factory to prevent damage in shipment by freezing. All units to be used with water only (i.e., those with the suffix number of 601 and 602) must be flushed twice with clear potable water before final filling to assure accuracy.

1-25. Drainage of the system is accomplished by removal of the drain plug at the bottom of the rear panel. Do not use any drain plug other than that provided by Bird. Use of a substitute plug could cause equipment overheating by crossflow in drain tubes. To refill the system, pour coolant in until the tank is approximately at the requisite level stated previously, and then run the motor a few seconds to pull fluid into the system. A

convenient method is to watch through the reservoir filler and stop the pump when the water level approaches the bottom. Do not run too long on original pourings, as partially dry operation of pump might ensue, with possible damage to the pump mechanism. Repeat filling in this manner until fluid level remains steady at the proper level, then run the load/sensor unit about five minutes and recheck fluid level before applying RF power (see 1-21, Coolant).

1-26. BLOWER FAN

1-27. The fan is wired direct to the ac line input and will always operate along with the pump when the ac switch is on. In addition to the basic function of producing requisite air flow through the radiators, this ventilation materially assists in cooling the pump/motor unit.

SECTION II - THEORY OF OPERATION

2-1. GENERAL

2-2. The Model 8775/76 style TERMALINE® Coaxial Load Resistor installed in this unit is unique in having its water supply primarily directed over the outer, wet-film type, resistive coating of the substrate. This technique is valuable in eliminating the need for an intermediate heat transfer fluid system. This method reduces the physical size of the load to a virtual minimum and makes it ideal for use in this calorimetric application. The construction and materials herein permit field repair of the unit (see Section IV - Maintenance).

2-3. HEAT TRANSFER

2-4. The 50 ohm resistor consists of a substrate made of a special compound and has a permanently deposited resistive film on its outer surface. The heat generated by absorption of RF power is transferred from the film to the water which flows over it through a restricted chamber surrounding the resistor body. This water, first carried to the front of the load resistor, passes over the entire length of the resistor and discharges through the sealed water chamber at the rear. The composite dielectric characteristics and the distinctive design of these enclosures provide a very accurate 50 ohm termination over the specified frequency range of this load, 1000Hz to 900MHz.

2-5. THEORY OF CALORIMETRY

2-6. The term calorimetry refers to the measurement of quantities of heat. Heat is energy in transition resulting from a temperature differential. This energy in transition may be expressed in ft-lb/h, Btu/m or cal/sec.

2-7. The "First Law" of thermodynamics states that energy can neither be created nor destroyed, but only converted from one form to another. This is the basic concept behind the calorimetric method of measurement. A basic definition should be noted: if a quantity of heat is transferred into one gram of water until the temperature of the water is increased one degree centigrade, it would be called one gram-calorie, more commonly referred to as one calorie. In the English system, if one pound of water will increase its temperature one Fahrenheit degree, one Btu of heat has been transferred into it.

Equation 1. $1\ \text{Btu} = 1\ \text{lb.} \times 1°\text{F}$
$1\ \text{Calorie} = 1\ \text{gram} \times 1°\text{C}$

The relationship of grams to pounds and °C to °F is such that it makes one Btu equal to 251.996 calories.

2-8. Another factor in calorimetric measurement should also be taken into consideration: the specific heat of a substance. It has been proven that different substances having a weight of one pound will require different amounts of energy to increase their temperature one degree Fahrenheit. To compensate for this behavior of different materials, including water, a

correction factor was assigned called specific heat. The units for specific heat are Btu/lb°F. By applying this correction factor to Equation 1, the calorimetric formula for heat thus becomes:

Equation 2. $1 \text{ Btu} = 1 \text{ lb.} \times 1°\text{F} \times 1 \text{ Btu/lb°F}$
$\text{heat} = \text{mass} \times \Delta T \times Cp$

Since 1 Btu of heat is equal to 778.16 ft-lb of work, and the time rate of doing work is power, ft-lb/h or Btu/h could be a description of electrical watts or mechanical ft-lb power. Thus, when the time element is introduced into Equation 2, it simply becomes:

Equation 3. $\text{Btu/h} = \text{mass (lb/h)} \times \Delta T(°\text{F}) \times Cp \text{ (Btu/lb°F)}$

This is the equation of calorimetry. Knowledge of delta T, rate of mass flow, and specific heat would produce Btu/h, equal to power.

2-9. DIGITAL RF CALORIMETER

2-10. Calorimetry as applied to this series calorimeter is essentially the same as described in the preceding paragraphs. The water cooled loads installed in the Series 8655/56-600A transfer almost 100% of RF heating power into the cooling liquid. This provides a means with which the elementary calorimetric formula can be utilized.

Equation 4. $\text{RF Power} = \text{flow} \times \Delta T \times \text{constant} \times Cp$

The electronic calorimeter synthesizes the flow rate, temperature differential and conversion factor, displaying the final result in kilowatts on a digital readout.

2-11. To determine the temperature it is necessary to linearly track temperatures between 0°C and 50°C. This is accomplished through electronic thermometers that produce a voltage output as a direct function of temperature in °C. The temperature difference is found by placing an electronic thermometer at the load water input and also at the load drain. Their voltage outputs are fed into a differential amplifier and the resulting output will be the temperature difference.

2-12. Flow rate is measured by a magnetic sensor which is located at the water input of the load. This metering device utilizes a turbine bladed rotor to generate a pulse output. These pulses are then fed into a frequency to voltage converter that produces a gallon per minute voltage output. By adjusting the output gain to the system's constant we implement our conversion factor. To synthesize these system variables, an analog multiplier is used. The X input of the multiplier is used for flow rate and the Y input is for temperature difference. By applying the output of the multiplier to a digital panel meter, the voltage measured will be the power consumption in kilowatts.

2-13. PRESSURE INTERLOCK CONTROL CIRCUIT

2-14. The interlock control circuit provides instantaneous fail-safe protection of the transmitter and load in the event of even momentary

interruption of the cooling water supply. This protection is necessary because dissipation of the heat generated by the RF power is critically dependent upon a required minimum water flow at all times regardless of system water temperature.

Note: The impeller of the centrifugal water pump is carefully selected for the necessary current flow. The proper operation of this equipment depends on these conditions being maintained. Do not alter the flow switch setting or disturb the pump.

2-15. The water pressure switch, installed close to the output port of the pump, is a "normally open" type; i.e., its electrical contact opens when deactivated. Closed during equipment operation, the switch is adjusted to open whenever water pressure drops below the safe flow point for the specific unit - about 25 lbs/in^2 (1.76kg/cm^2). When this occurs, the timer relay is instantly deactivated, thereby opening the interlock circuit and causing immediate transmitter shutdown.

2-16. After resuming operation of the load unit and restoring the calibrated water pressure, the time delay switch will keep the transmitter interlock "open" for an additional 1/2 to 3/4 second. This special safeguard assures proper operation of the cooling system before RF power can be applied to the load, preventing damage or burnout of the resistor element. Note - A special FLOW CONTROL switch is added to the front panel of this model. For the safety of the load resistor, it is important that this switch be in the correct position for RF power level used. In the LO position, input of over ten kilowatts will cause quick burnout of the load resistor. Use extreme caution in LO position. The switch controls a solenoid valve, normally closed, which opens to bypass some of the load resistor's water supply.

SECTION III - OPERATING INSTRUCTIONS

3-1. GENERAL

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************************************************************
*                      C A U T I O N                       *
*                                                          *
* Do not apply more than the rated RF power to the load.   *
* Do not block air flow - air enters housing through       *
* perforated grilles on each side and exhausts at the      *
* top.                                                     *
************************************************************
```

3-2. The Series 8655/56-600A Calorimetric Load/Sensor Unit has only one operating control, the FLOW CONTROL switch located on the front panel of the unit. This switch must be set for the power level used (LO setting, one to ten kilowatts; HI setting, above ten kilowatts power) before operation. Unless calorimetric measurements are to be taken, it is advised that this switch remain in the HI POWER position even though the load is used at low power. Once set, the presence of an operator is not required.

3-3. CONNECTING RF POWER TO LOAD

3-4. After installation, the coaxial RF transmission line may be attached. For the respective Models, 8655-600A and 8656-600A, the connections are as follows:

a. Model 8655-600A, 3-1/8 inch EIA, 50 ohms with swivel flange.

1. Use 3-1/8 inch EIA coupling kit, P/N 4600-020, which includes: six each 3/8-16 inch x 1-1/2 inch bolt and nut sets, O-Ring, and insulated center bullet.

2. Insert the center bullet, push in to seat insulator in facing, and install O-Ring in groove.

3. Connect coaxial input in straight line, push carefully on center contact to close. The swivel flange on the load/sensor unit makes connection independent of a fixed flange on the coaxial input.

4. Insert bolt sets, tighten evenly all around.

b. Model 8656-600A, 3-1/8 inch unflanged, 50 ohms.

1. Use coupling kit, P/N 5-726 or RCA MI-27791K-4A, consisting of an outer sleeve with two clamping bands and the center conductor coupling bullet.

2. Insert center bullet and bottom it on the midpoint nibs.

3. Position the outer sleeve, with clamps, over input connector.

4. Introduce transmission line and seat snugly against the coupling stops.

5. Position clamp bands evenly about 1-3/4 inch apart and tighten.

3-5. OPERATING AS A LOAD RESISTOR

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* Do not operate the load/sensor unit without connecting   *
* interlock. This is very important. Even momentary        *
* application of power to the load while the cooling cir-  *
* culation is off or possibly functioning improperly will  *
* cause immediate destruction of the resistor element.     *
************************************************************
```

a. Turn interlock supply on.

b. Turn on 115V or 230V ac power. For fan operation see 1-26, Blower Fan.

c. Apply RF power to load.

3-6. SHUTDOWN

a. Turn RF power to load off.

b. Wait five minutes, allowing pump and fans to run.

c. Turn ac power off. Stopping the load/sensor unit automatically opens the interlock connection.

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* Be sure flow control switch is in proper position for    *
* power level.                                             *
*                                                          *
* Do not apply more than the rated RF power to the load    *
* used.                                                    *
*                                                          *
* Do not block air flow. Air enters housing through        *
* perforated grilles on each side and exhausts at top.     *
************************************************************

************************************************************
*                      C A U T I O N                       *
*                                                          *
* RF power input over 10kW in the LO position will cause   *
* resistor burnout.                                        *
************************************************************
```

3-7. PERFORMANCE NOTES

3-8. Important - For correct calorimeter readings, the FLOW CONTROL switch on the front panel must be set as follows:

	Control Unit Power Reading	Load/Sensor Unit Switch Setting
Low Range	1-10kW	LO RF POWER
High Range	above 10kW	HI RF POWER

3-9. There are two thermoswitches used in the calorimetric load/sensor unit. One switch is located in a well on the load drain line, for the low power range. The other, located in the coolant storage tank, is for high power operation. These switches are in series with the pressure switch circuit, supplying voltage to the interlock relay. Controlled by the HI-LO setting switch, only one thermoswitch will be in operation at a time depending on power level used.

3-10. The Series 8655/56-600A Calorimetric Load/Sensor Unit will handle continuous power dissipation of 50kW at a maximum ambient temperature of 30°C. For other values, see Specifications on Page x. The Series 8655/56-600A are intended for use on CW, AM, FM, SSB, TV modulation envelopes, and within certain limits on radar or pulse modes. For information involving pulse type signals, contact the factory.

3-11. COOLING CHARACTERISTICS

3-12. The electrical performance of the Series 8655/56-600A Calorimetric Load Unit is affected by impurities or other chemical additives in the cooling liquid. Therefore, the cooling liquid should be clear potable water with industrially pure ethylene glycol, when used, and be kept clean at all times. See Paragraph 1-22 for definition of potable water.

3-13. Thermal performance is affected by impurities, particularly those which accumulate in the form of scale on the surface of the ceramic tube and other water passages. This results in an increase of thermal resistance of the load and in turn, may cause the load to overheat and fail.

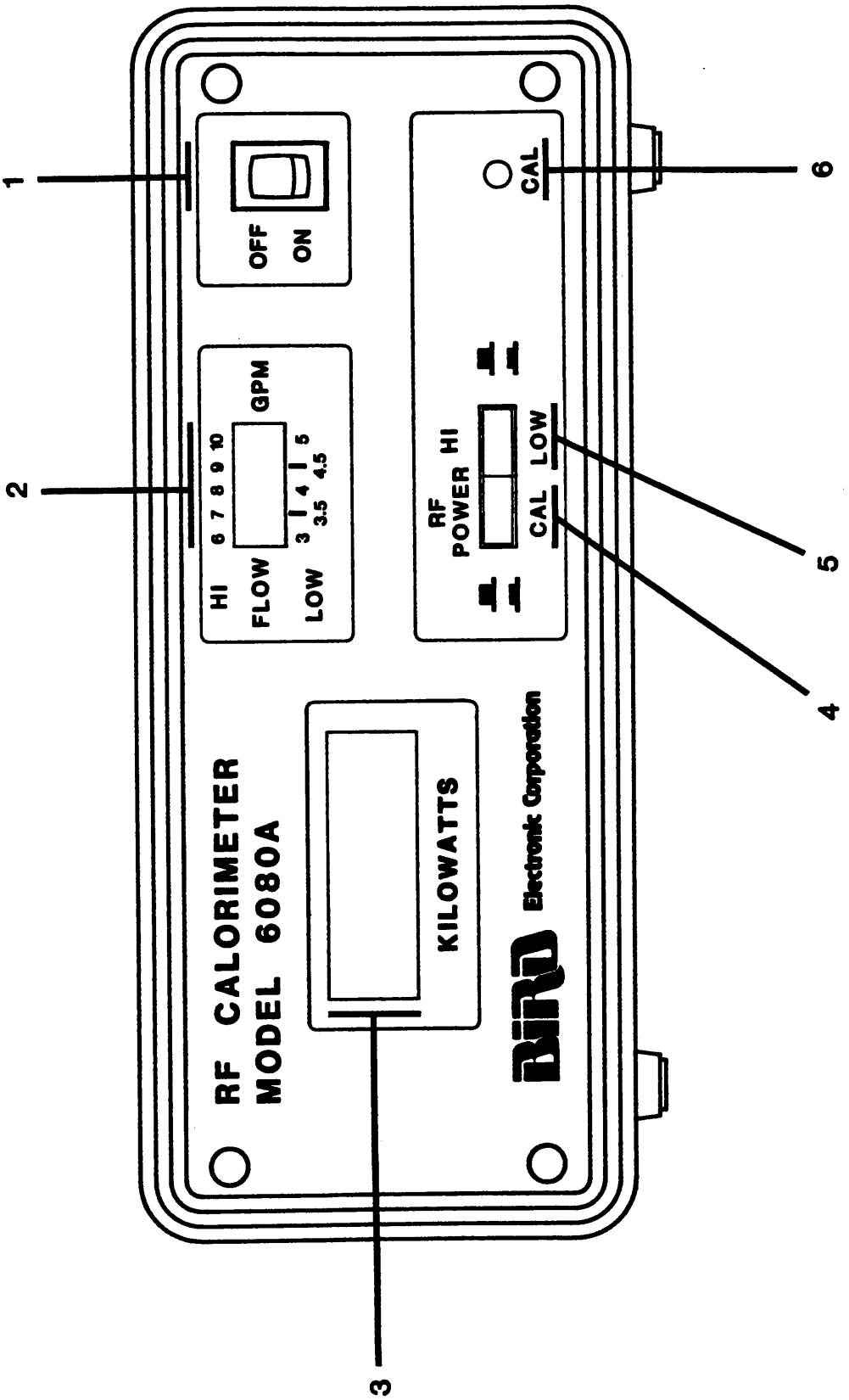
3-14. CONTROL UNIT (MODEL 6080A)

3-15. This section describes the operation of the Model 6080A Control Unit. Operator is given a description of front and rear panel features and is guided through a step by step format of how to take measurements. Calorimeter is installed per procedures in Section I - Installation.

3-16. FRONT PANEL LAYOUT

3-17. The following is a description of front panel features (see Figure 3-1).

FIGURE 3-1. FRONT PANEL LAYOUT.



1. ON / OFF SWITCH
2. FLOW INDICATOR
3. DISPLAY
4. RF POWER / CAL SWITCH
5. HI / LOW SWITCH
6. CAL ADJUST

1. ON/OFF Switch - Controls ac line power.

2. FLOW INDICATOR - Gives visual indication of coolant flow in gallons per minute (GPM). The flow indicator has two ranges, a low power range which indicates a flow of 3 to 5.25 GPM and a high power range which indicates a flow of 6 to 10.5 GPM. These ranges are selectable through the use of the HI/LO pushbutton.

3. DISPLAY - Gives a visual indication of the present value being measured. This value represents kilowatts of RF power being seen by the load/sensor unit.

4. RF POWER/CAL SWITCH - When not depressed RF power mode is selected. This mode is implemented during normal operating conditions and is used in conjunction with the HI/LO range button.

When the button is depressed then CAL mode is selected. Unit is now ready to perform initial system calibration.

5. HI/LO SWITCH - With the unit in RF power mode this button will select between High or Low power and flow ranges. In LO mode the usable power range is 1 to 10kW and flow range is 3 to 5.25 GPM. In HI power mode the upper power limit is determined by the series of load used. The Series 8630-600A utilizes only the low power mode. The HI range of the flow sensor is 6 to 10.5 GPM.

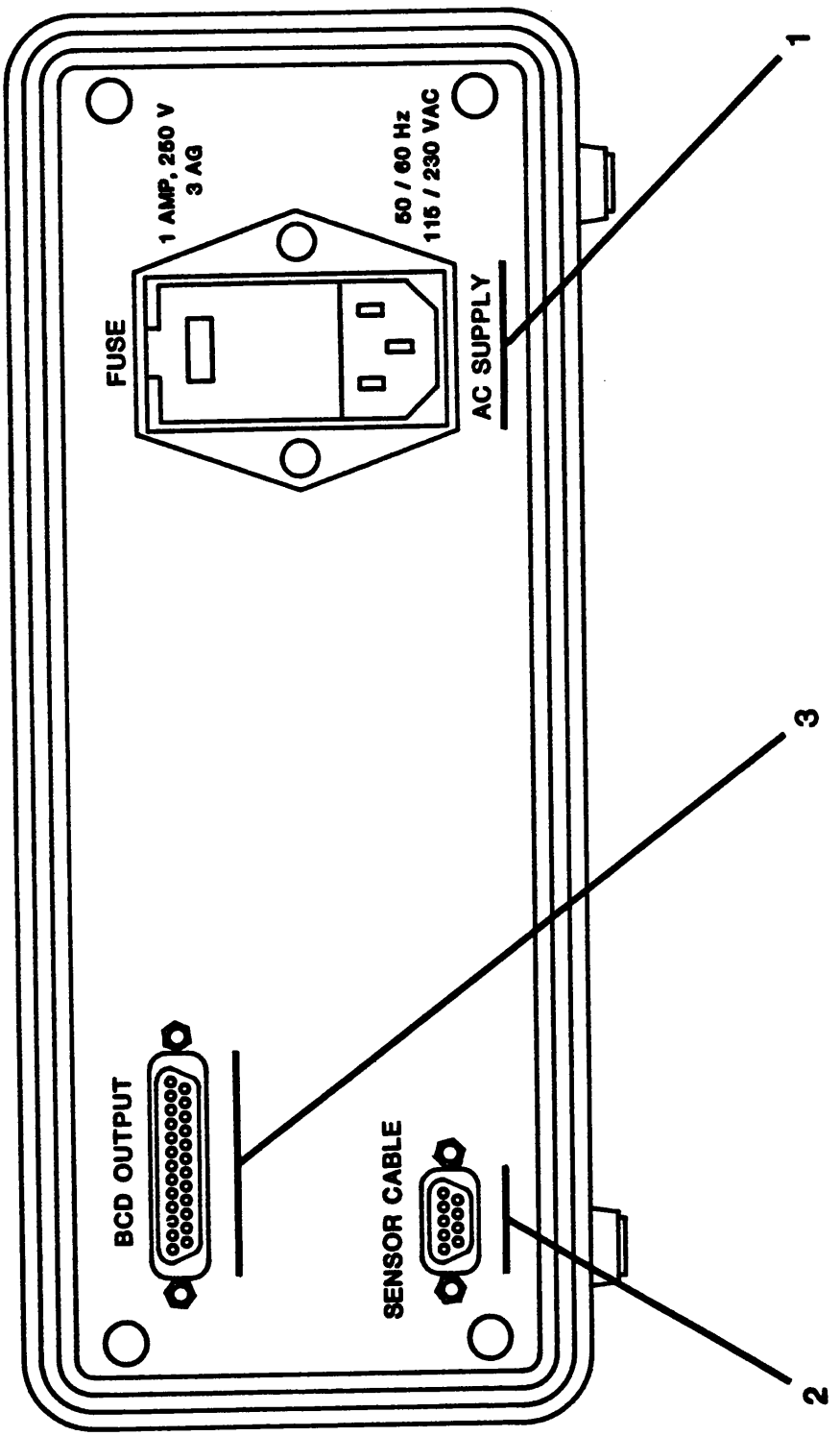
With unit in CAL mode the HI/LO button allows operator to perform initial calibration for both ranges.

6. CAL ADJUST - This is the adjustment potentiometer for nulling power ranges when unit is in CAL mode.

3-18. REAR PANEL LAYOUT

3-19. The following is a description of rear panel features (see Figure 3-2).

FIGURE 3-2. REAR PANEL LAYOUT.



1. AC LINE SENSOR
2. SENSOR CABLE CONNECTOR
3. BCD OUTPUT CONNECTOR

a. AC LINE MODULE - The ac line module provides a three function capability:

1. Contains the ac line socket for input of ac power.
2. Provides line voltage selection 115/230 volts.
3. Contains internally, an ac line fuse.

Location of fuse and instructions on line voltage selection are detailed in Section 1-12.

b. SENSOR CABLE - This 9-pin D-shell connector supplies the mating contacts for the sensor cable. Input/Output data passes to and from calorimetric control unit via this connector. Pin assignments for this connector are given below:

Pin No.	Function
1	Flow Frequency
2	Sensor Supply Voltage (+15V)
3	Input Voltage Reference (+5V)
4	Input Voltage Ratio
5	Input Temperature Voltage
6	Signal Ground
7	Output Voltage Reference (+5V)
8	Output Voltage Ratio
9	Output Temperature Voltage

c. BCD OUTPUT - This 25-pin D-shell connector supplies a BCD output for remote use. Various applications for this output are described in Section IX. Pin assignments for this connector are given below:

Pin No.	Function	Pin No.	Function
1	BCD 100	14	BCD Ground
2	BCD 200	15	Hold
3	BCD 400	16	NC
4	BCD 800	17	BCD 1000
5	NC	18	+5V
6	BCD 10	19	OE3 (Tens)
7	BCD 20	20	OE2 (Hundreds)
8	BCD 40	21	OE4 (Units + Overrange)
9	BCD 80	22	OE1 (Thousand + Polarity)
10	BCD 1	23	Overrange
11	BCD 2	24	Polarity
12	BCD 4	25	Data Valid
13	BCD 8		

3-20. START UP

3-21. Before applying ac line power to the calorimetric load/sensor or control unit make certain that ac line module is matched to the available line voltage and all safety precautions are taken.

3-22. Perform the following steps to achieve a proper start up condition:

```
************************************************************
*                      C A U T I O N                       *
*                                                          *
* The pump/motor must not be operated without sufficient   *
* coolant in the system or damage to its working parts     *
* will result.                                             *
************************************************************
```

a. Turn on ac power switch on the calorimetric load/sensor unit. This will start the coolant pump directly, regardless of the condition of the control system. The line power supply to the unit will usually be remotely controlled, and generally may be switched in conjunction with RF power loading of the system.

Operation of the pump/motor, initiating coolant flow, will close the pressure switch contacts. The high temperature thermoswitch in series with it is normally closed and this will start operation of the time delay. In approximately 3/4 second it will close contacts and the transmitter interlock will then permit the application of RF power. Do not apply RF power at this time.

b. Allow coolant flow and the load/sensor unit to stabilize for a minimum of five minutes.

c. Turn on ac power to the calorimeter control unit.

d. Set RF POWER/CAL switch to CAL mode.

e. Perform an initial calibration on both the HI and LO power ranges by first selecting the HI range and adjusting the CAL adjustment for a display indication of zero. Now select the LO range and adjust the CAL adjustment for zero. NEVER CALIBRATE UNIT WITH RF POWER APPLIED.

f. Return RF POWER/CAL switch to RF power mode.

g. If display still doesn't indicate zero, a fine adjustment can be made to the CAL adjustment while in RF power mode.

NOTE: If null setting could not be achieved, see Maintenance Section.

h. Flow indicator should show a stable flow of approximately 3.5 GPM. If flow is below 3.25 or above 3.75, see Maintenance Section.

3-23. Series 8655/56-600A RF Calorimeter is now ready for normal operation.

3-24. NORMAL OPERATION

```
**********************************************************
*                      C A U T I O N                     *
*                                                        *
* Do not exceed the power rating of the calorimetric load *
* unit.  Damage to the load resistor will result.        *
**********************************************************
```

3-25. With the Model 6080A Control Unit set in RF power mode, LO power range, RF power measurements can now be made. Apply RF power. The display will indicate RF power being measured in kilowatts. With large changes of transmitter power allow three minutes stabilization time to achieve stated accuracy.

3-26. SHUTDOWN

3-27. The following steps apply to Model 8655/56-600A system shutdown.

a. Turn off transmitter power.

b. Turn off Model 6080A Control Unit

c. Wait five minutes before turning off ac line power to calorimetric load/sensor unit.

SECTION IV - MAINTENANCE

4-1. GENERAL

4-2. Only a moderate amount of preventive maintenance is required for the Series 8655/56-600A Digital RF Calorimeter. Use reasonable care in handling; do not drop the main control unit or load assembly.

4-3. The coaxial load resistor installed in the load/sensor unit of the calorimeter is rugged and simple, requiring only nominal and routine attention. The load is designed to operate for long periods of time if care is taken not to exceed its power handling capabilities.

4-4. PREVENTIVE MAINTENANCE

4-5. Following the routine below will ensure years of failure-free operation.

a. CLEANING

1. A main factor in effective preventive maintenance is cleanliness. For optimum performance and service life, the calorimeter must be kept in a clean and dust-free condition. When not in use keep the main control unit in a clean cool environment.

2. The outside surface of the unit should be wiped free of dust and dirt at regular intervals. Particular attention should be given to the air intakes (see Sub-paragraph c-12). Occasionally, check condition of RF Coaxial connection. If required, disconnect the instrument from the transmission line and clean the connector parts, both metallic and insulator surfaces. The control cable connector must be kept clean. Carefully wipe the metallic contacts and connector body. A cotton swab stick is useful for this. The operating panel should be wiped clean with a soft cloth. Wipe the meter face only when necessary.

b. INSPECTION - Periodic inspection should be performed at three to six month intervals dependent on amount of continuous use.

1. Pressure switch - This unit is an essentially uncomplicated mechanism, requiring little care to provide long term service. Its operation can be checked easily by monitoring the interlock circuit while starting or stopping the pump/motor without any RF power applied to the equipment. This component is nonrepairable and must be replaced. See 5-12, Pressure Switch Replacement, for replacement procedure.

2. Connectors - Inspect all interconnections to the calorimetric load/sensor unit and calorimeter control unit for bent, broken, and missing pins.

c. ROUTINE SERVICE CHECKS

1. When the equipment is in use, watch the coolant level at regular intervals. Check once or twice a week normally, more often if used continuously or under high ambient temperatures. The coolant level should remain at the upper gauge mark on the back panel, whether the unit is running or not. For test measurement and addition of liquid if required, see 1-21, Coolant, and 1-24, Drainage and Filling. Use only potable water and industrially pure ethylene glycol - no automotive anti-freeze.

2. The radiator surfaces, particularly on the outside, should be checked through the grilles periodically for possible collection of dust and lint. If necessary release screws, 28 each, from edges of grilled side panels and remove these panels. Clean off any collected dust and lint with a radiator brush or any stiff bristle brush. If there is a buildup remove and clean under grille. Heavy lint coatings on the outside surface of the radiator unit can impair efficiency of the load/sensor unit - keep these clean.

3. The coolant strainer, located inside the load/sensor unit, is used to trap any small particles that may hinder the operation of the flow meter or load. This strainer is subject to occasional cleaning or element replacement. If the unit is heavily used the strainer should be checked and cleaned about once a month. This interval may be extended if experience shows that only a small amount of residue is found in the sediment bowl. Always check the strainer within 30 days after a coolant change.

Blockage of the filter screen of over 75% could reduce the flow in the system to an unacceptable level and cause the interlock relay to activate. For cleaning or replacement of strainer see Paragraph 5-17.

4-5. PERFORMANCE TEST

4-6. RF LOAD RESISTOR

4-7. Accurate measurement of the dc resistance between the inner and outer conductors of the RF input connector will provide a good check of the condition of the load resistor. For this measurement a resistance bridge or ohmmeter with an accuracy of 1% or better at 50 ohm is recommended. Use low resistance leads, perferably a short piece of 50 ohm coaxial cable with test clips attached. The measured resistance should not deviate more than ±2 ohms from the nominal value. Note - It is recommended that this resistance check be performed each time the load is to be used.

4-8. If measured resistance is greater than ±2 ohms from nominal value see Paragraph 5-7.

SECTION V - TROUBLESHOOTING AND REPAIR

5-1. GENERAL

5-2. Due to its electronic complexity, repair of the Model 8655/56-600A Series Digital RF Calorimeter systems is recommended only for certain malfunctions. Table 5-1 contains a list of problems that are commonly experienced with their probable cause and remedy.

Table 5-1. Troubleshooting Chart

LOAD/SENSOR UNIT

PROBLEM	POSSIBLE CAUSE	REMEDY
Fan and pump not operational	Power cord not connected ON/OFF switch is off	Check power cord connection, turn switch on.
AC applied but fan and pump not operational	Defective fuse Defective ON/OFF switch Disconnected wire	Check fuse. Check switch Connect lose wire using schematic as a reference. See Appendix A, Figure A1 or A2.
AC applied but fan not operational	Defective starting capacitor	Check capacitance. The capacitance should be 3μF.
	Defective fan	Replace fan.
AC applied but pump not operational	Pump overheated	Pump is thermally protected. Check ambient temperature specifications.
	Defective pump	Replace pump.

CONTROL UNIT

Panel meter does not illuminate	Power cord not connected ON/OFF switch is off	Check power cord connection. Turn switch on.
AC applied but panel meter not illuminated	Defective fuse Defective ON/OFF switch Loose or disconnected wires	Check fuse. Check switch. Check connections at headers J3 and J5.

Continued

PROBLEM	POSSIBLE CAUSE	REMEDY
	Improper supply voltage	Check the voltage at screw terminal number 8, located on the lower card of the panel meter. Check connections at screw terminals and check voltage. Should be approximately 5v. If voltage is not present replace PC board.
	Defective meter	Replace meter.

RF CALORIMETER SYSTEM

Refer to Figure 5-4 for location of head J1. J1 will be used as a test header throughout the remainder of the troubleshooting procedures. Figure 5-6 gives the pin functions for header J1.

Flow indicator inoperative	Poor cable connection	Check cable connection at load/sensor unit and calorimeter control unit.
	Loose or disconnected wires	Check connection of J1 on flow indicator PC board.
	Faulty flowmeter	Check frequency at pin 8 of header J1. If frequency is not approximately 350Hz and the reading is erratic, then proceed to replace flowmeter.
	Flow circuit defective	Check the voltage at pin 10 and frequency at pin 8 of header J1. The voltage should be approximately 1V and the frequency approximately 350Hz. If these readings are not present proceed to replace PC board.

Continued

PROBLEM	POSSIBLE CAUSE	REMEDY
	Faulty indicator	If all of the above corrections have already been tried, proceed to replace flow indicator PC board.
Display will not zero	Poor cable connection	Check cable connection at the load/sensor and calorimeter control unit.
	Sensor cable disconnected	Check sensor cable connection inside the load/sensor unit.
	Temperature sensors out of adjustment	Realign temperature sensors. See Paragraph 5-29.
	Input temperature sensor defective	Check the voltage at pin 3 of header J1. If the voltage is not approximately 625mV replace sensor. See Paragraph 5-31.
	Output temperature sensor defective	Check voltage at pin 12 of header J1. If the voltage is not approximately 625mV, replace sensor. See Paragraph 5-31.
	Temperature sensor circuit defective	Check voltage at pins 4 and 11. They should be the same, approximately 240mV. At 24°C ambient temperature if the voltage levels of the two pins are different and the above corrections have already been tried, proceed to replace PC board.

5-3. LOAD/SENSOR UNIT REPAIR/REPLACEMENT

5-4. The Series 8655/56-600A Load/Sensor Units are especially designed for independent, long term, trouble-free operation. Regular mechanical maintenance procedures, other than routine checks and cleaning care described previously, are not required. In case of malfunction of the unit or replacement of a major component, resistor repair excepted, the entire

unit may be returned to the factory. This applies especially to any RF calorimeter or load still under the one year warranty. Consult with the factory. Note - Do not tamper with operational settings or do other unauthorized maintenance work during the first year as it could be cause to void the warranty. Field repair of the load resistor may be performed as described in Section VIII - Internal Repair of the Load Resistor. Other replacements that might be needed are given in this section.

5-5. SPECIAL INSTRUCTIONS

5-6. Whenever maintenance work has been performed, including resistor repair, or there is reason to suspect that contamination has been introduced or dislodged into the unit's coolant, the system should be thoroughly flushed out. Do this by running the load/sensor unit with coolant but without RF power for a period of three to five minutes (see 1-24 Drainage and Filling). Follow immediately with complete as possible drainage of the circulating system, and refill with fresh, clean water. Note - Clear tap water, if not excessively hard, may be used for flushing until the last steps, which should be done with water of potable quality. The sequence should be repeated as required until the drained liquid is clear. Then fill with potable water and/or approved ethylene glycol mixture per 1-21 Coolant, and 1-24 Drainage and Filling.

5-7. RF LOAD RESISTOR

5-8. Resistor repair in the load may be done directly, without removing the water connections; follow procedures and diagrams in Section VIII - Internal Repair of the Load Resistor. They contain full dismounting and resistor change procedures. The full load assembly may be removed from the load/sensor unit case, as described in Subparagraphs 5-9a. through d., and following Section VIII - Internal Repair of the Load Resistor.

5-9. To remove the load resistor unit, take off the top panel by removing 26 screws around its perimeter. Turn all four handles outward and lift up the top panel assembly, disconnecting the small fan-supply plug seated on top of radiator block. Refer to Figure 7-1 for the following procedures:

a. Unscrew drain plug at the center of the rear panel of the unit and allow coolant to drain. Note - Be careful not to mislay this plug; do not replace it with any substitute plug. Then using an ordinary screwdriver, unscrew the hose clamp on the input sensor assembly inlet side and remove the hose. Then, following Temperature Sensor Replacement (Subparagraph 5-32), remove temperature sensor, unscrew the flow sensor connector, and remove the flow sensor.

b. Loosen the hex collar of the union on the output sensor assembly and remove from the load output adapter. The output adapter may now be unscrewed from the load's water chamber.

c. On the inside of the front panel, remove six 1/4-20 nuts using a 7/16 wrench. Nuts on the bottom side are accessible with a short length end-wrench. Note - Loosen the nuts only, do not twist or

disturb the screw heads on the front of the load resistor flange, as this will open its front connection.

d. Using care, the load resistor assembly may now be withdrawn straight out through the front panel. If the load resistor is to be returned to the factory for repair, do not disturb the water chamber fastened by six socket head cap screws on bolt circle at the back end of the load. Unscrew the input sensor subassembly from the inlet port at the back of the water chamber. Keep these components carefully stored with the housing for further use. If the unit is to be field repaired it is not necessary to remove the input sensor subassembly from the water chamber. Proceed with resistor replacement as described in Section VIII - Internal Repair of the Load Resistor.

e. Replace the load resistor by careful reversal of the above procedure. Be sure to replace coolant, using procedure in Paragraph 1-25. Check for leaks, especially at restored connections.

5-10. PUMP/MOTOR REMOVAL

5-11. For removal of the pump/motor unit the top and rear panels must be removed. Proceed as in Paragraph 5-9 including drainage in step 5-9a. When removing the rear panel, first take off the coolant gauge by unscrewing the two special 3/4 inch hex bolts securing it. Be careful not to lose the two spacer collars and O-Ring seals located between the gauge and coolant tank. When the coolant gauge is free, remove the 16 8-32 screws in the periphery of the back panel and it will come right off. Then proceed as follows:

a. Detach 3-wire leads from the 3-lug terminal block on the inside of the front panel. For reference, the color codes of the motor supply wires generally match the twistlock input wires, with the green ground wire going on the blue (ground) wire from the socket. The wires are attached to the motor terminals at the back, reading downwards from the top; green (ground), black (1), and white (6).

b. Loosen the hose clamp nearest the pump on the input hose and carefully remove the hose from the 90° input elbow at the center of the volute. Then loosen the clamp on the output hose from the end of the pump output extension just behind the pump/motor unit. This hose connects to the load input sensor subassembly and to the coolant bypass valve.

c. With this hose released from the input sensor subassembly, unscrew the 1-1/2 inch union nut on the pump output. This whole assembly, including the pressure switch, may be situated out of the way for pump/motor removal.

d. Using a 7/16 wrench, remove four 1/4-20 nuts from the corners of the motor mounting isolation bracket and lift the entire assembly off the isolators. The pump/motor unit is removed by lifting the entire assembly out the top of the load/sensor unit. Before this can be accomplished, however, the coolant tank may have to be loosened from its mounting and lifted in place slightly for the pump to clear. To

loosen the tank, remove the four screws in the corner brackets that hold the tank in place.

e. With the pump/motor unit removed from the load/sensor housing, unscrew the four 3/8-16 hex head bolt and nut fastenings that secure the motor base to the isolation bracket, freeing the pump motor assembly. Now the input and output pump fittings may be easily removed by twisting off counterclockwise. Remove the lower drain plug to drain off trapped water from the pump, then replace the plug.

f. Reverse all above procedures to replace. When replacing the threaded fittings, be sure to first coat only the external threads with a good pipe sealing compound. Coating just the external threads aids in keeping the pipe sealant compound from pressing into the cooling system and contaminating the coolant. Twist on all parts to their original angular position. Use care to rewire to the same terminal block connections.

5-12. PRESSURE SWITCH REPLACEMENT

5-13. For replacement of the coolant pressure switch proceed as far as step 5-9a.; however, complete drainage of the coolant as in step 5-9a. will not be required. Approximately two gallons of coolant should be a sufficient amount for switch replacement.

a. Loosen the pressure switch leads from the cable clamps on the heat exchanger frame and remove wire wrap to junction.

b. Disconnect the brown lead of the pressure switch, marked COM, from the thermoswitch terminal on the coolant tank. Detach the blue wire at the splice found in the wire harness near the harness junction. It is connected to a white wire at the splice.

c. The pressure switch may now be removed and replaced. Use a 11/16 end-wrench on the flats, provided on the switch, and unscrew the pressure switch in a counterclockwise direction.

d. Replace the unit by reversing the above procedure. Use a good pipe sealing compound on the threads of the pressure switch when installing.

5-14. TIME DELAY RELAY

5-15. The time delay relay is an integral component, factory set for the operation of this equipment; i.e., a 1/2 to 3/4 second delay isolated circuit relay (see Section II - Theory of Operation, Paragraphs 2-15 and 2-16). The relay is situated on the upper right inside of the front panel, mounted in an octal socket.

5-16. The relay cartridge cannot be disassembled or repaired in the field. A faulty unit should simply be replaced as follows:

a. Loosen the 8-32 pan head screw at the top of the relay clamp to release the retaining prongs of the clamp. Pull the time delay relay cartridge straight out of the socket.

b. To replace the relay reverse the procedure above. The socket is an ordinary octal type. When inserting the relay, rotate the cartridge for alignment of center post nub in the socket.

c. Prongs of the clamp match side slots in the socket holder. Fit the clamp in the slots and turn the head screw up snugly.

FIGURE 5-1. RF LOAD RESISTOR REMOVAL.

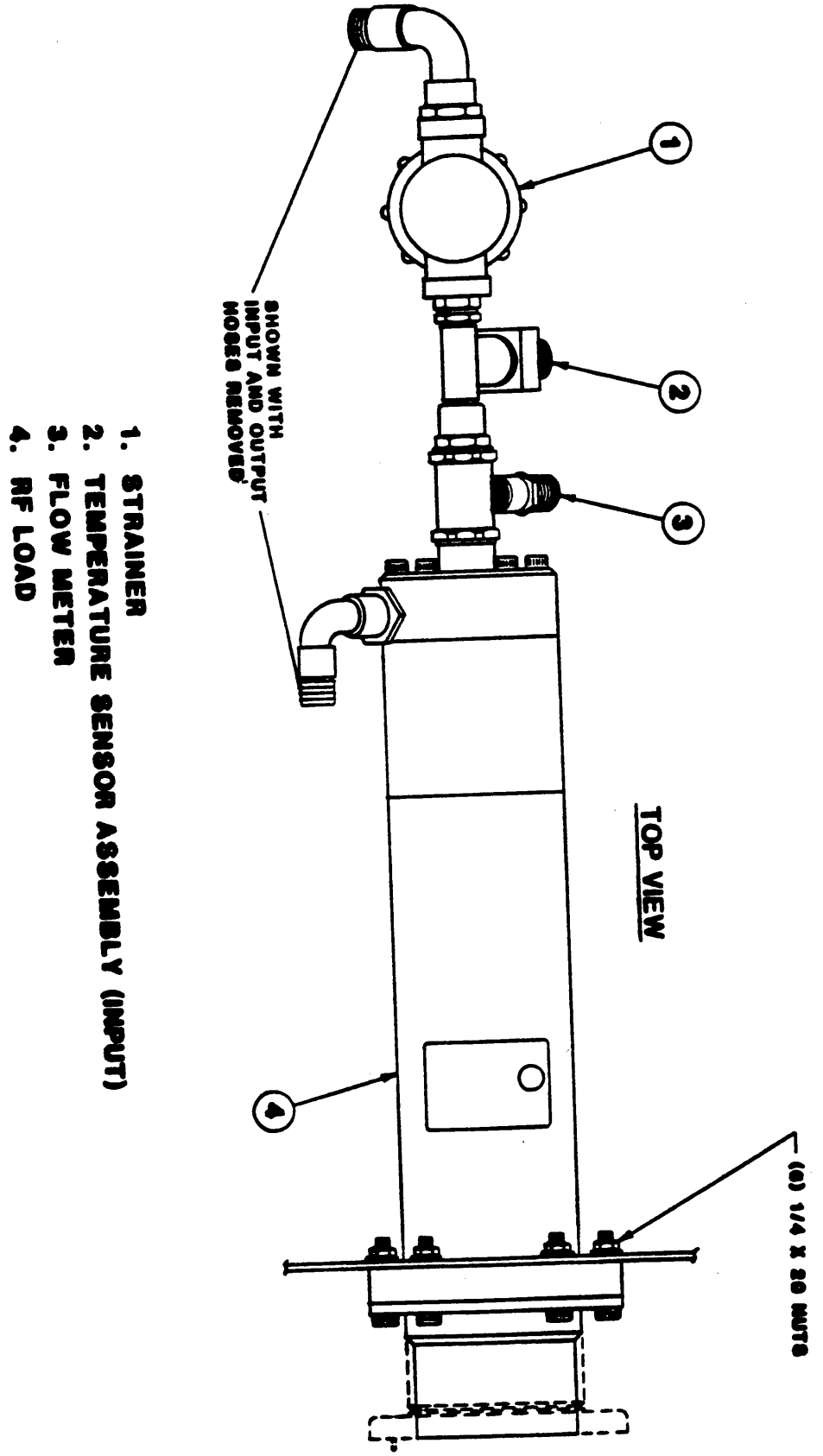


FIGURE 5-2. PUMP/MOTOR REMOVAL.

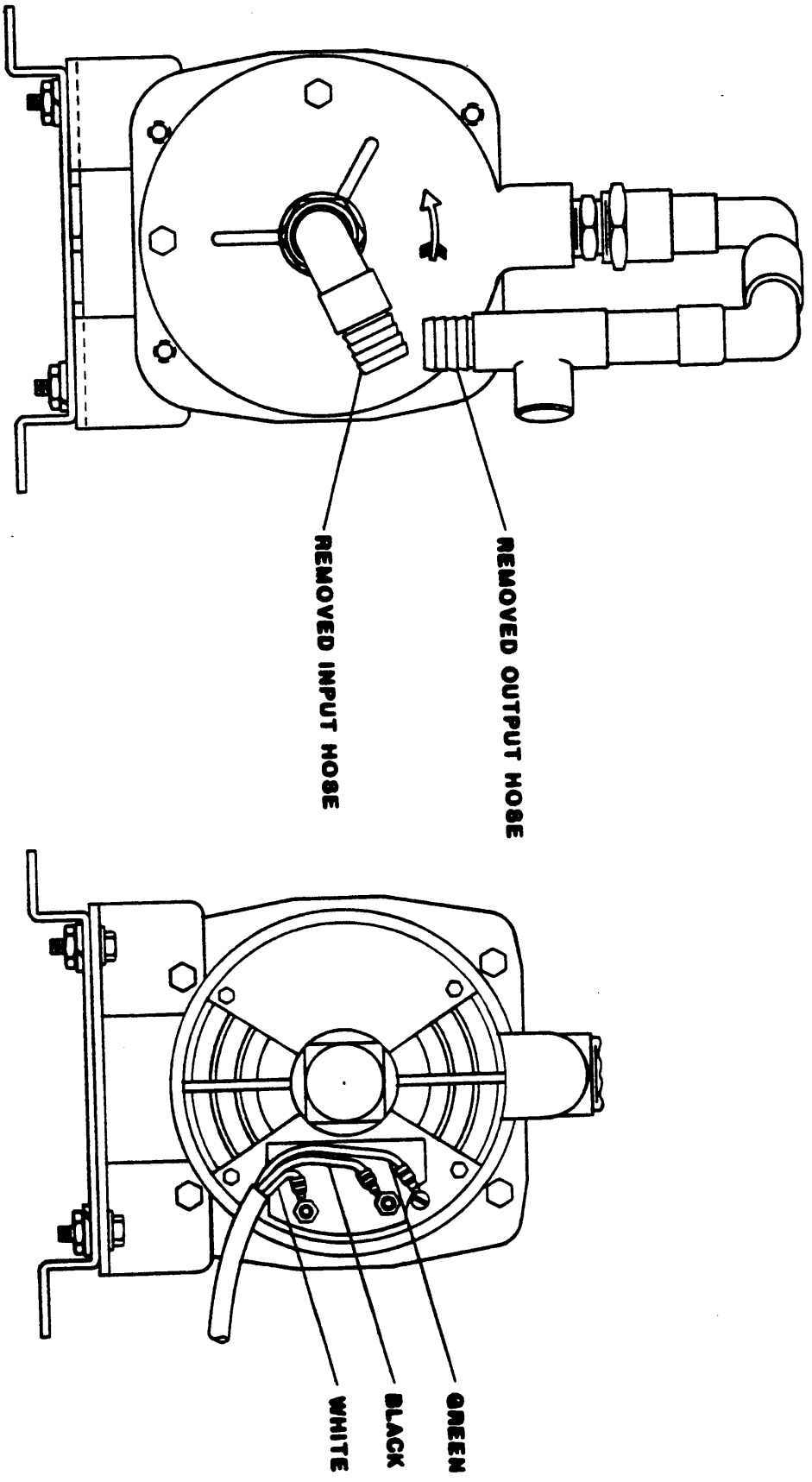
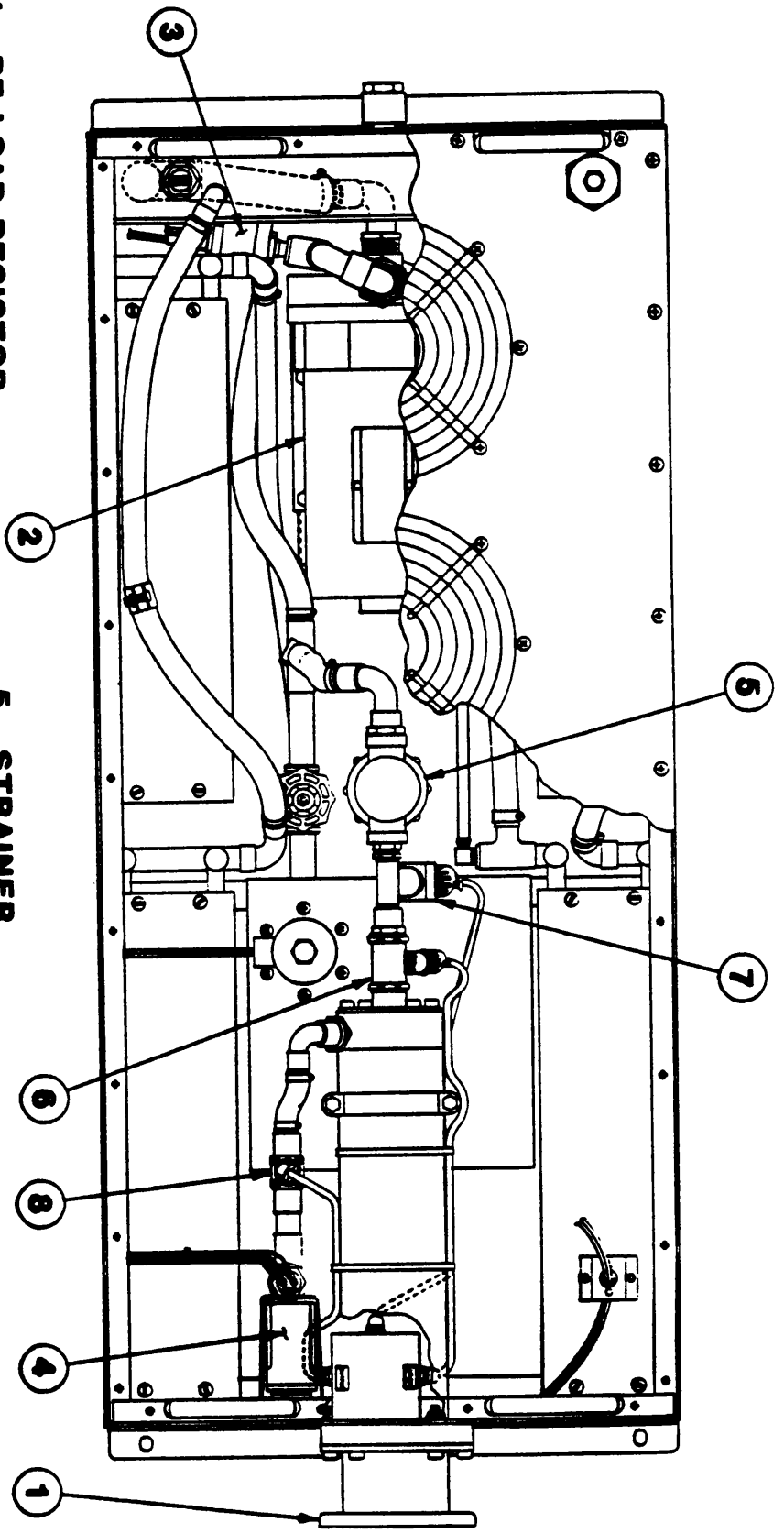


FIGURE 5-3. LOAD/SENSOR UNIT INTERNAL STRUCTURE.



5-17. COOLANT STRAINER CLEANING OR REPLACEMENT

5-18. To check or replace the screen of the coolant strainer follow the steps below:

a. Remove the 26 8-32 x 5/16 inch pan head screws from the periphery of the fan panel.

b. Carefully remove the fan panel. Turn all four handles outward and lift up the top panel assembly, disconnecting the small fan-supply plug seated on top of radiator block.

c. Set the panel aside and notice the strainer in the coolant line just behind the pump motor.

d. If the strainer sediment bowl and screen do not appear to have any amount of residue, proceed with step h, and reassemble the unit. If, however, the sediment bowl and filter screen are contaminated proceed with step e.

e. Partially drain the unit until the coolant level is below the level of the strainer. Place a cloth under the strainer to catch any spillage when the sediment bowl is removed.

f. The thread on the sediment bowl is a right hand thread. Grasp the sediment bowl in your hand and remove it by unscrewing it in a clockwise direction as viewed from the top.

g. When removing the sediment bowl, the filter screen may remain in the strainer body; remove it for cleaning as well. Rinse the sediment bowl and filter screen under clean running water. If the stainless steel screen should become disfigured or blocked beyond cleaning, it should be replaced.

h. Reassemble the strainer and load by reversing the above procedures. Position the filter screen in the strainer bowl and be sure the green gasket is properly positioned in place before reassembly.

i. Refill coolant system to proper coolant level (refer to Section 1-24 Drainage and Filling).

Note: The coolant control valve is used for factory calibration procedures for coolant flow. It must not be tampered with or adjusted for any reason other than precise factory calibration.

5-19. FLOWMETER REMOVAL

5-20. To remove the flowmeter take off the top panel by removing 26 screws around its perimeter. Lift up the top panel assembly, disconnecting the small fan-supply plug seated on top of radiator block.

a. Unscrew drain plug at center of rear panel of unit and allow coolant to drain. NOTE: Be careful not to mislay this plug. Do not replace it with any substitute plug. Then, using an ordinary screwdriver, unscrew the hose clamp on the input sensor assembly and remove the hose. Also disconnect the cable assemblies from the input temperature sensor and the flowmeter.

b. The flowmeter and input sensor assembly can be removed by firmly holding the load water chamber and turning the flowmeter counterclockwise with a 1-1/8 end-wrench. Notice the angular position of the flowmeter and temperature sensor to the load before removal, as it must be returned to this position when reinstalled.

c. Flowmeter can now be removed from the input temperature assembly. Remove the tru-seal fittings from the flowmeter and thread them on the new flowmeter until they bottom. Use Teflon or an equivalent type of plumber's tape on the threads of the flowmeter to insure a proper seal when reinstalling. Note: When applying plumber's tape to threads, take care to start applying tape at a minimum of 1 thread from the end, so no tape can get trapped inside the plumbing and clog flowmeter.

d. Thread the input end of flowmeter into the input temperature assembly until snug then tighten. Flowmeter should be in the same angular position as the temperature sensor. Note position of arrow on flowmeter when assembling. Arrow should be pointed away from input temperature assembly. Thread output end of flowmeter into water chamber of load resistor until snug, then tighten. The flowmeter must be in the same angular position, with respect to load, as it was before removal. Tighten tru-seal fittings. The tru-seal fittings are used to allow proper positioning of the flowmeter without the risk of leaks.

e. Be sure to replace coolant per Section 1-24, Drainage and Filling. Check for leaks, especially at restored connections.

5-21. CONTROL UNIT REPAIR/REPLACEMENT

5-22. This section shows PC board component layout and test points to aid operator. Follow troubleshooting chart while referring to this section.

5-23. Remove the four screws that secure the cover to the calorimetric control unit. This will expose the control unit's internal circuitry.

FIGURE 5-4. MAIN PC BOARD COMPONENT LAYOUT.

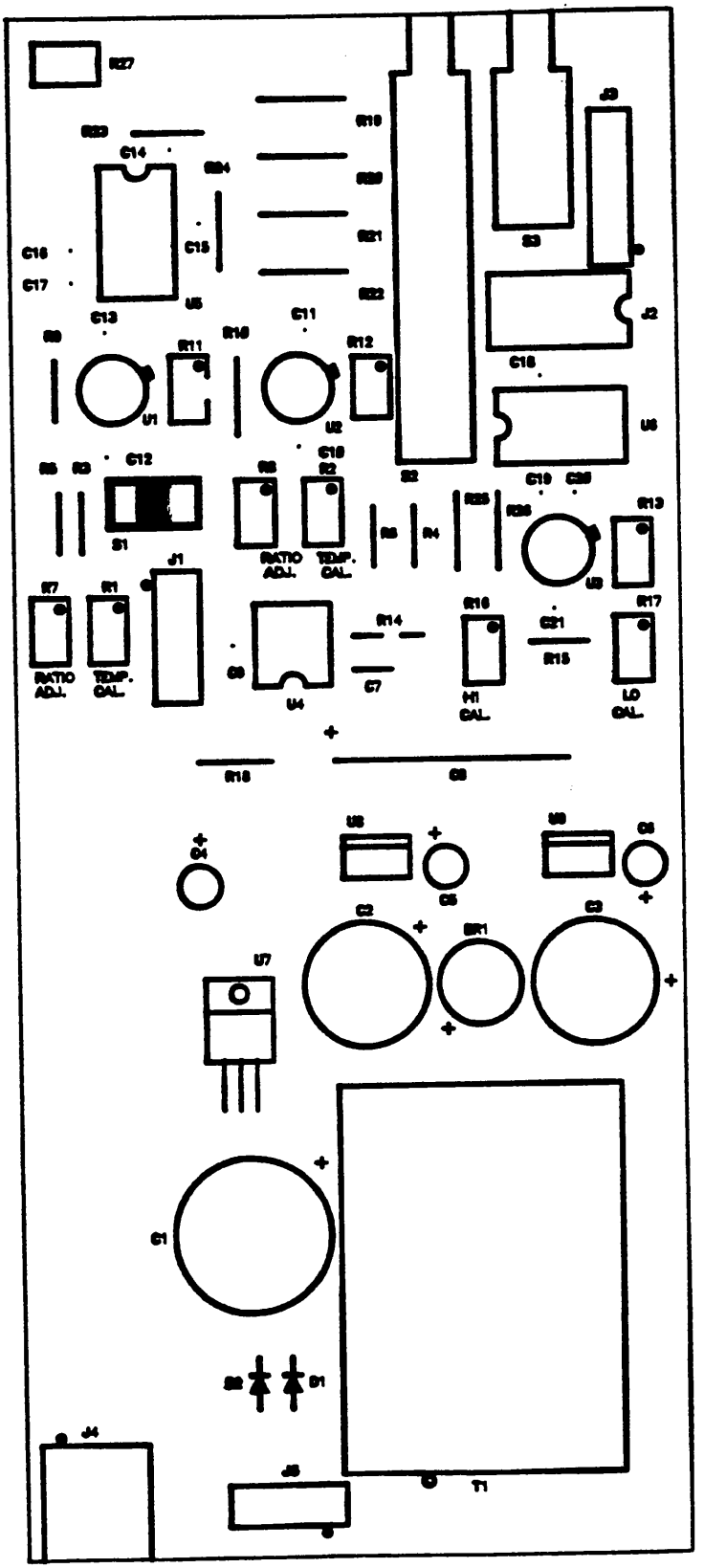


FIGURE 5-5. FLOW INDICATOR PC BOARD COMPONENT LAYOUT.

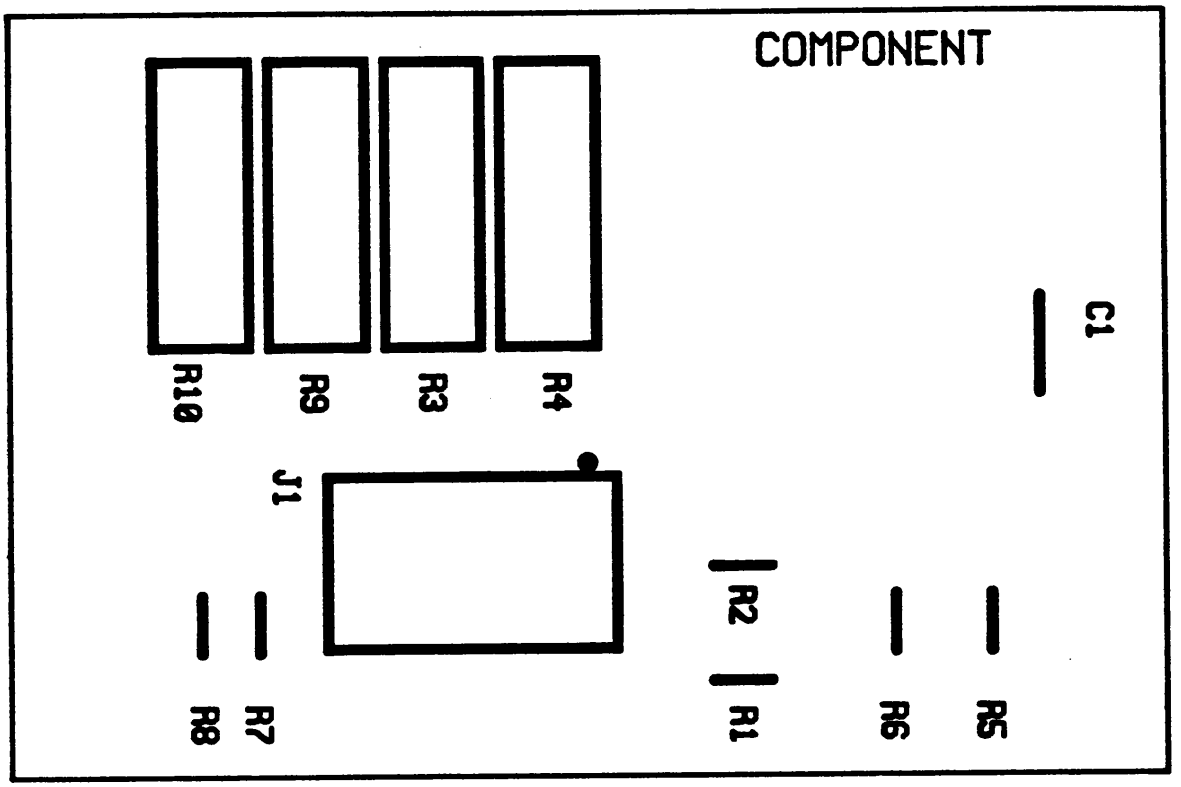
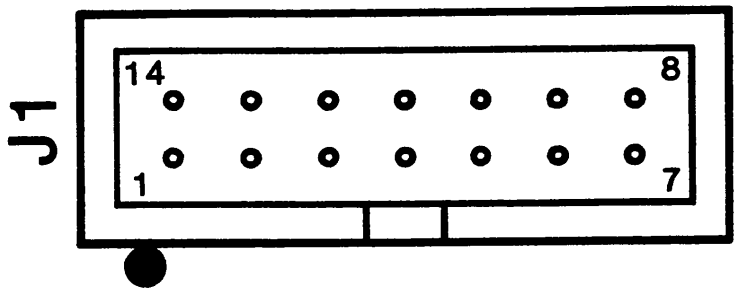


FIGURE 5-6. TEST HEADER PIN FUNCTIONS.



PIN 1	Input voltage reference +5V
PIN 2	Input voltage ratio
PIN 3	Input temperature voltage
PIN 4	Input temperature
PIN 5	Supply voltage +5V
PIN 6	Supply voltage +15V
PIN 7	Ground
PIN 8	Flow frequency
PIN 9	Supply voltage −15V
PIN 10	Flow voltage
PIN 11	Output temperature
PIN 12	Output temperature voltage
PIN 13	Output voltage ratio
PIN 14	Output voltage reference +5V

5-24. SYSTEM COMPONENT REPAIR/REPLACEMENT

5-25. After troubleshooting the complete calorimeter it may be necessary to repair or replace one of the following components:

a. Sensor cable
b. Perform a temperature sensor realignment
c. Replace temperature sensor

5-26. SENSOR CABLE

5-27. Remove sensor cable connectors from mating connectors on both the calorimeter control unit and load/sensor unit. This is done by unscrewing the connector mounting screws and pulling straight back on connector.

5-28. Pin to pin continuity from connector to connector can now be checked using a standard VOM. Refer to Table 5-2 for pin to pin connection. Any shorts or opens contrary to Table 5-2 require replacement of the sensor cable.

Table 5-2. Sensor Cable Pin Connections.

Connector 1 Pin	Connector 2 Pin
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9

Outside connector shells are at system ground and should be electrically connected together.

5-29. TEMPERATURE SENSOR REALIGNMENT

5-30. Each temperature sensor will have a voltage output of 10mV/°C. If sensors are out of calibration after temperature stabilizes (sensors should read within 1mV of each other) the following procedure for realignment must be performed:

a. Circulate water through the system until sensors stabilize. Measure temperature of circulating water. Measure voltage output (pins 4 and 11 of header J1, Figure 5-6) of both sensors. The sensor outputs should read within 1mV, at header. This output voltage is determined by the water temperature in °C.

Example: Water temperature is 5.5°C. Output voltage of each sensor then will be adjusted to 10mV x 5.5 = 55mV.

b. To adjust the output voltage, adjust 25K ohm potentiometer (R1 or R2) until proper settings are reached.

5-31. TEMPERATURE SENSOR REPLACEMENT

5-32. To replace a temperature sensor take off the top panel by removing 26 screws around its perimeter. Lift up top panel assembly, disconnecting the small fan-supply plug seated on top of radiator block. Set the panel aside. To remove sensor follow the procedure below:

a. Remove sensor cable assembly by unscrewing the circular connector.

b. Temperature sensor can now be removed by gripping sensor housing and turning by hand counterclockwise. Take care not to lose O-Ring on bottom of housing.

c. To install new temperature sensor assembly reverse the above steps. Take care to make sure O-Ring is properly seated in housing when screwing in temperature sensor assembly. Hand tighten this assembly.

d. Complete calibration is now required (see Section VI).

5-33. CUSTOMER SERVICE

5-34. Bird Electronic Corporation maintains a complete repair and calibration department at our corporate headquarters. This department is set up to provide the best possible service of Bird equipment.

5-35. All instruments returned for service must be shipped prepaid and to the attention of the Customer Service Group.

Bird Electronic Corporation
30303 Aurora Road
Cleveland (Solon), OH 44139-2794
Phone: 216-248-1200
Cable: BIRDELEC
Telex: 706898 Bird Elec UD

5-36. REPACKAGING

5-37. Should you need to return the RF Calorimeter, or associated parts, use the original shipping package if possible. If the original package is not available, use a heavy duty corrugated box with shock-absorbing material around all sides of the unit to provide a firm cushion and to prevent movement in container. Container should be properly sealed.

SECTION VI - CALIBRATION AND TEST PROCEDURES

6-1. GENERAL

6-2. This section contains information on both high and low power calibration.

6-3. REQUIRED TEST EQUIPMENT

ITEM	QTY	TYPE UNIT	RECOMMENDATIONS
1	1	DC Millivoltmeter	Digitec 268 or Equivalent
2	1	DC Power Supply	Sorensen QRD30-1 or Equivalent
3	1	AC Ammeter	Y.E.W., Model 2013-09
4	1	AC Voltmeter	Y.E.W., Model 2013-17
5	1	Potential Transformer	Y.E.W., Model 2261
6	1	Thermometer (Mercury)	0° to 30° Centigrade (0.1° Accuracy)
7	1	AC Power Source	20kW Output Minimum at 50 or 60Hz

6-4. CALIBRATION PROCEDURE

6-5. Model 8655/56-600 Calorimeter/Load Resistor Preparation -

a. Connect the load/sensor and calorimeter control unit's operating power cords to the appropriate voltage supply of 115V/60Hz or 230V/50Hz.

b. Check calorimeter control unit's ac line module for correct selection of line voltage.

c. Turn on calorimeter control unit by depressing ON/OFF button on front panel.

d. Turn on load/sensor unit by placing ON/OFF rocker switch in the ON position.

6-6. TEST EQUIPMENT PREPARATION

a. Turn dc millivolt meter on.

b. Turn dc power supply on.

c. Remove filler plug from the load/sensor unit and insert the thermometer into the coolant in the tank.

d. Connect the calorimeter sensor cable, P/N 6080-320-1, to the cable connector at the back panel of the load/sensor unit and back panel of calorimeter control unit.

e. Connect the ac power source output cable to the load input connector, but leave the ac power source turned off.

f. Connect Y.E.W. meters, if not already connected, as illustrated in Figure 6-1.

g. Leave the above equipment on for 15 minutes to stabilize before proceeding.

6-7. TEMPERATURE CALIBRATION

a. Assure that the coolant temperature has stabilized by reading the temperature indicated on the thermometer in the coolant then rechecking the thermometer after a few minutes. If the coolant temperature stays constant, the system is stabilized and you may proceed.

b. Remove four screws from upper cover to expose control unit internal circuitry.

c. Short the inputs to the temperature OP Amps:

1. Disconnect the calorimeter sensor cable from the rear panel connector of the load/sensor unit.

2. Short pins 3 and 12 of PC board connector J1 to PC board ground.

d. Connect the negative lead of the dc millivoltmeter to PC board ground and the positive lead of the dc millivoltmeter to the OUTPUT temperature, pin no. 11 of header J1.

e. Set the dc millivoltmeter to the 200mV range or lower and observe the indication on the voltmeter. Then adjust the voltage at (OUTPUT TEMP) by turning the offset null adjust potentiometer R12, to read zero ±20 microvolts. For location of adjustment potentiometer see Figure 6-2.

f. Move the positive lead of the dc millivoltmeter to the INPUT Temperature, pin no. 4 of header J1 and repeat step d. by adjusting the offset null potentiometer R11. This adjusts the OP Amp to produce an output voltage of zero volts when the input voltage is zero volts. Disconnect the shorting jumpers from pins 3 and 12 and reconnect the sensor cable to the rear panel of the load/sensor unit.

g. With the negative lead of the dc millivoltmeter still connected to PC board ground, measure and record the voltages at pin 12 ($V_{temp\ OUT}$) and pin 3 ($V_{temp\ IN}$) of header J1, see Figure 6-2. Then read and record the coolant temperature in

the load/sensor unit tank. Check these values three times to insure repeatability. Substitute these values into Equation 5 to solve for "r".

Equation 5: $$r = \frac{V_{temp}}{10\ (Ta + 273)}$$

Where:
r_1 = Temperature CAL ratio for input.
r_2 = Temperature CAL ratio for output.
Ta = Ambient temperature of coolant in °C (Thermometer Reading)
V_{temp_1} = Input voltage measured, in millivolts, at pin 4 of header J1.
V_{temp_2} = Output voltage measured, in millivolts, at pin 11 of header J1.

Calculate for "r_1" and "r_2" using both the measured V_{temp_1} and V_{temp_2} values.

Example 1: TA = 25°C
V_{temp_1} = 600mV
V_{temp_2} = 610mV

$$r_1 = \frac{V_{temp_1}}{10\ (Ta + 273)} = \frac{600}{10\ (25 + 273)} = \frac{600}{10 \times 298} = \frac{600}{2980} = 0.2013$$

$$r_2 = \frac{V_{temp_2}}{10\ (Ta + 273)} = \frac{610}{10\ (25 + 273)} = \frac{610}{10 \times 298} = \frac{610}{2980} = 0.2046$$

h. V_B (BIAS VOLTAGE) may now be determined by Equation 6.

Equation 6: $V_B = r \times 100mV$

Calculate for V_B using r_1 and r_2 for both input and output temperature OP Amps respectively.

Example 2: $r_1 = 0.2013$
$r_2 = 0.2046$

$V_{B1} = r_1 \times 100mV = 0.2013 \times 100mV = 20.13mV$
$V_{B2} = r_2 \times 100mV = 0.2046 \times 100mV = 20.46mV$

i. Set the ON/OFF switch of the control unit to OFF. Set switch S1 on PC board to position shown in Figure 6-3. Connect the dc power supply and the dc millivoltmeter as described below:

DC Power Supply: Positive lead to (OUTPUT TEMP) pin no. 11 of header J1.
Negative lead to ground.

DC Millivoltmeter: Positive lead to (OUTPUT TEMP) pin no. 11 of header J1.
Negative lead to ground.

j. Adjust the dc power supply output to read 100mV ±10uV on the dc millivoltmeter using the 200mV range. Note - Keeping the voltage at this level in the following adjustments is very critical.

k. When 100mV is stable, remove the positive lead of the dc millivoltmeter and connect to pin no. 13 of header J1. Now adjust R8, ratio adjust potentiometer, to read the V_{B2} value calculated for output temperature OP Amp. When this is done, reconnect the positive lead of dc millivoltmeter back to pin no. 11 of header J1 (OUTPUT TEMP) to check if the 100mV is still being applied. If not, adjust to 100mV and adjust your V_{B2} value again. This may take a few times to reconcile.

l. Keeping the ON/OFF switch of the control unit in the OFF position, set switch S1 on PC board to position shown in Figure 6-4. Connect the dc power supply and dc millivoltmeter as described below.

DC Power Supply: Positive lead to (INPUT TEMP) pin no. 4 of header J1.
Negative lead to ground.

DC Millivoltmeter: Positive lead to (INPUT TEMP) pin no. 4 of header J1.
Negative lead to ground.

Again adjust the dc power supply output to read 100mV ±10uV on the dc millivoltmeter using the 200mV range. Note - Keeping the voltage at this level in the following adjustments is very critical.

m. When 100mV is stable remove positive lead of the dc millivoltmeter and connect to pin no. 2 of header J1. Now adjust R7 (RATIO ADJ) potentiometer, to read the V_{B1} value. When this is done, reconnect the positive lead of dc millivoltmeter back to the (INPUT TEMP) pin no. 4 of header J1 to check if the 100mV is still being applied. If not, adjust to 100mV and adjust the V_{B1} value again. This may also take a few times to reconcile.

n. Remove dc power supply leads and return switch S1 to its center position and turn the control unit on.

o. Set the dc millivoltmeter selector switch to the two volt range and connect the positive clip lead to the (INPUT TEMP) pin no. 4 of header J1 and negative lead to ground (see Figure 6-5). Adjust R1 (TEMP CAL) potentiometer, to read the same temperature as the thermometer in the coolant (using 10mV = 1°C).

p. Keeping the dc millivoltmeter on the 2V range, move the positive clip lead to the (OUTPUT TEMP) pin no. 11 of header J1 and leave the negative lead attached to ground. Adjust R2 (TEMP CAL) potentiometer, to also read the same temperature as the thermometer in the coolant.

q. Place the ON/OFF switch of the load/sensor unit in the OFF position and wait a few minutes to allow the calorimeter to stabilize. Short pin 10 of PC board connector J1 to PC board ground. Set dc millivoltmeter on 200mV range and connect the positive clip lead to the side of R26 that is common to pin 6 of OP. Amp. U3 as shown in Figure 6-6. Adjust potentiometer R13 to read zero on the dc millivoltmeter. When this is done, remove all clip leads.

r. Place the ON/OFF switch of the load/sensor unit in the ON position and check unit calibration by pushing in the CAL button on the front of the control unit. Adjust the potentiometer on the front of the calorimeter control unit for a display reading of zero. Then switch the CAL button to the out position and if necessary, readjust the front panel potentiometer for a calorimeter reading of zero.

```
************************************************************
*                      W A R N I N G                       *
*                                                          *
* The following sections of this procedure involve the     *
* application of high power to the load. The following     *
* precautions must be observed to insure operator safety   *
* severe electrical burn or possibly death may result.     *
*                                                          *
* 1. Make sure that the coaxial power cable connector      *
* is securely fastened to the load and that the water      *
* is flowing before turning on the ac power source.        *
*                                                          *
* 2. Ensure that all Y.E.W. meter connections are tight    *
* before turning on ac power.                              *
*                                                          *
* 3. High voltage is present at the terminals of the       *
* Y.E.W. meters when the ac power source is on. Keep       *
* clear of these terminals.                                *
*                                                          *
* 4. Completely shut down the ac power source before       *
* changing the Y.E.W. meter connections, turning off the   *
* low voltage ac power source, or removing the power       *
* cable from the input connector.                          *
************************************************************
```

6-8. HI RANGE AC POWER CALIBRATION -

a. Connect Y.E.W. meters as shown in Figure 6-1. Make sure that all connections are tight.

b. Turn on ac power source and adjust the power variac to produce a reading of 17.3 amps on the Y.E.W. ammeter. In this position the ac power source output will be approximately 15kW.

c. Determine the actual power applied to the load/sensor unit coaxial input by reading the Y.E.W. meters and using Equation 7.

Equation 7: Power = V x I x K

Where: V = Voltage read at Y.E.W. voltmeter
I = Current read at Y.E.W. ammeter
K = Potential transformer ratio (20.067 for 2200V to 110V position)

Example 3: V = 43.3V I = 17.3 Amps
P = V x I x K = 43.3V x 17.3A x 20.067
P = 15.032kW

d. Adjust R16 (HI CAL) potentiometer, on the calorimeter control unit PC board, slowly to make the control unit DPM indicate the actual power being applied. Only a slight turn of the potentiometer is required to change the reading. Allow the display to stabilize after each slight amount of turn. Repeat steps 6-8c. and d. several times, due to power fluctuations, to assure accuracy of the unit to be within ±2 1/2% of actual power. The error percentage can be determined by Equation 8.

Equation 8: $\% \text{ error} = \frac{\text{Actual Power} - \text{Indicated Power}}{\text{Actual Power}} \times 100$

Where: Actual Power = Y.E.W. meter reading
Indicated Power = Calorimeter reading

e. Turn off ac power source and allow load/sensor unit to run for several minutes to cool until calorimeter control unit display is stabilized at zero.

6-9. LO RANGE AC POWER CALIBRATION -

a. Shift the flow control switch on the front panel of the load/sensor unit to the LO POWER position.

b. Now push in button marked RF POWER LO on the calorimetric control unit. Adjust front panel potentiometer for a zero display on the DPM. Then turn on the ac power source and

adjust power to 10 amps on the Y.E.W. ammeter. This will produce the power source output of approximately 5kW.

c. Again using Equation 7, determine the actual power applied to the load.

Where: V = 25.6V = reading from voltmeter
I = 10 amps = reading from ammeter
K = 20.067 = ratio constant

Example 4: P = 25.6 x 10 x 20.067
P = 5.14kW

d. Adjust R17 (LO CAL) potentiometer, on the calorimeter control unit PC board, slowly until the display of the DPM indicates the actual power being applied. After each adjustment allow the display to stabilize. The accuracy of the display reading must be within ±3% of actual power. If not, readjust R17 until it is within tolerance.

e. Shut off ac power source and let the load/sensor unit run for several minutes to allow the unit to cool until the calorimeter control unit display is stabilized at zero.

6-10. HI RANGE FLOW INDICATOR CALIBRATION

6-11. This section explains calibration of flow indicator HI range. Refer to Figure 6-7 while following the steps below.

a. Place the calorimeter control unit in the high range by releasing the range selector button. Also place the flow control switch on the load/sensor unit to the high position.

b. Connect the positive lead of dc millivoltmeter to the common leg of resistors R1 and R2 and negative lead to Pin 2 of J1 on flow indicator PC board. Adjust the voltage between the common leg of R1 and R2 and Pin 2 of J1 on flow indicator PC board to 511mV ± 1mV by adjusting R4.

c. Disconnect millivoltmeter and connect positive lead of frequency counter to pin 8 of header J1 on the main PC board and negative lead to PC board ground (see Figure 6-2). The frequency output will depend on the model of load resistor being used. Adjust R9 flow indicator PC board until the appropriate LED is lighted based on the expression 100Hz=1 GPM and that each LED represents 1/2 GPM with the scale starting at 6 GPM.

6-12. LO RANGE FLOW INDICATOR CALIBRATION

6-13. This section explains calibration of flow indicator LO range. Refer to Figure 6-7 while following the steps below.

a. Place the calorimeter control unit in low range by depressing the range selector button. Also place the flow control switch on the load/sensor unit to low range.

b. Connect the positive lead of dc millivoltmeter to the common leg of resistors R1 and R2 and the negative lead to pin 2 of J1 on flow indicator PC board. Adjust the voltage between the common leg of R1 and R2 and pin 2 of J1 on flow indicator PC board to 687mV ± 1mV by adjusting R3.

c. Disconnect millivoltmeter and connect positive lead of frequency counter to pin 8 of header J1 on the main PC board and negative lead to PC board ground (see Figure 6-2). The frequency output should be 350Hz ± 5Hz. If it is, proceed to adjust R10 (flow indicator PC board) until the third LED is lighted, which represents 3.5 GPM. If the frequency output is not 350Hz ± 5Hz, the flow control valve will have to be adjusted appropriately. See Figure 5-3 for location of flow control valve.

6-14. TEST PROCEDURES

a. Testing HI Power Range Accuracy -

1. Shift the flow control switch on the load/sensor unit's front panel to the HI POWER position. Set HI/LO switch to HI position on control unit and adjust CAL potentiometer on front panel for a display indication of zero.

2. Turn ac power source on and adjust power to read 14 amps on Y.E.W. ammeter to check accuracy for approximately 10kW. Using example formula as follows:

Where: V = 36 volt = reading on voltmeter
I = 14 amps = reading on ammeter
K = 20.067 = ratio constant

Example 5: 36 volts x 14 amps x 20.067 x 10.11kW

The display reading should be within ±2 1/2% of actual power being applied. If not, recalibrate HI range per calibration procedure.

3. Now increase the power to approximately 20kW. Check the accuracy at 20kW by comparing the actual power according to the Y.E.W. meters to the power indicated on the display. The control unit reading must still be within ±2 1/2% of the actual power.

4. Turn off ac power source and run the load/sensor unit for several minutes to allow the unit to cool until the control unit display indicates zero.

b. Testing LO Power Range Accuracy -

1. Shift the flow control switch of the load/sensor unit to the LO POWER position. Set HI/LO switch to LO position on the control unit and adjust CAL potentiometer until the display indicates zero.

2. Turn ac power source on and apply approximately 10kW, 14 amps on Y.E.W. ammeter. Check to see that the control unit accuracy is within the ±3% specification as described above.

3. Turn off ac power source and allow load/sensor unit to cool until control unit DPM indicates zero.

4. Connect potential transformer and Y.E.W. meters as shown in Figure 6-8.

5. Turn on ac power source and adjust power to read 4.5 amps on Y.E.W. ammeter to check accuracy at approximately 1kW. Use new example formula as follows:

Where: V = 56.9 volts = reading on voltmeter
I = 4.5 amps = reading on ammeter
K = 4 = ratio constant

Example 6: 56.9V x 4.5 amps x 4 = 1.02kW

The display reading should be within ±3% of actual power being applied. If not, recalibrate LO range per calibration procedures.

6. Turn off ac power source and run the load/sensor unit for several minutes to allow unit to cool.

7. After cooling is completed, turn off power to both units.

8. This completes all calibration and unit is now ready for use.

FIGURE 6-1. Y.E.W. METER CONNECTIONS - HI POWER CALIBRATION.

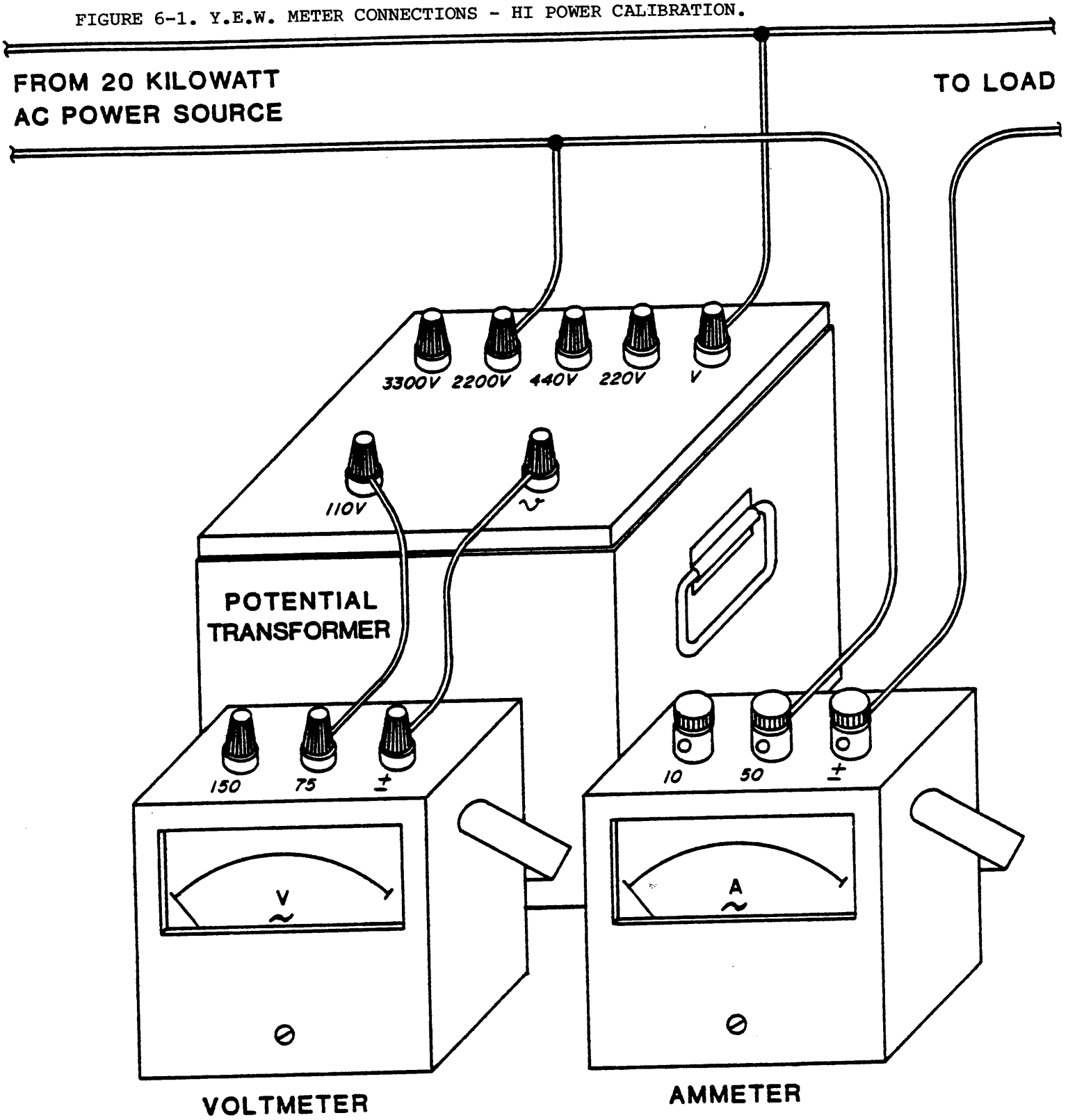


FIGURE 6-2. NULL TEMPERATURE SENSORS.

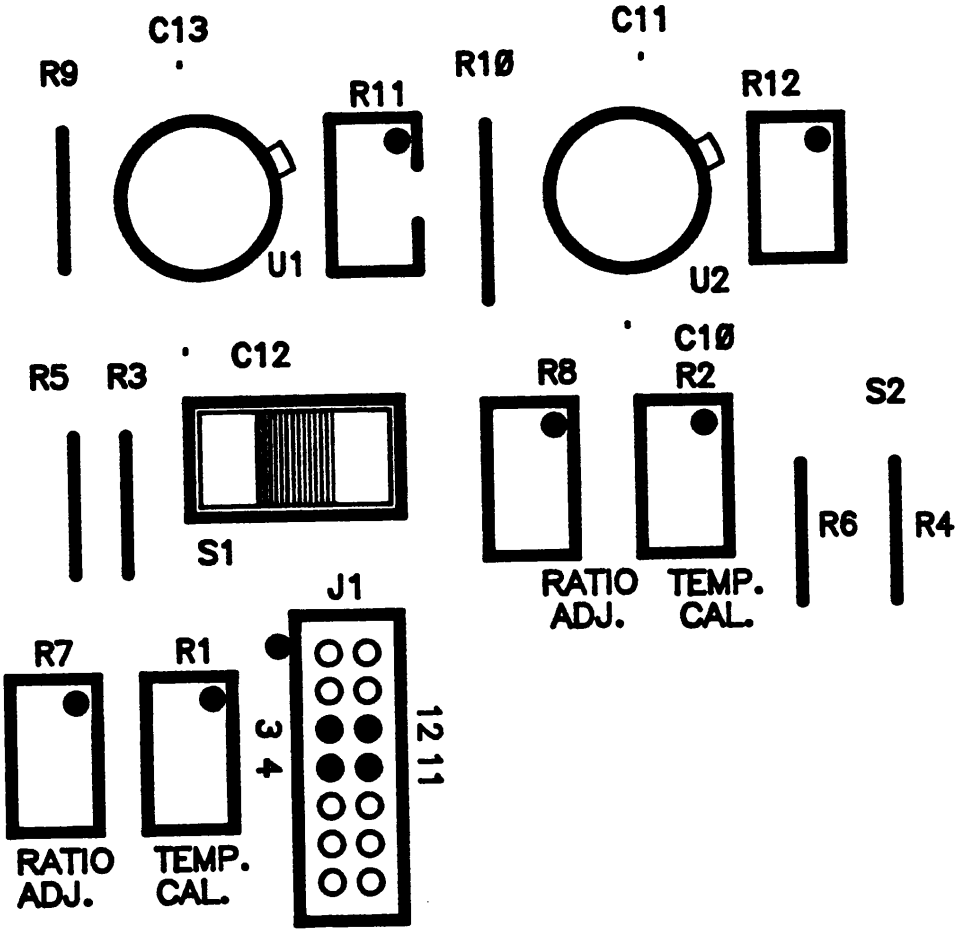


FIGURE 6-3. CALIBRATE OUTPUT TEMPERATURE SENSOR RATIO.

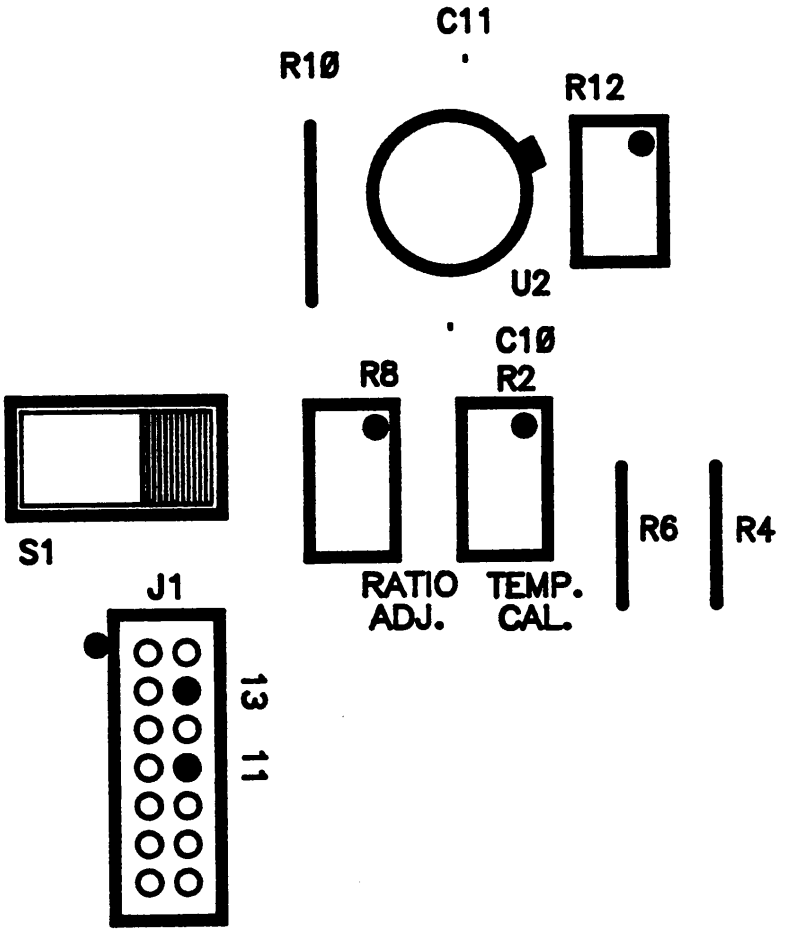


FIGURE 6-4. CALIBRATE INPUT TEMPERATURE SENSOR RATIO.

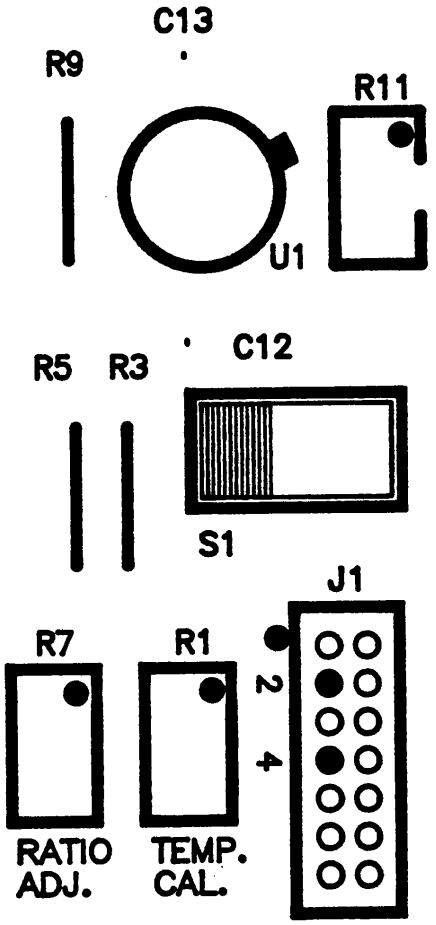


FIGURE 6-5. CALIBRATE TEMPERATURE SENSORS.

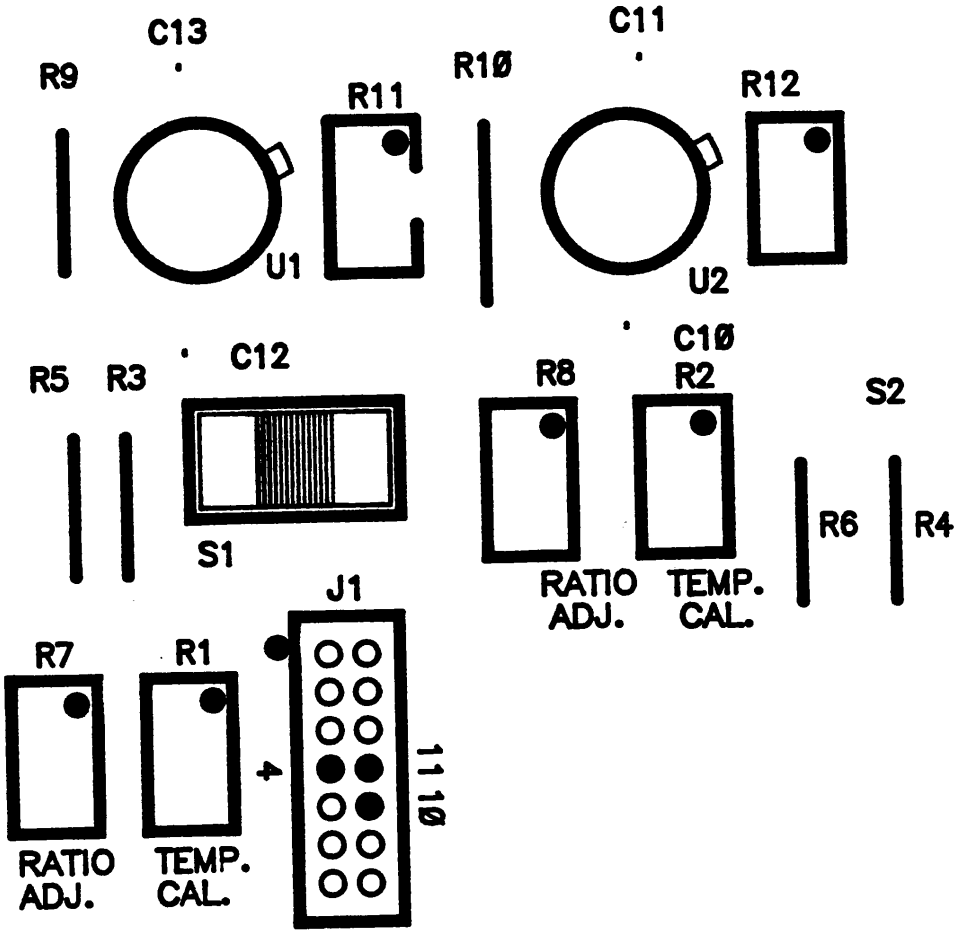


FIGURE 6-6. UNIT CALIBRATION.

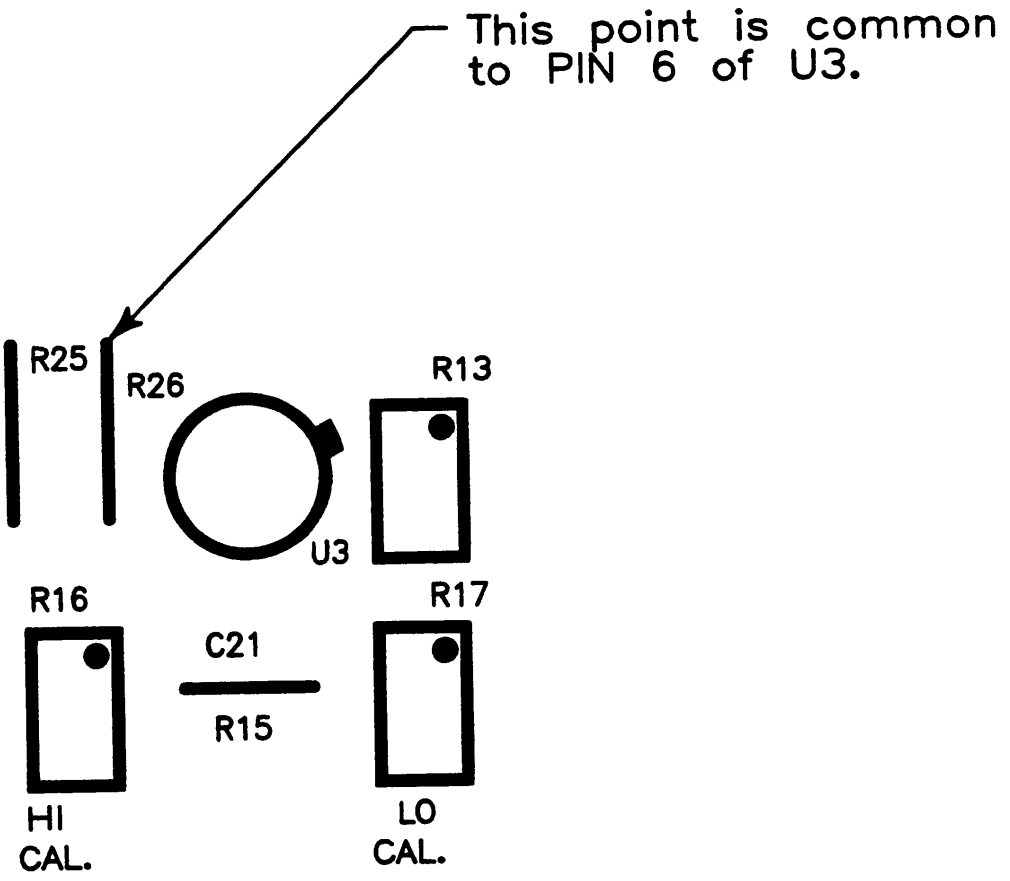


FIGURE 6-7. FLOW INDICATOR CALIBRATION.

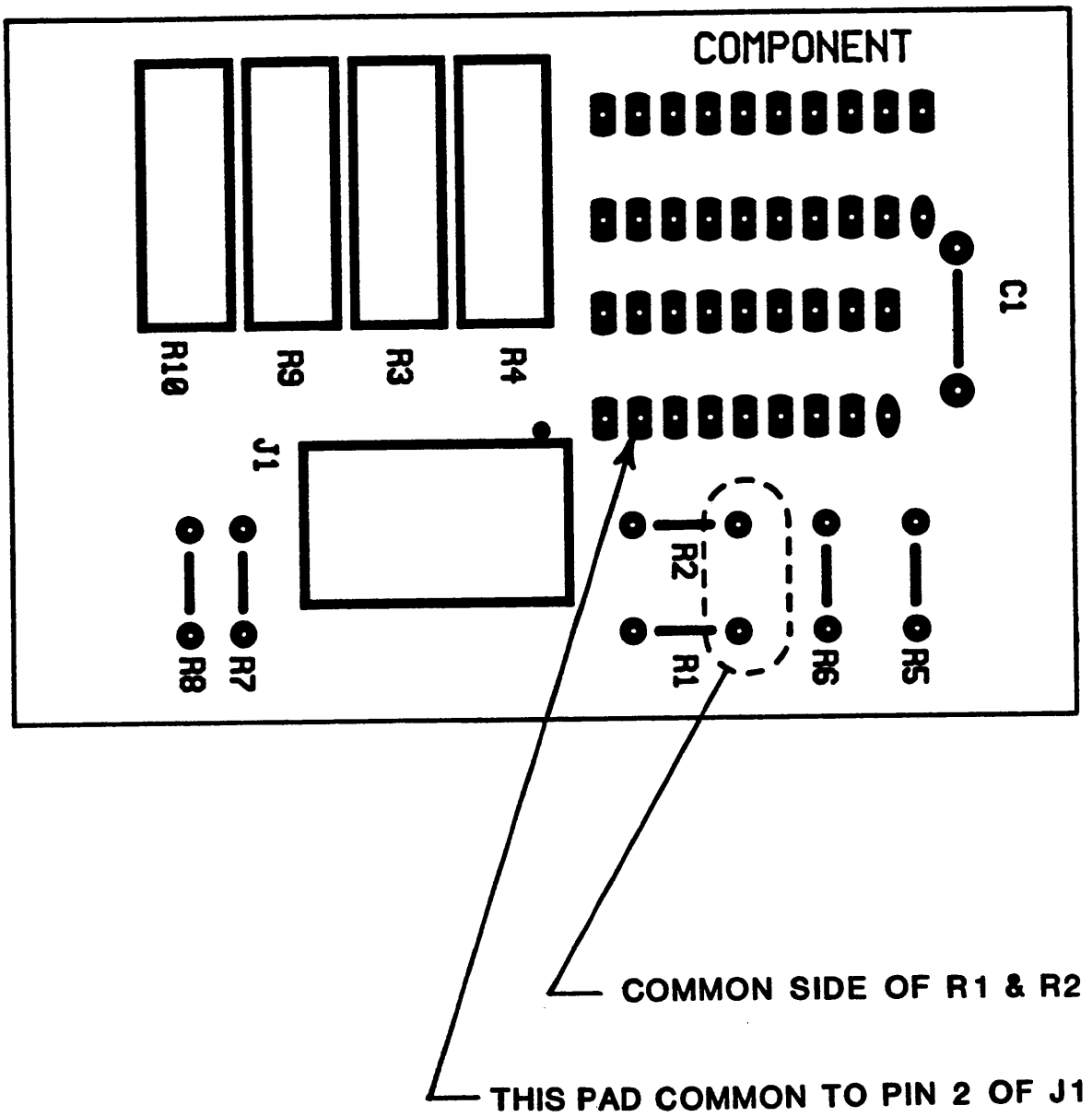
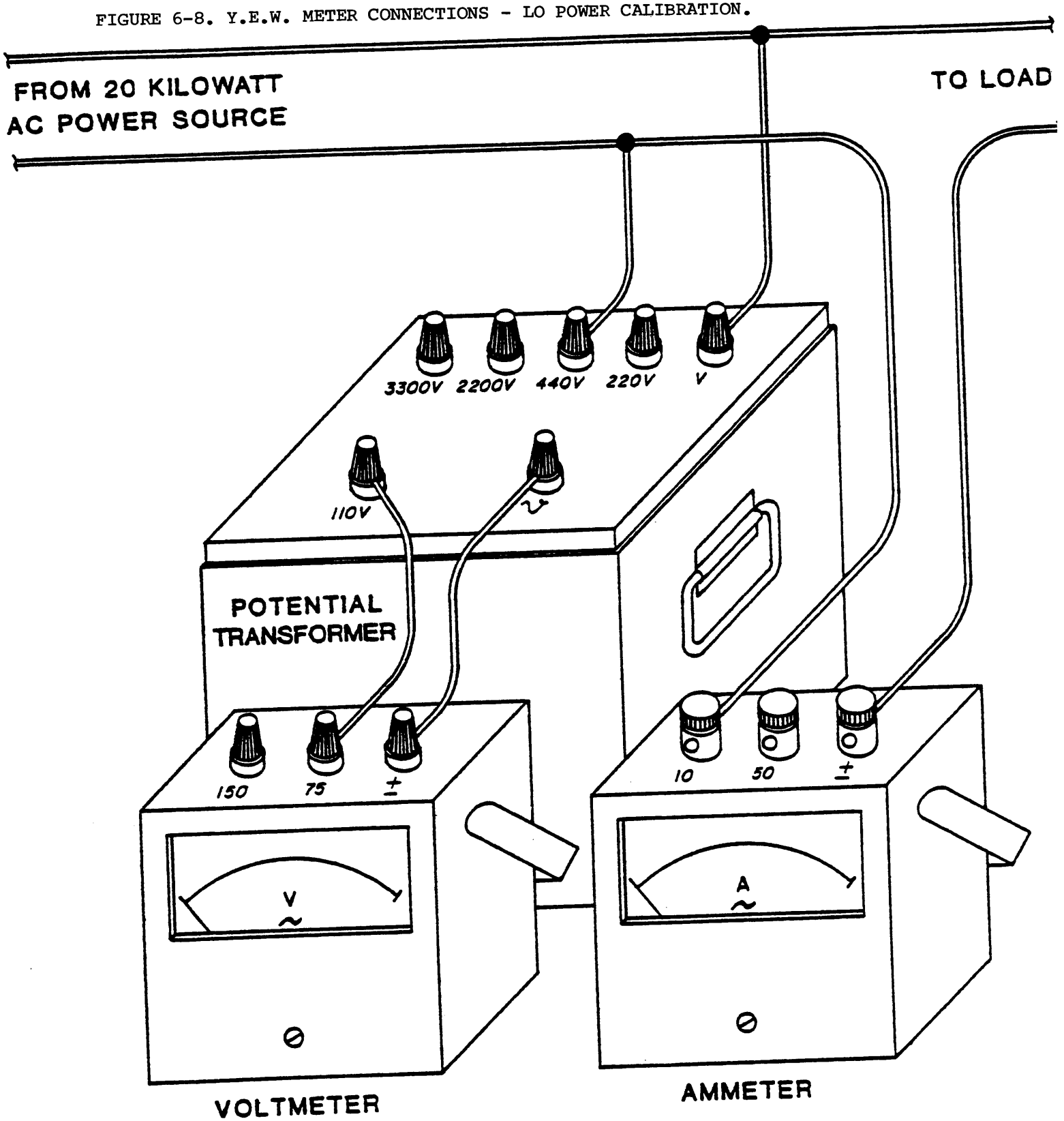


FIGURE 6-8. Y.E.W. METER CONNECTIONS - LO POWER CALIBRATION.



SECTION VII - REPLACEMENT PARTS LIST

7-1. GENERAL

7-2. The purpose of this section is to provide the user with a consumables type spare parts listing. Quantities used within the RF calorimeter/load resistor are indicated.

7-3. Refer to Figure 7-1 for location of spare parts. Item numbers correspond to call outs in Figure.

LOAD/SENSOR UNIT PARTS:

ITEM	QTY.	DESCRIPTION	PART NUMBER
1	1	Sensor Box Assembly	8640-633-2
2	1	Temperature Sensor Cable (Input)	6080-096-1
3	1	Temperature Sensor Cable (Output)	6080-096-1
4	1	Flow Sensor Cable	6080-025-3
5	1	Pressure Switch Assembly	8650-613
6	1	Temperature Sensor Assembly (Input)	6080-095-1
7	1	Temperature Sensor Assembly (Output)	6080-095-2
8	1	Flowmeter	5-1145-1
9	1	Pump 115V	5-1165-1
		230V	5-1165-2
10	1	Strainer	5-1648
11	1	Time Delay Relay 115V	5-1627
		230V	5-1625
12	1	Valve Assembly Bypass 115V	8650-621-1
		230V	8650-621-2
13	1	Coolant Gauge - Replacement kit includes: Body, self-sealing screws and O-Ring seals	5-1200
14	1	RF Load Resistor	
		Model 8655-( )	8755-101
		Model 8656-( )	8776-101
15*	4	Capacitor Starting Fans	5-873-2
16*	1	Fan, Serviced	
		Rear 115V	8650-093-1
		Rear 230V	8650-093-5
17*	1	Fan, Serviced	
		Mid Rear 115V	8650-093-2
		Mid Rear 230V	8650-093-6

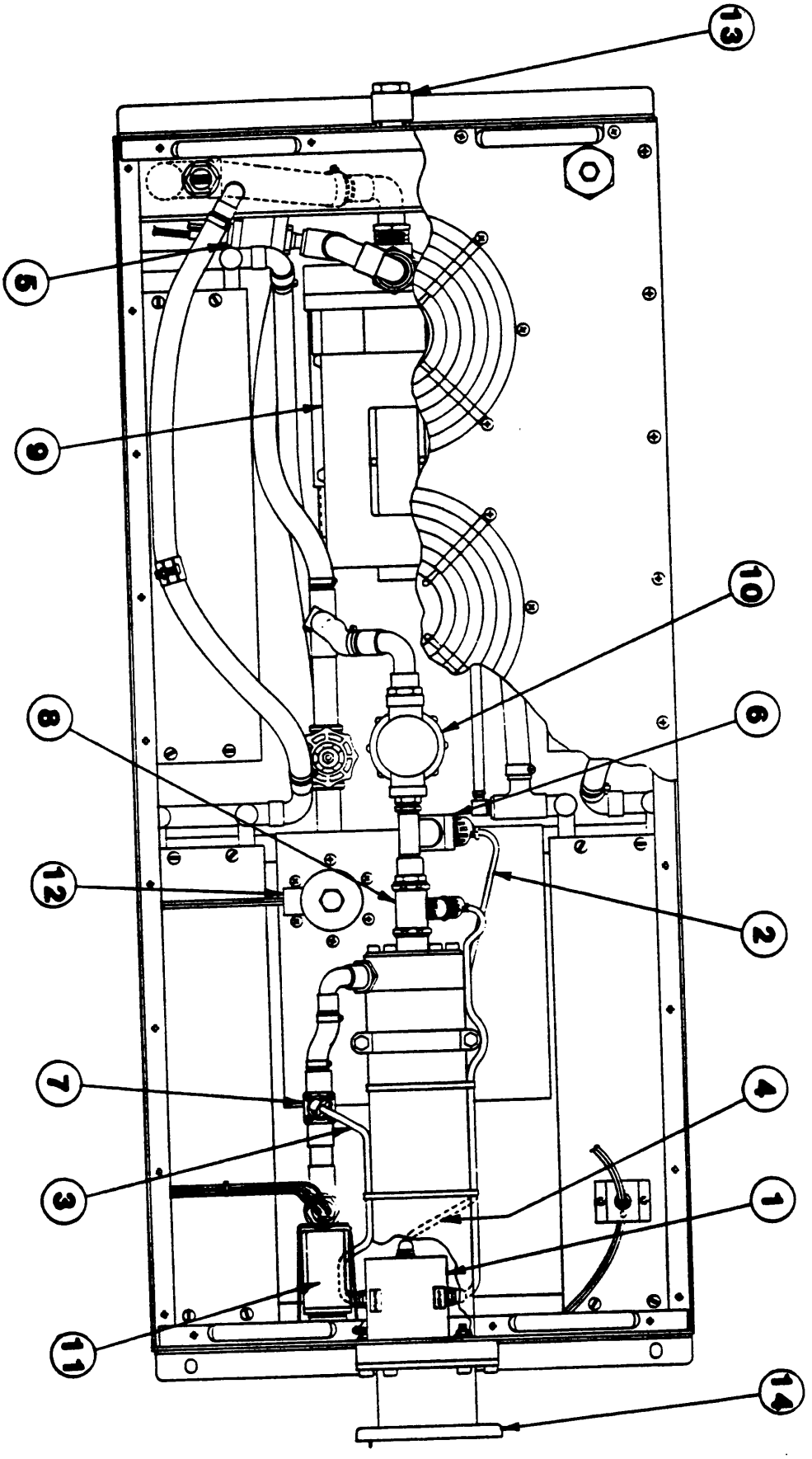
Continued

ITEM	QTY.	DESCRIPTION	PART NUMBER
18*	1	Fan, Serviced	
		Mid Front 115V	8650-093-3
		Mid Front 230V	8650-093-7
19*	1	Fan, Serviced	
		Front 115V	8650-093-4
		Front 230V	8650-093-8
20**	1	AC line cord 115V	5-1836
		230V	5-1837

*Located on fan panel, which is removed in Figure 7-1 to expose load/sensor unit internal components.

**Refer to Figure 1-1 for location of these parts.

FIGURE 7-1. REPLACEMENT PARTS ILLUSTRATION - LOAD/SENSOR UNIT.



7-4. Refer to Figure 7-2 for location of spare parts. Item numbers correspond to call outs in Figure.

CALORIMETER CONTROL UNIT PARTS:

ITEM	QTY.	DESCRIPTION	PART NUMBER
1	1	Main PC Board	6080-306
2	1	Flow Indicator PC Board	6080-318
3	1	3-1/2 Digit Panel Meter with optional BCD output	5-1910
4	1	Cable Assembly, BCD Option	6080-315
5	1	Switch, power assembly	6080-305
6*	1	AC Line Cord	4421-055
7*	1	Fuse	5-721-6

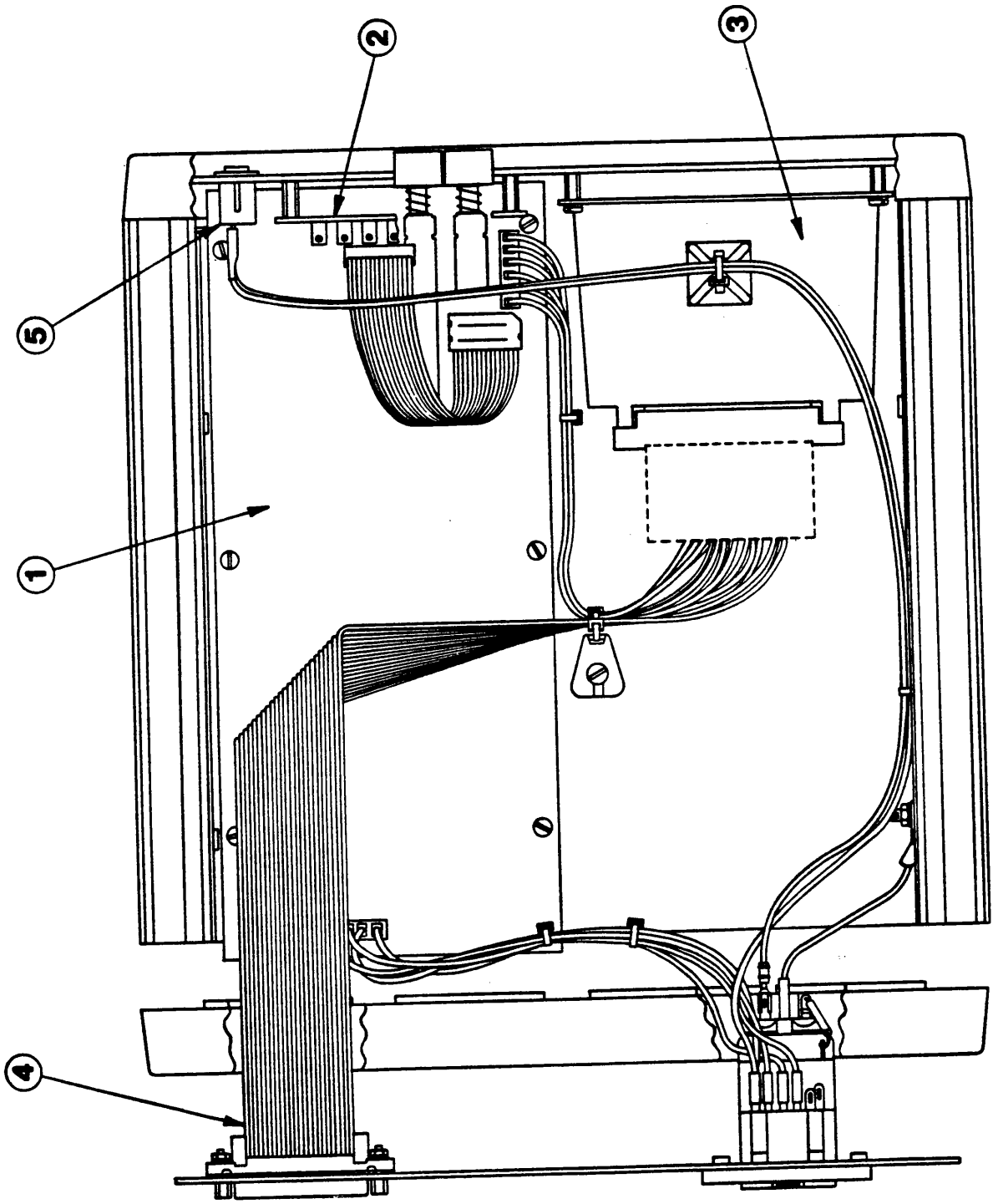
*Refer to Figure 1-1 and 1-2 for location of these parts.

ADDITIONAL PARTS:

ITEM	QTY.	DESCRIPTION	PART NUMBER
1	1	Sensor Cable	6080-320-1

NOTE: Sensor cables can be purchased in various lengths. For more information contact Bird Electronic Corporation.

FIGURE 7-2. REPLACEMENT PARTS ILLUSTRATION - CONTROL UNIT.



SECTION VIII - INTERNAL REPAIR OF THE LOAD RESISTOR

8-1. REPLACEMENT PROCEDURE FOR RESISTIVE ELEMENT

8-2. The water cooled load used in this calorimeter is designed to be quickly and easily repaired in the field. If in performing the dc resistance check described in Paragraph 4-7, a significant change in resistance is noted, or if for any reason the resistive element should fail, inexpensive replacement resistors are available. Installation is accomplished as described in this Section. Note - These repairs can be made by removing the load resistor entirely as described in Paragraph 5-8. However, it may usually be desirable to leave the water connections to the water chamber undisturbed. This may be accomplished by following step 8-3a., removing the main housing portion only.

8-3. RESISTOR REMOVAL - Note - Numbers in brackets [ ] are item numbers indicated in Figures 8-1 and 8-2.

a. Using a 3/16 hex socket wrench, unscrew the six 1/4-20 x 2-1/2 socket head cap screws [6] holding the water chamber [3] to the main load housing. When all screws are loose, pull the water chamber assembly, with screws, straight off. It may be necessary to rock the chamber gently while pulling it off carefully. Then remove the six 1/4-20 nuts and washers on the inside of the front panel flange fastening (do not loosen screws) and carefully draw the main portion of housing out the front end, leaving the water chamber [3] attached to its water lines.

b. The inner flow tube [9] will usually come out with the water chamber assembly being held to it by the compression of the inner O-Ring [4] water input seal. This is normal and if the resistor body is unbroken there will be no need to remove the inner flow tube from the water chamber assembly. The ground cap assembly [10] is fitted tightly within the water chamber and should normally remain with it. If the inner flow tube has stayed in the resistor section simply grasp the resistor stop sleeve [7] on the flow tube and pull out the assembly. Note - This includes the cushioning O-Ring [8] which fits loosely below the stop sleeve; always take care not to lose it. Also, if the brass stop sleeve [7] is removed at all notice that it has a small escape hole at the side and an access counterbore leading to it. In reassembly, be sure this counterbore is facing toward the O-Ring and the resistor [1]. This is essential for internal water venting. Notice the water outlet holes and also the small shoulder at the base of the inner flow tube. At reassembly, this must fit into a mating recess in the input fitting at the bottom.

c. If the resistor [1] is intact it may be easily pulled straight out of the load housing and is ready for replacement.

The outer flow tube is captive and will not come out of the housing at this stage.

8-4. INSPECTION

8-5. At this point, if the resistor has been successfully removed, inspect it carefully to insure that it is not fractured. In the majority of cases, even in the event of resistor failure, the resistor substrate will remain intact. Next, examine the inside of the load housing assembly for any apparent damage to the internal parts. If no damage had been found proceed with resistor replacement (see 8-6, Resistor Replacement). However, if the resistor is broken, other internal parts appear to be damaged, or if they do not fit together properly, proceed to 8-7, Replacement Procedure for Fractured Resistors.

8-6. RESISTOR REPLACEMENT

a. Insert new resistor [1] into the load housing until it reaches its fitting. Push in the resistor until it bottoms snugly. If resistor seems to be loose, refer to the procedure for the replacement of fractured resistors for instructions on how to tighten the resistor fitting.

b. Place the inner flow tube [9] inside the resistor and lower it until it reaches the resistor fitting. Gently work and twist the inner flow tube until it seats in the bottom of the input resistor fitting. This operation may also be done if the inner flow tube is still in position in the water chamber when the main housing is being reinstalled.

c. Make sure that the O-Ring [8] cushion is placed on the inner flow tube next to the resistor and the backup resistor sleeve [7] is right behind it. Watch orientation of sleeve (see Subparagraph 8-3b). There is no need to disturb the resistor cap assembly [10] in the water chamber for this procedure.

d. Now replace the water chamber [3], gently rocking and twisting the chamber to achieve the proper flat seat on the outer housing. Note - If the water chamber [3] does not seem to fit properly refer back to step 8-6b. to see that the inner flow tube is properly in place.

e. Tighten the six 1/4-20 x 2-1/2 socket head cap screws [6]. Check the dc resistance between the inner and outer conductors; it should be approximately 50 ohms (see Paragraph 4-7). Remount the load resistor to the panel reversing the procedures in 8-3, Resistor Removal. If the load resistor has been entirely removed reattach the water connections and the sensor subassemblies reversing the procedure in 5-9. Be sure to reattach sensor leads in sensor control box correctly. Restore coolant per 1-21, Coolant. Run pump/motor for five minutes and check thoroughly for leaks before applying any RF power to the load/sensor unit.

8-7. REPLACEMENT PROCEDURE FOR FRACTURED RESISTORS

```
**********************************************************
*                      W A R N I N G                     *
*                                                        *
* The resistor used in this load consists of a resistive *
* film on a special substrate.  If the substrate is      *
* broken, there will probably be sharp pieces or splin-  *
* ters inside the load housing.  Caution should be exer- *
* cised to avoid possible injury.                        *
**********************************************************
```

8-8. RESISTOR REMOVAL - Load previously removed from load/sensor unit.

a. The load should already be disassembled to the point of paragraph 8-3b. Now turn the load on end with the RF input connector up to allow any loose pieces of resistor to fall out of the load housing.

b. Using a 3/16 Allen wrench, loosen and remove the six 1/4-20 x 1-1/2 socket head cap screws [16] from the flanged end of the load housing, as shown in Figure 8-2. The outer conductor assembly [12] or [14] may now be easily removed.

c. Next remove the input center conductor assembly [11] or [13], Figure 8-2, by pulling it out of the load housing and then carefully removing any remaining pieces of the resistor. Normally in this disassembly, the outer flow tube will remain with the load housing. Restore it to this position after inspection and cleaning if it should come out. Inspect the inside of the load housing for any apparent damage.

d. Also, if it is in place in the water chamber pull out the inner flow tube. Inspect carefully for broken pieces. Then grasp the projecting hub of the resistor cap assembly [10] firmly with your fingers and pull straight off with a strong even force.

e. Under clear running water thoroughly wash all the inside portions of the three assemblies; i.e., input section, load housing and water chamber. To replace the resistor cap assembly, push in firmly to bottom in the water chamber.

8-9. RESISTOR REPLACEMENT

a. Insert replacement resistor [1] into the resistor fitting of the input center conductor assembly to test its tightness. The resistor should not have to be forced into the fitting but should be quite snug.

b. If the resistor is loose in the fitting press the slotted finger contacts of the fitting together slightly and try the resistor again. Continue closing the ends of the resistor

fitting until a snug fit is obtained. Then bottom the resistor in the fitting.

c. With the resistor still in place in the resistor fitting, insert the resistor and the input center conductor assembly into the load housing as illustrated in Figure 8-2, reversing procedure in Subparagraph 8-8c. Then replace the outer conductor assembly and the six 1/4-20 x 1-1/2 socket head cap screws and tighten.

d. Stand the load on end with the RF input connector down, place the inner flow tube inside the resistor, and lower it until it reaches the resistor fitting. Gently move and twist the inner flow tube until it seats in the bottom of the resistor fitting.

e. Continue same procedure as given in 8-6, Resistor Replacement, steps c. through e.

8-10. FRONT CONNECTOR ASSEMBLY

8-11. This portion of the load unit consists of the inner conductor [11] or [13] and the outer conductor [12] or [14], respectively. They may be released by removing the six screws [16] at the front of the housing flange as described in Subparagraph 8-8b. When the inner conductor has been pulled out, the O-Ring [15] resistor fitting seal to the outer water flow tube may be readily changed if desired. Do not attempt further disassembly of this part. If necessary, return to factory for repair.

8-12. REPLACEMENT PARTS LIST

8-13. MODELS 8775-101 & 8776-101 LOAD RESISTORS FOR MODULOAD® 8655/56

ITEM	QTY.	DESCRIPTION	PART NUMBER
1	1	Resistor	8755-027-3 or 8755-029-3
2	1	Resistor Cap Seal O-Ring - Outer	8410-009
3	1	Water Chamber	8755-014
4	1	Inlet Seal O-Ring	5-099
5		[Shown on drawing not used]	
6	6	1/4-20 x 2-1/2 Socket Head Cap Screws (SS)	Standard
7	1	Resistor Sleeve	8755-026
8	1	Sleeve Backup O-Ring	8110-059
9	1	Inner Flow Tube	8775-025
10	1	Resistor Ground Cap Assembly	8755-005
Front Connector Parts Assigned Per Model Type:			
Model 8775 - 3-1/8" EIA Connector 50 Ohms			
11	1	Center Conductor Input Assembly	8755-007
12	1	Outer Conductor Assembly	8755-004

Continued

ITEM	QTY.	DESCRIPTION	PART NUMBER
Model 8776 - 3-1/8" Unflanged Connector Flush Center Conductor 50 Ohms			
13	1	Center Conductor Input Assembly	8756-003
14	1	Outer Conductor Assembly	8756-002
For Both Models			
15	1	Center Conductor Assembly O-Ring	5-1127
16	6	1/4-20 x 1-1/2 Socket Head Cap Screws (SS)	Standard
17	1	Resistor Cap Seal O-Ring - Inner	5-567

FIGURE 8-1. RESISTOR REMOVAL.

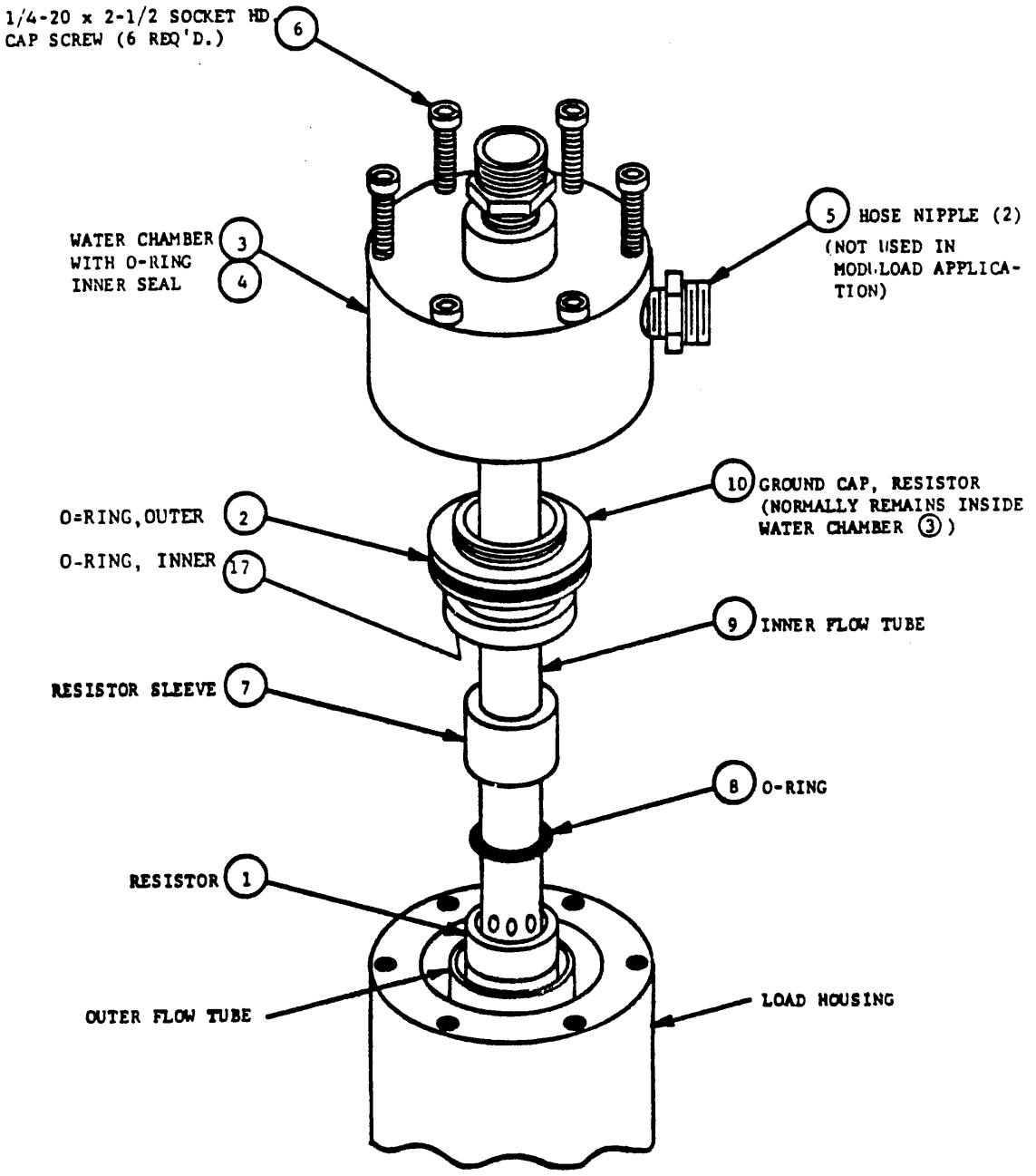
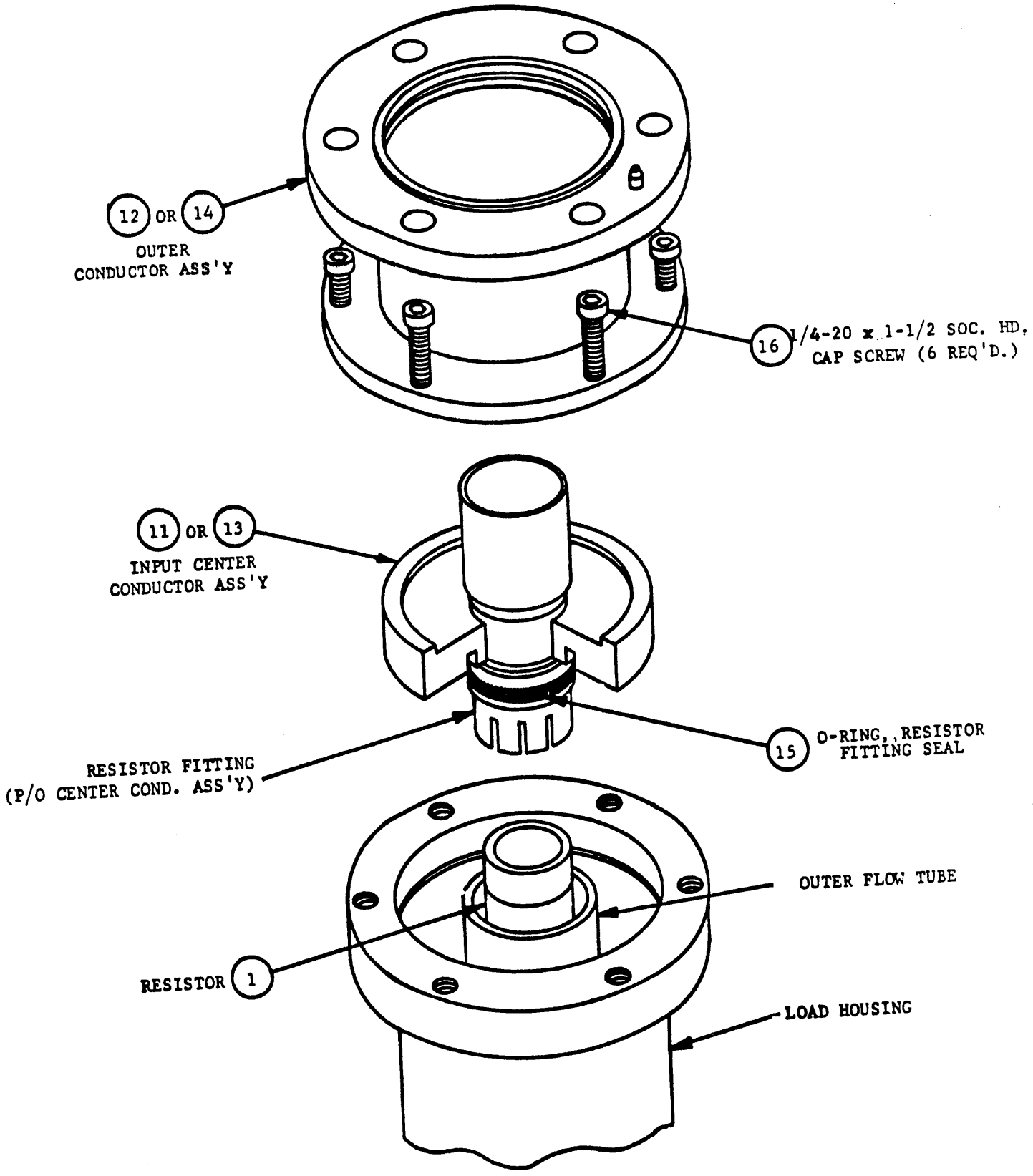


FIGURE 8-2. CONNECTOR REMOVAL.

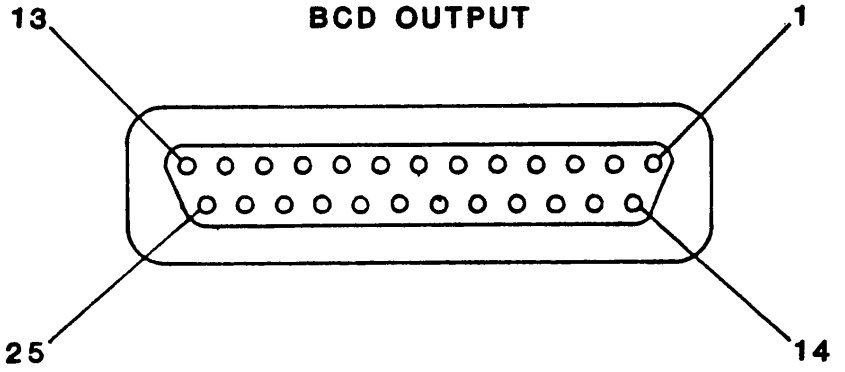


SECTION IX -BINARY-CODED-DECIMAL (BCD) OUTPUT CONNECTOR

9-1. GENERAL

9-2. A 25-pin D-shell connector for the Binary-Coded-Decimal outputs is provided on the upper left hand portion of back panel of the digital control unit. A drawing of the pin locations for same, with description of the pin assignments, is provided in Figure 9-1.

FIGURE 9-1. BCD CONNECTOR PIN FUNCTIONS.



Pin No.	Function	Pin No.	Function
1	BCD 100	14	BCD Ground
2	BCD 200	15	Hold
3	BCD 400	16	NC
4	BCD 800	17	BCD 1000
5	NC	18	+5V
6	BCD 10	19	OE3 (Tens)
7	BCD 20	20	OE2 (Hundreds)
8	BCD 40	21	OE4 (Units + Overrange)
9	BCD 80	22	OE1 (Thousand + Polarity)
10	BCD 1	23	Overrange
11	BCD 2	24	Polarity
12	BCD 4	25	Data Valid
13	BCD 8		

9-3. SUPPLY WIRING (SEE FIGURE 9-1)

a. Pin 18 must be powered by an external power supply, which must supply a regulated power of +5 Vdc @ 6mA.

Pin 14 is connected to the external power supply ground.

IMPORTANT NOTE:

BCD output and logic signals are referenced to the external power supply.

9-4. LOGIC INPUT WIRING (SEE FIGURE 9-1)

a. All Output Enable (OE) lines are internally pulled to ground through a 100k ohm resistor.

For a multiplexed BCD output, each digit can be disabled by putting a Logic "1" (+5 Vdc) on its OE line, and enabled by disconnecting it or pulling the OE line down to Logic "Ø" (Ø Vdc).

b. Putting a Logic "1" (+5 Vdc) on Data Hold (Pin 15) locks the present data into the output storage latches until the Data Hold is returned to Logic "Ø" (Ø Vdc). With removal of Logic "1", Data Hold will automatically return to Logic "Ø".

9-5. DATA OUTPUT WIRING

There are three commonly used output formats compatible with the Model 6080A. Once you have determined which format is required, follow the wiring instructions for that format only.

a. Full Parallel BCD Output Lines (See Figure 9-1):

1. For a fully parallel BCD output, no connections to the four output enable lines are necessary.

2. The Data Valid Signal (Pin 25) is Logic "1" when data is valid. See note at the end of Section 9-5.

b. Multiplexed BCD Output (Bit Parallel, Digit Serial) See Figure 9-1.

1. BCD Output

$2^{Ø}$ - Pin 10
2^{1} - Pin 11
2^{2} - Pin 12
2^{3} - Pin 13

2. Jumpers Required

Pin to Pin	Pin to Pin
12 - 3	1Ø - 1
3 - 8	1 - 6
8 - 24	6 - 17
13 - 4	11 - 2
4 - 9	2 - 7

3. Each digit will appear at these pins when its OE line is enabled, and all other lines are disabled.

NOTE: Thousand bit will appear at $2^{Ø}$ (Pin 1Ø).
Polarity bit will appear at 2^{2} (Pin 12).

c. 8 Bit Multiplexed (Sometimes used with 8 bit computers) See Figure 9-1:

1. BCD OUTPUT

PIN	OE3 and OE4* LOGIC "Ø"	OE1 and OE4* LOGIC "Ø"
10	Units $2^{Ø}$	Hundreds $2^{Ø}$
11	2^{1}	2^{1}
12	2^{2}	2^{2}
13	2^{3}	2^{3}
6	Tens $2^{Ø}$	Thousand
7	2^{1}	--
8	2^{2}	Polarity
9	2^{3}	--
23	Overrange	--

2. Jumpers Required

PIN TO PIN
1Ø - 1
11 - 2
12 - 3
13 - 4
6 - 17
8 - 24

*All other OE lines must be Logic "1".

3. The Data Valid Signal (Pin 25) is Logic "1" when data is valid.

NOTE: For low input signals (less than 10 counts). Data Valid Signal may not go to Logic "Ø" when data is updated, because its length is proportional to input signal and may become difficult to detect.

APPENDIX A - CALORIMETER LOAD/SENSOR UNIT SCHEMATICS

A-1. GENERAL

A-2. This section contains the schematics for the calorimeter's load/sensor unit wired for 115V or 230V.

FIGURE A-1. 50KW LOAD/SENSOR UNIT SCHEMATIC, 115V, 60HZ SUPPLY.

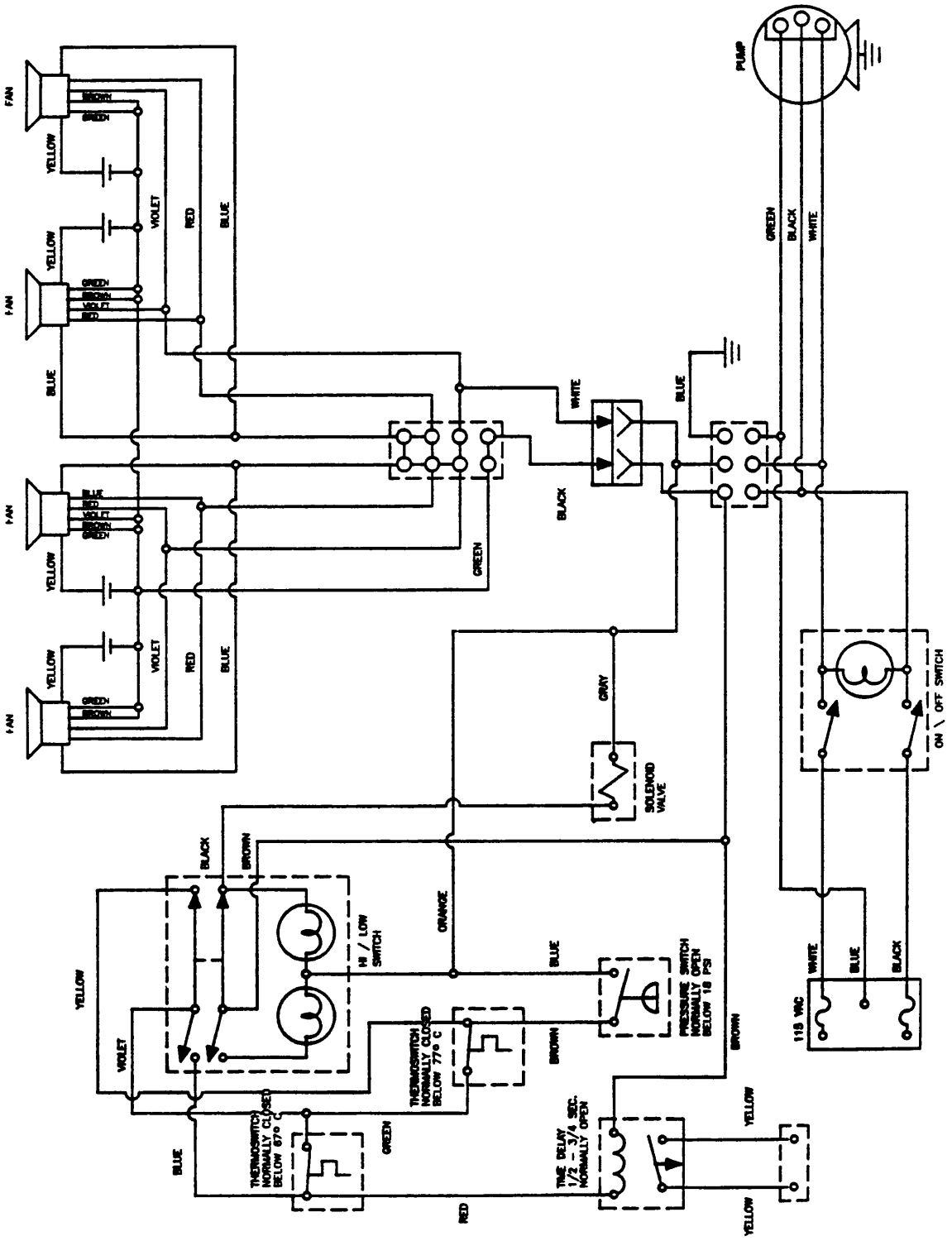


FIGURE A-2. 50KW LOAD/SENSOR UNIT SCHEMATIC, 230V, 50HZ SUPPLY.