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2176A

Multipoint Digital Thermometer

Instruction Manual

P/N 445486
April 1976
Rev.2, 9/88

FLUKE

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC, will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 2269, 5600 CG, Eindhoven, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

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1-1. INTRODUCTION

1-2. The Model 2176A Digital Thermometer is a portable, four-digit, thermocouple thermometer capable of resolving 0.1°C or 0.1°F over a temperature range of -99.9 to 999.9°C or -99.9 to 999.9°F. It features push-button selection of °C or °F, a four digit LED display, reference junction compensation (to eliminate the need for an ice-bath reference junction), the choice of using any one of four thermocouple types (J, K, E, or T) as the input device, dual-slope measurement techniques and digital linearization of the thermocouple inputs. Several options and accessories are also available for use with the 2176A.

1-3. Front panel switch controls include a push-button power switch (ON/OFF), a push-button temperature select switch (°C/°F), and a 10-position rotary switch for selecting the desired thermocouple. The rotary switch is labeled CHANNEL SELECT and the thermocouple inputs are identified as 1 through 10.

1-4. The front-panel display consists of five, seven-segment, high-intensity LED's, and features leading zero suppression. Four of the LED's are used to display numeric data, including a minus sign for negative temperature indications. The fifth LED displays the selected °C or °F scale character. An open-thermocouple detector causes the display to blink when an open circuit is sensed at any one of the selected thermocouple input terminals.

1-5. A plug-in module at the rear of the 2176A provides 10 pairs of screw-type input terminals for attaching individual thermocouples to the desired channels. These terminals are an integral part of an isothermal block and serve as the reference junction for the reference junction compensator. (The reference junction compensator provides the physical and electrical equivalent of, and eliminates the need for, an ice bath reference junction at 0°C or 32°F.)

NOTE

All thermocouples connected to the input terminals must be of the same type.

1-6. The actual measurement range of the 2176A is determined by the type of thermocouples being used as the input devices. Any one of four thermocouple types can be used; J, K, E or T. To ensure the proper linearization of the selected thermocouple input, a corresponding linearization program must be selected on the interior of the unit. Selection is accomplished by installing a type select pcb which corresponds to the input thermocouple. A single type select pcb is supplied with the unit to match the thermocouple specified at the time of purchase. The remaining pcb's are individually available as accessories and are described in Table 1-1.

Table 1-1. 2176A ACCESSORIES

MODEL NO.	DESCRIPTION
Y8205	Carrying Case
C86	Carrying Case
Y2004	Case and Battery Pack
P20E	E-Type Thermocouple Probe
P20J	J-Type Thermocouple Probe
P20K	K-Type Thermocouple Probe
P20T	T-Type Thermocouple Probe
M00-100-714	Front Panel Dust Cover
M00-200-611	Rack Mounting Kit, Offset
M00-200-612	Rack Mounting Kit, Center
M00-200-613	Rack Mounting Kit, Side-by-Side
2160A-7016	J-Type Select PCB
2160A-7017	K-Type Select PCB
2160A-7019	E-Type Select PCB
2160A-7018	T-Type Select PCB
2166A-7010	Extra-Input Connector Module

1-7. Accessories and options available for use with the 2176A are listed and described in Tables 1-1 and 1-2, respectively. Both options are field installable. Either one, but not both, of the options can be installed in a unit. Detailed information concerning each option and accessory is given in Section 6 of this manual, Option and Accessory Information.

1-8. The 2176A is designed to operate from either ac line power or an external 12V dc source. A choice of any one of three line power configurations are available: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Specify the required configuration at the time of purchase.

Table 1-2. 2176A OPTIONS

OPTION NUMBER	DESCRIPTION
–02	Digital Output Unit
–04	Analog Output Unit

1-9. SPECIFICATIONS

1-10. Specifications for the 2176A are given in Table 1-3.

Table 1-3. SPECIFICATIONS

ELECTRICAL

Compatible Thermocouple Types	Unit can be calibrated to operate with any one of the following thermocouple types: J, K, T, E
Measurement Method	Dual-slope integration over a 100 ms period
Zero Drift	None. Automatic zero correction
Reading Rate	2.5 readings per second
°C to °F Conversion	Switch selectable
Input Characteristics	
Input Connections	Screw terminals on isothermal connector
Input Circuit	Two-wire per channel isolated, 10-channel, switch selectable
Input Impedance	$>$ 100 MΩ
Input Current	$<$ 500 pA
Source Impedance	$\leq$ 5kΩ. 5kΩ causes $<$ 0.2°C (.36°F) error with k thermocouple
Overload	Display flashes when input voltage exceeds full-scale temperature range
Open Input	Display flashes to indicate open at input terminals
Maximum Input Voltage	130V dc or 130V ac (rms) between any pair of inputs
Maximum Input Voltage (without damage)	400V dc or ac peak continuously between inputs or between either input and ground
Maximum Common Mode Voltage (without damage)	400V dc or ac peak
Common Mode Rejection	$\geq$ 120 dB @ 50, 60, 400 Hz ±0.1% with 1kΩ source impedance unbalance
Normal Mode Rejection	$\geq$ 60 dB @ 50, 60, 400 Hz ±0.1%
Accuracy	See Table 1 for °C specifications and Table 2 for °F specifications
Response Time to Rated Accuracy	$<$ 2.0 seconds
Linearization	Digital with four selectable programs in LSI ROM
Linearization Programs	
J, K, T and E	32 straight line segments for positive inputs and 16 for negative inputs

Table 1-3. SPECIFICATIONS (Cont.)

Reference Junction Compensation

20 to 30°C (68 to 86°F)

J, K, T, E . . . . . 0.025 degrees per degree

0 to 20°C, 30 to 50°C (32 to 68°F, 86 to 122°F)

J, K . . . . . 0.032 degrees per degree

T, E . . . . . 0.045 degrees per degree

Temperature Coefficient . . . . . 0.005% of reading per °C

Internal Temperature Rise . . . . . ⩽ 8°C (14.4°F)

Table 1 . ACCURACY SPECIFICATIONS °C

THERMOCOUPLE TYPE	TEMPERATURE RANGE °C	RESOLUTION AND REPEATABILITY (±°C)	APPLICABLE TEMPERATURE RANGE °C	MAXIMUM ERROR INCLUDING NBS CONFORMITY (±°C)*				NBS CONFORMITY (±°C)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 23 to 27°C	90 Days 20 to 30°C	1 Year 15 to 35°C	
J	–99.8 to 777.8	0.1	–99.8 to 0 0 to 777.8	0.6 0.5	0.8 0.6	1.1 0.8	1.3 1.2	0.19 0.15
K	–99.8 to 999.8	0.1	–99.8 to 0 0 to 999.8	0.8 0.6	0.9 0.7	1.3 1.2	1.6 1.5	0.2 0.18
T	–99.8 to 400	0.1	–99.8 to 0 0 to 400	0.7 0.5	0.7 0.6	1.1 0.7	1.7 1.0	0.19 0.15
E	–99.8 to 999.8	0.1	–99.8 to 0 0 to 999.8	0.7 0.6	0.8 0.7	1.1 1.1	1.8 1.5	0.17 0.18

*Includes reference junction and conformity errors. Excludes thermocouple errors.

Table 1-3. SPECIFICATIONS (Cont.)

Table 2- . ACCURACY SPECIFICATIONS °F

THERMOCOUPLE TYPE	TEMPERATURE RANGE °F	RESOLUTION AND REPEATABILITY (±°F)	APPLICABLE TEMPERATURE RANGE °F	MAXIMUM ERROR INCLUDING NBS CONFORMITY (±°F)*				NBS CONFORMITY (±°F)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 72 to 81°F	90 Days 68 to 86°F	1 Year 59 to 95°F	
J	–99.8 to 999.8	0.1	–99.8 to 32 32 to 999.8	1.1 0.9	1.2 1.0	1.8 1.4	2.3 1.8	0.27 0.2
K	–99.8 to 999.8	0.1	–99.8 to 32 32 to 999.8	1.3 1.2	1.4 1.2	2.2 1.6	2.8 2	0.28 0.26
T	–99.8 to 752	0.1	–99.8 to 32 32 to 752	1.1 0.8	1.1 1	1.9 1.2	3.1 1.7	0.3 0.2
E	–99.8 to 999.8	0.1	–99.8 to 32 32 to 999.8	1.1 1	1.1 1.1	1.9 1.5	3.2 2	0.25 0.25

*Includes reference junction and conformity errors. Excludes thermocouple errors.

GENERAL

Type of Display . . . . . LED, 0.56 in high.

Power Requirements

Line Operation . . . . . 115V ac ±10%, 50 to 440 Hz, 8W. 100V ac and 230V ac version are also available.

External DC Source . . . . . 11 to 15V dc @ 400 mA

Size . . . . . 2.52 in (H) x 8.55 in (W) x 9.9 in (D) (6.40 cm x 21,72 cm x 25,15 cm). See Figure 1-1.

Weight . . . . . 3 lbs. 4 oz. (1.47 kg)

ENVIRONMENTAL

Temperature

Operating . . . . . 0 to 50°C (32 to +122°F)

Storage . . . . . –40 to 75°C (–40 to 167°F)

Humidity

0 to 50°C (32 to 122°F) . . . . . 80% non-condensing

0 to 35°C (32 to 95°F) . . . . . 90% non-condensing

Shock and Vibration . . . . . Meets requirements of MIL Standard 810

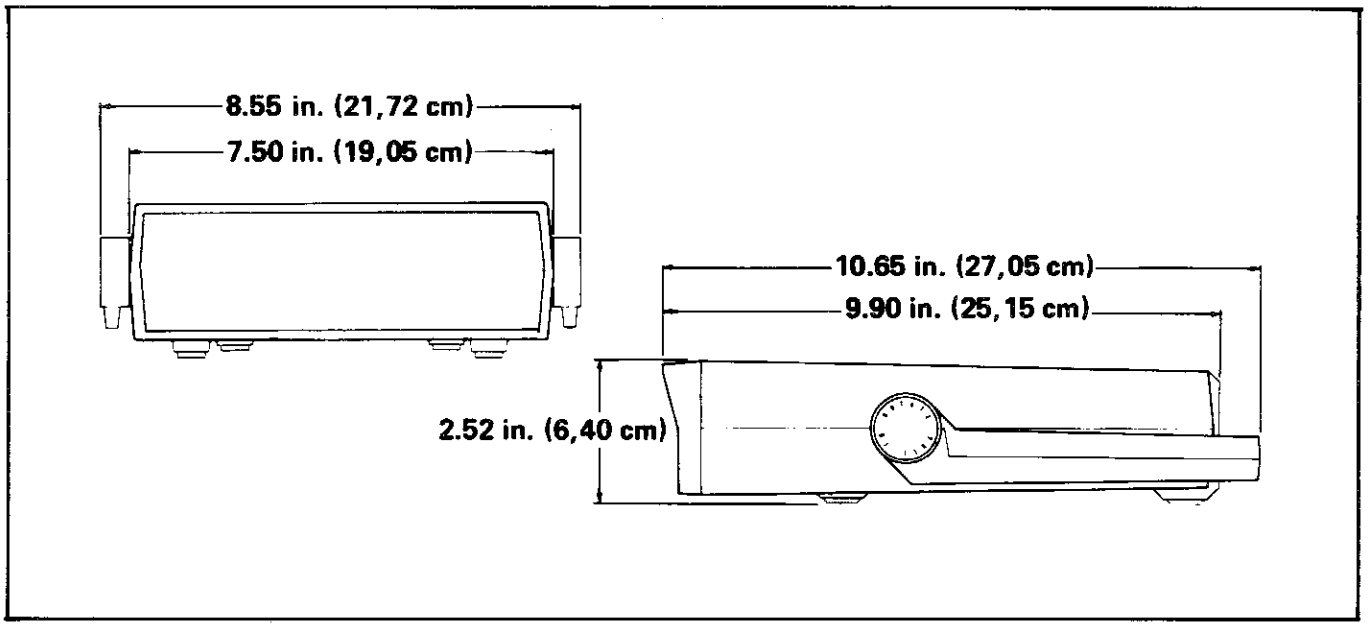
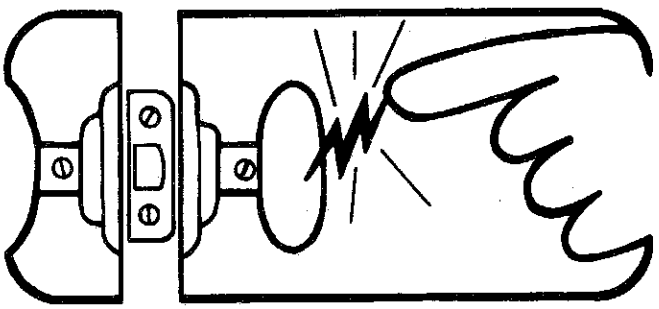


Figure 1-1. Outline Drawing

static awareness

A Message From

John Fluke Mfg. Co., Inc.

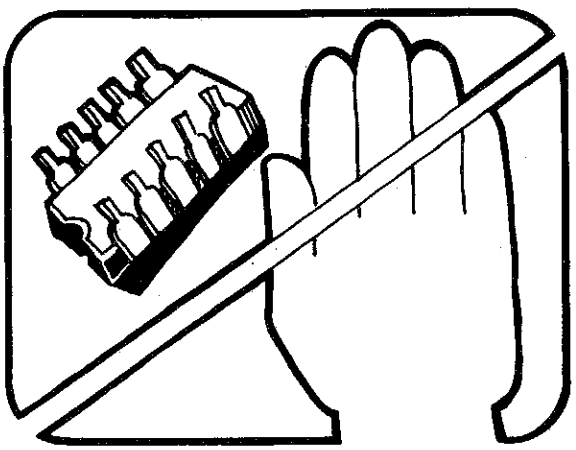


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

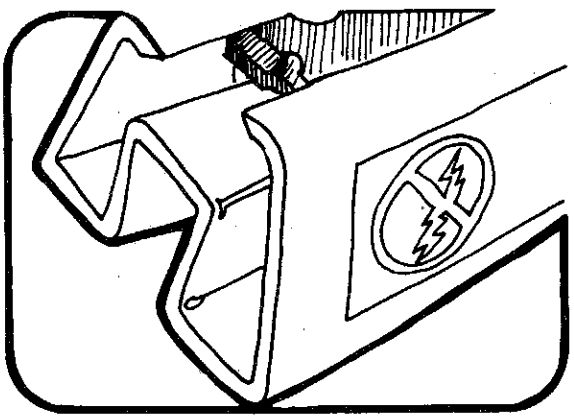
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

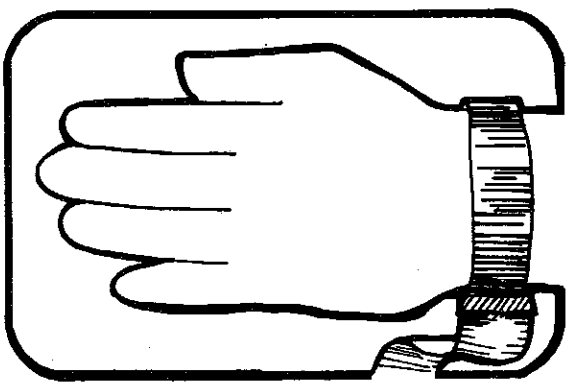
The following practices should be followed to minimize damage to S.S. devices.



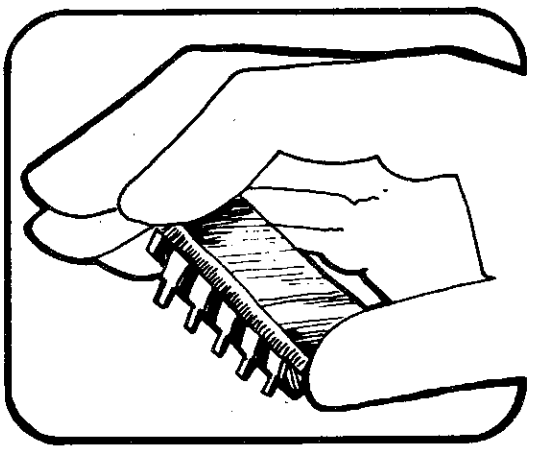
1. MINIMIZE HANDLING



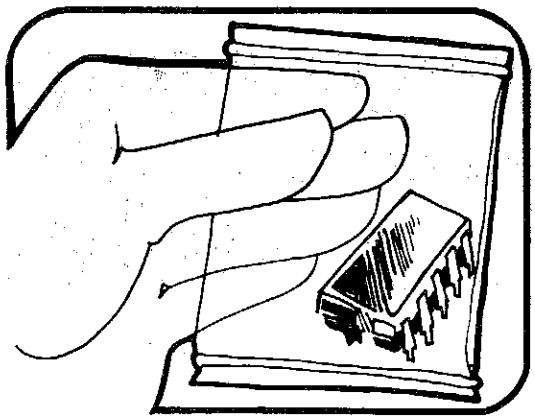
2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.



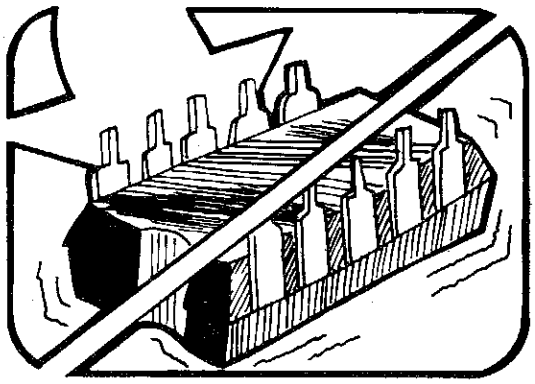
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES. USE A HIGH RESISTANCE GROUNDING WRIST STRAP.



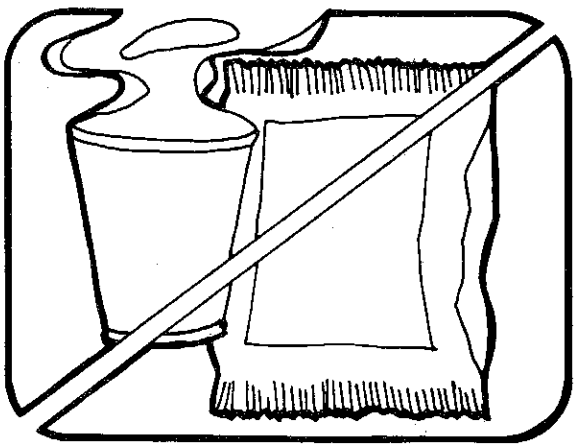
4. HANDLE S.S. DEVICES BY THE BODY



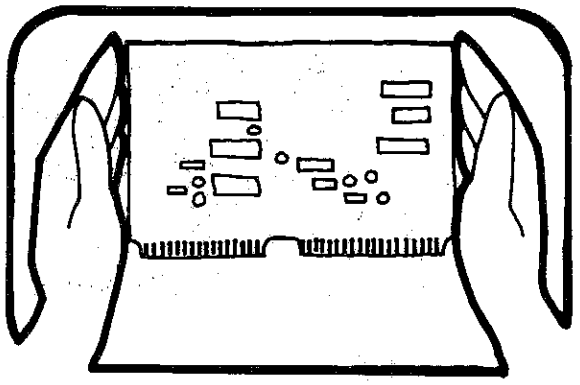
5. USE STATIC SHIELDING CONTAINERS FOR HANDLING AND TRANSPORT



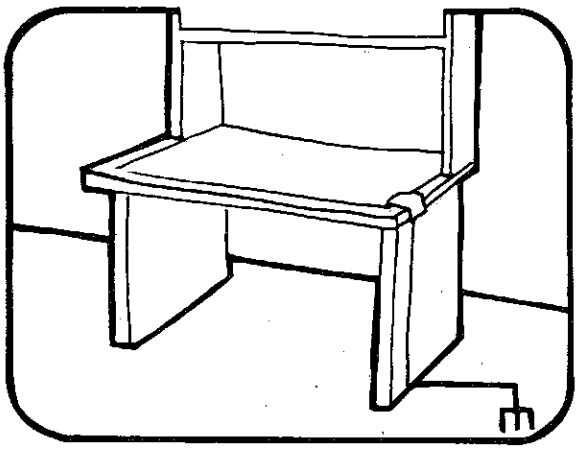
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR HELPS TO PROTECT INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION

10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.

11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

A complete line of static shielding bags and accessories is available from Fluke Parts Department, Telephone 800-526-4731 or write to:

JOHN FLUKE MFG. CO., INC.
PARTS DEPT. M/S 86
9028 EVERGREEN WAY
EVERETT, WA 98204

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Section 2
Operating Instructions

WARNING!

Due to the possible presence of lethal voltages, the procedures in paragraphs 2-21 and 2-27 should be performed by qualified personnel only.

2-1. INTRODUCTION

2-2. This section of the manual contains information about installation and operation of the Model 2176A Multipoint Digital Thermometer. It is recommended that the contents of this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, please contact your nearest Fluke Technical Service Center, or the John Fluke Mfg. Co. Inc., P.O. Box C9090, Everett, WA 98026, Tel. (206) 356-5400. A list of Technical Service Centers is located in Section 7 of this manual.

2-3. SHIPPING INFORMATION

2-4. The 2176A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-5. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INPUT POWER

2-7. The 2176A can be operated from either ac line power or an external 12V dc source. The unit is energized when either or both sources are connected to their proper input terminals, and the front-panel POWER switch is set to ON.

2-8. AC Line Voltage

2-9. The 2176A is factory wired to operate from one of three ac line voltages. These are: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Before connecting the 2176A to the ac line, check to ensure that the instrument is wired to accommodate the local line voltage. A decal on the underside of the unit defines the particular line voltage required to operate the instrument.

2-10. The rear panel ac input connector is a three-prong, U-ground connector which permits the instrument to be connected, via the power cord, to the appropriate line voltage. The offset prong on this connector is connected to the 2176A power supply, and should be connected through the power cord to a high quality earth ground.

2-11. External 12V dc Source

2-12. The external 12V dc source connects to two screw terminals provided on the rear of the 2176A. The decal on the bottom of the unit defines their location and polarity. The external source should be capable of supplying at least 400 mA at 11V dc.

2-13. RACK INSTALLATION

2-14. The 2176A is designed for field and bench-top use or for installation in a standard 19-inch equipment rack using an accessory rack-mounting kit. Kits are available for left, right, center or side-by-side mounting of the 2176A. Information regarding installation of the rack mounting accessories is given in Section 6 of this manual, Option and Accessory Information.

2-15. OPERATING FEATURES

2-16. The location of all 2176A controls, indicators and connectors are shown in Figure 2-1, and described in Table 2-1.

2-17. OPERATING NOTES

2-18. The following paragraphs describe various conditions which should be considered before operating the 2176A.

2-19. Option Information

2-20. Supplementary operating instructions are necessary when operating a 2176A which is equipped with one of the available options. Detailed information regarding the operation of each available option is given in Section 6 of this manual, Option and Accessory Information

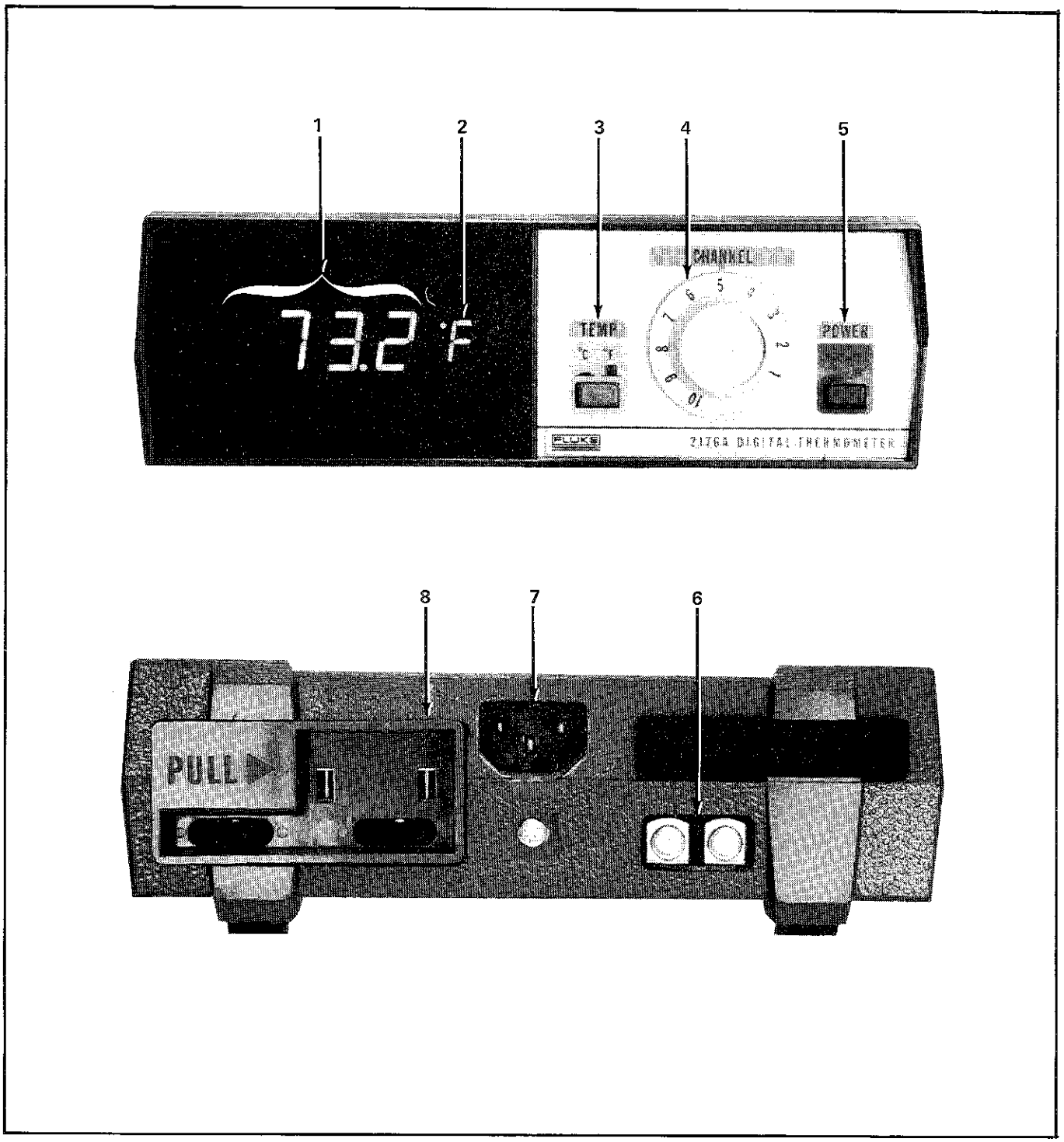


Figure 2-1. Controls, Indicators and Connectors

Table 2-1. 2176A CONTROLS, INDICATORS AND CONNECTORS

REF. NO.	NAME	FUNCTION
1	Digital Display	Displays a four digit readout of the measured input temperature. Leading-zero suppression and a fixed decimal point are also included. A minus sign is displayed for negative temperature measurements. The absence of a polarity sign indicates a positive temperature measurement.
2	Temperature Scale Indicator	Displays the temperature scale represented by the digital display data; °C or °F.
3	TEMP Scale Switch	Selects the temperature scale for the digital display. When the switch is depressed (IN), the °C scale is selected. The °F scale is selected when the switch is released (OUT).
4	CHANNEL SELECT Switch	Selects 1 of 10 possible thermocouple inputs to be used as the thermometer input. The temperature of the selected thermocouple is continuously read and displayed.
5	POWER Switch	Switches the 2176A on or off regardless of the input power source. The instrument is turned-on when the switch is depressed.
6	External 12V dc Input	Provides screw-type input terminals for connecting an external 12V dc power source. The 12V dc connections are not required when the unit is being operated from ac line power.
7	Input Power Connector	Provides the means of connecting the instrument through a power cord to ac line power. Line power is not required when the unit is being operated from an external 12V dc source.
8	Multipoint Input Module	Provides 10 pairs of screw type input terminals for connecting up to 10 of the same type thermocouples. Slots are provided at the rear of the drawer for strain relief of the thermocouple bundles.

2-21. Fuse Replacement

2-22. The ac line-input section of the 2176A power supply is fuse protected. The fuse is located on the interior of the unit near the power transformer. To access the fuse, disconnect the unit from line power, remove the rear-panel retaining screw located beneath the ac line connector, and pull the case from the instrument. When replacement is necessary, use a MDL (Slo-blo) 1/8A fuse.

2-23. Overload and Open Thermocouple Indication

2-24. The front panel display, in addition to providing a measurement reading, is designed to serve as an overrange or open thermocouple indicator. When the measurement range of the input thermocouple is exceeded, or when the thermocouple inputs are open circuited, the display will blink. The blinking indication does not mean that the instrument is being exposed to a damaging input condition.

2-25. Thermocouple Connections

2-26. The 2176A is capable of monitoring the temperature of 1 of 10 thermocouple probes of the same type. The probes connect to the unit through a plug-in Multipoint Input Module as shown in Figure 2-2. Ten pairs of screw-type terminals are provided for completing the thermocouple input connections. Each set of terminals is identified by a channel number from 1 to 10 and the attached thermocouple probe assumes that channel number. A particular channel is selected and measured by setting the front panel CHANNEL SELECT switch to the corresponding channel number.

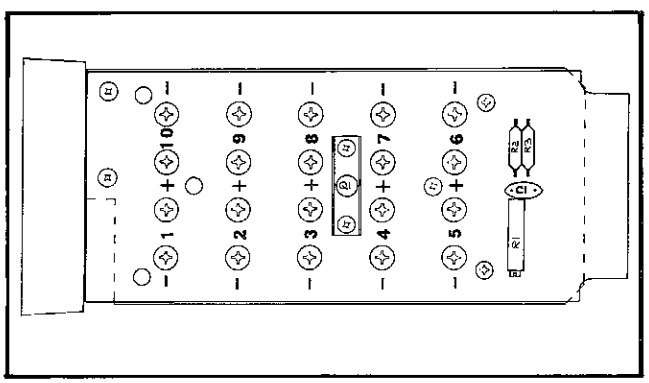


Figure 2-2. Multipoint Input Module

2-27. Thermocouple Compatibility

2-28. The 2176A is designed to operate in conjunction with a selected type of thermocouple probe. A decal on the bottom of the unit identifies the compatible thermocouple type. When necessary, the 2176A can be modified in the field to accommodate any one of the following thermocouple types: J, K, E or T. Use the following procedure to change thermocouple types:

a. Refer to Table 1-1 in Section 1 of this manual and order the type select pcb which corresponds to the desired thermocouple type. These pcb's are low-cost items and can be purchased from any one of the John Fluke Technical Service Centers (See Section 7) or from the John Fluke Mfg. Co., Inc.

b. Disconnect the 2176A from line power.

c. Remove any ribbon-cable connectors that may be attached to the rear of the 2176A.

d. Disconnect the power cord from the rear of the unit.

e. Remove the rear-panel screw located just below the power input connector.

f. Pull the 2176A front panel and pcb assembly out the front of the plastic case.

g. Unplug and remove the currently installed type select pcb from the position shown in Figure 2-3, and install the new pcb in its place.

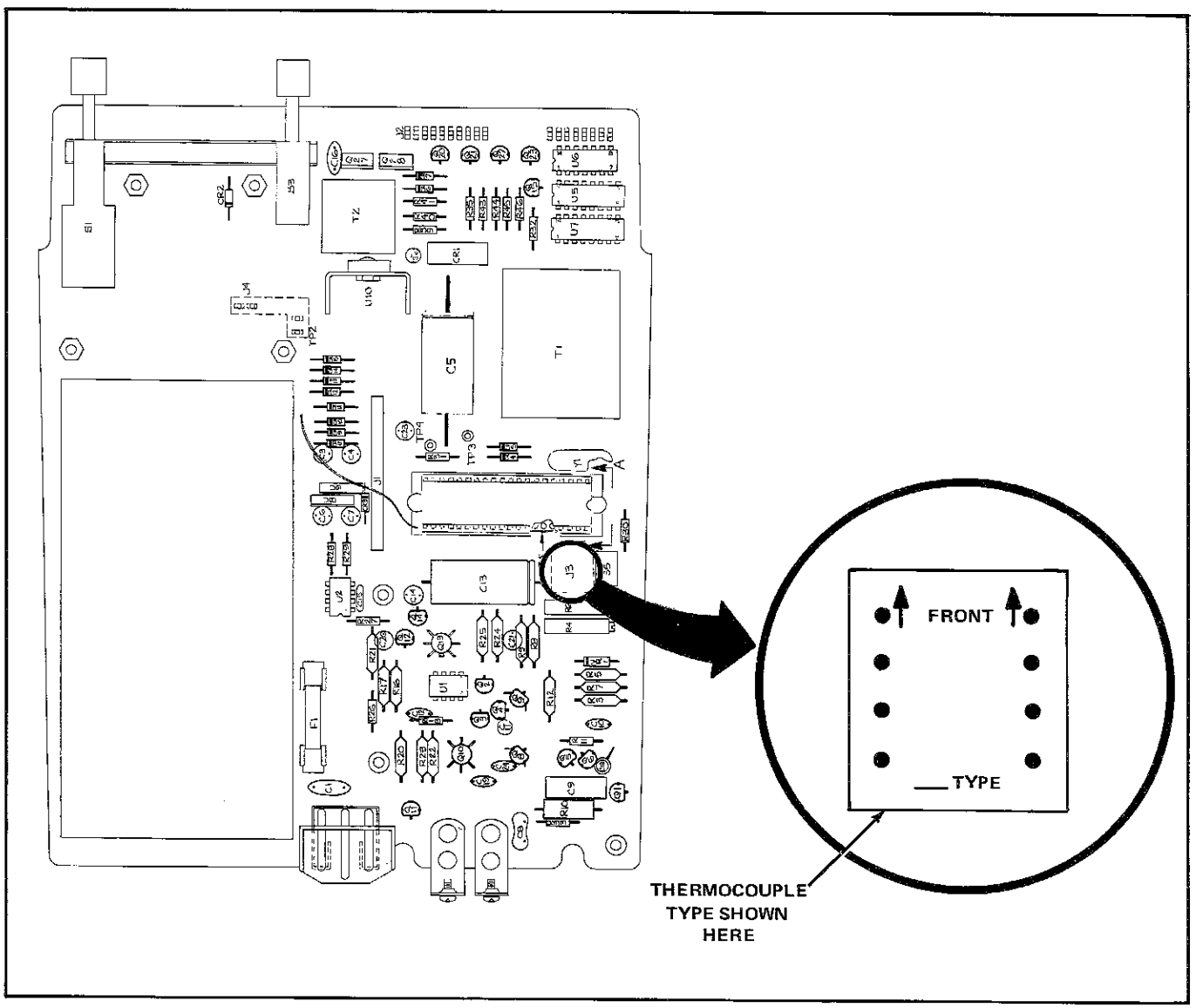


Figure 2-3. Type Select PCB, Location and Installation Details

NOTE

The thermocouple type is etched on the type select pcb's. When properly installed the arrows on the pcb point toward the digital display.

h. Place a piece of tape over the thermocouple type indications on the bottom-side decal, and mark the new thermocouple type on it.

i. Connect the unit to line power, and complete the routine calibration procedure given in Section 4 (Maintenance) of this manual.

j. Install the unit in its case.

2-29. OPERATION

2-30. With reference to previous paragraphs in this section, use the following procedure to operate the 2176A:

a. Refer to the decal on the bottom of the unit and determine the compatible thermocouple type.

b. Locate the Multipoint Input Module on the rear of the unit.

c. Place your forefinger in the recess marked by the arrow and pull the drawer straight out the rear of the unit.

d. Guide the thermocouple probe connections through one of the module's rear panel openings and connect them to the desired thermocouple channel input terminals, 1 through 10. A total of 10 thermocouples (all the same type) can be simultaneously connected in this manner. Mark each probe so that it can be readily associated with its corresponding channel, 1-10.

e. Reposition the module in the 2176A and press it firmly into position.

f. Connect the unit to the appropriate line power, as defined on the bottom-decal, or to an external 12V dc source.

g. Energize the 2176A by depressing the POWER switch.

h. Determine the thermocouple probe to be monitored and set the CHANNEL SELECT switch to the corresponding channel.

i. Set the TEMP switch to the desired temperature scale, °C or °F.

j. Refer to Section 6 of this manual for instructions concerning the operation of the –02 and –04 Options.

k. Expose the thermocouple assigned to the selected channel to a temperature within its specified range (See bottom decal). The probe temperature will be displayed on the front panel.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description followed by a circuit analysis of the 2176A. Simplified circuit diagrams and timing diagrams are included, as necessary, to supplement the text. Detailed schematics are given in Section 8 of this manual.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The Model 2176A Multipoint Digital Thermometer, as shown in Figure 3-1, is a portable four-digit, manual-scan, thermocouple thermometer capable of measuring any 1-of-10 possible like-type-thermocouple inputs and resolving 0.1°C or 0.1°F over a temperature range of -99.9 to +999.9°C or -99.9 to 999.9°F. It features switch selection of temperature scale (°C/°F) and thermocouple channel (1-10), reference junction compensation (to eliminate the need for an ice-bath reference junction), dual-slope integration, LSI digital control logic (includes linearization programs for J, K, E and T type thermocouples), a four-digit LED display, and power inputs for both ac line and external 12V dc operation.

3-5. In operation, the 2176A executes a continuous series of measurement cycles to update the temperature display. The measurement cycle is controlled entirely by an LSI digital IC, and includes three major subcycles; Auto-Zero period, Integrate period and Read period. Each subcycle controls the operation of the analog section of a dual-slope integrator which, in turn, generates a compare output to control the digital conversion performed by the LSI digital IC.

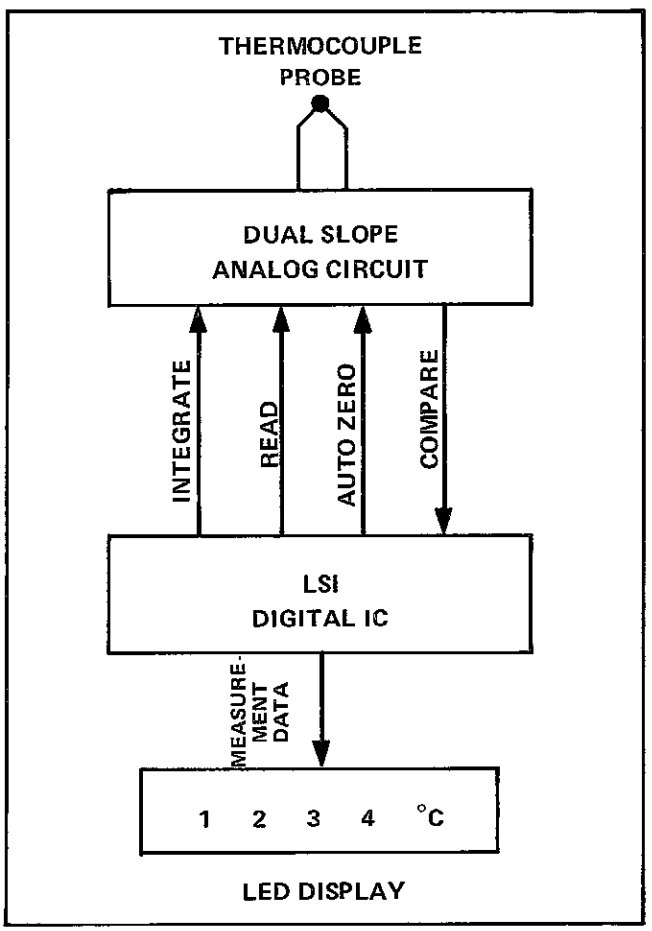


Figure 3-1. 2176A Simplified Block Diagram

3-6. The configuration of the analog section of the 2176A, during each phase of the measurement cycle, is established by a combination of FET switches that are controlled by the LSI digital IC. The measurement cycle begins with the Auto-Zero period. During this period, the reference junction compensation voltage and the accumulated dc offset voltages present in the analog section are sampled and held by capacitors. These voltages are used later in the measurement cycle to cancel measurement errors introduced by offset voltages and reference junction voltage errors created at the input terminal connections. As a result, the final measurement is proportional to the thermocouple probe output voltage and does not include offset errors or reference junction voltage errors. During the Integrate period, the thermocouple input voltages (probe voltage and input terminal voltages) are applied to the integrator, and the algebraic sum of these voltages is integrated over a 100 ms period. At the end of this period, the thermocouple input voltages are removed from the integrator and the Read period is started. A reference voltage is applied to the integrator during the Read period causing the integrator capacitor to be discharged at a linear rate. When the integrator output reaches zero a compare signal is generated to end the Read period. The duration of the Read period is translated by the LSI digital IC to provide a digital indication proportional to the thermocouple probe temperature.

3-7. CIRCUIT ANALYSIS

3-8. Circuit analysis of the 2176A is discussed in two sections; digital and analog. The digital section is covered first, and particular attention is paid to the control it exercises on the analog section. The analysis of the analog section covers the analog measurement circuitry and the 2176A power supply.

3-9. Digital Section

3-10. The digital section of the 2176A consists of an LSI digital IC, a hex buffer, a seven-segment decoder/driver and an LED display. Its function is to convert the non-linear thermocouple probe voltage, as measured by the analog section, into a linear digital display. The display provides a direct reading of probe temperature in °C or °F.

3-11. The LSI digital IC contains all of the 2176A control logic and linearizing capability, and provides the hex buffer and seven-segment decoder with the data necessary to update the LED display. The linearization of the nonlinear input signal is accomplished by selecting one of four programs which vary the rate at which the measurement counts are accumulated. The program is selected to match a particular thermocouple type. Program selection is accomplished by a series of plug-in type select pcb's which are available as accessories.

3-12. Measurement data is continuously strobed out of the LSI digital IC in bcd, character-serial format. At the end of each measurement cycle, an update flag is raised to signify that a new reading is available. When an overload occurs, the number of accumulated counts are stored and presented, along with a blanking pulse, as output data. The blanking pulse alternately turns the display on and off to indicate the presence of an overload.

3-13. The basic measurement cycle, as shown in Figure 3-2, comprises three subcycles; a 100 ms minimum Auto-Zero period, a 100 ms Integrate period, and a variable Read period. The auto-zero period is extended to 300 ms when an overload occurs. To accommodate settling times in the analog section, a 500 us hold signal is inserted at the beginning and at the end of the Integrate period.

3-14. Analog Section

3-15. ANALOG MEASUREMENT CIRCUIT

3-16. The analog measurement circuit is shown in simplified form in Figure 3-3. It consists of a thermocouple input circuit, a reference-junction compensator, a voltage reference, a Buffer Amplifier, an Integrator, a Comparator, and a combination of FET switches. The switches are shown in their open state and are closed by the measurement cycle commands generated by the LSI digital IC. Each switch is assigned a letter designation which corresponds to a measurement cycle command shown in Figure 3-2.

3-17. The Thermocouple Input circuit consists of a 2-pole, 10 position rotary switch connected to a R-C filter and a pair of voltage protection diodes on the thermometer pcb. The algebraic sum of the selected thermocouple probe and the input terminal voltages are passed through the rotary switch and filter, and appear at the arm of switch C.

3-18. The Reference-Junction Compensator consists of an isothermal block, 10 pairs of screw type input terminals, and a transistor temperature sensor. The isothermal block maintains a known temperature differential between the input terminals and the temperature sensing transistor. Thermocouple voltages introduced by the dissimilar metals at the input terminals vary as the isothermal block adjusts to ambient temperature. Temperature changes are sensed by the forward-biased transistor which produces a correction voltage equivalent to the thermocouple voltage created at the input terminals. Predictable characteristics of a forward-biased P-N junction allow the Reference-Junction Compensator to function over a wide temperature range. The correction voltage is matched to the thermocouple probe type by a selected Offset Resistor which is supplied on a plug-in type select pcb. The correction voltage appears at the arm of switch B1.

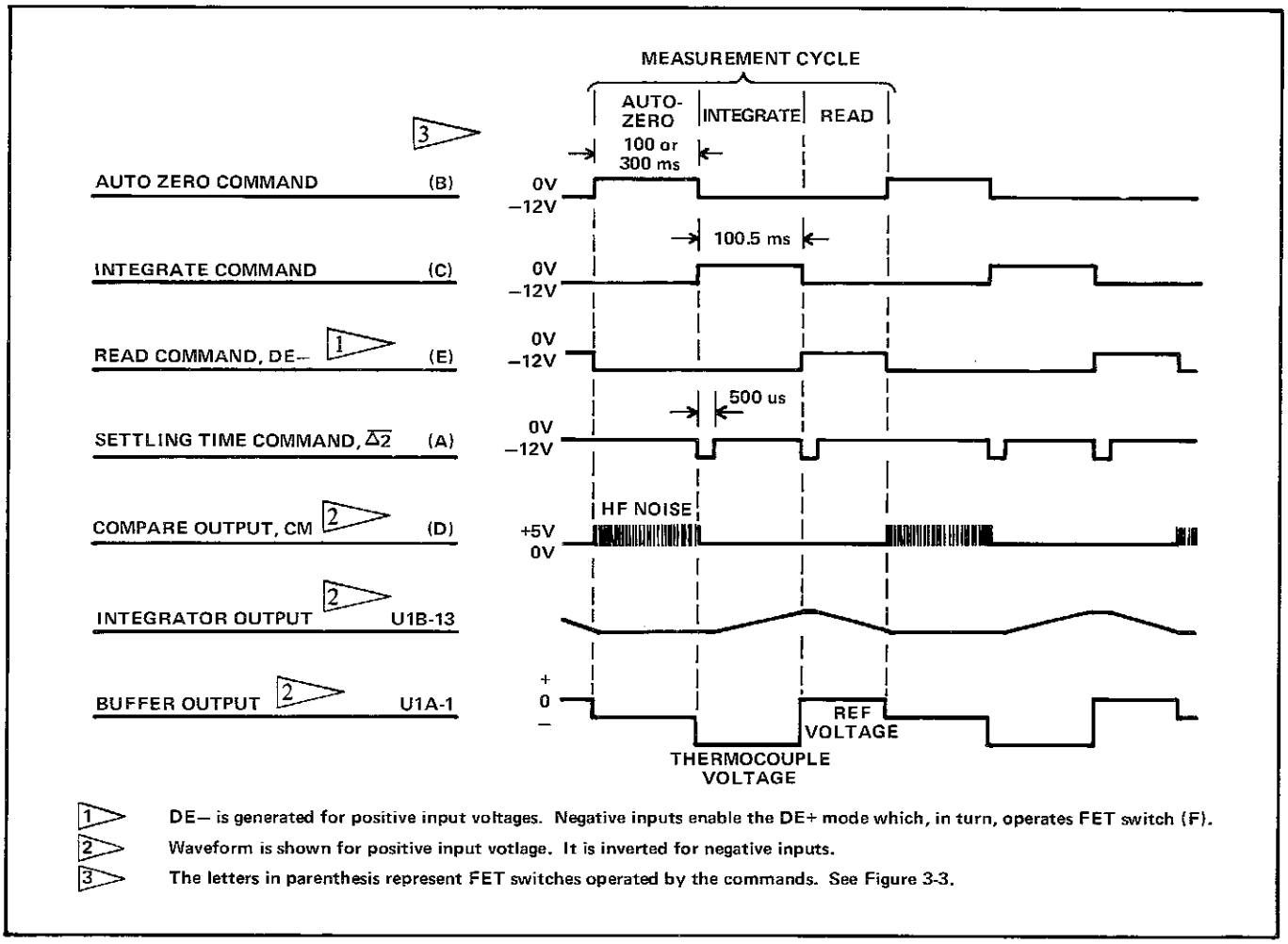


Figure 3-2. Measurement Cycle Waveforms

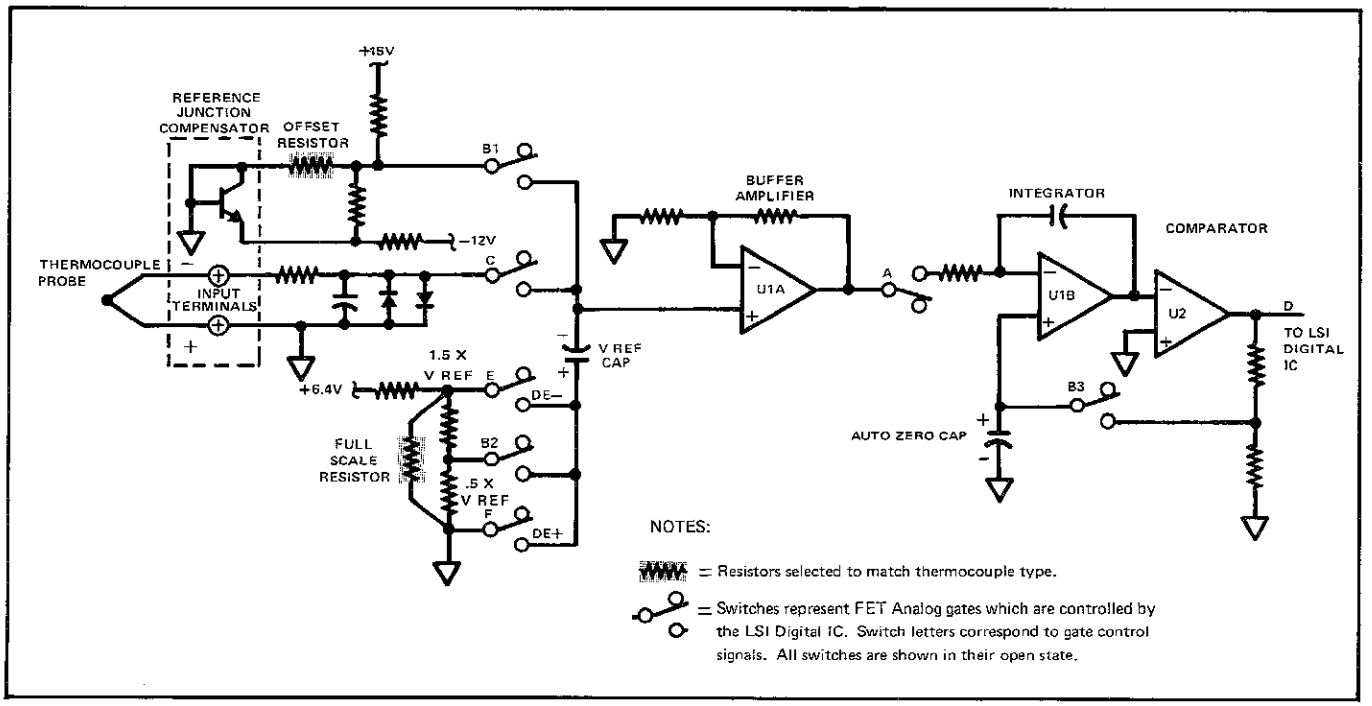


Figure 3-3. Analog Section, Simplified Circuit Diagram

3-19. The voltage reference consists of a resistor divider which is supplied by an accurate 6.4V dc reference voltage. The divider is calibrated to match the thermocouple probe type by a selected resistor on the plug-in type select pcb. Two voltages are available at the divider outputs; 0.5 x V ref, and 1.5 x V ref. These voltages appear at the arms of switches B2 and E, respectively.

3-20. The Buffer, Integrator and Comparator amplifiers combine to perform the analog functions of the Integrate, Read and Auto-Zero periods. The Buffer is used to provide integrator inputs during all three periods. The Integrator integrates the Buffer output voltage during the Integrate and Read periods, and functions, in combination with the Comparator, as a closed-loop amplifier during the Auto-Zero period.

3-21. During the first phase of each measurement cycle, the analog section goes through an Auto-Zero period. During this time, three auto-zero switches (B1, B2 and B3) are closed by the Auto Zero command from the LSI digital IC. Two of the switches (B1 and B2) charge the V ref capacitor to a level equal to the algebraic sum of the 0.5 x V ref output, plus the correction voltage generated by the Reference-Junction Compensator. At the same time, the correction voltage is amplified by the Buffer Amplifier and presented through switch A to the Integrator input. The third switch (B3) connects the Integrator and Comparator in a closed loop configuration and allows the Auto-Zero capacitor to charge to a value which is proportional to the Reference-Junction-Compensator correction voltage plus the offset voltages present in the Buffer, Integrator and Comparator amplifiers. At the end of the measurement cycle, switches B1, B2 and B3 are opened. The V ref capacitor and the Auto-Zero capacitor retain their charge for use later in the measurement cycle.

3-22. The Integrate period starts on the leading edge of the Integrate Command from the LSI digital IC; switch A is open and switch C is closed. The thermocouple input voltage is applied through switch C to the buffer input. After a 500 us settling period, switch A closes and the Buffer output voltage is applied to the Integrator input for 100 ms. As the integrator capacitor charges, the Integrator drives the Comparator output to either 0 or +5V dc to indicate the polarity of the thermocouple input voltage, positive or negative, respectively. The comparator output is sent to the LSI digital IC for use during the Read period. At the end of the Integrate period, the integrator capacitor is charged to a level and polarity that is proportional to the thermocouple probe voltage and switch C returns to its open state.

3-23. The Read period starts at the end of the Integrate period and one of two Read Modes is enabled depending upon the input polarity sensed by the comparator at the end of the Integrate period. If a positive input is sensed, a DE– Read Mode is enabled. Similarly a DE+ Read Mode is enabled when a negative input is sensed.

3-24. If the DE– Read Mode is commanded, switch A is opened and E is closed. Switch E applies a 1.5 x V ref input to the positive side of the V ref capacitor. This voltage is algebraically added to the voltage stored in the V ref capacitor during the previous Auto-Zero period (0.5 x V ref + Reference-Junction-Compensator voltage). As a result, the input to the Buffer Amplifier is a positive voltage equal to V ref plus the Reference-Junction-Compensator voltage.

3-25. If the DE+ Read Mode is commanded, switch A is opened and F is closed. Switch F grounds the positive side of the V ref capacitor and causes the Buffer amplifier input to be driven to the voltage stored in the V ref capacitor during the previous Auto-Zero period (0.5 x V ref + Reference-Junction Compensator voltage). As a result, the input to the Buffer Amplifier is a negative voltage equal to 0.5 x V ref plus the Reference-Junction-Compensator voltage.

3-26. After a 500 us settling time, switch A closes and the Buffer output voltage is applied to the Integrator input. This causes the integrator capacitor to discharge at a linear rate determined by the reference voltage. The discharge continues until the integrator output voltage reaches zero volts, the level existing prior to the integrate period. This level is sensed by the Comparator which signals the LSI digital IC to terminate the A/D conversion of measurement data.

3-27. Offset voltages present during the Integrate and Read periods are cancelled out by offset voltages that were sampled and held during the Auto-Zero period. However, the Reference-Junction-Compensator voltage (also sampled and held during Auto Zero) is added to the integrator voltage during the Integrate period. As a result, the displayed temperature is equal to the thermocouple probe temperature.

3-28. POWER SUPPLY

3-29. The 2176A power supply consists of a power transformer, fuse, power input connector, a dc-to-dc converter, and associated regulating circuits. The function of the power supply is to provide the unit with the necessary operating voltages during both external battery (12V dc) and ac line operation. Operating voltages include: +5, +6.8, +15 and –12V dc. All voltages except the +5V dc is regulated. During line operation, an additional +5V ac (rms) source is available for use by ground-isolated output options (–02 and –04).

NOTE

The –02 and –04 output options are functional only when the unit is operated from the ac line.

3-30. The dc-to-dc converter is energized by a +9.6V dc input which is derived from either the power transformer during line operation, or the external dc source. Conventional regulating and isolating techniques produce +6.8, +15, –12 and +5V dc operating voltages at the dc-to-dc converter output.

Section 4
Maintenance

WARNING!

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual provides information about warranty, factory service, maintenance, performance testing, routine recalibration and recalibration after repair. The performance test is recommended when the instrument is received and later as a preventive maintenance tool or for testing after repair. The test verifies performance at several temperatures within the range of a given thermocouple type. Specifications are provided both for annual and for a more precise 90-day performance-testing cycle.

4-3. SERVICE INFORMATION

4-4. The instrument is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located on the back of the title page located in the front of this manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these service centers is included in Section 7 of this manual. If requested, an estimate will be provided to the customer before any work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Access Information

4-8. Access to the Multipoint Input Module does not require removal of the instrument from its case.

a. The Multipoint Input Module is a plug-in pcb assembly which is removable from the rear of the 2176A. A finger-slot marked PULL allows the module to be grasped and pulled from the case. Internal connector pressure holds the module in place.

b. The Main PCB Assemblies may be accessed in the following manner:

1. Set the POWER switch to OFF and disconnect the ac and 12V dc power cords from the unit.

2. If the thermocouple wires are connected to the Multipoint Input Module, remove the module.

3. Remove the phillips-head screw located in the center of the rear panel.

4. Pull the instrument from the front of the case.

4-9. Cleaning

4-10. Clean the instrument periodically to remove dust, grease and other contamination. Use the following procedure:

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They will react with plastic materials used in manufacture of the instrument.

a. Clean the front panel and case with a soft cloth dampened with a mild solution of detergent and water.

b. Clean the surface of the pcb using clean dry air at low pressure (≤20 psi). If grease is encountered, spray with Freon T. F. Degreaser or anhydrous alcohol and remove grime with clean dry air at low pressure.

4-11. Fuse Replacement

WARNING!

DISCONNECT THE UNIT FROM LINE POWER BEFORE ATTEMPTING FUSE REPLACEMENT.

4-12. The input power fuse is located on the interior of the unit near the power transformer. If replacement is necessary, use an MDL (Slo-blo) 1/8A fuse.

4-13. Service Tools

4-14. No special tools are required for maintenance or repair.

4-15. PERFORMANCE TEST

4-16. Table 4-1 lists the equipment required for performance testing and recalibration. If the recommended model of test equipment is not available, a substitute that meets the minimum use specifications may be used. Table 4-2 outlines the Performance Test. A Performance Checklist at the end of this section may be reproduced or removed to provide a written record of results. The Performance Test verifies instrument performance to specifications for initial acceptance or for maintenance. (Periodic recalibration requires the calibration procedure beginning in paragraph 4-27). If the thermometer fails to meet specifications, it requires recalibration or repair. Review Table 4-2, then continue.

NOTE

The Performance Test should be conducted at an ambient temperature of 25 ± 2° C (77 ± 3.6° F).

4-17. Set-up Procedure

4-18. The following steps prepare for performance testing:

a. Remove the thermometer from its case.

b. Locate the RJD jumper on the main pcb (See Figure 4-1) and set it to the RJD position. (This defeats the reference-junction circuitry.)

c. Connect a voltage divider to a dc voltage calibrator as in Figure 4-2. (See Table 4-1 for specifications.)

Table 4-1. TEST EQUIPMENT REQUIREMENTS

TEST EQUIPMENT	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
Thermocouple Probes	Type J, K, T, E ANSI C96.1 (select type compatible with thermometer)	Omega TJ36 Series, Grounded Sheath
Mercury, thermometer (either °C or °F)	0.02°C Resolution 0.05°F Resolution	Princo Model ASTM-56C Princo Model ASTM-56F
Dewar Flask/Cap	1-pint capacity	Thermos
DC Voltage Calibrator	Output Voltage: 0 to 10V Accuracy: 0.002% Resolution: 10 mV	Fluke Model 343A
Voltage Divider 100:1 or Kelvin-Varley Divider (Shunt output with 1 uf capacitor)	Ratio: 0.005%	Fluke Y2022 or Fluke 720A or Fluke 750A
Variable Line-Voltage Transformer	100, 115, 230V ac, as required, ±10%	General Radio VARIAC W5HM
Decade Resistor	Accuracy: 1% Ranges: 1K, 10K and 100K	General Radio 1434

Table 4-2. PERFORMANCE TEST DESCRIPTION

TEST	PERFORMANCE SPECIFICATIONS	TEST METHOD	PARAGRAPH NO.
Setup	– – – –	– – – –	4-17
Overload and Open Input Test	The display flashes to indicate both over range input voltages and open input terminals.	An over range voltage is applied to the thermocouple input terminals, and the input terminals are open circuited.	4-19
Line Voltage Regulation	Satisfactory performance with any line voltage within ±10% of nominal; 100, 115 or 230V ac.	The display is monitored during the accuracy test as the line voltage is varied.	4-21
Accuracy Test	Temperature Accuracy as stated in Table 4-3	Known input voltages are substituted for the thermocouple inputs. Cardinal-point checks ensure accuracy over the entire temperature range.	4-23
Internal Temperature Rise	<8°C (14.4°F) above ambient	The thermocouple input terminals are shorted and the temperature of the reference junction is displayed.	4-25

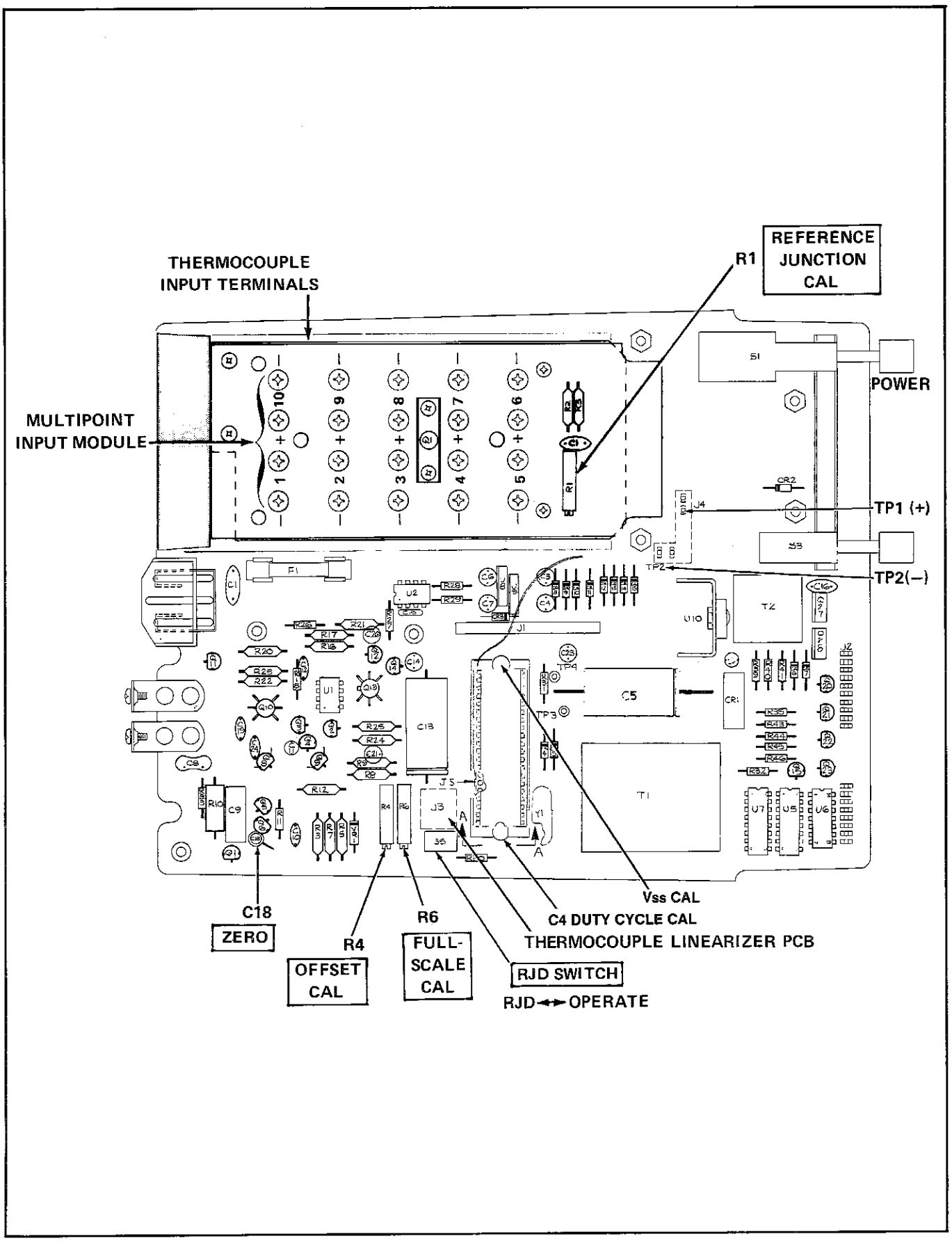


Figure 4-1. Test Point and Adjustment Locations

d. Connect the voltage-divider output to a pair of thermocouple input terminals. Any pair may be used. Match polarity.

e. Connect a variable line-power transformer to line power and adjust the output to the nominal line voltage at which the thermometer is designed to operate; 100, 115, or 230V ac.

f. Connect a power cord between the transformer output and the thermometer ac line connector.

g. Set the thermometer front-panel controls as follows:

1. POWER switch to ON.
2. TEMP switch to °F or °C.
3. CHANNEL Select switch to the channel used in d. above.

h. Set the calibrator to zero volts output, 10 volt range, and turn it on.

4-19. Overload and Open Input

4-20. The following procedure tests the thermometer overload and open-circuit detectors:

a. Set the calibrator output to 10V dc. The thermometer display should begin to flash. While the display is lit, it should read the high end of the temperature range assigned to the compatible thermocouple type:

J	=	999.9° F	or	777.9° C
K	=	999.9° F	or	999.9° C
T	=	752.0° F	or	400.0° C
E	=	999.9° F	or	999.9° C

b. Set the calibrator output to OV dc.

c. Remove the input connections at the thermometer thermocouple input terminals. The display should begin to flash and read the low end of the temperature range:

J	=	-99.9° F	or	-99.9° C
K	=	-99.9° F	or	-99.9° C
T	=	-99.9° F	or	-99.9° C
E	=	-99.9° F	or	-99.9° C

d. This completes the Overload and Open-Input test.

4-21. Line Voltage Regulation

4-22. Line voltage regulation is tested in conjunction with the accuracy test given in the following paragraphs. As the accuracy test is executed, vary the line voltage ± 10% with the variable line-power transformer to ensure the proper operation within the line-voltage limits.

4-23. Accuracy Test

4-24. The following procedure tests the accuracy of the thermometer:

a. Connect the voltage-divider output leads to the same pair of thermocouple input terminals previously selected in 4-18 d. and g. above.

b. Refer to Table 4-3 and select the group of values that correspond to the thermocouple type used with the thermometer.

c. Sequentially, set the calibrator to obtain each of the divider output voltages listed within the selected group, and check the thermometer display against the appropriate display limits; 90-day or 1-year. Vary the ac voltage over the specified ± 10% operating range. Check to see that the thermometer is still reading within accuracy specifications.

d. Remove the voltage divider from the thermometer input.

e. Set the RJD switch to the operate position.

f. Install the thermometer in its case.

g. Connect a thermocouple of the appropriate type to the same thermocouple input terminals previously selected. Match polarity. J, K, T and E thermocouples have a red wire for the negative lead.

h. Place the thermocouple in a room-temperature lag bath. (See Figure 4-3 for an illustration of lag-bath construction. Two holes should be drilled in the thermos lid to provide a snug fit for the mercury thermometer and thermocouple probe.)

i. Refer to Table 4-4. Determine if the thermometer display is within the specified range of the lag-bath temperature reading.

NOTE

Allow sufficient time for the mercury thermometer to come to a stable lag-bath temperature reading.

Table 4-3. TEMPERATURE ACCURACY

TYPE	°F			°C		
	DIVIDER OUTPUT (mV dc)	DISPLAY LIMITS		DIVIDER OUTPUT (mV dc)	DISPLAY LIMITS	
		90 DAY	1 YEAR		90 DAY	1 YEAR
J	29.263	990.6 to 993.4	990.2 to 993.8	42.640	754.8 to 756.4	754.5 to 756.8
	2.288	110.6 to 113.4	110.2 to 113.8	2.288	43.6 to 45.2	43.2 to 45.6
	–1.643	–29.8 to –26.2	–30.3 to –25.7	–2.175	–45.5 to –43.3	–45.7 to –43.1
	–3.198	–89.8 to –86.2	–90.3 to –85.7	–3.686	–78.9 to –76.7	–79.1 to –76.5
K	22.059	990.4 to 993.6	990 to 994	40.404	976.6 to 979	976.3 to 979.3
	2.709	150.4 to 153.6	150 to 154	0.884	21 to 23.4	20.7 to 23.7
	–1.691	–50.2 to –45.8	–50.8 to –45.2	–1.691	–45.7 to –43.1	–46 to –42.8
	–2.475	–90.2 to –85.8	–90.8 to –85.2	–2.848	–79.1 to –76.5	–79.4 to –76.2
T	20.188	730.8 to 833.2	730.3 to 733.7	19.497	377.1 to 378.5	376.8 to 378.8
	0.879	70.8 to 73.2	70.3 to 773.7	0.879	21.5 to 22.9	21.2 to 23.2
	–1.240	–29.9 to –26.1	–31.1 to –24.9	–2.009	–56.7 to –54.5	–57.3 to –53.9
	–2.370	–89.9 to –86.1	–91.1 to –84.9	–2.720	–78.9 to –76.7	–79.5 to –76.7
E	39.694	990.5 to 993.5	990 to 994	74.694	976.7 to 978.9	976.3 to 979.3
	2.694	110.5 to 113.5	110 to 114	2.694	43.3 to 45.5	42.9 to 45.9
	–1.897	–29.9 to –26.1	–31.2 to –24.8	–3.080	–56.7 to –54.5	–57.4 to –53.8
	–3.641	–89.9 to –86.1	–91.2 to –84.8	–4.196	–78.9 to –76.7	–79.6 to –76.0

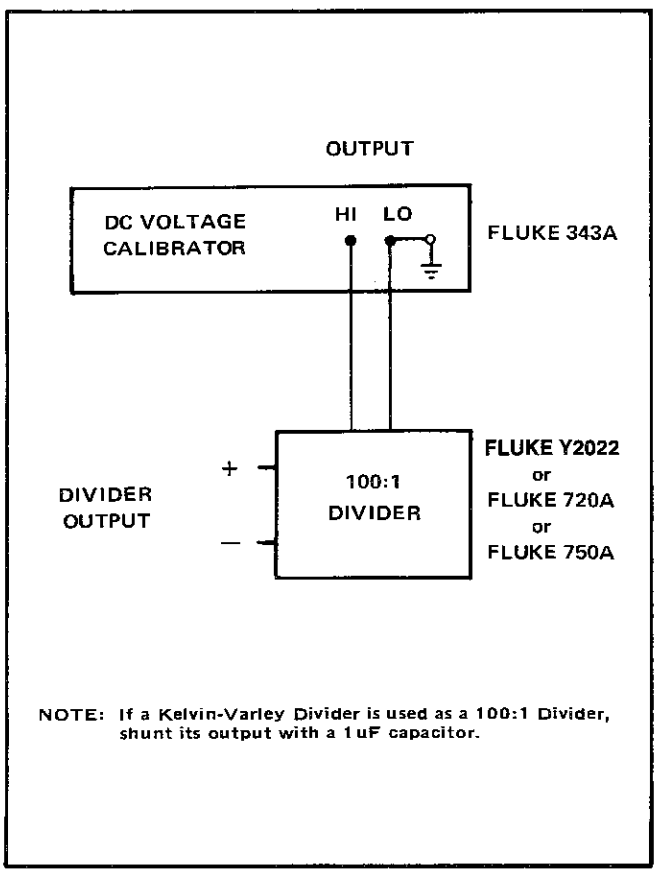


Figure 4-2. Voltage Divider-Calibrator Connection

j. This completes the accuracy test portion of the Performance Test.

4-25. Internal Temperature Rise.

4-26. The following procedure measures the thermometer's internal temperature as sensed by the reference junction:

a. Connect a copper wire between the thermocouple input terminals (in place of the thermocouple leads used in the preceding test).

NOTE

This procedure assumes that the thermometer has been energized for at least 30 minutes.

b. Monitor the ambient temperature (room temperature) using a mercury thermometer near the back of the digital thermometer.

c. The digital thermometer will display the temperature of the internal reference junction. This temperature should not exceed the ambient temperature by more than 8.0° C (14.4° F).

d. Remove the short from the thermocouple input terminals.

e. This completes the test for internal temperature rise.

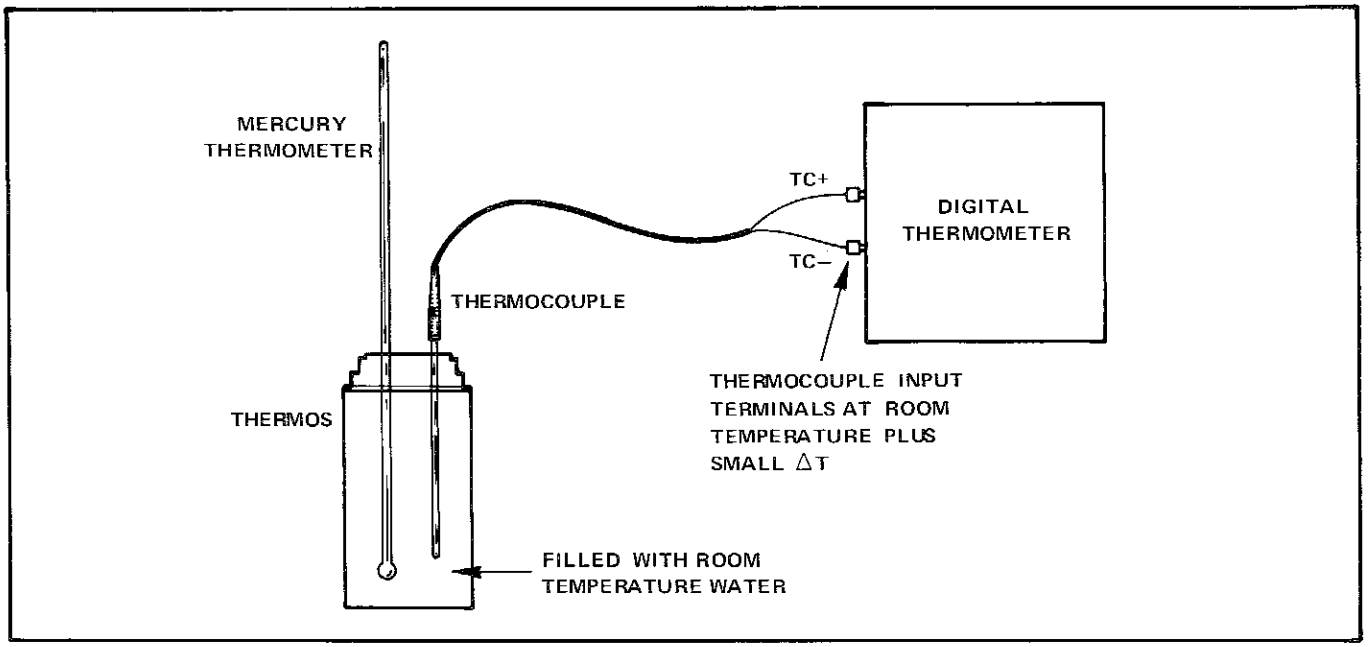


Figure 4-3. Room Temperature Lag Bath

4-27. CALIBRATION

4-28. The thermometer should be calibrated every year or every 90 days, depending on the desired accuracy. Calibration should be performed also after the thermometer has been repaired.

4-29. Calibration of either the °F or °C scale, ensures the accuracy of both scales. Either scale can be verified after calibration by executing the accuracy portion of the Performance Test.

4-30. Observe all notes and precautions to ensure accuracy of calibration and to avoid damage to the digital thermometer. Observe also that reference-junction adjustment (Paragraph 4-36) is not required for routine or periodic calibration.

4-31. Calibration Procedure

4-31a. OSCILLATOR REGULATOR ADJUSTMENT

a. Adjust Vss as follows:

1. Put the instrument in °F mode.
2. Using an oscilloscope, observe the Strobe 0 signal on pin 9 of U4 with respect to digital common.
3. Using a DMM, measure between digital common and pin 1 of U4.
4. Adjust Vss (R4) on the oscillator regulator for maximum (around 8V). If the strobe 0 pulse width in step 2 is not 320 us and stable, then decrease Vss until the Strobe 0 pulse width in step 2 is 320 μs and stable.
5. Observing the DMM reading, continue to decrease Vss 200 mV below the point reached in step 4. (For example, if Vss in step 4 is 7.65V, reduce to 7.45V.)
6. Put the instrument in °C mode.
7. With the thermocouple circuit open, check for proper indication of the display in °C mode (i.e., flashing -99.9). If the display is not flashing -99.9, decrease Vss until -99.9 is displayed. Then continue to decrease Vss another 200 mV.

b. Adjust the clock duty cycle as follows:

1. Using a 13 pf (10X) scope probe, observe the system clock signal on pin 2 of U4 with respect to digital common.
2. Adjust the oscillator regulator capacitor (C4) for the maximum amplitude clock signal and record the peak-to-peak value.

3. Adjust C4 for mimimum amplitude clock signal and record the peak-to-peak value.

4. Set C4 so that the peak-to-peak amplitude is .2 less than midway between the values in steps 2 and 3.

4-32. SET-UP FOR CALIBRATION

a. Complete the equipment connections shown in Figure 4-2, by doing the following:

1. Connect the 100:1 divider specified in Table 4-1.

2. Apply power to the calibrator and turn it on. Allow sufficient warm-up time to assure calibration-output-voltage accuracy.

b. Remove the thermometer from its case. See paragraph 4-7.

c. Locate the RJD switch on the main pcb. Set it to to the RJD position. (This defeats the reference-junction circuitry.)

d. Connect the voltage-divider output to a pair of thermocouple input terminals.

e. Connect a short length of copper wire between the thermocouple input terminals.

f. Set the thermometer front panel controls as follows:

1. POWER switch to ON.

2. TEMP switch to °F or °C.

3. CHANNEL Select switch to the channel used in d. above.

Table 4-4. REFERENCE-JUNCTION ACCURACY LIMITS

TYPE THERMOCOUPLE	°F	°C
J	±1.5°	±1.5°
K	±2.0°	±1.5°
T	±1.5°	±1.5°
E	±1.5°	±1.5°
The thermometer should read within the above limits for either the 90-day or 1-year check.		

4-33. ZERO ADJUSTMENT

a. Adjust C18 to obtain a steady or flashing 0.0 or -0.0 for the Celsius scale, or to obtain a steady 32.0 for the Fahrenheit scale.

4-34. FULL SCALE ADJUSTMENT

a. Determine the thermocouple compatible with the thermometer. The decal on the bottom of the thermocouple case or the markings on the plug-in linearizer (type-select) pcb indicate the thermocouple type. (See Figure 4-1.)

b. Remove the short and connect the 100:1 divider output to the thermocouple input terminals. Match polarity.

c. Refer to Table 4-5 and set the calibrator output to obtain the voltage divider output specified for the compatible thermocouple type, for the degree scale being used.

Table 4-5. FULL SCALE CALIBRATION

PROBE TYPE	°F		°C	
	DIVIDER OUTPUT (mV dc)	DISPLAY READING	DIVIDER OUTPUT (mV dc)	DISPLAY READING
J	+29.263	992.0°F	42.640	755.6°C
K	+22.059	992.0°F	40.404	977.8°C
T	+20.188	732.0°F	19.497	377.8°C
E	+39.694	992.0°F	74.694	977.8°C

d. Adjust the FULL-SCALE CAL potentiometer, R6 (Figure 4-1), to obtain the temperature display specified in Table 4-5.

4-35. OFFSET ADJUSTMENT

a. Set the RJD switch to the operate position.

b. Remove the divider leads from the thermocouple input terminals.

c. Short the thermocouple input terminals with a small piece of copper wire.

d. Remove the 100:1 divider from the calibrator output.

e. Set the calibrator to the 10V dc range.

f. Adjust the calibrator output to .5785V dc.

CAUTION

Be sure the voltage output of the calibrator is .5785V dc before proceeding to the next step. Improper voltage could damage the digital thermometer. Do not use the divider to obtain .5785V dc because the output impedance will create an error.

g. Connect the positive lead from the calibrator to the positive thermocouple input terminal (TP1(+) of the same pair previously selected.

h. Connect the negative lead from the calibrator to Test Point 2. (TP2(–) in Figure 4-1).

i. Adjust the OFFSET CAL potentiometer, R4, for a temperature display of 25.0° C or 77.0° F.

j. Remove the calibrator output from the thermocouple input terminal used and TP2(–).

k. Remove the short at the thermocouple input terminals.

l. If the thermometer is being calibrated on a routine calibration cycle, or because of thermocouple type-change, this completes calibration. Reassemble the thermometer.

m. If the thermometer is being recalibrated because of repair or if reference-junction adjustment is desired, proceed with paragraph 4-36.

n. Extra multipoint pcb assemblies can be purchased for the 2176A. Reference junctions for these units are adjusted at the factory. If the extra multipoint pcb assembly has been repaired or if there is other reason to adjust its reference junction, install the multipoint pcb in a calibrated 2176A and proceed with paragraph 4-36.

4-36. REFERENCE-JUNCTION ADJUSTMENT

a. Connect a compatible thermocouple probe to the same input terminals selected previously by the CHANNEL select switch. Match polarity. J, K, T, and E thermocouples have a red wire for the negative lead.

b. Place the thermocouple in a room-temperature lag bath. (See Figure 4-3 for an illustration of lag-bath construction.)

c. Use an accurate mercury thermometer to monitor the temperature of the lag-bath. (See Table 4-1.)

d. Adjust the REFERENCE-JUNCTION CAL potentiometer, R1, to obtain a display that agrees with the lag-bath temperature.

NOTE

When adjusting the reference junction of a multipoint pcb assembly that was purchased as an option, it may not be possible to obtain a display that agrees exactly with the lag-bath temperature. In such a case, set the reference-junction potentiometer, R1, for a display reading as close to lag-bath temperature as possible. The difference will be small and within the calibration accuracy specified for the instrument.

e. Remove the thermocouple and reassemble the digital thermometer.

4-37. REFERENCE-JUNCTION BIAS-RESISTOR SELECTION

4-38. If the reference-junction transistor Q1 is replaced, then the reference-junction bias resistor R3 must also be replaced. This is a selected resitor which must be matched to Q1. To select the resistor:

a. Complete the calibration paragraphs 4-32 through 4-35.

b. Connect a compatible thermocouple probe to the input terminals. Match polarity. J, K, T and E thermocouples have a red wire for the negative lead.

c. Center the reference-junction pot R1.

d. Connect a decade resistance box that has ranges including 1K, 10K, and 100K, in place of the reference-junction bias resistor R3. (See Table 4-1.)

e. Place the thermocouple in a room-temperature lag bath. (See Table 4-3 for an illustration of lag-bath construction.)

f. Use an accurate mercury thermometer to monitor the temperature of the lag bath. (See Table 4-1.)

g. Adjust the decade resistance box for the value from Table 4-6 that causes the thermometer to read closest to lag-bath temperature. This will be the value of the reference-junction bias resistor R3.

h. Disconnect the decade box and install the selected R3.

i. Adjust the reference junction potentiometer so that the thermometer reading matches the lag-bath temperature.

j. Remove the thermocouple and reassemble the digital thermometer.

k. This completes the selection of R3. This also completes the calibration of the reference junction.

Table 4-6. BIAS RESISTOR VALUES

VALUE	JOHN FLUKE PART NUMBER	VALUE	JOHN FLUKE PART NUMBER
49.9K	268821	90.9K	223537
52.3K	237248	100K	248807
54.9K	271353	110K	234708
57.6K	289116	124K	288407
60.4K	291419	140K	289439
63.4K	235382	162K	375998
68.1K	236828	191K	375923
73.2K	237222	237K	288373
78.7K	289058	309K	235283
84.5K	229492	562K	235358

4-39. CALIBRATION TECHNIQUES

4-40. Calibration of the reference junction (R1) can be performed using any type of thermocouple except B-type. Once the reference junction has been calibrated for one type of thermocouple, it will be in calibration for use with any other thermocouple type. Therefore, a calibration facility that maintains several digital thermometers which are configured for different thermocouple types, requires only one thermocouple probe and its corresponding linearizer (type-select) pcb in order to calibrate the reference junction of all of the instruments. A K-type thermocouple and linearizer pcb are recommended. The following procedure illustrates:

a. Calibrate the repaired thermometer with the K-type thermocouple and K-type linearizer pcb installed. Follow paragraphs 4-32 through 4-36. This calibrates the reference junction.

b. Change the thermometer to another type of thermocouple by changing the linearizer pcb and repeating paragraphs 4-32 through paragraph 4-35 only. These paragraphs do not require the actual thermocouple probe, but accomplish full-scale calibration for the non-K-type probe without disturbing the reference-junction calibration just set in a. above.

4-41. Thermocouple Accuracy Relating to the Reference-Junction Calibration Technique

4-42. The thermocouples specified in the list of calibration equipment meet specifications of ANSI Standard C96.1. The specifications for these probes can be as much as 4°F absolute error at or near room temperature. The first conclusion is that those probes could produce a calibration error of ± 4° F when used for calibrating the reference junction. This is an erroneous conclusion. Figure 4-3 illustrates the set-up for calibration. Figure 4-4A illustrates the reference-junction compensation circuitry and Figure 4-4B illustrates the equivalent thermocouple circuit formed by the connection of the thermocouple to the input of the instrument. Note that in Figure 4-4B, the two thermocouple junctions formed at the input of the instrument (plus thermocouple wire (+TC) to the plus input terminal and the minus thermocouple wire (–TC) to the minus input terminal) can be represented as a single junction of +TC to –TC whose temperature is that of the input terminals of the instrument. The reference-junction circuitry senses the terminal temperature and generates a voltage that is equal to the voltage generated by the equivalent thermocouple formed at the input terminals referenced to ice point (See Figure 4-4A). For example, suppose the input terminals of the instrument and the attached probe are at the same temperature of 25° C. Since the thermocouple output voltage is proportional to the temperature between the two junctions, the output is zero volts. The reference-junction circuitry supplies a compensating voltage to the instrument such that the instrument will read 25° C. When calibrating the reference junction using the lag-bath technique, the reference is adjusted so that the instrument reads the lag-bath temperature. In using the lag-bath technique, there is only a small temperature difference, ΔT, between the thermocouple junction in the probe and the equivalent thermocouple junction formed at the input terminals of the instrument. The voltage output across the thermocouple circuit is proportional to the temperature difference, ΔT, between the two junctions. Hence, since ΔT is small, there is a small input voltage applied to the input of the instrument. This small input voltage will represent ΔT accurately to within less than .1° F. Therefore, when the reference junction is calibrated so that the instrument reads lag-bath temperature, the error introduced by the thermocouple will be less than .1° F.

4-43. Over-all Accuracy

4-44. The instrument will read very accurately around room temperature (See paragraph 4-1) but as the measured temperature increases or decreases from room temperature, the amount of thermocouple output deviation from NBS Standard 125, becomes the limiting factor in the accuracy of the instrument. If the thermocouple is in error by +4° F, at 900° F the display will be +4° F higher than if the thermocouple conformed perfectly to NBS Standard 125. Error specifications for the instrument do not include thermocouple probe inaccuracies. Those errors must be added to the instrument error in order to obtain an over-all accuracy figure.

4-45. TROUBLESHOOTING

4-46. A troubleshooting guide for the thermometer is given in Table 4-6. The guide is a simplified decision table and is recommended for use in isolating a problem to a functional circuit group. Details necessary to troubleshoot a fault in a functional circuit group can be derived from Section 3 Theory of Operation and Section 8 Schematic Diagrams.

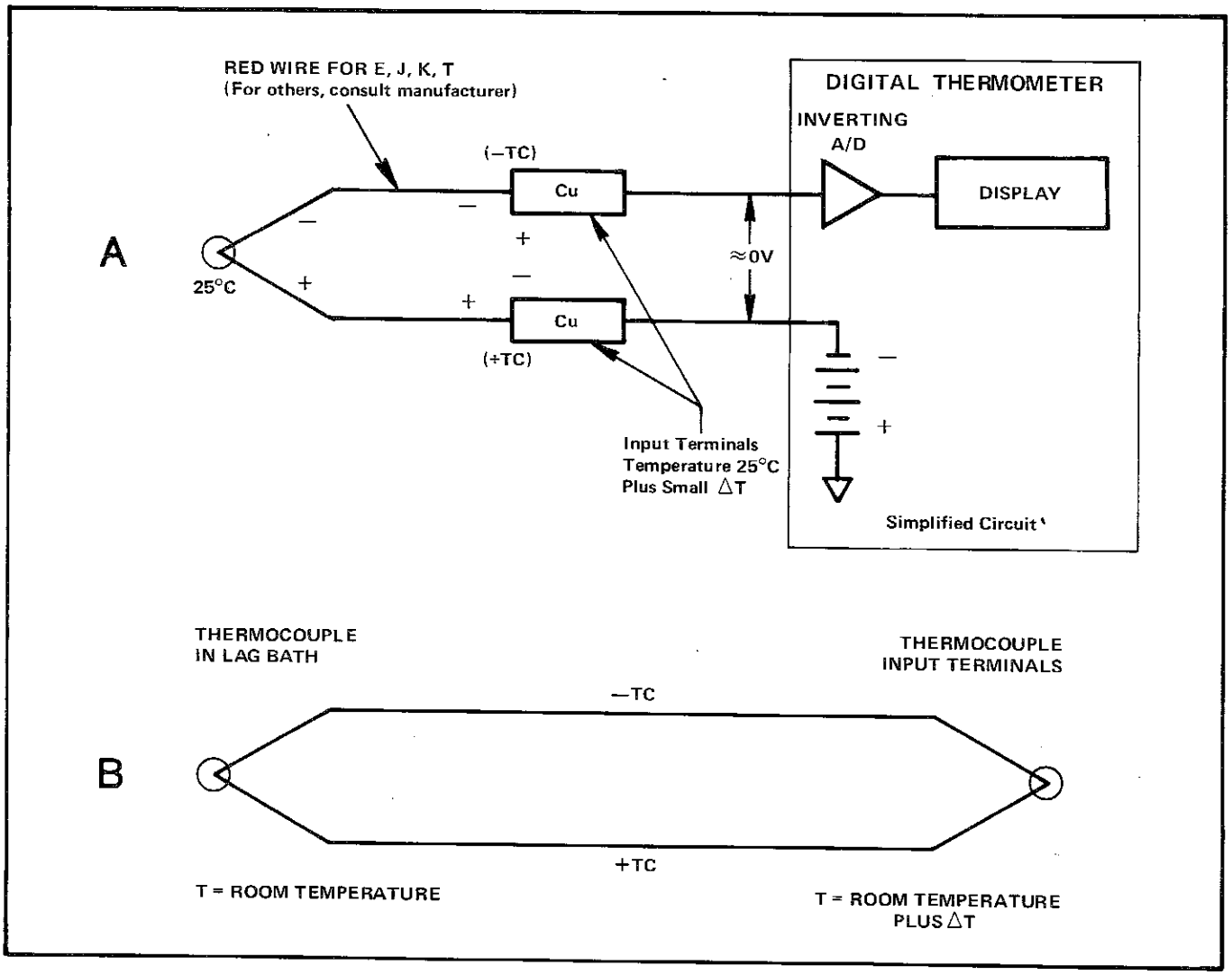


Figure 4-4. Reference-Junction Compensation Circuitry

Table 4-7. TROUBLESHOOTING GUIDE

STEP	INSTRUCTION	IF YES GO TO	IF NO GO TO	GO TO
1	Energize the unit and connect a short across the thermocouple input terminals.			2
2	Does the display light?	16	3	
3	Is the power fuse blown?	4	5	
4	Replace fuse.			2
5	Are all power supply voltages present; +5, Vss , +15 and −12V dc?	7	6	
6	Repair power supply.			2
7	Are Strobe Out pulses present at pins 9, 10, 11 and 12 of U4. (Use logic common as reference.)?	10	8	
8	Is crystal operating?	10	9	
9	Replace crystal.			2
10	Are display drivers functioning?	13	11	
11	Is output data present at pins 4, 5, 6 and 7 of U4?	12	13	
12	Replace display drivers as necessary.			2
13	Are $\overline{\Delta 2}$, AZ, INT, DE+ or DE−, and CM present at U4?	14	15	
14	Display PCB defective. Repair as necessary.			2
15	U4 is defective. Replace.			2
16	Does display read approximate ambient temperature?	21	17	
17	Refer to Section 3 of this manual and use a scope to check for the presence of the waveforms shown in Figure 3-2.			18
18	Are all waveforms correct?	20	19	
19	Perform the necessary repairs to the analog circuit.			17
20	Calibrate the thermometer.			21
21	End. Thermometer is functional.			

PERFORMANCE TEST CHECKLIST

Fluke Model 2175A Digital Thermometer

Serial Number _____
Tested By: _____
Date: _____

°F VERIFICATION TABLE (Temperature Accuracy)

PROBE TYPE	NOMINAL TEMPERATURE °F	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	992	990.6		993.4	990.2		993.8
	112	110.6		113.4	110.2		113.8
	–28	–29.8		–26.2	–30.3		–25.7
	–88	–89.8		–86.2	–90.3		–85.7
K	992	990.4		993.6	990		994
	152	150.4		153.6	150		154
	–48	–50.2		–45.8	–50.8		–45.2
	–88	–90.2		–85.8	–90.8		–85.2
T	732	730.8		733.2	730.3		733.7
	72	70.8		73.2	70.3		73.7
	–28	–29.9		–26.1	–31.1		–24.9
	–88	–89.9		–86.1	–91.1		–84.9
E	992	990.5		993.5	990		994
	112	110.5		113.5	110		114
	–28	–29.9		–26.1	–31.2		–24.8
	–88	–89.9		–86.1	–91.2		–84.8

Line Voltage Regulation _____ Passed ( ) Failed ( )
Accuracy Test _____ See Verification Tables

°F VERIFICATION TABLE (Reference-Junction Accuracy)

PROBE TYPE	90-Day or 1-Year	
	Deviation Error From Room-Temperature Lag Bath	
	Maximum	Actual
J	±1.5°	
K	±2.0°	
T	±1.5°	
E	±1.5°	

PERFORMANCE TEST CHECKLIST, Cont.

°C VERIFICATION TABLE (Temperature Accuracy)

PROBE TYPE	NOMINAL TEMPERATURE °C	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	755.6	754.8	_____	756.4	754.4	_____	756.8
	44.4	43.6	_____	45.2	43.2	_____	45.6
	–44.4	–45.5	_____	–43.3	–45.7	_____	–43.1
	–77.8	–78.9	_____	–76.7	–79.1	_____	–76.5
K	977.8	976.6	_____	979	976.3	_____	979.3
	22.2	21	_____	23.4	20.7	_____	23.7
	–44.4	–45.7	_____	–43.1	–46	_____	–42.8
	–77.8	–79.1	_____	–76.5	–79.4	_____	–76.2
T	377.8	377.1	_____	378.5	376.8	_____	378.8
	22.2	21.5	_____	22.9	21.2	_____	23.2
	–55.6	–56.7	_____	–54.5	–57.3	_____	–53.9
	–77.8	–78.9	_____	–76.7	–79.5	_____	–76.7
E	977.8	976.7	_____	978.9	976.3	_____	979.3
	44.4	43.3	_____	45.5	42.9	_____	45.9
	–55.6	–56.7	_____	–54.5	–57.4	_____	–53.8
	–77.8	–78.9	_____	–76.7	–79.6	_____	–76.0

Overload

Overrange . . . . . Passed ( ) Failed ( )

Open Circuit . . . . . Passed ( ) Failed ( )

Internal Temperature Rise . . . . . <8.0°C (14.4°F) above ambient

°C VERIFICATION TABLE (Reference-Junction Accuracy)

PROBE TYPE	90-Day or 1-Year	
	Deviation Error From Room-Temperature Lag Bath	
	Maximum	Actual
J	±1.5°	
K	±1.5°	
T	±1.5°	
E	±1.5°	

Section 5
List of Replaceable Parts

TABLE OF CONTENTS

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alpha-numerically by assembly. Electrical components are listed by reference designation and mechanical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

a. Reference Designation or Item Number.

b. Description of each part.

c. Fluke Stock Number.

d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)

e. Manufacturer's part Number or Type.

f. Total Quantity per assembly or component.

g. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

a. Quantity

b. FLUKE Stock Number

c. Description

d. Reference Designation or Item Number

e. Printed Circuit Board Part Number

f. Instrument model and Serial number

* Indicates MOS device which may be damaged by static discharge.

Table 5-1. 2176A Final Assembly
(See Figure 5-1.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
A 1	*	THERMOMETER PCB ASSEMBLY	433367	89536	433367	1		
A 2	*	POINT SELECT PCB ASSEMBLY	425603	89536	425603	1		
A 3	*	MULTIPOINT INPUT MODULE	425629	89536	425629	1		
A 4	*	TYPE SELECT PCB ASSEMBLY				1		1
A 5	*	DISPLAY PCB ASSEMBLY	443515	89536	443515	1		
A 6	*	OSCILLATOR REGULATOR PCB ASSEMBLY	835470	89536	835470	1		
F 1		FUSE,.25X1.25,0.125A,250V,SLOW	166488	71400	MDL1-8A	1		
FL 1		FILTER,LENS	456418	89536	456418	1		
H 1		SCREW,MACH,SEMS,PH,P,STL,6-32X.250	178533	89536	178533	4	5	
H 2		SCREW,MACH,PH,P,STL,8-32X0.250	228890	89536	228890	2		
H 3		SCREW,MACH,PH,P,SS,6-32X.250	844951	89536	844951	20	1	
H 4		SCREW,MACH,PH,P,STL,4-40X0.250	129890	73734	19022	7		
H 5		SCREW,MACH,PH,P,STL,4-40X0.500	152132	89536	152132	2		
H 6		SCREW,MACH,PH,P,4-40X0.375	837690	89536	837690	1		
H 7		SCREW,THD FORM,PHP,STL,6-20X3/8	288266	89536	288266	2		
H 8		SCREW,MACH,PH,P,6-32X0.312	837708	89536	837708	1		
H 9		SCREW,MACH,SEMS,PH,P,STL,6-32X.250	178533	89536	178533	3		
H 10		SCREW,THD CUT,PHP,STL,6-32X1/4	114942	89536	114942	2		
H 11		SCREW,MACH,PH,P,STL,4-40X0.625	145813	89536	145813	2		
H 12		SCREW,MACH,PHP SEMS,STL,4-40X1/4	185918	89536	185918	2		
H 13		WASHER,FLAT,ALUM,0.137X0.707X0.032	340505	89536	340505	2		
H 14		WASHER,FLAT,STEEL,#4,0.030 THK	147728	89536	147728	2		
MP 1		ISOTHERMAL SHELL	438093	89536	438093	1		
MP 2		CONTACT,EARTH COMMON	338640	89536	338640	1		
MP 3		CONTACT,VOLTAGE	338657	89536	338657	2		
MP 4		INSULATOR, RECEPTACLE	338624	89536	338624	1		
MP 5		CARD GUIDE,NYLON,4.50X0.070,2 SNAP	256461	23880	1450F	2		
MP 6		PUSHBUTTON SML RECT C L REPL GREEN	419747	89536	419747	1		
MP 7		PUSHBUTTON SML RECT C L REPL.DK P G.	419689	89536	419689	1		
MP 8		BUSHING,SNAP-IN,NYLON,0.125 ID	102988	28520	SB250-2	1		
MP 10		ISOTHERMAL COVER	438028	89536	438028	1		
MP 11		ISOTHERMAL CARRIER	438101	89536	438101	1		
MP 12		ISOTHERMAL BLOCK	440438	89536	440438	1		
MP 13		5/16 X 5/16 # 9109-E	352484	89536	352484	2		
MP 14		ASSY, CHANNEL SELECT KNOB	445361	89536	445361	1		
MP 15		CASE,THERMOMETER	432526	89536	432526	1		
MP 16		FRONT PANEL	417485	89536	417485	1		
MP 17		HOLE PLUG	439547	89536	439547	1		
MP 18		DECAL, FRONT PANEL	428565	89536	428565	1		
MP 19		DECAL,BOTTOM	436444	89536	436444	1		
MP 20		DECAL, KNOB	347401	89536	347401	2		
MP 21		8000A-8006 HANDLE,MOLDED	330092	89536	330092	1		
MP 23		THERMOMETER INPUT SHORT	656736	89536	656736	1		
MP 24		SHIELD	438440	89536	438440	1		
MP 25		CLAMP, TRANSISTOR	437756	89536	437756	1		
MP 26		JUMPER STRIP, 10 PART CARRIER	373316	89536	373316			
MP 27		INSULATOR, LINE CONTACT	344184	89536	344184	1		
T 1		POWER TRANSFORMER 115/230	437616	89536	437616	1		
TM 1		2176A INSTRUCTION MANUAL	445486	89536	445486	1		
W 1		CORD,LINE,5-15/IEC,3-18AWG,SVT	343723	89536	343723	1		

An * in 'S' column indicates a static-sensitive part.

NOTES:

NOTE 1 = One of the following Type Select PCB Assemblies is installed:

J Type - 415653
K Type - 415661
T Type - 415927
E Type - 415935

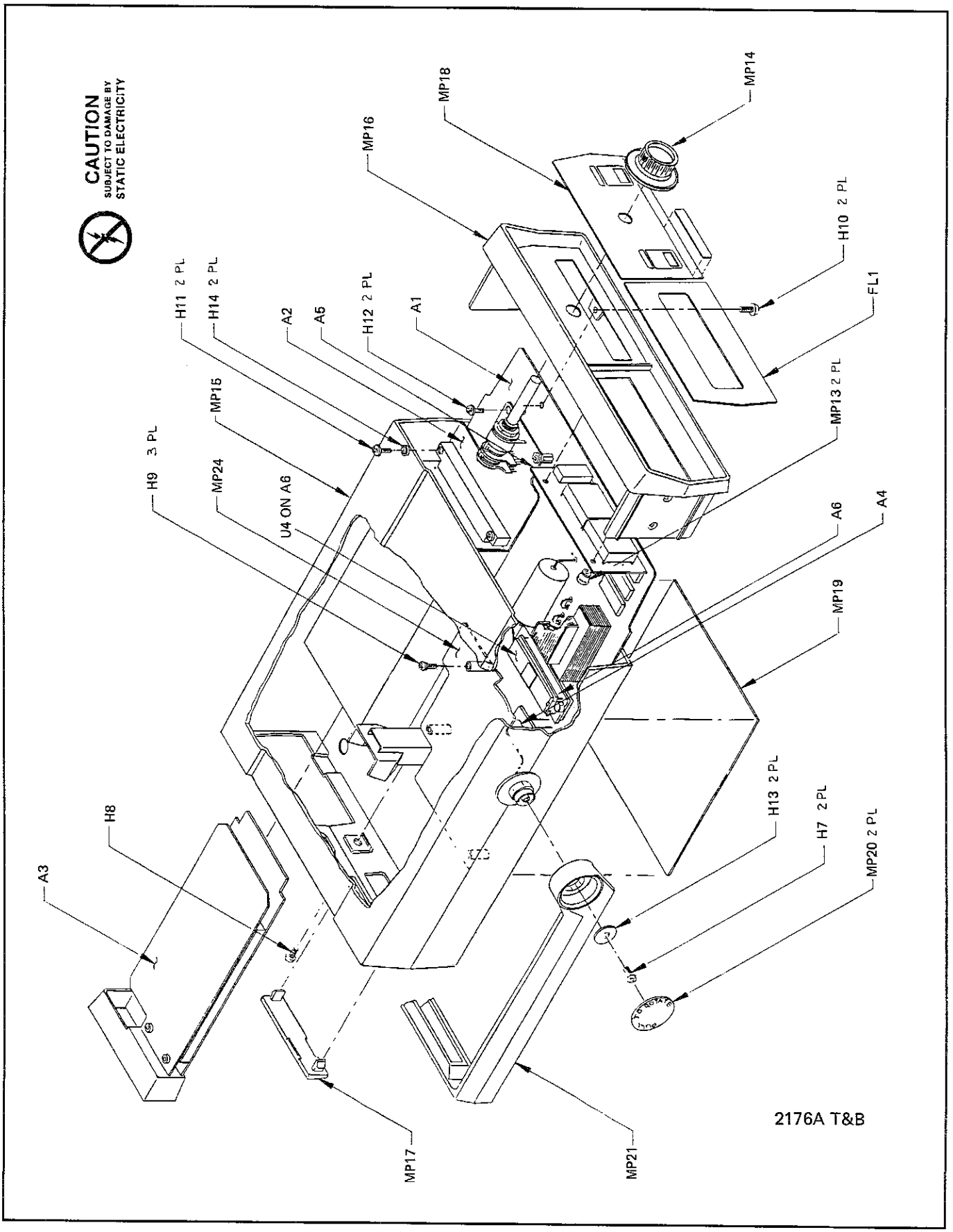


Figure 5-1. 2176A Final Assembly

Table 5-2. A1 Thermometer PCB Assembly
(See Figure 5-2.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
C 1		CAP,CER,0.01UF,+-20%,3000V,Z5U	266320	89536	266320	1		
C 3, 4, 26		CAP,TA,6.8UF,+-20%,35V	363713	56289	196D685X0035KA1	3		
C 5		CAP,AL,4700UF,+75-20%,16V	379370	80031	3050HJ472U015	1		
C 6, 7, 14,		CAP,TA,10UF,+-20%,20V	330662	56289	196D106X0020KA1	6		
C 20, 21, 23			330662					
C 8		CAP,MICA,100PF,+-1%,500V	226126	72136	DM15F101F	1		
C 9		CAP,POLYES,0.47UF,+-10%,100V	369124	89536	369124	1		
C 10		CAP,CER,100PF,+-10%,1000V,S3N	105593	71590	DD-101	1		
C 11		CAP,TA,2.2UF,+-10%,15V	364216	56289	196D225X0015HA1	1		
C 12		CAP,CER,0.025UF,+-20%,100V,Z5W	168435	56289	C023B101H253M	1		
C 13		CAP,POLYPR,0.47UF,+-10%,50V	363085	89536	363085	1		
C 15		CAP,CER,2700PF,+-20%,100V,X7R	362889	89536	362889	1		
C 16		CAP,CER,0.0012UF,+-10%,500V,Z5R	106732	71590	CF122	1		
C 18		CAP,VAR,0.25-1.5PF,1700V,TEFLON	218206	72982	530-000	1		
C 19		CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C016B102G102K	1		
C 24		CAP,CER,1.0PF,+-0.25PF,50V,M7J	436477	80031	2222-638-03108	1		
CR 1	*	DIODE,SI,RECT,BRIDGE,BV=100V,IO=1.0A	392910	09423	FB200	1	1	
CR 2	*	DIODE,SI,100 PIV,1.0 AMP	343491	01295	1N4002	1	1	
CR 3- 15	*	DIODE,SI,BV=75V,IO=150MA,500MW	203323	07910	1N4448	13	1	
H 1		SCREW,MACH,PH,P,SS,6-32X.250	844951	89536	844951	1		
H 2		NUT,CAP EXT LW,STL,6-32X.109	152819	89536	152819	1		
H 3		RIVET,S-TUB,OVAL,STL,.118X.156	103424	89536	103424	4		
J 1		SOCKET,1 ROW,PWB,0.100CTR,18 POS	435024	00779	583773-8	1	1	
J 2		PIN,SINGLE,PWB,0.025 SQ	267500	00779	87022-1	18	1	
J 3, 4		HEADER,1 ROW,.100CTR,4 PIN	807297	89536	807297	2		
J 5		SOCKET,IC,40 PIN	429282	09922	DILB40P-108	1		
MP 1		HEAT DIS,VERT FIN,1.000X0.710X0.500	352765	91502	PA1-1CB	1		
MP 2		HLDR,FUSE,1/4,PWB MT	485219	91833	3529	2	1	
MP 3		SPACER,RND,SOLUBLE,0.062IDX0.156OD	296319	32559	T0806	2		
MP 4		BRACKET,RT ANGLE,TAPPED,STL,8-32	435271	89536	435271	2	1	
MP 5		SPACER,SWAGED,RND,BRASS,6-32X0.500	284380	89536	284380	3		
MP 6		SPACER,RND,SOLUBLE,0.250IDX0.480OD	441238	32559	T0-19-05	1		
MP 7		JUMPER STRIP, 10 PART CARRIER	373316	89536	373316			
MP 8		SPACER,SWAGED,HEX,BRASS,4-40X0.313	200642	89536	200642	4		
Q 1- 6, 8,	*	TRANSISTOR,SI,N-JFET,TO-92	343830	12040	NSSF50024	10	1	
Q 9, 12, 14	*		343830					
Q 10	*	DUAL JFET OFFSET SELECTED	439703	89536	439703	1	1	
Q 11, 15	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	218396	04713	2N3904	2	1	
Q 13	*	TRANSISTOR,SI,N-JFET,DUAL,TO-71	379321	89536	379321	1	2	
Q 20- 23	*	TRANSISTOR,SI,NPN,DARLINGTON	381798	04713	MPSA-13	4	1	
Q 27, 28	*	TRANSISTOR,SI,BV= 50V, 10W,TO-202	477331	04713	MDS01A	2	1	
R 3		RES,MF,15.8K,+-1%,0.125W,100PPM	293688	91637	CMF551582F	1		
R 4, 6		RES,VAR,CERM,25K,+-20%,0.5W	285213	11236	190PC253B	2		
R 5		RES,MF,261K,+-1%,0.125W,25PPM	257535	89536	257535	1		
R 7		RES,MF,187K,+-1%,0.125W,25PPM	257469	89536	257469	1		
R 8		RES,MF,2K,+-0.1%,0.125W,25PPM	340174	91637	CMF552001B	1		
R 9		RES,MF,1K,+-0.1%,0.125W,25PPM	340380	91637	CMF55	1		
R 10		RES,CC,47K,+-5%,1W	150219	01121	CB4735	1		
R 11, 29		RES,CF,1M,+-5%,0.25W	348987	80031	CR251-4-5P1M	2		
R 12		RES,MF,26.7K,+-0.1%,0.125W,25PPM	344465	89536	344465	1		
R 16, 17		RES,MF,14.7K,+-1%,0.125W,100PPM	226225	91637	CMF551472F	2		
R 18		RES,CF,470,+-5%,0.25W	343434	80031	CR251-4-5P470E	1		
R 20		RES,MF,28.7K,+-1%,0.125W,100PPM	235176	91637	CMF552872F	1		
R 21		RES,MF,61.9K,+-1%,0.125W,100PPM	237230	91637	CMF556192F	1		
R 22		RES,MF,19.1K,+-1%,0.125W,100PPM	234963	91637	CMF551912F	1		
R 23		RES,MF,1K,+-1%,0.125W,100PPM	168229	91637	CMF551001F	1		
R 24, 25		RES,MF,82.5K,+-1%,0.125W,100PPM	246223	91637	CMF558252F	2		
R 26		RES,CF,680K,+-5%,0.25W	442517	80031	CR251-4-5P680K	1		
R 27		RES,CF,100,+-5%,0.25W	348771	80031	CR251-4-5P100E	1		
R 28, 33		RES,CF,220K,+-5%,0.25W	348953	80031	CR251-4-5P220K	2		
R 30, 31, 32		RES,CF,20K,+-5%,0.25W	441477	80031	CR251-4-5P20K	3		
R 35		RES,CF,130,+-5%,0.25W	442301	80031	CR251-4-5P130E	1		
R 39		RES,CF,2K,+-5%,0.25W	441469	80031	CR251-4-5P2K	1		
R 40		RES,CF,22,+-5%,0.25W	381145	80031	CR251-4-5P22E	1		
R 41		RES,CF,330,+-5%,0.25W	368720	80031	CR251-4-5P330E	1		
R 43, 44, 45,		RES,CF,27K,+-5%,0.25W	441501	80031	CR251-4-5P27K	4		
R 46			441501					
S 1		IEE-SCHADOW PUSHBUTTON SWITCH	428508	89536	428508001			
S 5		SWITCH,SLIDE,DPDT	423129	89536	423129	1		

An * in 'S' column indicates a static-sensitive part.

Table 5-2. A1 Thermometer PCB Assembly (cont.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
TP 2		HEADER,1 ROW,.150CTR,12 PIN	810358	89536	810358			
TP 3, 4		TERM,UNINSUL,FEEDTHRU,HOLE,TURRET	321364	88245	2010C-6	2		
U 1	*	IC,OP AMP,SOURCE CNTRLD,DUAL,LO-NOISE	478032	04713	MC4558NCP1	1		
U 2	*	IC,COMPARATOR,8 PIN DIP	352195	01295	SN72311P	1	1	
U 5	*	IC,TTL,BCD-7SEG LED/INCNDSCNT DRIVER	340109	01295	SN7447AN	1	1	
U 6		RES,NET,DIP,14 PIN,7 RES,130,+-5%	381616	89536	381616	1	1	
U 7	*	IC,CMOS,HEX BUFFER	381830	02735	CD4050AE	1		
U 8	*	IC,VOLT REG,FIXED,+15 VOLTS,1.5 AMPS	413187	04713	MC7815CT	1	1	
U 9	*	IC,VOLT REG,FIXED,-12 VOLTS,1.5 AMPS	381665	04713	MC7912CP	1	1	
U 10	*	IC,VOLT REG,FIXED,+8 VOLTS,1.5 AMPS	407627	04713	MC7808CT	1	1	
VR 1	*	ZENER,COMP, 6.4V, 2%, 2 PPM TC, 0.5MA	393579	04713	1N4567	1	3	
Y 1	*	CRYSTAL,400KHZ,+-0.05%,HC-33/U	403352	89536	403352	1		

An * in 'S' column indicates a static-sensitive part.

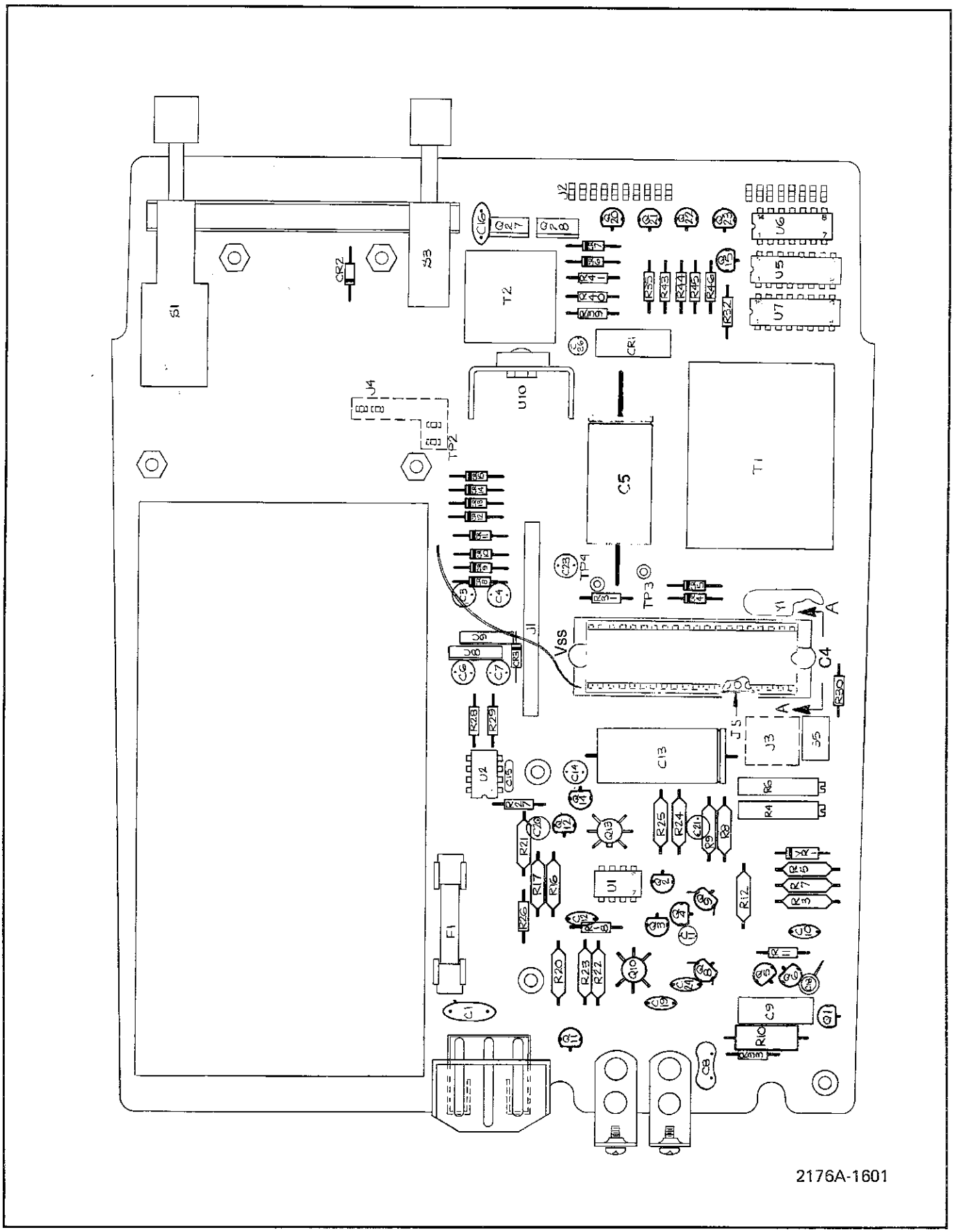
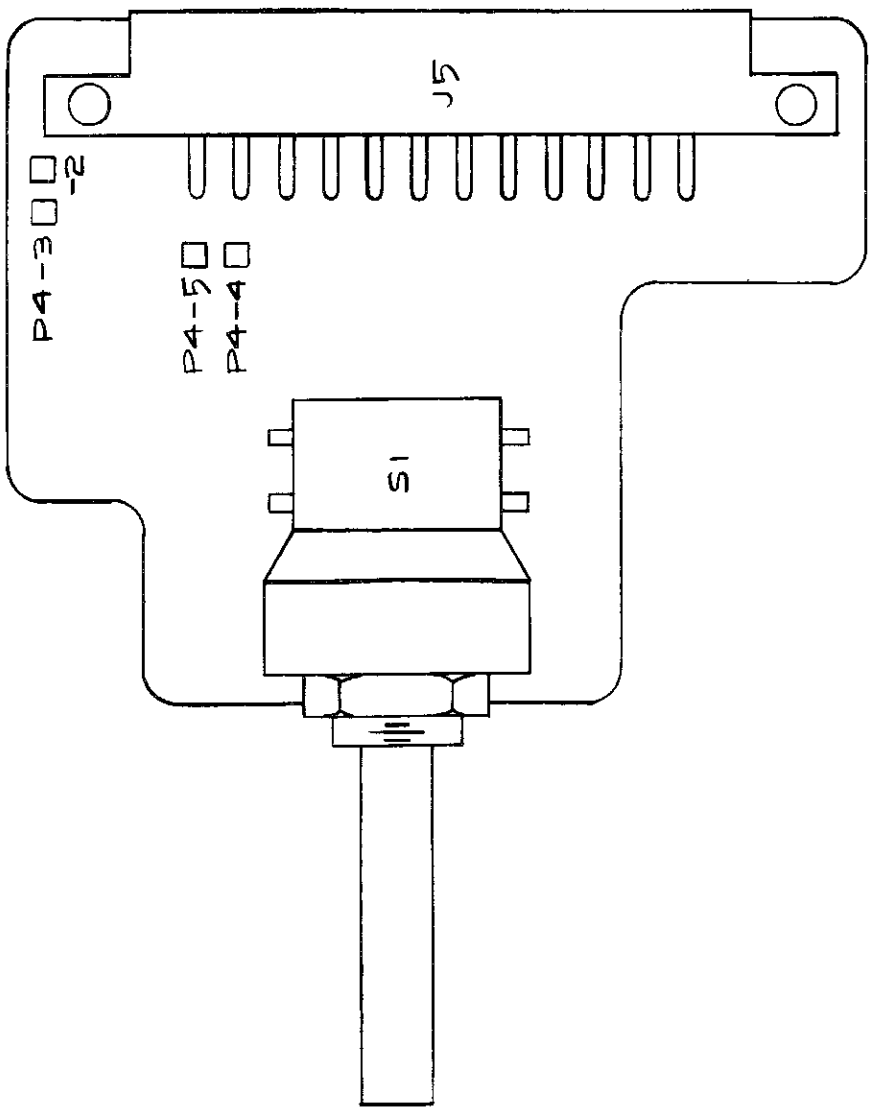


Figure 5-2. AI Thermometer PCB Assembly

Table 5-3. A2 Point Select PCB Assembly
(See Figure 5-3.)

REFERENCE DESIGNATOR -A-	-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-	TOT QTY-	R S -Q	NOT -E-
J	5		CONN,PWB EDGE,REC,90,0.156 CTR,24 POS	436022	89536	436022	1		
P	4		SOCKET,SINGLE,PWB,FOR 0.025 PIN	267476	00779	858612	4		
S	1		SWITCH ROTARY,2 POLE,10 POS,2 DECK	428110	89536	428110	1		
MP	1		SWITCH ACCESSORY,ROTARY,PC MOUNT	418897	89536	418897	1		

An * in 'S' column indicates a static-sensitive part.



2166A-1602

Figure 5-3. A2 Point Select PCA Assembly

Table 5-4. A3 Multipoint Input Module
(See Figure 5-4.)

REFERENCE DESIGNATOR -A->-NUMERICS----->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N O T -E-
C 1		CAP,CER,1000PF,+-10%,500V,X5S	357806	56289	C016B102G102K	1		
MP 1		SPACER,RND,STEEL,6-32X0.125	423038	89536	423038	20		
Q 1	*	TRANSISTOR,SI,NPN,SMALL SIGNAL	329698	89536	329698	1		
R 1		RES,VAR,CERM,100K,+-20%,0.5W	268581	71450	190PC104B	1		
R 2		RES,MF,255K,+-1%,0.125W,100PPM	221630	91637	CMF55	1		
R 3		RES,MF,562K,+-1%,0.125W,100PPM	235358	89536	235358			1
R 3		RES,MF,1.05M,+-1%,0.125W,100PPM	260737	89536	260737			1
R 3		RES,MF,464K,+-1%,0.125W,100PPM	271908	91637	CMF554643F			1

An * in 'S' column indicates a static-sensitive part.

NOTES:

NOTE 1 = Reference Designator R3 is a factory Selected Part.

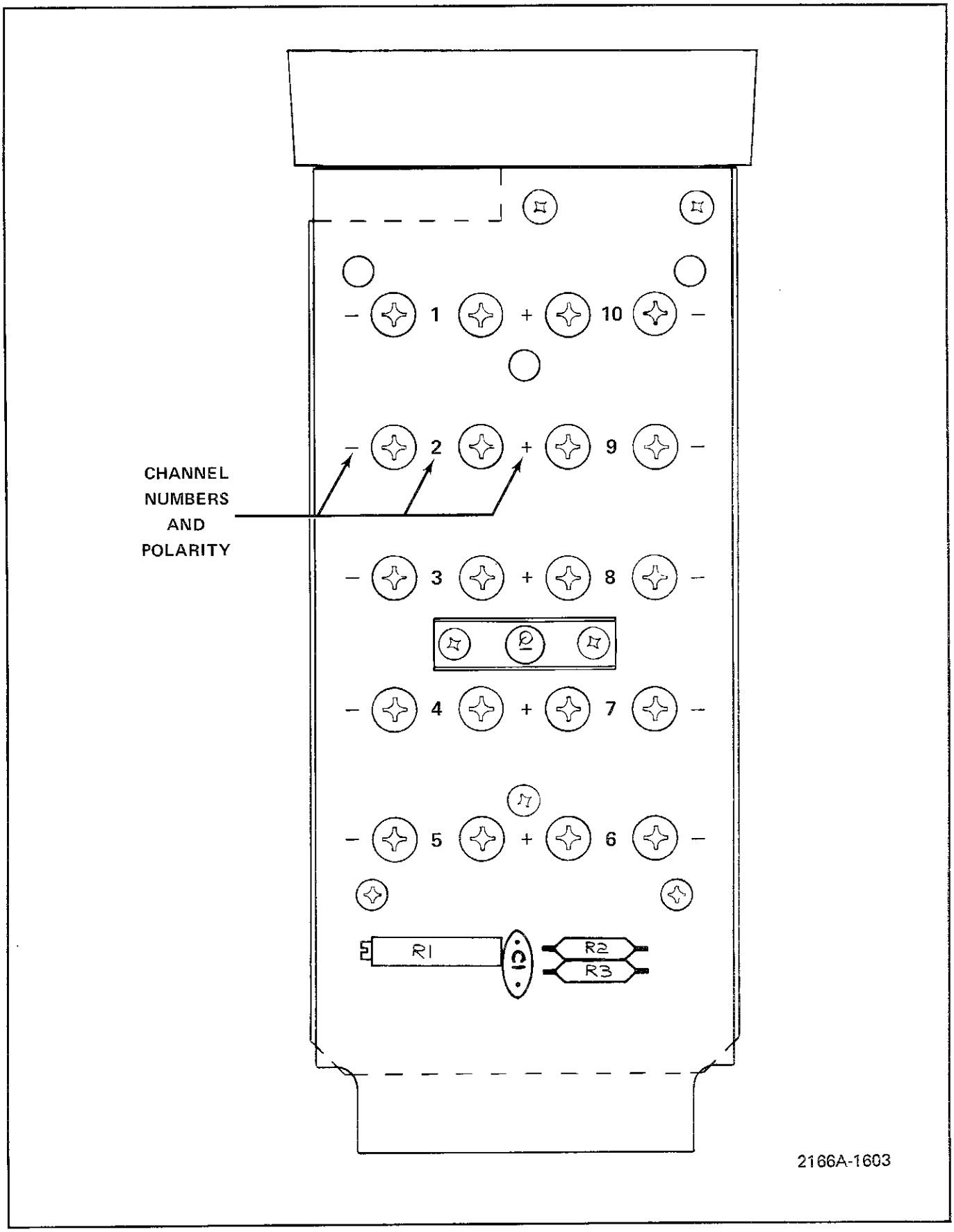
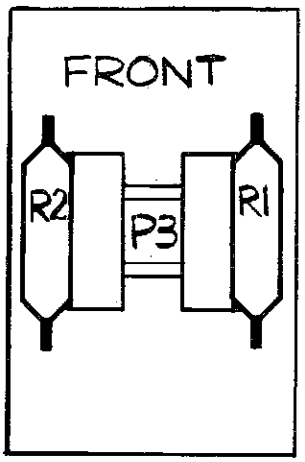


Figure 5-4. A3 Multipoint Input Module

Table 5-5. A4 Type Select PCB Assembly
(See Figure 5-5.)

REFERENCE DESIGNATOR -A>-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	T Y P -E-
P 3		SOCKET,IC,8 PIN	418608	89536	418608	1		
R 1		RES,MF,3.74K,+-1%,0.125W,25PPM	260547	91637	CMF553741F	1		KT
R 1		RES,MF,53.6K,+/-1%,1/8W	291401	91637	MFF1-85362F	1		E
R 1		RES,MF,10.7K,+/-1%,0.125W,25PPM	423681	91637	CMF551072F	1		J
R 2		RES,MF,619,+/-0.1%,0.125W,100PPM	423715	89536	423715	1		J
R 2		RES,MF,481.4,+-0.1%,0.125W,100PPM	423723	89536	423723	1		K
R 2		RES,MF,483.7,+/-0.1%,0.125W,100PPM	423731	89536	423731	1		T
R 2		RES,MF,732,+/-0.1%,1/8W	423749	91637	MFF1-87320B	1		E

An * in 'S' column indicates a static-sensitive part.



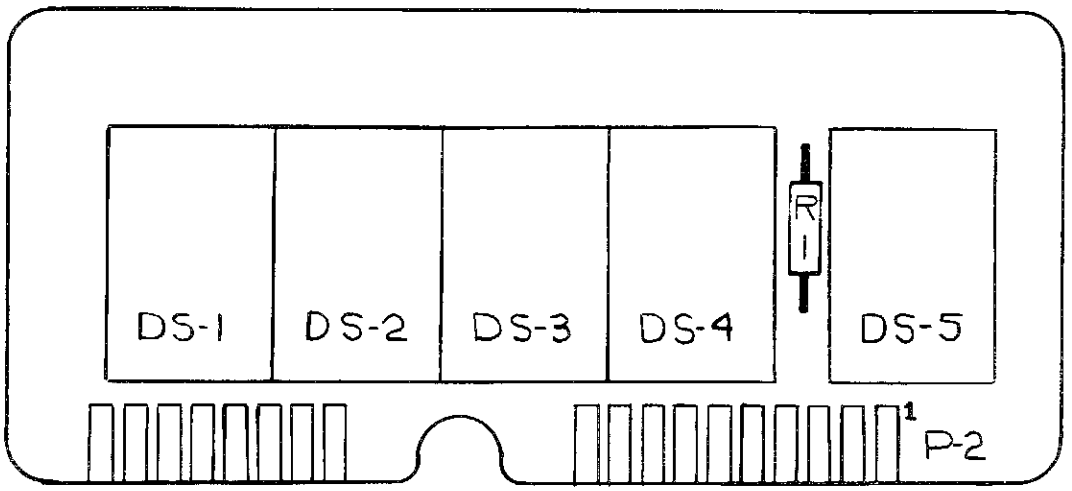
2160A-1612

Figure 5-5. A4 Type Select PCB Assembly

Table 5-6. A5 Display PCB Assembly
(See Figure 5-6.)

REFERENCE DESIGNATOR -A->-NUMERICS---->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-----	TOT QTY-	R S -Q	N 0 T -E-
DS 1- 5	*	LED,RED,7 SEGMENT,NUMERIC	418012	28480	5082-7651	5		
P 2		SOCKET,SINGLE,PWB,FOR 0.025 PIN	375329	00779	85863-3	18	1	
R 1		RES,CF,150,+-5%,0.25W	343442	80031	CR251-4-5P150	1		

An * in 'S' column indicates a static-sensitive part.



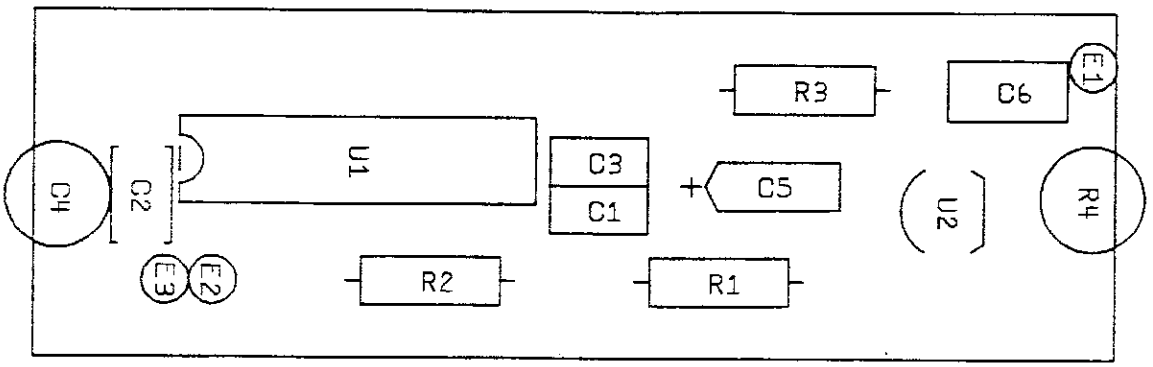
2165A-1603

Figure 5-6. A5 Display PCB Assembly

Table 5-7. A6 Oscillator Regulator PCB Assembly
(See Figure 5-7.)

REFERENCE DESIGNATOR -A->-NUMERICS->	S	DESCRIPTION	FLUKE STOCK --NO--	MFRS SPLY -CODE-	MANUFACTURERS PART NUMBER -OR GENERIC TYPE-	TOT QTY-	RS -Q	NOT -E-
C 1		CAP,CER,22PF,+-2%,100V,C0G	512871	89536	512871	1		
C 2		CAP,CER,120PF,+-5%,50V,C0G	837633	89536	837633	1		
C 3		CAP,CER,180PF,+-5%,100V,C0G	603506	56289	C023B501E181M	1		
C 4		CAP,VAR,9-90PF,50V,CER	643130	73899	DV2SN90D	1		
C 5		CAP,TA,10UF,+-20%,25V	772491	89536	772491	1		
C 6		CAP,CER,0.22UF,+-20%,50V,Z5U	519157	51406	RPE11125U224M50V	1		
P 5	*	SOCKET,IC,HIGH PROFILE,40PIN	830984	89536	830984	1		
R 1		RES,CF,2.2M,+-5%,0.25W	342659	80031	CR251-4-5P2M2	1		
R 2		RES,CF,3.3K,+-5%,0.25W	348813	80031	CR251-4-5P3K3	1		
R 3		RES,MF,931,+-1%,0.125W,50PPM	320366	89536	320366	1		
R 4		RES,VAR,CERM,5K,+-20%,0.3W	733659	89536	733659	1		
U 1	*	IC,CMOS,HEX INVERTER	404681	02735	CD4069BE	1		
U 2	*	IC,VOLT REG,ADJ,1.2 TO 32 V,0.1 A	810242	89536	810242	1	1	
U 4	*	LSI,IC,PMOS 2160	803452	89536	803452	1		

An * in 'S' column indicates a static-sensitive part.



2160A-1622

Figure 5-7. A6 Oscillator Regulator PCB Assembly

Section 6
Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information concerning the Options and Accessories available for use with the Model 2176A Digital Thermometer. The first portion of this section provides a brief description of each option and accessory. The depth of detail is intended to give the prospective user an adequate first aquaintance with the features and capabilities of each. Detailed information concerning specifications, operating instruction, maintenance, list of replaceable parts and schematics is supplied separately with some options and accessories, and is designed to comprise the second portion of this section. Unique page and paragraph numbering is assigned to each of the add-on descriptions to allow separation into easily identifiable subsections. The material is prepunched (T-punched) to permit insertion without disassembling the manual. Table 6-1 lists the available options and accessories and defines the manner in which each is documented.

6-3. CARRYING CASE (Y8205)

6-4. The Model Y8205 Carrying Case, is a soft vinyl plastic container designed for the storage and transport of the 2176A. The case provides the unit with adequate protection against normal handling and storage conditions. In addition to a shoulder strap, the Y8205 is equipped with a storage compartment for probes, power cord, and other compact accessories.

6-5. CASE AND BATTERY PACK (Y2004)

6-6. The Model Y2004 Case and Battery Pack consists of a case, 12V battery pack and charger for use with the 2176A. The Y2004 is especially recommended because the 2176A does not have a self-contained rechargeable battery pack, but has an external 12V power connector. Typical operating time with batteries having a full charge is six hours. Recharge time at 25° C is approximately 15 hours.

Table 6-1. OPTIONS AND ACCESSORIES

MODEL OR OPTION NO.	DESCRIPTION	DOCUMENTATION SUPPLIED	
		WITH UNIT	HERE IN
C86	Carrying Case		●
Y8205	Carrying Case		●
Y2004	Case & Battery Pack		●
P20E	E-Type TC Probe		●
P20J	J-Type TC Probe		●
P20K	K-Type TC Probe		●
P20T	T-Type TC Probe		●
M00-100-714	Front Panel Dust Cover		●
M00-200-611	Rack Mtg. Kit, Offset	●	
M00-200-612	Rack Mtg. Kit, Center	●	
M00-200-613	Rack Mtg. Kit,side-by-side	●	
2160A-7016	J-Type Select PCB		●
2160A-7017	K-Type Select PCB		●
2160A-7019	E-Type Select PCB		●
2160A-7018	T-Type Select PCB		●
2166A-7010	Extra Input Connector Module		●
–02	Digital Output Unit	○	●
–04	Analog Output Unit	○	●

○ = T-punched for insertion in Section 6 of this manual

● = Not T-punched

6-7. CARRYING CASE (C86)

6-8. The Model C86 Carrying Case, Figure 6-1, is a molded polyethylene container, with handle, designed for use in transporting the 2176A. This rugged case provides the unit with maximum protection against rough handling and adverse weather conditions. A separate storage compartment is provided for probes, power cord, and other compact accessories.

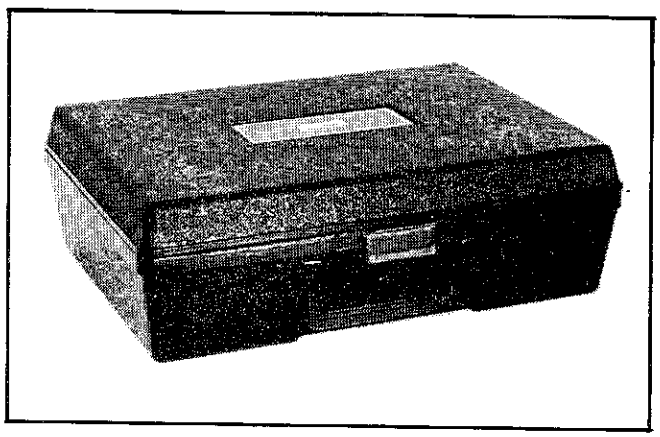


Figure 6-1. C86, Carrying Case

6-9. THERMOCOUPLE PROBES

6-10. Four types of thermocouple probe assemblies (E, J, K, and T) are available from Fluke for use with the 2165A. See Table 6-1. Each thermocouple is enclosed in a 6-inch x ⅛ inch iconel sheath and includes a heavy duty transition splice and spring. See Figure 6-2. The thermocouple junction is grounded to the sheath and 36-inch trimmed leads are included on all units. Refer to the Tables under Specifications in Section 1 of this manual for the temperature ranges recommended for each thermocouple type.

6-11. FRONT PANEL DUST COVER (M00-100-714)

6-12. The front panel dust cover is a molded plastic snap-on accessory which fits over the front panel of the 2176A. The dust cover provides protection for the front panel controls, and is useful when storing or transporting the unit.

6-13. RACK MOUNTING KITS

6-14. Three rack mounting kits are available for mounting the 2176A in a standard 19-inch equipment rack. The kits, listed in Table 6-1, provide the option of either offset mounting (left/right), center mounting or side-by-side mounting.

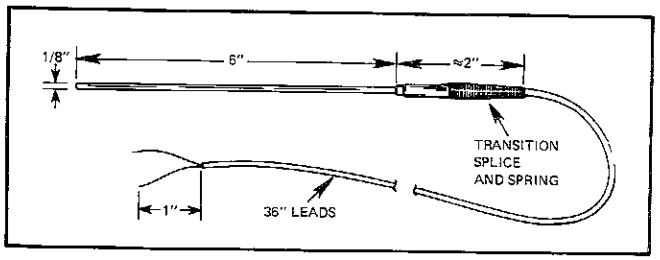


Figure 6-2. P20 Series Thermocouple Probes

6-15. TYPE SELECT PCB's

6-16. A series of plug-in type select pcb's are available as accessories to allow the thermocouple compatibility of the 2176A to be changed by the user. The available type select pcb's are listed in Table 6-1, and the instructions necessary to interchange pcb's in the 2176A are given in Section 2 of this manual under Thermocouple Compatibility. Only one of the type select pcb's can be installed in the 2176A at any given time.

6-17. EXTRA MULTIPOING INPUT MODULE (2166A-7010)

6-18. The Multipoint Input Module is identical to the input module supplied with the basic 2176A. The use of one or more additional modules is advantageous when it is necessary to measure groups of thermocouples located in different areas. By connecting convenient groups (1-to-10 of the same type thermocouples) of thermocouples to separate Multipoint Input Modules, the 2176A can be used to monitor any given group by plugging in the appropriate module. Details concerning this module are given in the appropriate sections of this manual.

6-19. DIGITAL OUTPUT UNIT, OPTION –02

NOTE

The Digital Output Unit is not operational when the 2176A is powered by an external 12V dc source.

6-20. The Digital Output Unit (Option –02) is a field installable pcb that mounts on the interior of the 2176A and provides a digital output which is equivalent to the displayed measurement data. The digital output is positive-true, TTL compatible and is presented in bcd, character-parallel format. All displayed characters are represented at the output. Output data is solicited by an External Trigger input and valid data is ensured by Busy and $\overline{\text{Busy}}$ outputs.

6-21. External connections to the Digital Output Unit are made through a 34-pin cable which is supplied with the pcb.

6-22. ANALOG OUTPUT UNIT, OPTION –04

NOTE

The Analog Output Unit is not operational when the 2176A is powered by an external 12V dc source.

6-23. The Analog Output Unit is a field installable pcb assembly which provides the 2176A with a rear-panel analog output voltage proportional to the displayed measurement data. The output voltage is electrically isolated from the 2176A and covers a voltage range of –0.4 to +4V dc. Automatic polarity sensing is provided for both °C and °F measurements to ensure that the polarity of the output voltage agrees with the displayed polarity. Since the analog output terminals are isolated from the 2176A, the output voltage is referenced to the low terminal of the external recording device (voltmeter, strip-chart recorder, etc.).

6-24. External connections to the Analog Output Unit are made through a connector and cable which is supplied with the pcb.

Model 2160-02 Digital Output Unit

602-1. INTRODUCTION

602-2. The Digital Output Unit (Option -02) is a field installable pcb that mounts in the interior of any of the 2160A/2170A series of Digital Thermometers and provides a digital output which is equivalent to the displayed measurement data. The digital output is positive-true TTL compatible and is presented in bcd code, parallel by bit, parallel by character. All displayed characters are represented at the output. Updated output data is available after each thermometer measurement cycle, and can be recorded in either of two operating modes; free-run or triggered operation. In each mode, the trailing edge of a Busy/$\overline{\text{Busy}}$ output pulse is used to command the recorder. This pulse is generated at the end of each measurement cycle in the free-run mode. In the triggered mode this pulse is generated only after an external trigger input is received at the Digital Output Unit.

602-3. External connections to the Digital Output Unit are made through a 34-pin connector and 6-foot ribbon cable, which is supplied with the pcb.

602-4. SPECIFICATIONS

Digital I/O Logic - DTL, TTL compatible.
Logical "1" = 4.5 to + 5.5V dc
Logical "0" = 0 to + 0.5V dc

Available Data - - Four digits, polarity and function

Data Format - - BCD, positive true, character parallel, bit parallel

Isolation - - - I/O data is fully isolated to 300V dc or ac peak

Controls - - - External Trigger and External Trigger Enable

Output Flags - - Busy and $\overline{\text{Busy}}$

602-5. INSTALLATION

602-6. The Digital Output Unit may be installed in any of the 2160A/2170A series of digital thermometers. Two installation procedures follow. Use the one that applies to the model number of your thermometer.

602-7. Models 2160A and 2170A.

a. Disconnect the thermometer from line power.

b. Remove the rear panel and the thermometer assembly from the thermometer case. (two rear panel screws hold both in position).

c. Position the thermometer pcb assembly and the Digital Output Unit pcb as shown in Figure 602-1.

d. Carefully plug the Digital Output Unit's flex cable into the connector provided on the thermometer pcb. See Figure 602-1.

e. Determine the thermometer's assigned temperature scale (°C or °F) and assign the same scale to the Digital Output Unit by installing a jumper

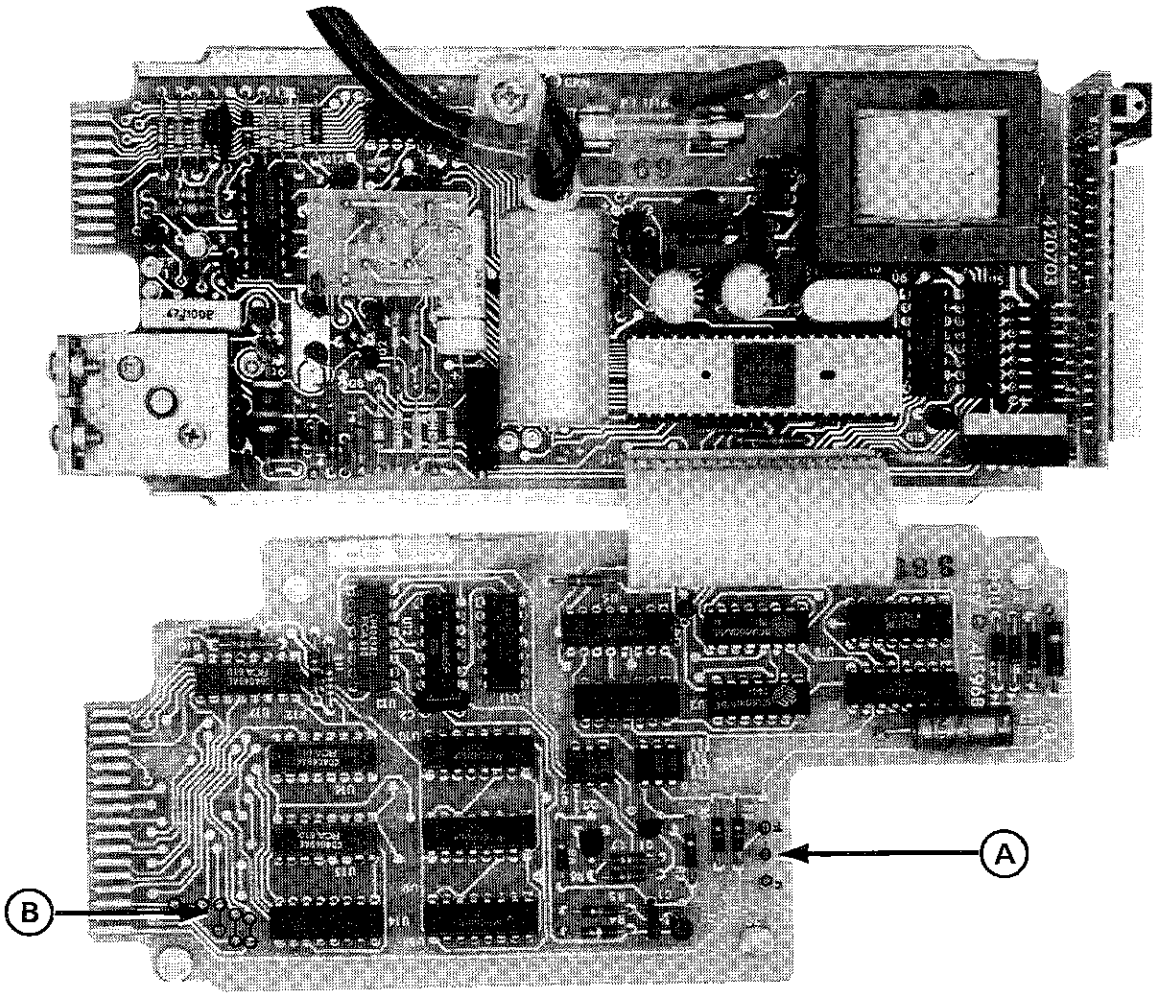


Figure 602-1
DIGITAL OUTPUT UNIT INSTALLATION DETAILS, 2160A/2170A

between the appropriate terminals (°C or °F) as shown in Figure 602-1 location A.

f. Refer to location B in Figure 602-1 and check the Digital Output Unit pcb to see if four jumpers are installed in that location. They must be installed if the pcb is being used in a Model 2170A, 2175A or 2176A and must be removed if the pcb is being used in a Model 2160A, 2165A, 2166A or 2168A. These jumpers are included as part of the mounting hardware.

g. Turn the Digital Output Unit pcb over so that it is component side down and on top of the thermometer pcb assembly. (Component sides will face and the circuit/solder side of the DOU will be up).

h. Align the two pcb's with the support rails at the rear of the thermometer case (main pcb on bottom and Digital Output Unit pcb on top), and slide them into the case.

i. Slide one sheet of mylar insulation under the main pcb and one on top of the Digital Output Unit (one sheet is supplied with the Digital Output Unit and the other is part of the Thermometer).

j. Position and secure the thermometer's rear panel using the screws that were removed in step b. of this procedure.

602-8. Models 2165A, 2166A, 2168A, 2175A, 2176A.

a. Disconnect the thermometer from line power.

b. Remove the center, rear-panel screw from the thermometer and separate the instrument from the case.

c. Refer to Figure 602-2, location B and remove the two screws indicated, from the thermometer pcb.

d. Position the Digital Output Unit over the thermometer pcb as shown in Figure 602-2 and carefully plug the Digital Output Unit's flex cable into the connector provided on the thermometer pcb assembly.

e. Using the hardware supplied with the Digital Output Unit (screws, stand-offs, nuts, and washers) mount the Digital Output Unit pcb to the thermometer pcb. Hardware installation details are shown in Figure 602-2 locations B and C.

NOTE

Insure that all four screws are properly tightened. The two in location C are used to make electrical connections between the pcb's.

f. Check the Digital Output Unit pcb to ensure there is no jumper installed at location A as shown in Figure 602-2. Remove any jumper that may be present.

g. Refer to location D in Figure 602-2 and check the Digital Output Unit pcb to see if four jumper wires are installed. They must be installed if the pcb is being used in a Model 2170A, 2175A or 2176A, and must be removed if the pcb is being used in a Model 2160A, 2165A, 2166A or 2168A. (See paragraph 602-18)

h. Install the thermometer and Digital Output Unit pcb's in the thermometer case, and secure them using the rear-panel screw removed in step b of this procedure.

602-9. OPERATING NOTES

602-10. The following paragraphs describe various conditions that should be considered before attempting to operate the Digital Output Unit.

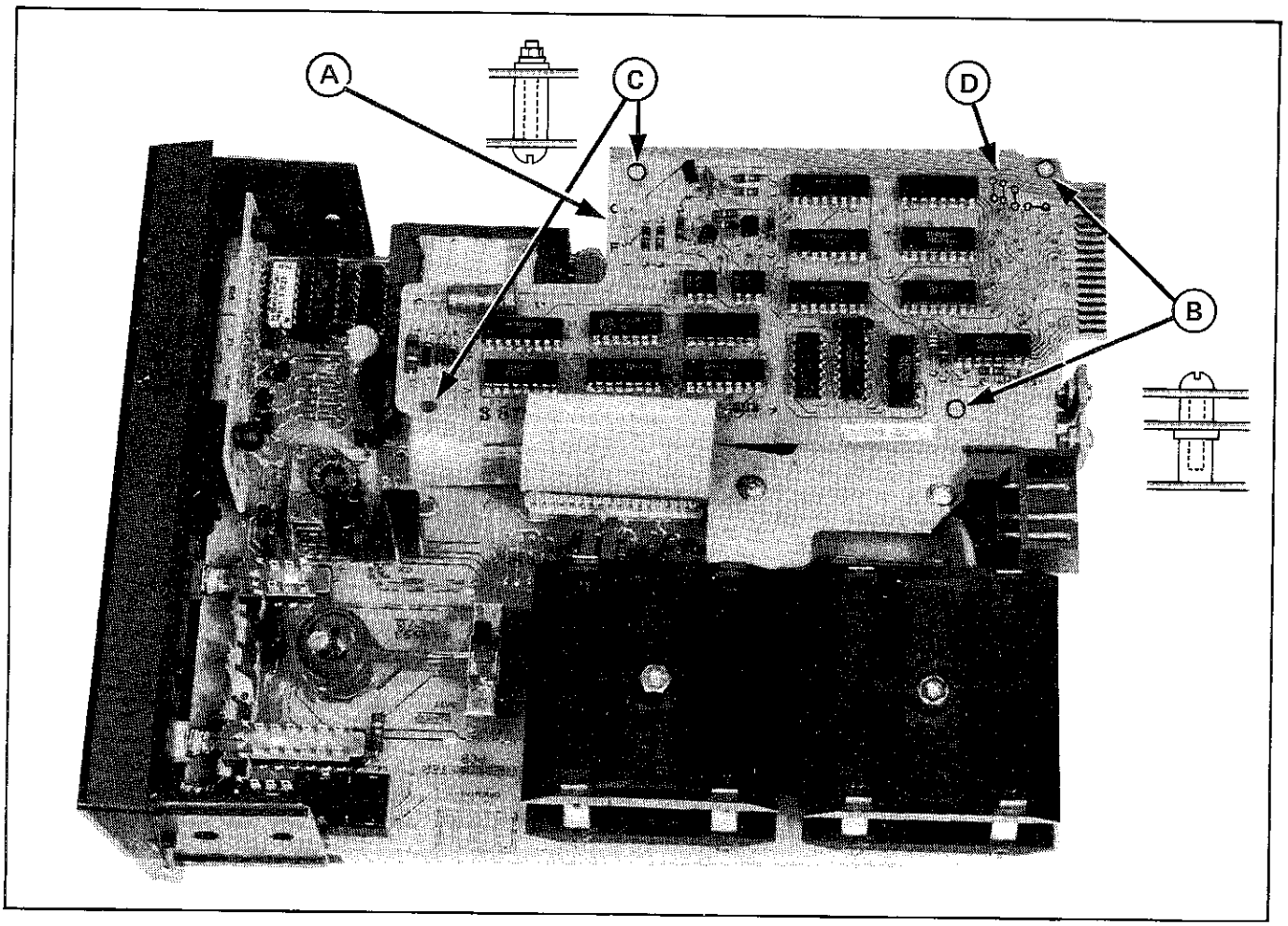


Figure 602-2
DIGITAL OUTPUT UNIT INSTALLATION DETAILS, 2165A, 2166A, 2168A, 2175A and 2176A

602-29. Free-run mode is enabled by grounding pin 6 (enable). Numeric measurement data from the thermometer is transmitted (on a continual basis) to the Digital Output Unit in bit-parallel character-serial format. It is received on a four-bit data bus (DB0 thru DB3) and is accompanied by a series of timing pulses that are used to control and synchronize the overall operation of the Digital Output Unit. As each character is serially placed on the data bus, its presence and validity is signified by the generation of a data valid (DV) pulse. Similarly the beginning of a new measurement word (five serial characters) is marked by the generation of a Strobe Out (SO) pulse. Since, measurement data is continually repeated on the data bus, and each measurement word occurs many times during a measurement cycle, a third pulse is required to ensure that the Digital Output Unit can be updated only at the end of a measurement cycle. This is accomplished by an Update pulse which occurs at the end of each measurement cycle and lasts for the duration of the next five DV pulses. Each of these pulses (DV, SO and Update) are shown in the timing diagram in Figure 602-5.

602-30. In addition to numeric data, the digital thermometer also transmits polarity and overload information with each measurement word. This data is provided to the Digital Output Unit as two separate inputs and each is present for the duration of the measurement cycle (i.e., both inputs are updated at the end of each measurement cycle).

602-31. The transfer of measurement data from the digital thermometer to the Digital Output Unit begins when the Update pulse goes high, and continues until the measurement word has been repeated four times. As the word is read the first time, the timing logic enables a data multiplexer (MUX) to serially couple the most-significant-bit (8) from each of the five measurement characters across the guard. These serial bits are then presented to the data input of a 20-bit shift register. The second, third and fourth readings serialize the 4, 2, and 1 bits respectively, from each of the five measurement words and couples them across the guard to the shift register input. During this entire serializing process, the multiplexer also enables the Data Valid pulse to be coupled across the guard. As each data bit is presented to the shift register, the Data Valid pulse clocks it into the shift register. At the end of the fourth reading the multiplexer is disabled to inhibit subsequent measurement data and Data Valid pulses from crossing the guard. As a result the entire measurement word (five 4-bit characters) is stored in the shift register, and is available in parallel format for use by an external printer.

NOTE

Since the most-significant-digit (MSD) of the five character measurement word never exceeds three, overload and polarity information is coupled across the guard as the 8 and 4 bits of the MSD. The SO pulse is used to gate this information to the multiplexer during the first data valid period of the first and second readings. See table of output data in Figure 602-3.

602-32. During the data transfer process, the control logic detects presence of the Data Valid pulse and generates a Busy and $\overline{\text{Busy}}$ pulse at the output connector. These pulses, when active, indicate that the shift register is being loaded and output data is, therefore, invalid. Normally the trailing edge of either the Busy or $\overline{\text{Busy}}$ pulse is used as a print command to trigger the external printer.

602-33. To this point, the operation described is for the free-run mode where pin 6 is grounded so that the shift register, and the output, is updated at the end of every measurement cycle. A second operating mode, triggered operation, is possible whereby output data is updated only on command. This mode is enabled by holding the Enable input high. With Enable high, the Data Valid pulse is inhibited from reaching the shift register and the output data remains unchanged regardless of changes in measurement data. However, if a negative-going External Trigger is applied to the control logic, the register will be updated at the end of the next measurement cycle. Trigger timing is not critical since the control logic insures that a measurement cannot be initiated during the data transfer period. Instead, the trigger is stored and used to solicit data during the next data transfer period.

602-34. The 8-4-2-1 bits of the fifth decade (LSD) of measurement data are not valid when the Digital Output Unit is used with a Model 2160A, 2165A, 2166A or 2166A Digital Thermometer. Therefore, plug-in jumpers have been provided on the pcb so that the fifth decade of measurement data can be isolated from the output connector. These jumpers should be installed only when the Digital Output Unit is being used with a Model 2170A, 2175A, or 2176A Digital Thermometer.

602-35. CALIBRATION

602-36. The Digital Output Unit does not require calibration. If the unit fails to operate, check proper cable connections between the unit, the digital thermometer, and the external printer. Isolate the problem to the Digital Output Unit by checking the overall operation of the digital thermometer. If the thermometer operates properly, the problem is either on the Digital Output Unit pcb or the external printer.

602-37. LIST OF REPLACEABLE PARTS

602-38. A list of replaceable parts for the Digital Output Unit is given in Table 602-2. Refer to Section 5 of the digital thermometer manual for ordering information.

Table 602-2. LIST OF REPLACEABLE PARTS

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	FINAL ASSEMBLY, DIGITAL OUTPUT UNIT, MODEL 2160A-02						
A1	Digital Output Unit PCB Assembly (2160A-4030)	415950	89536	415950	1		
	Insulator, mylar	415513	89536	415513	1		
	Spacer, aluminum, 0.5 inch	102616	89536	102616	2		
	Spacer, aluminum, 1.063 in	201020	89536	291020	2		
	Connector, 34-pin	424242	89536	424242	1		
	DIGITAL OUTPUT UNIT PCB ASSEMBLY (2160A-4030) FIGURE 602-4						
C1	Cap, cer, 0.01 μF ±20%, 100V	149153	56289	C023B101F103M	1		
C2	Cap, mica, 33 pF ±5%, 500V	160317	72136	DM15E331J	1		
C3	Cap, elect, 220 μF –10/+50%, 10V	236935	73445	ET221X010A5	1	1	
C4	Cap, Ta, 10 μF ±20%, 15V	193623	56289	196D106X0015A1	1		
CR2, CR3	Diode, Si, 1A	368738	04713	1N4004	2	1	
P1	Cable and connector assembly	418764	00779	1-86942-7	1		
Q1, Q2, Q3	Xstr, Si, NPN	218396	04713	2N3904	3	1	
R1, R2	Res, comp, 20K ±5%; ¼ W	221614	01121	CB2035	2		
R3, R8	Res, comp 2K ±5%, ¼ W	202879	01121	CB2025	2		
R4	Res, comp, 100K ±5%, ¼ W	148189	01121	CB1045	1		
R5	Res, comp 15K ±5%, ¼ W	148114	01121	CB1535	1		
R6, R7	Res, comp 16K ±5%, ¼ W	221606	01121	CB1635	2		
R9, R11	Res, comp, 33K ±5%, ¼ W	148155	01121	CB3335	2		
R10, R12	Res, comp, 10K ±5%, ¼ W	148106	01121	CB1035	2		
R13	Res, comp 100 ±5%, ½ W	108100	01121	EB1015	1		
R14	Res, comp, 51K ±5%, ¼ W	193334	01121	CB5135	1		
U1, U8, U9, U10	IC, C-MOS, dual four-bit shift register ⊗	340125	04713	MC14015CP	4	1	
U2	IC, C-MOS, qual bilateral switch ⊗	363838	02735	CD4016AE	1	1	
U3	IC, C-MOS, quad and-or select gate ⊗	419010	02735	CD4019AE	1	1	
U4	IC, C-MOS, dual four-input NOR gate ⊗	363820	04713	MC14002CP	1	1	
U5, U13, thru U17	IC, C-MOS, hex buffer/inverter ⊗	381848	05303	CD4049AE	6	1	
U6, U7	IC, isolator, optically coupled	380014	50522	MCT2	2	1	
U11	IC, MOS, dual D-type flip-flop ⊗	340117	04713	MC14013L	1	1	
U12	IC, C-MOS, qual two input NOR gate ⊗	355172	04713	MC14001P	1	1	
U18	IC, C-MOS, hex buffer/inverter ⊗	381830	02735	CD4050AE	1	1	
VR1	Diode, zener, 5.6V	277236	04713	IN752A	1	1	
	Connector female, 1-pin	376418	22526	75060-007	1		

⊗ Indicates MOS device which may be damaged by static discharge.

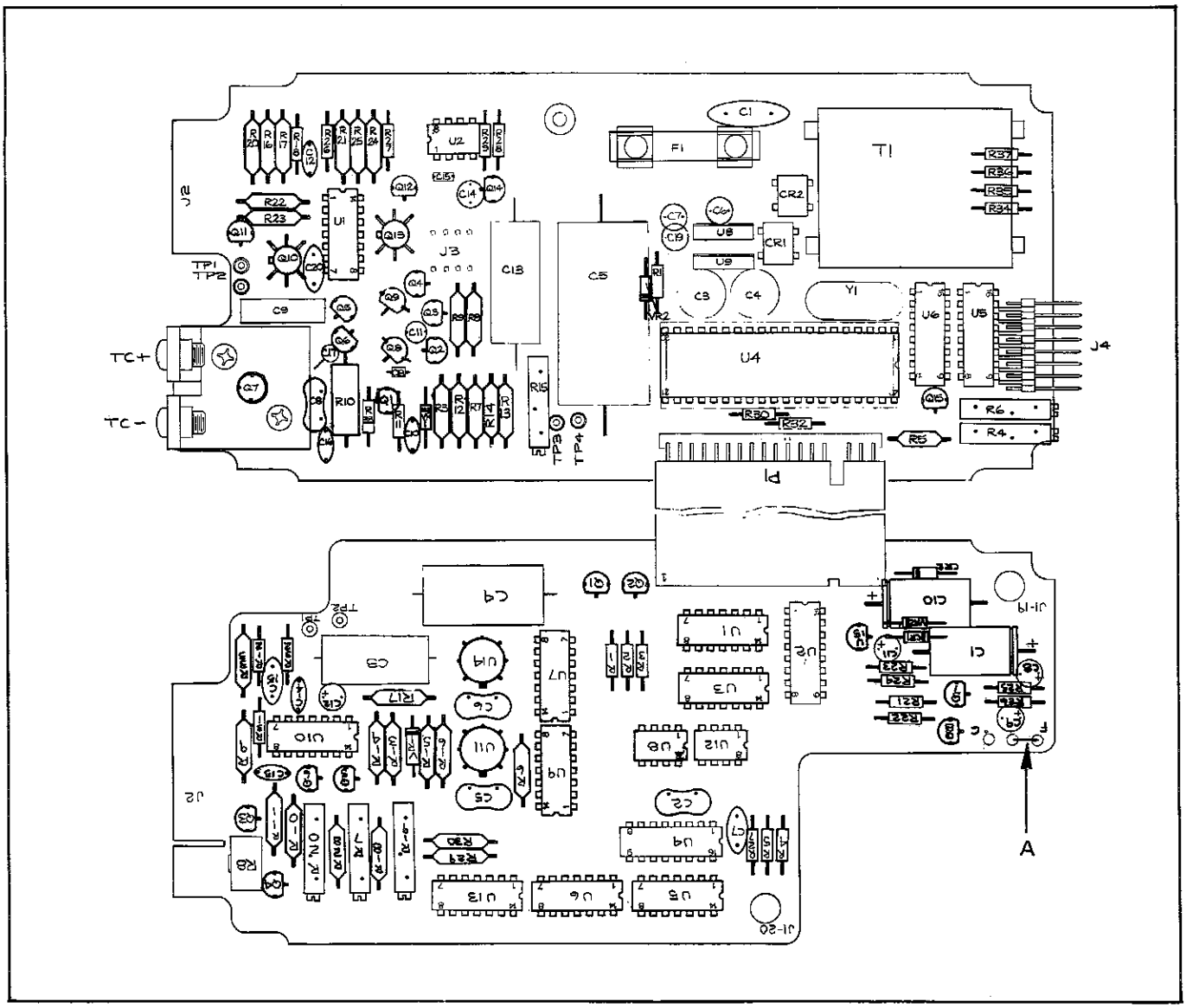


Figure 604-1.
ANALOG OUTPUT UNIT INSTALLATION DETAILS, 2160A AND 2170A

f. Turn the Analog Output Unit pcb over so that it is component side down and on top of the thermometer pcb assembly. (Component sides of pcb's will be facing and circuit side of AOU pcb will be up).

g. Align the two pcb's with the support rails at the rear of the case (thermometer pcb on top), and slide them into the case.

h. Slide one sheet of mylar insulation under the main pcb and one on top of the Analog Output Unit (one sheet is supplied with the Analog Output Unit and the other is part of the 2160A/2170A.

i. Position and secure the thermometer's rear panel using the screws that were removed in step b of this procedure.

604-8. Models 2165A, 2166A, 2168A, 2175A and 2176A.

a. Disconnect the thermometer from line power.

b. Remove the center, rear-panel screw from the thermometer and separate the instrument from the case.

c. Refer to Figure 604-2, location B and remove the two screws indicated from the thermometer pcb.

d. Position the Analog Output Unit pcb over the thermometer pcb with the component side up as shown in Figure 604-2 and carefully plug the Analog Output Unit's flex into the connector provided on the thermometer pcb assembly.

into the connector provided on the thermometer pcb assembly.

e. Using the hardware supplied with the Analog Output Unit (screws, stand-offs, nuts, and washers) mount the Analog Output Unit pcb to the thermometer pcb. Hardware installation details are shown in Figure 604-2, locations B and C.

NOTE

Insure that all four screws are properly tightened. The two in location C are used to make electrical connections between the pcb's.

f. Check the Analog Output Unit pcb to ensure that there is no jumper installed in location A as shown in Figure 604-2. Remove any jumper that may be present.

g. Install the thermometer and Analog Output Unit pcb's in the thermometer case, and secure them using the rear-panel screw removed in step b. of this procedure.

604-9. OPERATING NOTES

604-10. The following paragraphs describe various conditions that should be considered before attempting to operate the Analog Output Unit.

604-11. Output Cable Connections

604-12. The Analog Output Unit is supplied with an output cable and connector. The connector is keyed and the cable color coded so that the red wire is the analog HI output and the black wire is the LO output.

604-13. Temperature Scale Jumpers

604-14. When the Analog Output Unit is used with the Model 2160A or 2170A Digital Thermometer, the appro-

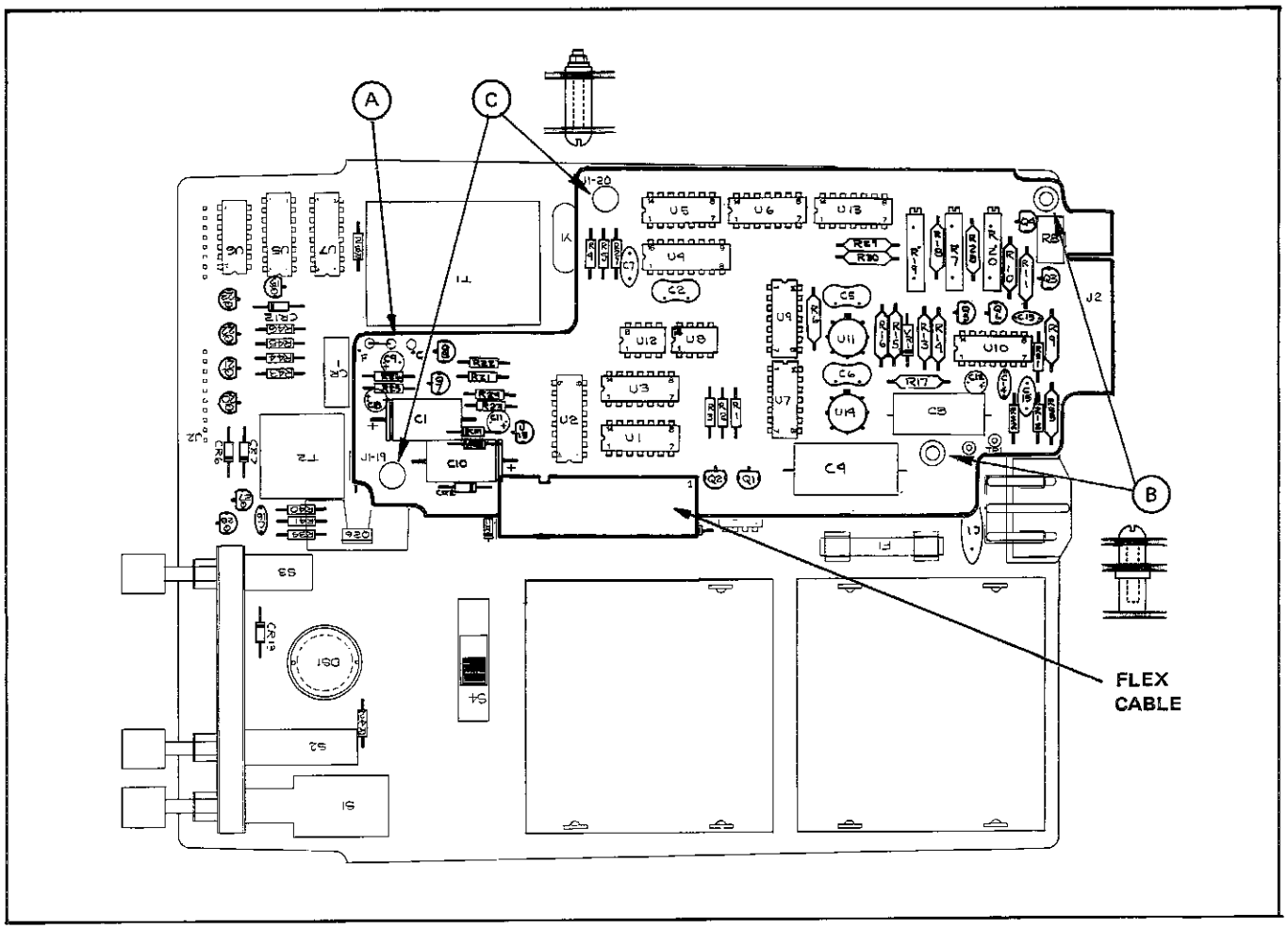


Figure 604-2.
ANALOG OUTPUT UNIT INSTALLATION DETAILS, 2165A, 2166A, 2168A, 2175A AND 2176A

priate temperature scale (°C or °F) must be specified on the Analog Output Unit by installing a jumper wire at location A as shown in Figure 604-1. The jumper must be removed from both the °C and °F locations when the Analog Output Unit is being operated with the Model 2165A, 2166A, 2168A, 2175A or 2176A, Digital Thermometer. These units are equipped with a front panel temperature-scale-select switch (°C or °F) that automatically provides the Analog Output Unit with the proper temperature scale information.

604-15. OPERATION

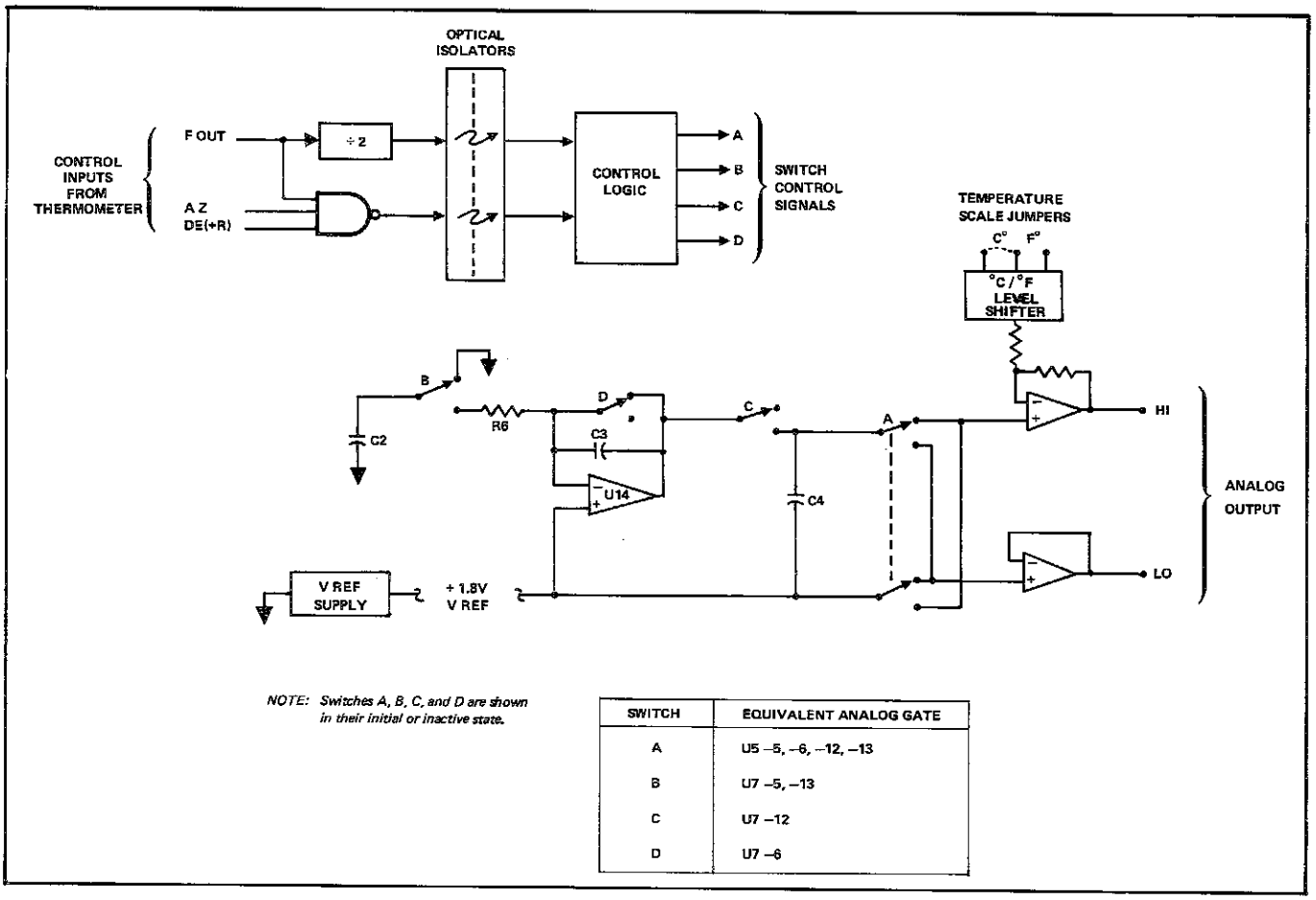
604-16. Once installed, the Analog Output Unit requires no operator attention other than ensuring that the external analog instrument is set to the desired range. Temperature-polarity is indicated by a plus or minus output voltage, and temperature magnitude is indicated as a 1 mV per °C or °F output. Therefore, a +100°measurement would be indicated by a +100 mV output from the Analog Output Unit.

604-17. THEORY OF OPERATION

604-18. The function of the Analog Unit is to convert the linearized read clock (F OUT/℄) from the digital thermometer into an isolated analog output voltage which is proportional to the thermometer's displayed temperature. This voltage, in turn, may be used to drive an external analog instrument and, thereby, provide a continuous analog indication of the measured temperature. A simplified circuit diagram of the Analog Output Unit is given in Figure 604-4. See Figure 604-8 for a detailed schematic.

604-19. Input data to the Analog Output Unit is received from the digital thermometer in the form of a read clock, an Auto Zero pulse, and a DE(+R) polarity command. These inputs are electrically isolated from the unit's analog output by two photo-isolators and a guard crossing. Similarly, a 5V ac operating voltage (derived from the digital thermometer) is transformer coupled across the guard where it is rectified by a voltage doubler to provide the isolated logic with a +12V dc operating voltage.

604-20. The Read Clock enters the Analog Output Unit during the thermometer's read period and is designated on the Analog Output Unit schematic as F OUT. Duty cycle and pulse count of the read clock varies as a function of the thermocouple linearization program and the magnitude of the temperature measured. Each read-clock pulse received



NOTE: Switches A, B, C, and D are shown in their initial or inactive state.

SWITCH	EQUIVALENT ANALOG GATE
A	U5 –5, –6, –12, –13
B	U7 –5, –13
C	U7 –12
D	U7 –6

Figure 604-3.
ANALOG OUTPUT UNIT SIMPLIFIED CIRCUIT DIAGRAM

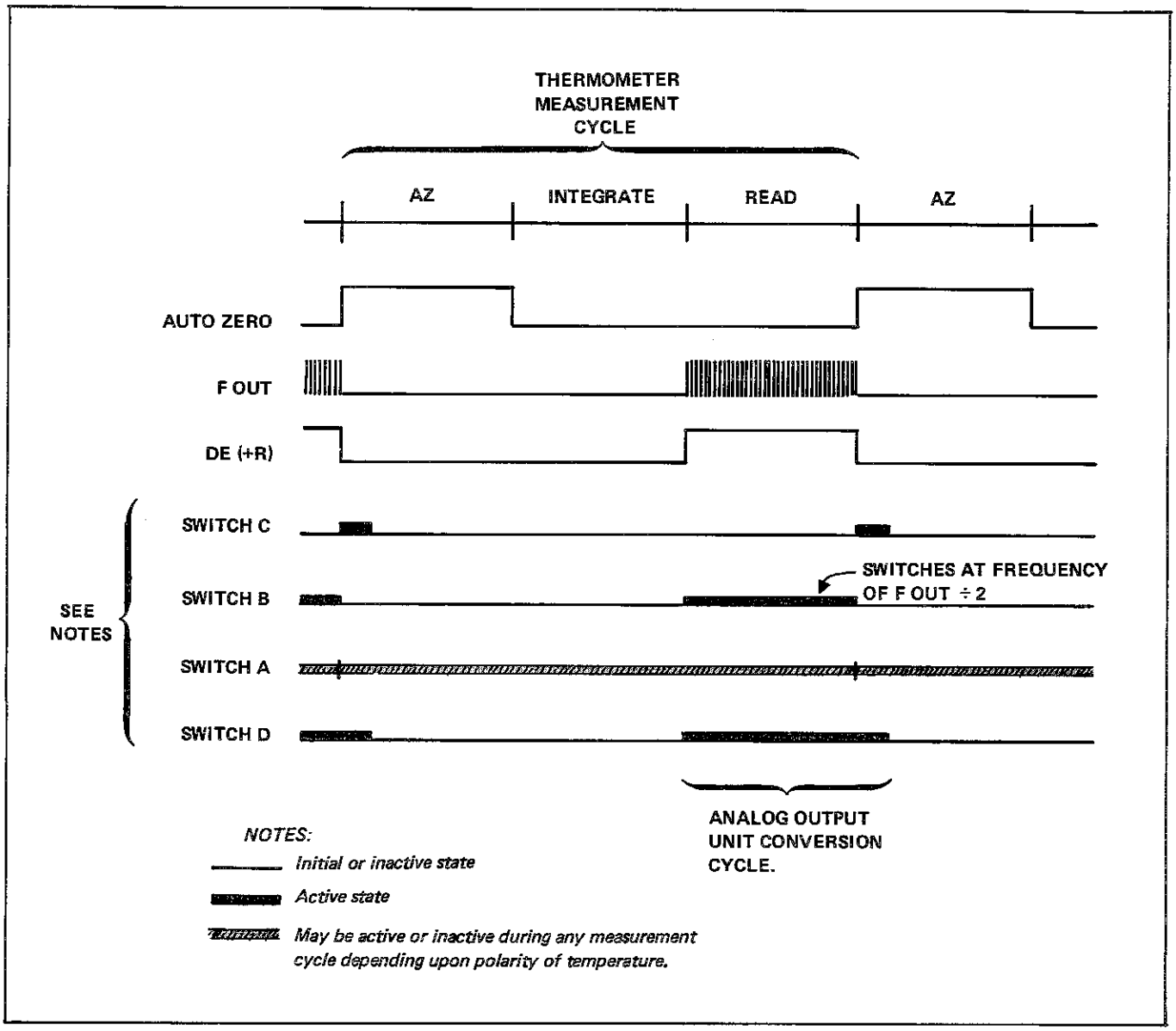


Figure 604-4.
ANALOG OUTPUT UNIT TIMING DIAGRAM

represents a temperature increment of 0.1 degree and will eventually appear at the analog output as a 100 μV increment.

604-21. Polarity data is received from the thermometer in the form of the DE+ command and is present for the duration of the read period. A negative temperature is indicated when the DE+ line is high (OV dc), and a positive temperature is present when the DE+ line is low (-12V dc). A single flip-flop is used to store the polarity data for later use in determining the polarity of the analog output voltage.

604-22. At the end of the read period, the accumulated magnitude and polarity data is transferred to the analog output where it will remain until updated at the end of the next read period and the beginning of the next measurement cycle.

604-23. As input data is received from the digital thermometers, it is coupled across the guard to the digital control logic where it is conditioned for use in controlling a series of analog gates. These gates are shown in Figure 604-3 as switches A, B, C and D. Initial operation begins with the switches in the positions shown (inactive). Capacitors C2 and C3 are discharged and C4 is charged to a value proportional to the previous reading.

604-24. When the read period begins, switch D is energized to allow C3 to charge, and switch B is toggled at the rate of ½ F OUT(F OUT÷2). The toggle action of switch B alternately charges and discharges capacitor C2, thereby, causing C3 to accumulate a charge which is proportional to the number of pulses generated during the read period. The charge rate of C3 is determined by the +1.8 to +2.8V dc reference level at the + input of the integrator amplifier

(U14) and the value of C2. With respect to logic common, the integrator output starts at +1.8V for a 0°C or 32°F reading and increases to approximately +6.0V dc for a full scale reading of 3999.

604-25. At the end of the read period, the read clock and switch B are stopped, and C3 is charged to a value proportional to the thermometer reading. At this time a 4 ms pulse is generated by the control logic to close switch C. During this period, the differential voltage between the +1.8V reference and the integrator amplifier output is impressed across capacitor C4, and delivered through polarity switch A to the analog output buffers. At the end of the 4 ms period, switch C opens and capacitor C4 maintains the analog output until it is updated following the next read period.

604-26. The Digital Thermometer produces no read-clock pulses for readings of 0°C and 32°F. With no read-clock pulses input, the Analog Output Unit will produce an output of zero volts. This is acceptable for use with the °C temperature scale. However, on the °F scale an analog output of 32 mV dc is required for a 32°F reading. To provide this output, a level shifter is included on the Analog Output Unit pcb. It is enabled when the temperature scale jumper or the temperature select switch is placed in the °F position. A fixed +32 mV offset is added to the HI analog output buffer, thereby adding to all readings taken on the °F scale. Placing the temperature scale jumper or switch in the °C position returns the offset voltage to zero volts.

604-27. CALIBRATION

604-28. The Analog Output Unit should be calibrated whenever its parent digital thermometer is calibrated, or after repair of either. In the following procedure, it is assumed that the Analog Output Unit has been properly installed in a 2160A/2170A series Digital Thermometer and that the thermometer has been calibrated. Table 604-1 lists the equipment necessary to calibrate the Analog Output Unit.

Table 604-1.
TEST EQUIPMENT REQUIREMENTS

INSTRUMENT	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
DC Voltage Calibrator	0 to +10V dc adjustable, 10 μV resolution	Fluke 343A
Digital Voltmeter	10 μV resolution on 1V range	Fluke 8800A
Resistors 9900Ω, 100Ω or Kelvin-Varley Divider (Shunt output with 1 μF capacitor	1/4W, ±0.02% ratio matched to 0.005% ±10 ppm TC, WW	Fluke A21-5 Fluke 720A

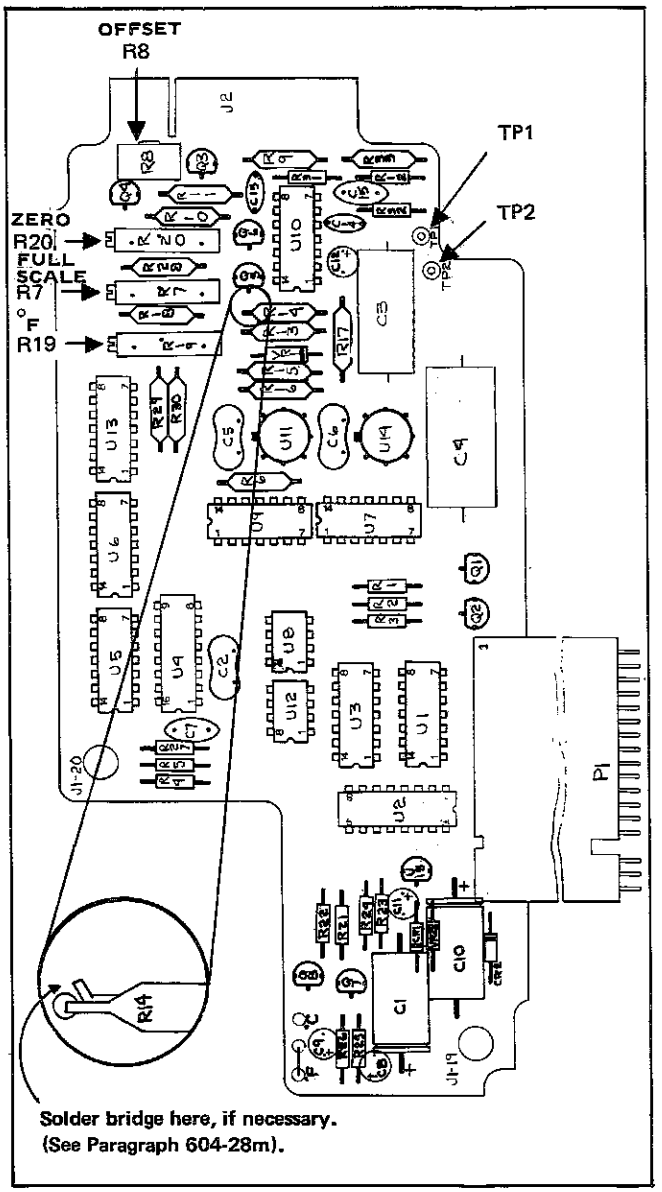


Figure 604-5.
TEST POINT AND ADJUSTMENT LOCATIONS

NOTE

This calibration procedure should be performed at an ambient temperature of 25 +2°C (77 ± 3.6°F). All test point and adjustment locations are shown in Figure 604-5.

a. Set thermometer and Analog Output Unit to the °C scale.

1. On Models 2160A and 2170A two jumpers must be positioned to select temperature scale. One is located behind the thermometer display lens and the other is located on the Analog Output pcb. Refer to the operating notes in both the thermometer manual and this sub section for jumper locations.

2. On Models 2165A, 2166A, 2168A, 2175A and 2176A the °C temperature scale for both the thermometer and the Analog Output Unit is selected by setting the front panel TEMP switch to the °C position.

NOTE

If the Analog Output Unit is being calibrated in a Model 2168A Digital Thermometer, set the front panel type select switch to "C".

b. Complete the equipment connections shown in Figure 604-6. Use copper wire to interconnect the divider output and the thermometer input.

1. Set calibrator to the 10V range; OV output.

2. Set DVM to lowest dc voltage range.

NOTE

When adjusting the calibrator output in the following steps it may be necessary to reverse the calibrator output leads to obtain the proper polarity at the thermometer display.

c. Energize the thermometer and associated test instruments.

d. Adjust the calibrator output to obtain a thermometer display of 00°C (If the thermometer is configured for use with B type thermocouples make sure the zero reading is solid, i.e., not blinking).

e. Using a clip-lead, short TP 1 to TP 2 on the Analog Output Unit pcb.

f. Adjust Offset pot R8 to obtain a DVM reading of 0±50 μV dc.

g. Remove the short between TP 1 and TP 2.

h. Adjust Zero pot R20 to obtain a DVM reading of 0 ±350 μV dc (thermometer display should still indicate 00°C).

i. Select °F temperature scale on both the thermometer and the Analog Output Unit pcb. (See step a. of this procedure.) The thermometer display should now read 32 or 32.0°F.

j. Adjust °F pot R19 to obtain a DVM reading of +0.032V dc ±350 μV.

k. Increase the calibrator output until the thermometer display begins to blink. The temperature displayed (should be positive) indicates the upper limit of the temperature range assigned to the thermometer.

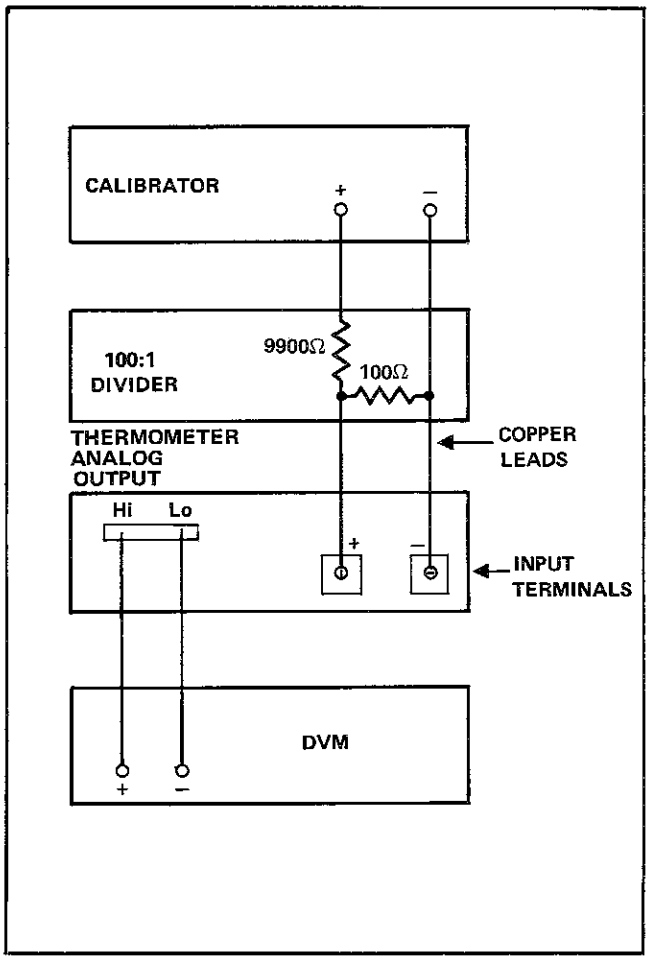


Figure 604-6.
CALIBRATION EQUIPMENT CONNECTIONS

l. Decrease the calibrator output until the thermometer displays an even temperature value which is 5 to 10 degrees below the upper limit.

NOTE

If the adjustment range of R7 is insufficient to complete step m, solder a shorting bridge across R14 using the pcb land patterns provided on the Analog Output Unit pcb. See Figure 604-5.

m. Adjust Full Scale pot R7 to obtain a DVM reading proportional to the thermometer display ±0.25% ±1 mV. The Analog Output Unit generates a 1 mV output for each degree displayed. For example, a +3980°F displayed temperature will cause the Analog Output Unit to generate +3.980V dc ±.0109V dc.

n. Repeat steps a through m of this procedure to eliminate errors due to adjustment interaction.

o. Decrease the calibrator output until the thermometer displays an even temperature value which is 5 to 10 degrees above the lower temperature limit. The DVM should display a value equal to the thermometer display ±0.25% ±1 mV.

604-29. LIST OF REPLACEABLE PARTS

604-30. A list of replaceable parts for the Analog Output Unit is given in Table 604-2. Refer to section 5 of the Digital Thermometer Manual for ordering information.

Table 604-2. LIST OF REPLACEABLE PARTS

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	FINAL ASSEMBLY, ANALOG OUTPUT UNIT, MODEL 2160A-04						
A1	Analog Output Unit PCB Assembly (2160A-4040)	415976	89536	415976	1		
	Connector, 34-pin	424242	89536	424242	1		
	Insulator, mylar	415513	89536	415513	1		
	Spacer, aluminum 0.5 inch	102616	89536	102616	2		
	Spacer, aluminum, 1.063 inch	201020	89536	201020	2		
A1	ANALOG OUTPUT UNIT, PCB ASSEMBLY 2160A-04						
	Figure 604-7	415976	89536	415976	REF		
C1, C10	Cap, elect, 220 μF ± 20%, 20V	429845	25403	ET221X016A5	2	1	
C2	Cap, mica, 150 pF ± 20%, 500V	226134	72136	DM15F151F	1		
C3	Cap, mylar, 2 μF ± 20%, 100V	334185	14752	230B1B205	1		
C4	Cap, mylar, 1 μF ± 20%, 200V	106450	84411	X663FIMFD 20200V	1		
C5, C6	Cap, mica, 56 pF ± 5%, 500V	148528	72136	DM15F560J	2		
C7	Cap, cer, 0.01 μF ± 20%, 100V	149153	56289	C023B101F103M	1		
C8, C9, C11, C12	Cap, ta, 10 μF ± 20%, 20V	330662	56289	196D106X 0020KA1	4		
C13, C14	Cap, cer, 0.22 uF ±20%, 50V	309849	72982	8131-050-651M	2		
C15	Cap, cer, 0.025 uF ±20%	168435	56289	C023B101H253M	1	1	
CR1, CR2	Diode, Si	203323	07910	IN4448	2		
P1	Cable and Connector Assembly	440255	89536	440255	1	1	
Q1, Q2	Xstr, J-FET, N-channel	343830	89536	343830	2	2	
Q3 thru Q8	Xstr, Si, NPN	218396	04713	2N3904	6		
R1, R2, R4 R5, R12, R23, R24	Res, comp, 10K ± 5%, ¼W	148106	01121	CB1035	7		
R3	Res, comp, 5.1K ± 5%, ¼W	193342	01121	CB5125	1		
R6, R18	Res, mf, 1K ± 1%, 1/8W	168229	91637	MFF1-81001F	2		
R7	Res, pot, 500 ± 20%, ½W	267849	71450	190PC501B	1	1	
R8	Res, pot, 500 +10%, 1/2W	291120	89536	291120	1	1	
R9	Res, mf, 19.1K ± 1%, 1/8W	234963	91637	MFF1-81912F	1		

Table 604-2 (Cont.). LIST OF REPLACEABLE PARTS

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART. NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R10	Res, mf, 51.1K ±1%, 1/8W	289553	91637	MFF1-85112F	1		
R11	Res, mf, 100 ± 1%, 1/8W	168195	91637	MFF1-81000F	1		
R13	Res, mf, 1.5K ± 1%, 1/8W	313098	91637	MFF1-81501F	1		
R14	Res, mf, 402 ± 1%, 1/8W	289611	91637	MFF1-84020F	1		
R15	Res, mf, 1.82K ± 1%, 1/8W	293670	91637	MFF1-81821F	1		
R16	Res, mf, 4.64K ± 1%, 1/8W	296020	91637	MFF1-84641F	1		
R17, R30	Res, mf, 2.32K ± 1%, 1/8W	260315	91637	MFF1-82321F	2		
R19	Res, pot, 5K ± 20%, ½W	267872	71450	190PC502B	1	1	
R20	Res, pot, 200 ± 20%, ½W	284711	71450	190PC201B	1	1	
R21, R22, R25, R26	Res, comp, 20K ± 5%, ¼W	221614	01121	CB2035	4		
R27	Res, comp, 510K ± 5%, ¼W	276685	01121	CB5145	1		
R28	Res, mf 40.2 ± 1%, 1/8W	245373	91637	MFF1-840R2F	1		
R29	Res, mf, 200 ± 1%, 1/8W	245340	91637	MFF1-82000F	1		
R31, R32	Res, comp, 100 ±5%, 1/4W	147926	01121	CB1015	2		
R33	Res, mf, 24.9 ±1%, 1/8W	296657	91637	MFF1-824R9F	1		
U1, U6, U13	IC, MOS, dual D-type Flip-flop (X)	340117	04713	MC14013L	3	1	
U2, U4	IC, C-MOS, hex buffer/inverter (X)	381848	02735	CD4049AE	2	1	
U3, U5, U7	IC, C-MOS, quad bi lateral switch (X)	363838	02735	CD4016AE	3	1	
U8, U12	IC, isolator, optically coupled	354746	28480	5082-4350	2	1	
U9	IC, C-MOS, quad bi lateral switch (X)	408062	02735	CD4066AE	1	1	
U10	IC, linear, quad opnl ampl	402669	12040	LM324N	1	1	
U11, U14	IC, linear, opnl ampl	453357	02735	CA3140	2	1	
U15	IC, linear, POS voltage regulator	408138	07263	78L12WC	1	1	
VR1	Diode, zener, 6.4V	429019	04713	IN4582	1	1	
	Connector, female, 1-pin	376418	22526	75060-007	3		
	Jumper, plug-in	373316	89536	373316	1		

803452

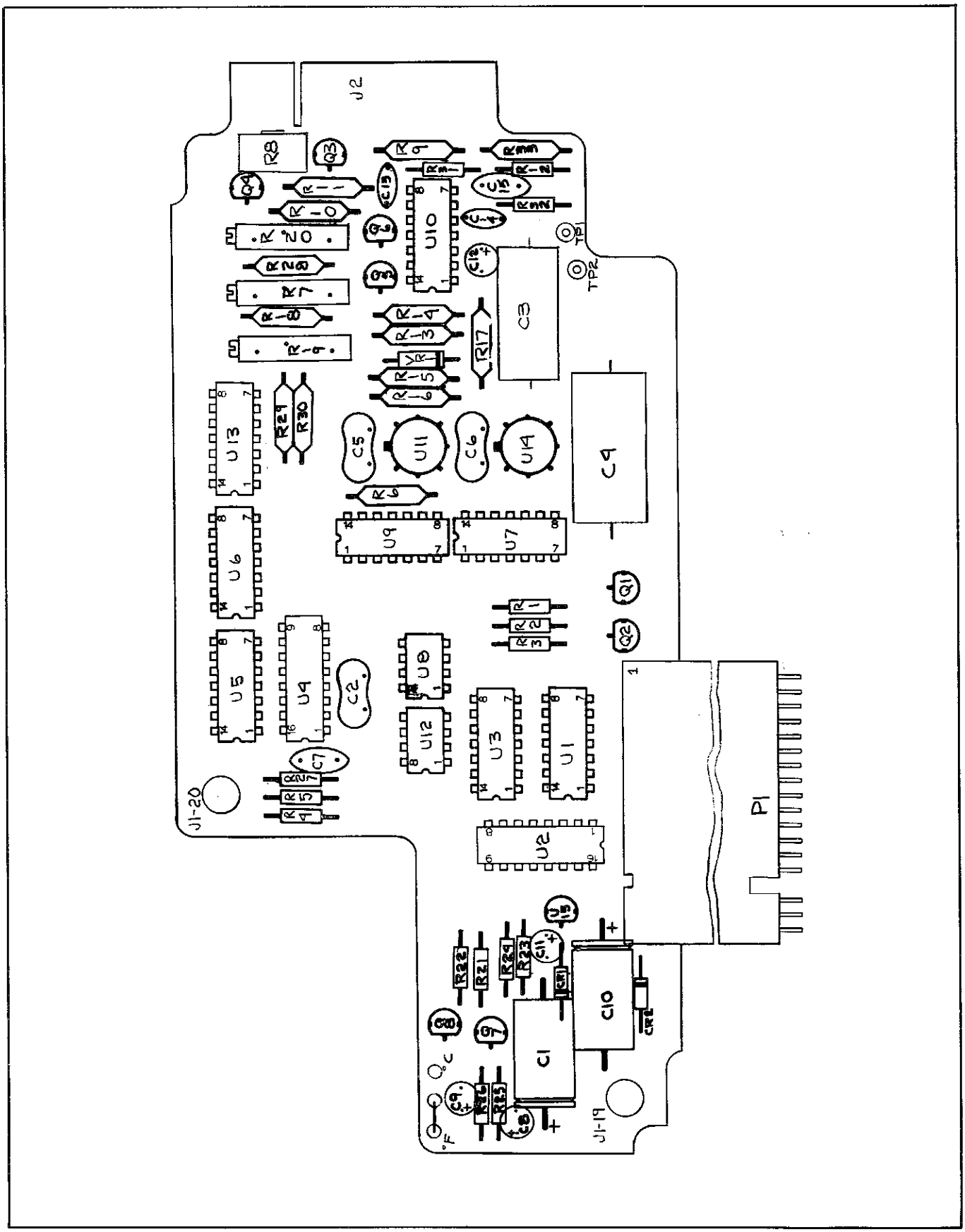


Figure 604-7
ANALOG OUTPUT UNIT PCB ASSEMBLY COMPONENT LOCATION (2160A-1640)

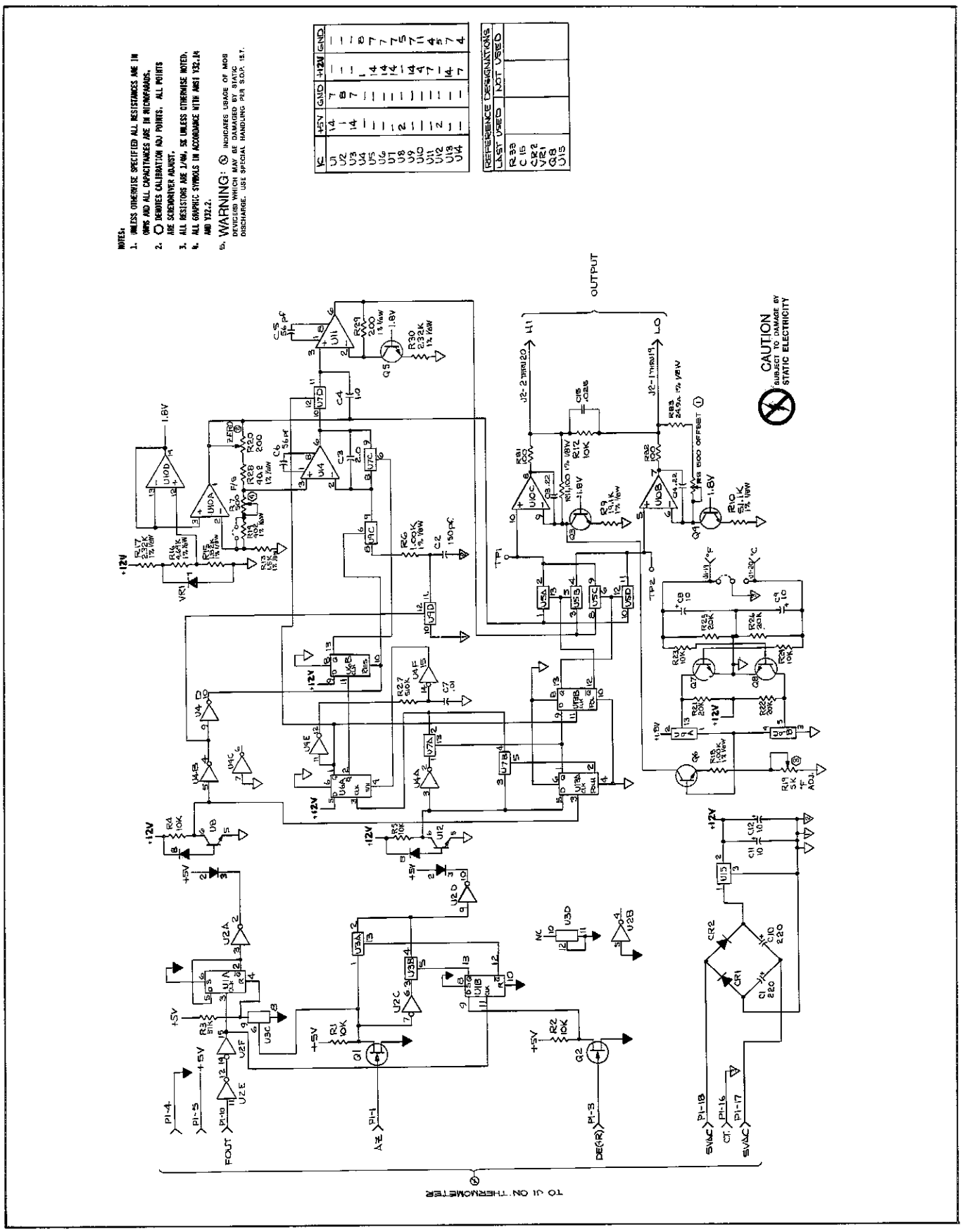


Figure 604-8
ANALOG OUTPUT UNIT PCB ASSEMBLY SCHEMATIC (2160A-1040)

Federal Supply Codes for Manufacturers

D9816
Westermann Wilhelm Augusta-Anlage
Mannheim-Nackarau Germany

S0482
Sony Corp.
Tokyo, Japan

S3774
Oshino Electric Lamp Works
Tokoyo, Japan

0AD86
IN General
El Paso, TX

0AE89
Autosplice Inc.
Woodside, NY

0BW21
Noritake Co. Inc.
Burlington, MA

0ANF0
Topaz Semiconductor Inc
San Jose, CA

0DSM7
Conductive (Pkg) Containers Inc.
Brookfield, WI

0CLN7
Emhart Fastening Group
Shelton, CT

0FB81
S-Mos Systems Inc.
San Jose, CA

0FFP1
Eveready LTD
Ever Ready Special Battery Div.
Dawley Telford Salop UK

00199
Marcon Electronics Corp
Kearny, NJ

00213
Nytronics Comp. Group Inc.
Darrlington, NC

00327
Welwyn International Inc.
Westlake, OH

00656
Aerovox Corp.
New Bedford, MA

00686
Film Capacitors Inc.
Passaic, NJ

00779
AMP, Inc.
Harrisburg, Pennsylvania

00853
Sangamo Weston Inc
Components Div
Pickens, NC

01091
Allied Plastics Co.
Los Angeles, CA

01101
Wabash Inc
(Formerly Wabash Magnetics)
Wabash, IN

01121
Allen Bradley Co.
Milwaukee, WI

01281
TRW Electronics & Defense Sector
R F Devices
Lawndale, CA

01295
TX Instruments Inc.
Semiconductor Group
Dallas, TX

01526
Genicom
Waynesboro, VA

01537
Motorola Communications &
Electronics Inc.
Franklin Park, IL

01686
RCL Electronics/Shallcross Inc.
Electro Components Div.
Manchester, NH

01884
Sprague Electric Co.
(Now 56289)

01961
Varian Associates Inc.
Pulse Engineering Div.
Convoy, CT

01963
Cherry Electrical Products Corp
Waukegan, IL

02111
Spectrol Electronics Corp.
City of Industry, CA

02114
Amperex Electronic Corp.
Ferrox Cube Div.
Saugerties, NY

02131
General Instrument Corp.
Government Systems Div.
Westwood, MA

02395
Sonar Radio Corp.
Hollywood, FL

02533
Leigh Instruments Ltd.
Frequency Control Div.
Don Mills, Ontario, Canada

02606
Fenwal Labs
Division of Travenal Labs
Morton Grove, IL

02660
Bunker Ramo-Eltra Corp.
Amphenol NA Div.
Broadview, IL

02697
Parker-Hannifin Corp.
O-Ring Div
Lexington, KY

02735
RCA-Solid State Div.
Somerville, NJ

02768
ITW (IL Tool Works)
Fastex Division
Des Plaines, IL

02799
Arco Electronics Inc.
Chatsworth, CA

03296
Nylon Molding Corp.
Monrovia, CA

03445
Lercon Electronics Inc
Burbank, CA

03508
General Electric Co.
Semiconductor Products
& Batteries
Auburn, NY

03797
Genisco Technology Corp.
Eltronics Div.
Rancho Dominquez, CA

03877
Gilbert Engineering Co.Inc
Incon Sub of Transitron
Electronic Corp.
Glendale, AZ

03888
KDI Electronics Inc.
Pyrofilm Div.
Whippany, NJ

03911
Clairex Corp.
Clairex Electronics Div.
Mount Vernon, NY

03980
Muirhead Inc.
Mountainside, NJ

04009
Cooper Industries, Inc.
Arrow Hart Div.
Hartford, CT

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, CA

04221
Midland-Ross Corp.
Midtex Div.
N. Mankato, MN

04222
AVX Corp.
AVX Ceramics Div.
Myrtle Beach, SC

04423
Telonic Berkley Inc.
Laguna Beach, CA

04713
Motorola Inc.
Semiconductor Group
Phoenix, AZ

04946
Standard Wire and Cable
Rancho Dominquez, CA

05173
General Radio
NY,NY.
Replaced by:

24655
Genrad,INC.
Concord, MA

05236
Jonathan Mfg. Co.
Fullerton, CA

05245
Corcom Inc.
Libertyville, IL

05276
ITT Pomona
Electronics Div.
Pomona, CA

05277
Westinghouse Elec. Corp.
Semiconductor Div.
Youngwood, PA

05347
Ultronix Inc
Grand Junction, CO

05397
Union Carbide Corp.
Materials Systems Div.
Cleveland. OH

05571
Sprague Electric Co.
(Now 56289)

05574
Viking Connectors Inc
Sub of Criton Corp.
Chatsworth, CA

05791
LYN-TRON
Burbank, CA

05820
EG & G Wakefield Engineering
Wakefield, MA

05839
Advance Electrical
Chicago, IL

05972
Loctite Corp.
Newington, CT

Federal Supply Codes for Manufacturers (cont)

06001
General Electric Co.
Electric Capacitor Product Section
Columbia, SC

06141
Fairchild Weston Systems Inc.
Data Systems Div.
Sarasota, FL

06192
La Deau Mfg. Co.
Glendale, CA

06229
Electrovert Inc.
Elmsford, NY

06383
Panduit Corp.
Tinley Park, IL

06473
Bunker Ramo Corp.
Amphenol NA Div.
SAMS Operation
Chatsworth, CA

06540
Mite Corp
Amatom-Electrical Div

06555
Beede Electrical Instrument
Penacook, NH

06665
Precision Monolithics
Sub of Bourns Inc.
Santa Clara, CA

06666
General Devices Co. Inc.
INpolis, IN

06739
Electron Corp.
Littleton, CO

06743
Gould Inc.
Foil Div.
Eastlake, OH

06751
Components Inc.
Semcor Div.
Phoenix, AZ

06776
Robinson Nugent Inc.
New Albany, IN

06915
Richco Plastic Co.
Chicago, IL

06961
Vernitron Corp.
Piezo Electric Div.
Bedford, OH

06980
EIMAC
(See Varian)
San Carlos, CA

07047
Ross Milton Co., The
Southampton, PA

07138
Westinghouse Electric Corp.
Industrial & Govemment
Tube Div.
Horseheads, NY

07233
Benchmark Technology Inc.
City of Industry, CA

07239
Biddle Instruments
Blue Bell, PA

07256
Silicon Transistor Corp.
Sub of BBF Inc.
Chelmsford, MA

07261
Avnet Corp.
Culver City, CA

07263
Fairchild Semiconductor
North American Sales
Ridgeview, CT

07344
Bircher Co. Inc., The
Rochester, NY

07374
Optron Corp
Woodbridge, CT

07557
Campion Co. Inc.
Philadelphia, PA

07597
Bumdy Corp.
Tape/Cable Div.
Rochester, NY

07716
TRW Inc. (Can use 11502)
IRC Fixed Resistors/
Burlington
Burlington, VT

07792
Lerma Engineering Corp.
Northampton, MA

07810
Bock Corp.
Madison, WI

07910
Teledyne Semiconductor
Mtn. View, CA

07933
Raytheon Co.
Semiconductor Div.
Mountain View, CA

08FG6
Calmos Systems Inc.
Kanata, Ont. Canada

080A9
Dallas Semiconductor
Dallas, TX

08111
MF Electronics
New Rochelle, NY

08235
Industro Transistor Corp.
Long Island City, NY

08261
Spectra-Strip
An Eltra Co.
Garden Grove, CA

08445
Electri-Cord Mfg., Inc
Westfield, PA

08530
Reliance Mica Corp.
Brooklyn, NY

08718
ITT Cannon Electric
Phoenix Div.
Phoenix, AZ

08806
General Electric Co.
Minature Lamp Products
Cleveland, OH

08863
Nylomatic
Fallsington, PA

08988
Skottie Electronics Inc.
Archbald, PA

09021
Airco Inc.
Airco Electronics
Bradford, PA

09023
Comell-Dublier Electronics
Fuquay-Varina, NC

09214
General Electric Co.
Semiconductor Products Dept.
Auburn, NY

09353
C and K Components Inc.
Newton, MA

09423
Scientific Components Inc.
Santa Barbara, CA

09922
Bumdy Corp.
Norwalk, CT

09969
Dale Electronics Inc.
Yankton, SD

09975
Burroughs Corp.
Electronics Components
Detroit, MI

1A791
LFE Electronics
Danvers, MA

1B715
(United Shoe & Nylock Corp)
-Nylock Fastener Corp.-
Paramus, NJ

10059
Barker Engineering Corp.
Kenilworth, NJ

10389
IL Tool Works Inc.
Licon Div.
Chicago, IL

11236
CTS Corp.
Resistor Products Div.
Berne, IN

11237
CTS Corp of CA
Electro Mechanical Div.
Paso Robles, CA

11295
ECM Motor Co.
Schaumburg, IL

11358
Columbia Broadcasting System
CBS Electronic Div.
Newburyport, MA

11403
Vacuum Can Co.
Best Coffee Maker Div.
Chicago, IL

11502 (can also use 35009)
TRW Inc.
TRW Resistive Products Div.
Boone, NC

11503
Keystone Columbia Inc.
Freemont, IN

11532
Teledyne Relays Teledyne
Industries Inc.
Hawthorne, CA

11711
General Instrument Corp.
Rectifier Div.
Hicksville, NY

11726
Qualidyne Corp.
Santa Clara, CA

12014
Chicago Rivet & Machine Co.
Naperville, IL

12020
Ovenaire
Div. of Electronic Technologies
Charlottesville, VA

12038
Simco
(Div of Ransburg Corp)
Hatfield, PA

12040
National Semiconductor Corp.
Danbury, CT

12060
Diodes Inc.
Northridge, CA

12136
PHC Industries Inc.
Formerly Philadelphia Handle Co.
Camden, NJ

12300
AMF Canada Ltd.
Potter-Brumfield
Guelph, Ontario, Canada

12323
Practical Automation Inc.
Shelton, CT

12327
Freeway Corp.
Cleveland, OH

12406
Elpac Electronics Inc.
Santa Ana, CA

12443
Budd Co.,The
Plastics Products Div.
Phoenixville, PA

12581
Hitachi Metals International Ltd.
Hitachi Magna-Lock Div.
Big Rapids, MO

12615
US Terminals Inc.
Cincinnati, OH

12617
Hamlin Inc.
LaKe Mills, WI

12673
Wesco Electrical
Greenfield, MA

12697
Clarostat Mfg. Co. Inc.
Dover, NH

12749
James Electronic Inc.
Chicago, IL

12856
MicroMetals Inc.
Anaheim, CA

12881
Metex Corp.
Edison, NJ

12895
Cleveland Electric Motor Co.
Cleveland, OH

12954
Microsemi Corp.
Components Group
Scottsdale, AZ

12969
Unitrode Corp.
Lexington, MA

13050
Potter Co.
Wesson, MS

13103
Thermalloy Co., Inc.
Dallas, TX

13327
Solitron Devices Inc.
Tappan, NY

13511
Bunker-Ramo Corp.
Amphenol Cadre Div.
Los Gatos, CA

13606
Sprague Electric Co.
(Use 56289)

13689
SPS Technologies Inc.
Hatfield, NJ

13764
Micro Plastics
Flippin, AZ

13919
Burr-Brown Research Corp.
Tucson, AZ

14099
Semtech Corp.
Newbury Park, CA

14140
McGray-Edison Co.
Commercial Development Div.
Manchester, NH

14189
Ortronics, Inc.
Orlando, FL

14193
Cal-R-Inc.
Santa Monica, CA

14301
Anderson Electronics
Hollidaysburg, PA

14329
Wells Electronics Inc.
South Bend, IN

14482
Watkins-Johnson Co.
Palo Alto, CA

14552
Microsemi Corp.
(Formerly Micro-Semiconductor)
Santa Ana, CA

14604
Elmwood Sensors, Inc
Pawtucket, RI

14655
Comell-Dublier Electronics
Div. of Federal Pacific
Electric Co. Govt Cont Dept.
Newark, NJ

14704
Crydom Controls
(Division of Int Rectifier)
El Segundo, CA

14752
Electro Cube Inc.
San Gabriel, CA

14936
General Instrument Corp.
Discrete Semi Conductor Div.
Hicksville, NY

14949
Trompeter Electronics
Chatsworth, CA

15412
Amtron
Midlothian, IL

15542
Scientific Components Corp.
Mini-Circuits Laboratory Div.
Brooklyn, NY

15636
Elec-Trol Inc.
Saugus, CA

15782
Bausch & Lomb Inc.
Graphics & Control Div.
Austin, TX

15801
Fenwal Eletronics Inc.
Div. of Kidde Inc.
Framingham, MA

15818
Teledyne Inc. Co.
Teledyne Semiconductor Div.
Mountain View, CA

15849
Useco Inc.
(Now 88245)

15898
International Business
Machines Corp.
Essex Junction, VT

16068
International Diode Div.
Harrison, NJ

16162
MMI
Southfield, MI

16245
Conap Inc.
Olean, NY

16258
Space-Lok Inc.
Burbank, CA

16352
Codi Corp.
Linden, NJ

16469
MCL Inc.
LaGrange, IL

16473
Cambridge Scientific Industries
Div. of Chemed Corp.
Cambridge, MD

16733
Cablewave Systems Inc.
North Haven, CT

16742
Paramount Plastics
Fabricators Inc.
Downey, CA

16758
General Motors Corp.
Delco Electronics Div.
Kokomo, IN

17069
Circuit Structures Lab
Burbank, CA

17117
Electronic Molding Corp.
Woonsocket, RI

17338
High Pressure Eng. Co. Inc.
OK City, OK

17504
Aluminum Filter Co.
Carpinteria, CA

17545
Atlantic Semiconductors Inc.
Asbury Park, NJ

17745
Angstrohm Precision, Inc.
Hagerstown, MD

17856
Siliconix Inc.
Santa Clara, CA

18178
E G & Gvactee Inc.
St. Louis, MO

18235
KRL/Bantry Components Inc.
Manchester, NH

18310
Concord Electronics
New York, NY

18324
Signetics Corp.
Sacramento, CA

18377
Parlex Corp.
Methuen, MA

18520
Sharp Electronics Corp.
Paramus, NJ

18542
Wabash Inc.
Wabash Relay & Electronics Div.
Wabash, IN

18565
Chomerics Inc.
Woburn, MA

18612
Vishay Intertechnology Inc.
Vishay Resistor Products Group
Malvern, PA

18632
Norton-Chemplast
Santa Monica, CA

18677
Scanbe Mfg. Co.
Div. of Zero Corp.
El Monte, CA

18736
Voltronics Corp.
East Hanover, NJ

18786
Micro-Power
Long Island City, NY

18927
GTE Products Corp.
Precision Material Products
Business Parts Div.
Titusville,PA

19080
Robinson Electronics Inc.
San Luis Obispo, CA

19112
Garry Corp.
Langhorne, PA

19315
Bendix Corp., The
Navigation & Control Group
Teterboro, NJ

19451
Perine Machine Tool Corp.
Kent, WA

19482
Delta Electronics
Alexandria, VA

19613
MN Mining & Mfg. Co.
Textool Products Dept.
Electronic Product Div.
Irving, TX

19647
Caddock Electronics Inc.
Riverside, CA

19701
Mepco/Centralab Inc.
A N. American Philips Co.
Mineral Wells, TX

2B178
Wire Products
Cleveland, OH

2K262
Boyd Corporation
Portland, OR

2Y384
North American Philips Lighting Corp.
Van Wert, OH

20584
Enochs Mfg. Inc.
INpolis, IN

20891
Cosar Corp.
Dallas, TX

21317
Electronics Applications Co.
El Monte, CA

21604
Buckeye Stamping Co.
Columbus, OH

21845
Solitron Devices Inc.
Semiconductor Group
Rivera Beach, FL

21847
Aertech
Now TRW Microwave Inc.
Sunnyvale, CA

21962
Vectron Corp.
Replaced by: S.W. Electronics

22526
DuPont, EI DeNemours & Co. Inc.
DuPont Connector Systems
Advanced Products Div.
New Cumberland, PA

22626
Micro Semiconductor
(Now 14552)

22670
GM Nameplate
Seatle, WA

22767
ITT Semiconductors
Palo Alto, CA

22784
Palmer Inc.
Cleveland, OH

23050
Product Comp. Corp.
Mount Vernon, NY

23223
CTS Microelectronics
Lafayette, NY

23237
I.R.C., Inc.
Microcircuits Divison
Philadelphia, PA

23302
S.W. Electronics & Mfg. Corp.
Cherry Hill, NJ

23730
Mark Eyelet and Stamping Inc.
Wolcott, CT

23732
Tracor Applied Sciences Inc.
Rockville, MD

23880
Stanford Applied Engineering
Santa Clara, CA

23936
William J. Purdy Co.
Pamotor Div.
Burlingame, CA

24347
Penn Engineering Co.
S. El Monte, CA

24355
Analog Devices Inc.
Norwood, MA

24444
General Semiconductor
Industries, Inc.
Tempe, AZ

24546
Bradford Electronics
Bradford, PA

24618
Transcon Mfg.
Now: D.J. Associates Inc.

24655
Genrad Inc.
(Replaced General Radio 05173)
Concord, MA

24759
Lenox-Fugle Electronics Inc.
South Plainfield, NJ

24796
AMF Inc.
Potter & Brumfield Div.
San Juan Capistrano, CA

24931
Specialty Connector Co.
Greenwood, IN

24995
ECS
Grants Pass, OR

25088
Siemen Corp.
Isilen, NJ

25099
Cascade Gasket
Kent, WA

25403
Amperex Electronic Corp.
Semiconductor & Micro-Circuit Div.
Slatersville, RI

25435
Moldtronics, Inc
Downers Grove, IL

25706
Dabum Electronic & Cable Corp.
Norwood, NJ

26402
Lumex,Inc.
Bayshore, NY

26629
Frequency Sources Inc.
Sources Div.
Chelmsford, MA

26806
American Zettler Inc.
Irvine, CA

27014
National Semiconductor Corp.
Santa Clara, CA

27167
Corning Glass Works Corning
Electronics
Wilmington, NC

27264
Molex Inc.
Lisle, IL

27440
Industrial Screw Products
Los Angeles, CA

27494
Staffall, Inc.
Providence, RI

27745
Associated Spring Barnes Group Inc.
Syracuse, NY

27918
Component Parts Corp.
Bellmore, NY

27956
Relcom (Now 14482)

28175
Alpha Metals
Chicago, IL

28198
Positronic Industries
Springfield, MO

28213
MN Mining & Mfg. Co.
Consumer Products Div.
3M Center
Saint Paul, MN

28309
Kaiser
Minette,AL.

28425
Serv-O-Link
Euless, TX

28478
Deltrol Corporation
Deltrol Controls Div.
Milwaukee, WI

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, CA

Federal Supply Codes for Manufacturers (cont)

28484
Emerson Electric Co.
Gearmaster Div.
McHenry, IL

28520
Heyco Molded Products
Kenilworth, NJ

28932
Lumax Industrials, Inc
Altoona, PA

29083
Monsanto Co.
Santa Clara, CA

29604
Stackpole Components Co.
Raleith, NC

29907
Omega Engineering Inc.
Stamford, CT

3D536
Aimsco Inc.
Seattle, WA

30035
Jolo Industries Inc.
Garden Grove, CA

30045
Solid Power Corp.
Farmingdale, NY

30146
Symbex Corp.
Painesville, OH

30148
AB Enterprise Inc.
Ahoskie, NC

30161
Aavid Engineering Inc.
Laconia, NH

30315
Itron Corp.
San Diego, CA

30323
IL Tool Works Inc.
Chicago, IL

30800
General Instrument Corp.
Capacitor Div.
Hicksville, NY

30838
Fastec
Chicago,ILL

31019
Solid State Scientific Inc.
Willow Grove, PA

31091
Alpha Industries Inc.
Microelectronics Div.
Hatfield, PA

31323
Metro Supply Company
Sacramento, CA

31433
Kemet Electonics Corp.
Simpsonville, NC

31448
Army Safeguard Logistics Command
Huntsville, AL

31471
Gould Inc
Semiconductor Div
Santa Clara, CA

31522
Metal Masters Inc.
Baldwin, MS

31746
Cannon Electric
Woodbury, TN

31827
Budwig
Ramona, CA

31918
ITT-Schadow
Eden Prairie, MN

32293
Intersil
Cupertino, CA

32539
Mura Corp.
Westbury, Long Island, N.Y.

32559
Bivar
Santa Ana, CA

32719
Siltronics
Santa Ana, CA

32767
Griffith Plastics Corp.
Burlingame, CA

32879
Advanced Mechanical Components
Northridge, CA

32897
Murata Erie North America Inc.
Carlisle Operations
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Div.
Riverside, CA

33025
M/A ComOmni Spectra, Inc. (Replacing Omni Spectra)
Microwave Subsystems Div.
Tempe, AZ

33096
CO Crystal Corp.
Loveland, CO

33173
General Electric Co.
Owensboro, KY

33246
Epoxy Technology Inc.
Billerica, MA

33292
Pioneer Sterilized Wiping Cloth Co.
Portland, OR

33297
NEC Electronics USA Inc.
Electronic Arrays Inc. Div.
Mountain View, CA

33919
Nortek Inc.
Cranston, RI

34114
Oak Industries
Rancho Bernardo, CA

34263
CTS Electronics Corp.
Brownsville,TX

34333
Silicon General Inc.
Garden Grove, CA

34335
Advanced Micro Devices (AMD)
Sunnyvale, CA

34359
MN Mining & Mfg. Co.
Commercial Office Supply Div.
Saint Paul, MN

34371
Harris Corp.
Harris Semiconductor
Products Group
Melbourne, FL

34576
Rockwell International Corp.
Newport Beach, CA

34641
Instrument Specialties
Euless, TX

34649
Intel Corp.
Santa Clara, CA

34802
Electromotive Inc.
Kenilworth, NJ

34848
Hartwell Special Products
Placentia, CA

35009
Renfrew Electric Co. Ltd.
IRC Div.
Toronto, Ontario, Canada

35986
Amrad
Melrose Park, IL

36665
Mitel Corp.
Kanata, Ontario, Canada

36701
Van Waters & Rogers
Valley Field, Quebec, Canada

37942
Mallory Capacitor Corp.
Sub of Emhart Industries
INpolis, IN

39003
Maxim Industries
Middleboro, MA

4F434
Plastic Sales
Los Angeles, CA

40402
Roderstein Electronics Inc.
Statesville, NC

42498
National Radio
Melrose, MA

43543
Nytronics Inc.(Now 53342)

43744
Panasonic Industrial Co.
San Antonio, TX

43791
Datron Systems
Wilkes Barre, PA

44655
Ohmite Mfg. Co.
Skokie, IL

47001
Lumberg Inc.
Richmond, VA

47379
ISOCOM
Campbell, CA

49569
IDT (International Development & Trade)
Dallas, TX

49671
RCA Corp.
New York, NY

49956
Raytheon Company
Executive Offices
Lexington, MA

5D590
Mostek Corp.
Replaced by: SGS Thompson Microelectronics

5F520
Panel Components Corp.
Santa Rosa, CA

5P575
Nobel Electronics
Suffern, NY

5W664
NDK
Div. of Nihon Dempa Kogyo LTD
Lynchburg, VA

5U802
Dennison Mfg. Co.
Framingham, MA

50088
SGS - Thomson Microelectronics Inc.
Carrollton, TX

50120
Eagle-Picher Industries Inc.
Electronics Div.
CO Springs, CO

50157
Midwest Components Inc.
Muskegon, MS

50356
Teac Corp. of America
Industrial Products Div
Montebello, CA

50364
MMI, Inc.(Monolithic Memories Inc)
Military Products Div.
Santa Clara, CA

50472
Metal Masters, Inc.
City of Industry, CA

50541
Hypertronics Corp.
Hudson, MA

50558
Electronic Concepts, Inc.
Eatontown, NJ

50579
Litronix Inc.
Cupertino, CA

50891
Semiconductor Technology
Stuart, FL

50934
Tran-Tec Corp
Columbus, NE

51167
Aries Electronics Inc.
Frenchtown, NJ

51284
Mos Technology
Norristown, PA

51249
Heyman Mfg. Co.
Cleveland, OH

51372
Verbatim Corp.
Sunnyvale, CA

51398
MUPAC Corp.
Brockton, MA

51406
Murata Erie, No. America Inc.
(Also see 72982)
Marietta, GA

51499
Amtron Corp.
Boston, MA

51506
Accurate Screw Machine Co.
(ASMCO) Nutley, NJ

51605
CODI Semiconductor Inc.
Kenilworth, NJ

51642
Centre Engineering Inc.
State College, PA

51705
ICO/Rally
Palo alto, CA

51791
Statek Corp.
Orange, CA

51984
NEC America Inc.
Falls Church, VA

52063
Exar Integrated Systems
Sunnyvale, CA

52072
Circuit Assembly Corp.
Irvine, CA

52152
MN Mining & Mfg.
Saint Paul, MN

52333
API Electronics
Haugpauge,Long Island,NY

52361
Communication Systems
Piscataway, NJ

52500
Amphenol, RF Operations
Burlington, MA

52525
Space-Lok Inc.
Lerco Div.
Burbank, CA

52531
Hitachi Magnetics
Edmore, MO

52745
Timco
Los Angeles, CA

52763
Stettner-Electronics Inc.
Chattanooga, TN

52769
Sprague-Goodman Electronics Inc.
Garden City Park, NY

52771
Monitorm Corp.
Amatrom Div.
Santa Clara, CA

52840
Western Digital Corp.
Costa Mesa, CA

53021
Sangamo Weston Inc.
(See 06141)

53036
Textool Co.
Houston, TX

53184
Xciton Corp.
Lathan, NY

53217
Technical Wire Products Inc.
Santa Barbara, CA

53342
Opt Industries Inc.
Phillipsburg, NJ

53673
Thompson CSF Components Corp.
(Semiconductor Div)
Conaga Park, CA

53718
Airmold/W. R. Grese & Co.
Roanoke Rapids, NC

53848
Standard Microsystems
Hauppauge, NY

53894
AHAM Inc.
RanchoCA, CA

53944
Glow-Lite
Pauls Valley, OK

54178
Plasmetex Industries Inc.
San Marcos, CA

54294
Shalloross Inc.
Smithfield, NC

54453
Sullins Electronic Corp.
San Marcos, CA

54473
Matsushita Electric Corp.
(Panasonic)
Secaucus, NJ

54492
Cinch Clamp Co., Inc.
Santa Rosa, CA

54583
TDK
Garden City, NY

54590
RCA Corp
Distribution & Special Products
Cherry Hill, NY

54869
Pihor International Corp.
Arlington Heights, IL

54937
DeYoung Mfg.
Bellevue, WA

54590
RCA Corp.
Electronic Components Div.
Cherry Hill, NJ

55026
American Gage & Machine Co.
Simpson Electric Co. Div.
Elgin, IL

55112
Plessey Capacitors Inc.
(Now 60935)

55261
LSI Computer Systems Inc.
Melville, NY

55285
Bercquist Co.
Minneapolis, MN

55322
Samtech Inc.
New Albany, IN

55408
STI-CO Industries Co
Buffalo, NY

55464
Central Semiconductor Corp.
Hauppauge, NY

55557
Microwave Diode Corp.
W.Stewarstown, NH

55566
R A F Electronic Hardware Inc.
Seymour, CT

55576
Synertek
Santa Clara, CA

55680
Nichicon/America/Corp.
Schaumburg, IL

55943
D J Associates, Inc
(Replaced Transcon Mfg.-24618)
Fort Smith, AZ

56282
Utek Systems Inc.
Olathe, KS

56289
Sprague Electric Co.
North Adams, MA

56365
Square D Co.
Corporate Offices
Palatine, IL

56375
WESCORP
Div. Dal Industries Inc
Mountain View, CA

56481
Shugart Associates
Sub of Xerox Corp.
Sunnyvale, CA

56637
RCD Components Inc.
Manchester, NH

56708
Zilog Inc.
Campbell, CA

56856
Vamistor Corp. of TN
Sevierville, TN

56880
Magnetics Inc.
Baltimore, MD

57026
Endicott Coil Co. Inc.
Binghamton, NY

57053
Gates Energy Products
Denver, CO

57170
Cambridge Thermionic
Cambridge, MA
Replaced by:
71279
Interconnection Products Inc.

57668
R-ohm Corp
Irvine, CA

57962
SGS - Thomson Microelectronics Inc
Montgomeryville, PA

58014
Hitachi Magnalock Corp.
(Now 12581)

58104
Simco
Atlanta, GA

58364
BYCAP Inc.
Chicago, IL

58451
Precision Lamp
Cotat, CA

58474
Superior Electric Co.
Bristol, CT

58614
Communications Instruments Inc.
Fairview, NC

59124
KOA-Speer Electronics Inc.
Bradford, PA

59422
Holmberg Electronics
Irvine, CA

59610
Souriau Inc
Valencia, CA

59635
HV Component Associates
Howell, NJ

59640
Supertex Inc.
Sunnyvale, CA

59660
Tusonix Inc.
Tucson, AZ

59730
Thomas and Betts Corp.
IA City, IA

59831
Semtronics Corp.
Watchung, NJ

6H053:
American Components Inc.
an Insilco Co. RPC Div.
Hayesville, NC

6L611
Allen, Robert G. Inc.
Van Nuys, CA

6U850
Burgess Switch Co., Inc
Northbrook, IL

6U095
AMD Enterprises, Inc.
Roswell, GA

6X403
SGS/ATES Semiconductor Corp.
INpolis, IN

6Y440
Micron Technology Inc.
Boise, ID

60046
Power Dynamics Inc
West Orange, NJ

60197
Precicontact Inc.
Langhorne, PA

60386
Squires Electronics Inc
Cornelius, OR

60395
Xicor Inc.
Milpitas, CA

60399
Torin Engineered Blowers
Div. of Clevepak Corp.
Torrington, CT

60496
Micrel Inc.
Sunnyvale, CA

60705
Cera-Mite Corp.
(formerly Sprague)
Grafton, WI

60911
Inmos Corp.
CO Springs, CO

60935
Westlake Capacitor Inc.
Tantalum Div.
Greencastle, IN

60958
ACIC
Intercomp Wire & Cable Div.
Hayesville, NC

61271
Fujitsu Microelectronics Inc
San Jose, CA

61394
SEEQ Technology Inc.
San Jose, CA

61429
Fox Electronics
Cape Coral, FL

61529
Aromat Corp.
New Providence, NJ

61752
IR-ONICS Inc
Warwick, RI

61772
Integrated Device Technology
Santa Clara, CA

61802
Toshiba
Houston, TX

61857
SAN-O Industrial Corp.
Bohemia, Long Island, NY

61935
Schurter Inc.
Petaluma, CA

62351
Apple Rubber
Lancaster, NY

62643
United Chemicon
Rosemont, IL

62712
Seiko Instruments
Torrance, CA

62793
Lear Siegler Inc.
Energy Products Div.
Santa Ana, CA

63743
Ward Leonard Electric Co.Inc.
Mount Vernon, NY

64154
Lamb Industries
Portland, OR

64155
Linear Technology
Milpitas, CA

64537
KDI Electronics
Whippany, NJ

64782
Precision Control Mfg. Inc.
Bellevue, WA

64834
West M G Co.
San Francisco, CA

64961
Electronic Hardware LTD
North Hollywood, CA

65092
Sangamo Weston Inc.
Weston Instruments Div.
Newark, NJ

65786
Cypress Semi
San Jose, CA

65940
Rohm Corp & Whatney
Irvine, CA

65964
Evox Inc.
Bannockburn, IL

66150
Entron Inc.
Winslow Teltronics Div.
Glendale, NY

66302
VLSI Technology Inc.
San Jose, CA

66419
Exel
San Jose, CA

66450
Dyna-Tech Electronics, Inc
Walled Lake, MI

66608
Bering Industries
Freemont, CA

66891
BKC International Electronics
Lawrence, MA

66958
SGS Semiconductor Corp.
Phoenix, AZ

66967
Powerex Inc
Auburn, NY

67183
Altera
Santa Clara, CA

68919
WIMA
% Harry Levinson Co.
Seattle, WA

7F361
Richmond-Division of Dixico
% Zellerbach Paper Co.
Seattle, WA

7F844
Moore Business Forms, Inc
Seattle, WA

7G902
Textron Inc.
Camcar Div.
Rockford, IL

7J395
Universal Plastics
Welshpool, WA

7J696
AMD Plastics
East Lake, OH

7K354
Omni Spectra Inc
Los Altos, CA

7Z884
ALPS
Seattle, WA

7X634
Duracell USA
Div. of Dart & Kraft Inc.
Valdese, NC

70290
Almetal Universal Joint Co.
Cleveland, OH

70485
Atlantic India Rubber Works Inc.
Chicago, IL

70563
Amperite Company
Union City, NJ

70903
Cooper-Belden Corp.
Geneva, IL

71002
Bimbach Co. Inc.
Farmingdale, NY

71034
Bliley Electric Co.
Erie, PA

71183
Westinghouse Electric Corp.
Bryant Div.
Bridgeport, CT

71279
Interconnection Products Inc.
Formerly Midland-Ross Cambion Div.
Santa Ana, CA

71400
Bussman Manufacturing
Div. McGraw-Edison Co.
St. Louis, MO

71450
CTS Corp.
Elkhart, IN

71468
ITT Cannon Div. of ITT
Fountain Valley, CA

71482
General Instrument Corp.
Clare Div.
Chicago, IL

71590
Mepco/Centralab
A North American Philips Co.
Fort Dodge, IA

71707
Coto Corp.
Providence, RI

71744
General Instrument Corp.
Lamp Div/Worldwide
Chicago, IL

71785
TRW Inc.
Cinch Connector Div.
Elk Grove Village, IL

71984
Dow Corning Corp.
Midland, MI

72005
AMAX Specialty Metals Corp.
Newark, NJ

72136
Electro Motive Mfg. Corp.
Florence, NC

72228
AMCA International Corp.
Continental Screw Div.
New Bedford, MA

72259
Nytronics Inc.
New York, NY

72619
Amperex Electronic Corp.
Dialight Div.
Brooklyn, NY

72653
G C Electronics Co.
Div. of Hydrometals Inc.
Rockford, IL

72794
Dzus Fastner Co. Inc.
West Islip, NY

72928
Gulton Industries Inc.
Guderman Div.
Chicago, IL

72962
Elastic Stop Nut
Div. of Harrard Industries
Union, NJ

72982
Erie Specialty Products, Inc
Formerly: Murata Erie
Erie, PA

73138
Beckman Industrial corp.
Helipot Div.
Fullerton, CA

73168
Fenwal Inc.
Ashland, MA

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, CA

73445
Amperex Electronic Corp.
Hicksville, NY

73559
Carlingswitch Inc.
Hartford, CT

73586
Circle F Industries
Trenton, NJ

73734
Federal Screw Products Inc.
Chicago, IL

73743
Fischer Special Mfg. Co.
Cold Spring, KY

73893
Microdot
Mt. Clemens, MS

73899
JFD Electronic Components
Div. of Murata Erie
Oceanside, NY

73905
FL Industries Inc.
San Jose, CA

73949
Guardian Electric Mfg. Co.
Chicago, IL

74199
Quam Nichols Co.
Chicago, IL

74217
Radio Switch Co.
Marlboro, NJ

74306
Piezo Crystal Co.
Div. of PPA Industries Inc.
Carlisle, PA

74445
Holo-Krome Co.
Elmwood, CT

74542
Hoyt Elect.Instr. Works Inc.
Penacook, NH

74840
IL Capacitor Inc.
Lincolnwood, IL

74970
Johnson EF Co.
Waseca, MN

75042
TRW Inc.
IRC Fixed Resistors
Philadelphia, PA

75297
Kester Solder Div.
Litton Systems, Inc
Des Plaines, IL

75376
Kurz-Kasch Inc.
Dayton, OH

75378
CTS Knights Inc.
Sandwich, IL

75382
Kulka Electric Corp.
(Now 83330)
Mount Vernon, NY

75569
Performance Semiconductor Corp.
Sunnyvale, CA

75915
Littelfuse Tracor
(Formerly: Tracor-Littelfuse)
Des Plaines, IL

76854
Oak Switch Systems Inc.
Crystal Lake, IL

77122
TRW Assemblies & Fasteners Group
Fastener Div.
Moutainside, NJ

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, IN

77542
Ray-O-Vac Corp
Madison, WI

77638
General Instrument Corp.
Rectifier Div.
Brooklyn, NY

77900
Shakeproof Lock Washer Co.
(Now 78189)

77969
Rubbercraft Corp. of CA Ltd.
Torrance, CA

78189
IL Tool Works Inc.
Shakeproof Div.
Elgin, IL

78277
Sigma Instruments Inc.
South Braintree, MA

78290
Struthers Dunn Inc.
Pitman, NJ

78553
Eaton Corp.
Engineered Fastener Div.
Cleveland, OH

Federal Supply Codes for Manufacturers (cont)

78592
Stoeger Industries
South Hackensack, NJ

79497
Western Rubber Co.
Goshen, IN

79727
C - W Industries
Southampton, PA

79963
Zierick Mfg. Corp.
Mount Kisco, NY

8C798
Ken-Tronics, Inc.
Milan, IL

8D528
Baumgartens
Atlanta, GA

8F330
Eaton Corp.
Cutler Hammer Product Sales Office
Mountain View, CA

8T100
Tellabs Inc.
Naperville, IL

80009
Tektronix
Beaverton, OR

80031
Mepco/Electra Inc.
Morristown, NJ

80032
Ford Aerospace &
Communications Corp.
Western Development
Laboratories Div.
Palo Alto, CA

80145
LFE Corp.
Process Control Div.
Clinton, OH

80183
Sprague Products
(Now 56289)

80294
Bourns Instruments Inc.
Riverside, CA

80583
Hammerlund Mfg. Co. Inc.
Paramus, NJ

80640
Computer Products Inc.
Stevens-Arnold Div.
South Boston, MA

81073
Grayhill Inc.
La Grange, IL

81312
Litton Systems Inc.
Winchester Electronics Div.
Watertown, CT

81439
Therm-O-Disc Inc.
Mansfield, OH

81483
International Rectifier Corp.
Los Angeles, CA

81590
Korry Electronics Inc.
Seattle, WA

81741
Chicago Lock Co.
Chicago, IL

82227
Airpax Corp.
Cheshire Div.
Cheshire, CT

82240
Simmons Fastner Corp.
Albany, NY

82305
Palmer Electronics Corp.
South Gate, CA

82389
Switchcraft Inc.
Sub of Raytheon Co.
Chicago, IL

82415
Airpax Corp
Frederick Div.
Frederick, MD

82872
Roanwell Corp.
New York, NY

82877
Rotron Inc.
Custom Div.
Woodstock, NY

82879
ITT
Royal Electric Div.
Pawtucket, RI

83003
Varo Inc.
Garland, TX

83014
Hartwell Corp.
Placentia, CA

83055
Signalite Fuse Co.
(Now 71744)

83058
TRW Assemblies & Fasteners Group
Fasteners Div.
Cambridge, MA

83259
Parker-Hannifin Corp.
O-Seal Div.
Culver City, CA

83298
Bendix Corp.
Electric & Fluid Power Div.
Eatonville, NJ

83315
Hubbell Corp.
Mundelein, IL

83330
Kulka Smith Inc.
A North American Philips Co.
Manasquan, NJ

83478
Rubbercraft Corp. of America
West Haven, CT

83553
Associated Spring Barnes Group
Gardena, CA

83740
Union Carbide Corp.
Battery Products Div.
Danbury, CT

84171
Arco Electronics
Commack, NY

84411
American Shizuki
TRW Capacitors Div.
Ogallala, NE

84613
FIC Corp.
Rockville, MD

84682
Essex Group Inc.
Peabody, MA

84830
Lee Spring Co. Inc
Brooklyn, NY

85367
Bearing Distributing Co.
San Fransisco, CA

85372
Bearing Sales Co.
Los Angeles, CA

85480
W. H. Brady Co.
Industrial Product
Milwaukee, WI

85840
Brady WH Co
Industrial Products Div
Milwaukee, WI

85932
Electro Film Inc.
Valencia, CA

86577
Precision Metal Products Co.
Peabody, MA

86684
Radio Corp. of America
(Now 54590)

86928
Seastrom Mfg. Co. Inc.
Glendale, CA

87034
Illuminated Products Inc.
(Now 76854)

87516
Standard Crystal
KS City, KS

88044
Aeronautical Standards Group
Dept. of Navy & Air Force

88219
GNB Inc.
Industrial Battery Div.
Langhorne, PA

88245
Winchester Electronics
Litton Systems-Useco Div.
Van Nuys, CA

88486
Triangle PWC Inc.
Jewitt City, CT

88690
Essex Group Inc.
Wire Assembly Div.
Dearborn, MI

88786
Atlantic India Rubber Co.
Goshen, IN

88978
Philips (Now Fluke)
Mahwah, NJ

89020
Amerace Corp.
Buchanan Crimptool Products Div.
Union, NJ

89265
Potter-Brumfield
(See 77342)

89462
Waldes Truarc, Inc.
Long Island, NY

89536
John Fluke Mfg. Co., Inc.
Everett, WA

89597
Fredericks Co.
Huntingdon Valley, PA

89709
Bunker Ramo-Eltra Corp.
Amphenol Div.
Broadview, IL

89730
General Electric
Lamp Div.
Newark, NJ

9R216
Data Composition Svc, Inc
Laurel, MD

9S171
Port Plastics
Tukwila, WA

9W423
Amatom
El Mont, CA

90201
Mallory Capacitor Co.
Sub of Emhart Industries Inc.
Indianapolis, IN

90215
Best Stamp & Mfg. Co.
KS City, MO

90303
Duracell Inc.
Technical Sales & Marketing
Bethel, CT

91094
Essex Group Inc.
Suflex/IWP Div.
Newmarket, NH

91247
IL Transformer Co.
Chicago, IL

91293
Johanson Mfg. Co.
Boonton, NJ

91462
Alpha Industries Inc.
Logansport, IN

91502
Associated Machine
Santa Clara, CA

91506
Augat Alcoswitch
N. Andover, MA

91507
Froeliger Machine Tool Co.
Stockton, CA

91637
Dale Electronics Inc.
Columbus, NE

91662
Elco Corp.
A Gulf Western Mfg. Co.
Connector Div.
Huntingdon, PA

91737
ITT Cannon/Gremar
(Now 08718)

91802
Industrial Devices Inc.
Edgewater, NJ

91833
Keystone Electronics Corp.
NY, NY

91836
King's Electronics Co. Inc.
Tuckahoe, NY

91929
Honeywell Inc.
Micro Switch Div.
Freeport, IL

91934
Miller Electric Co.
Woonsocket, RI

91967
National Tel-Tronics
Div. of electro Audio Dynamics Inc
Meadville, PA

91984
Maida Development Co.
Hampton, VA

91985
Norwalk Valve Co.
S. Norwalk, CT

92218
Wakefield Corp., The
Wakefield, ME

92527
VTC Inc.
Bloomington, MN

92607
Tensolite Co.
Div. of Carlisle Corp.
Buchanan, NY

92914
Alpha Wire Corp.
Elizabeth, NJ

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, MA

94144
Raytheon Co.
Microwave & Power Tube Div.
Quincy, MA

94222
Southco Inc.
Concordville, PA

94988
Wagner Electric Corp.
Sub of Mcgraw-Edison Co.
Whippany, NJ

95146
Alco Electronic Products Inc.
Switch Div.
North Andover, MA

95263
Leecraft Mfg. Co.
Long Island City, NY

95275
Vitramon Inc.
Bridgeport, CT

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, OH

95348
Gordo's Corp.
Bloomfield, NJ

95354
Methode Mfg. Corp.
Rolling Meadows, IL

95573
Campion Laboratories Inc.
Detroit, MI

95712
Bendix Corp.
Electrical Comp. Div.
Franklin, IN

95987
Weckesser Co. Inc.
(Now 85480)

96733
SFE Technologies
San Fernando, CA

96853
Gulton Industries Inc.
Measurement & Controls Div.
Manchester, NH

96881
Thomson Industries Inc.
Port WA, NY

97464
Industrial Retainer Ring
Irvington, NJ

97525
EECO Inc.
Santa Ana, CA

97540
Whitehall Electronics Corp.
Master Mobile Mounts Div.
Fort Meyers, FL

97913
Industrial Electronic
Hardware Corp.
NY, NY

97945
Pennwalt Corp.
SS White Industrial Products
Piscataway, NJ

97966
CBS
Electronic Div.
Danvers, MA

98094
Machlett Laboratories Inc.
Santa Barbara. CA

98159
Rubber-Teck Inc.
Gardena, CA

98278
Malco A Microdot Co.
South Pasadena, CA

98291
Sealectro Corp.
BICC Electronics
Trumbill, CT

98372
Royal Industries Inc.
(Now 62793)

98388
Lear Siegler Inc.
Accurate Products Div.
San Deigo, CA

98978
IERC
(International Electronic Research Corp.)
Burbank, CA

99120
Plastic Capacitors Inc.
Chicago, IL

99217
Bell Industries Inc.
Elect. Distributor Div.
Sunnyvale, CA

99378
ATLEE of DE Inc.
N. Andover, MA

99392
Mepco/Electra Inc.
Roxboro Div.
Roxboro, NC

99515
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Bunker Ramo- Eltra Corp.
Barnes Div.
Lansdown, PA

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Section 8
Schematic Diagrams

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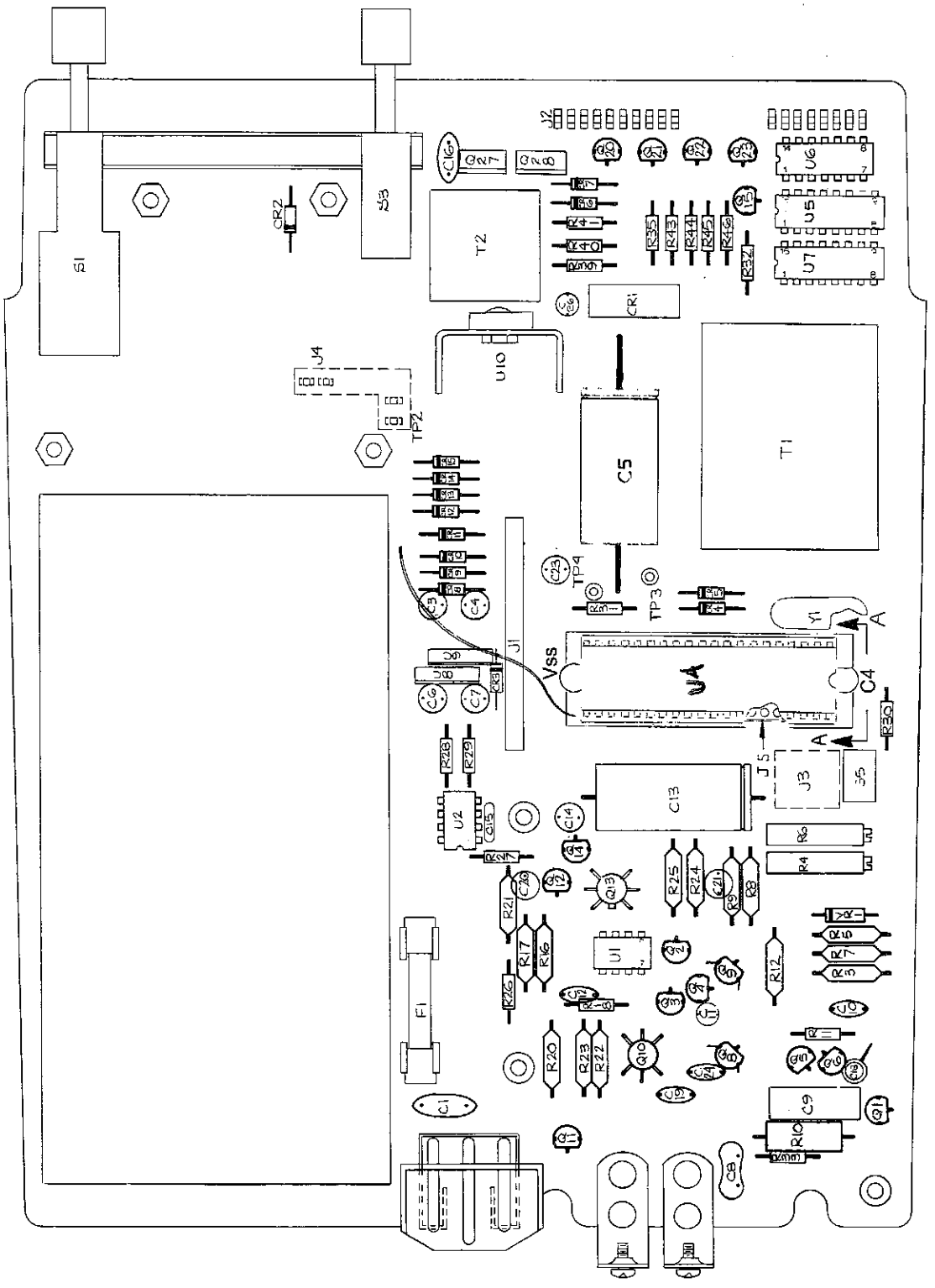


Figure 8-1. A1 Thermometer PCB Assembly

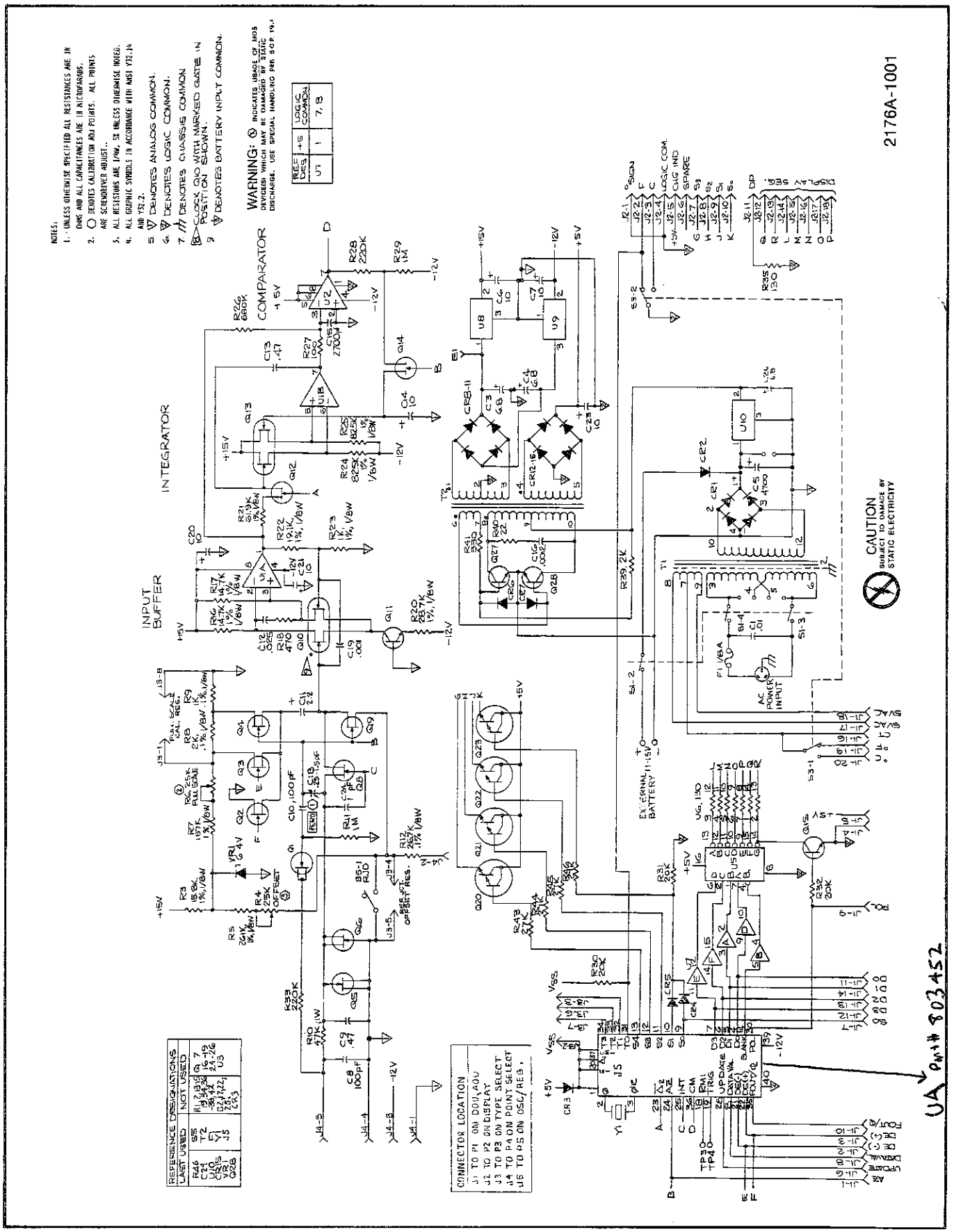
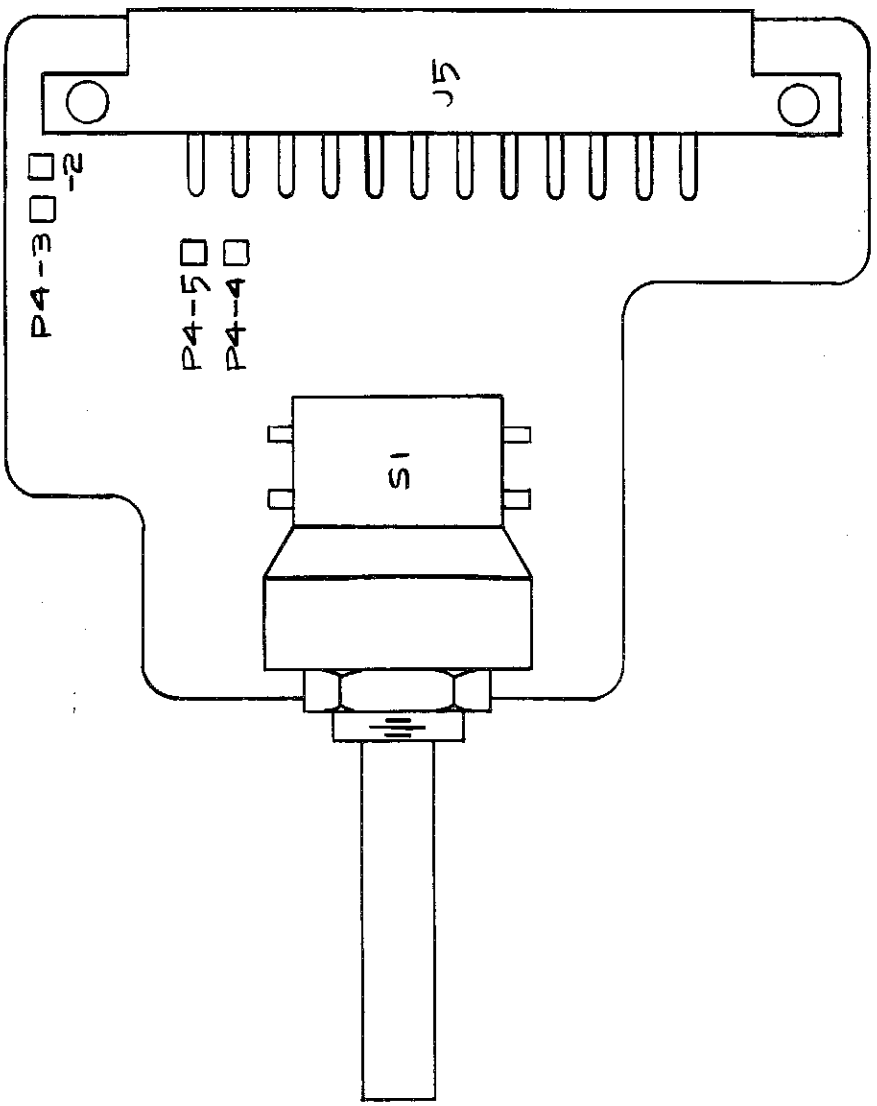


Figure 8-1. A1 Thermometer PCB Assembly (cont)



2166A-1602

Figure 8-2. A2 Point Select PCB Assembly

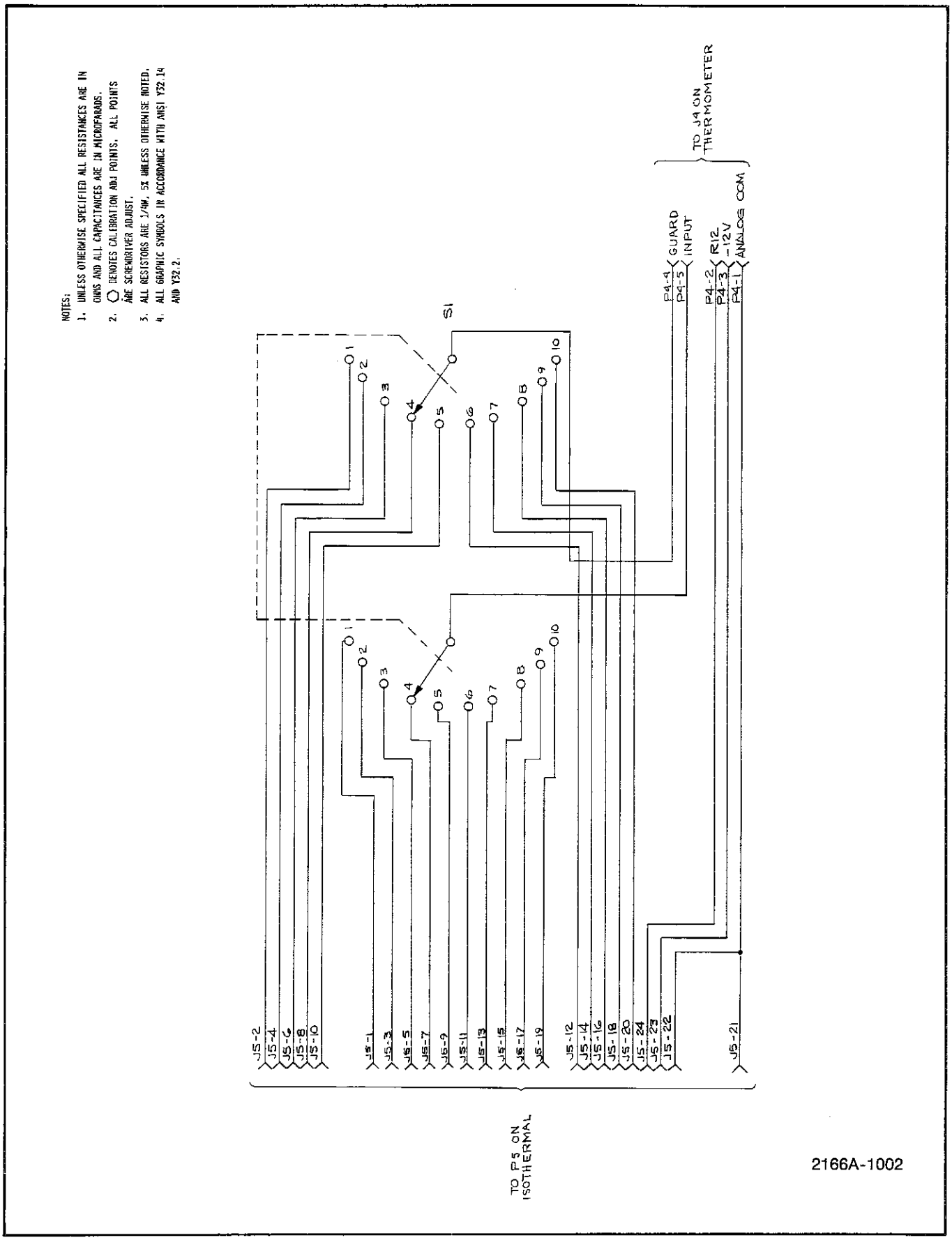


Figure 8-2. A2 Point Select PCB Assembly (cont)

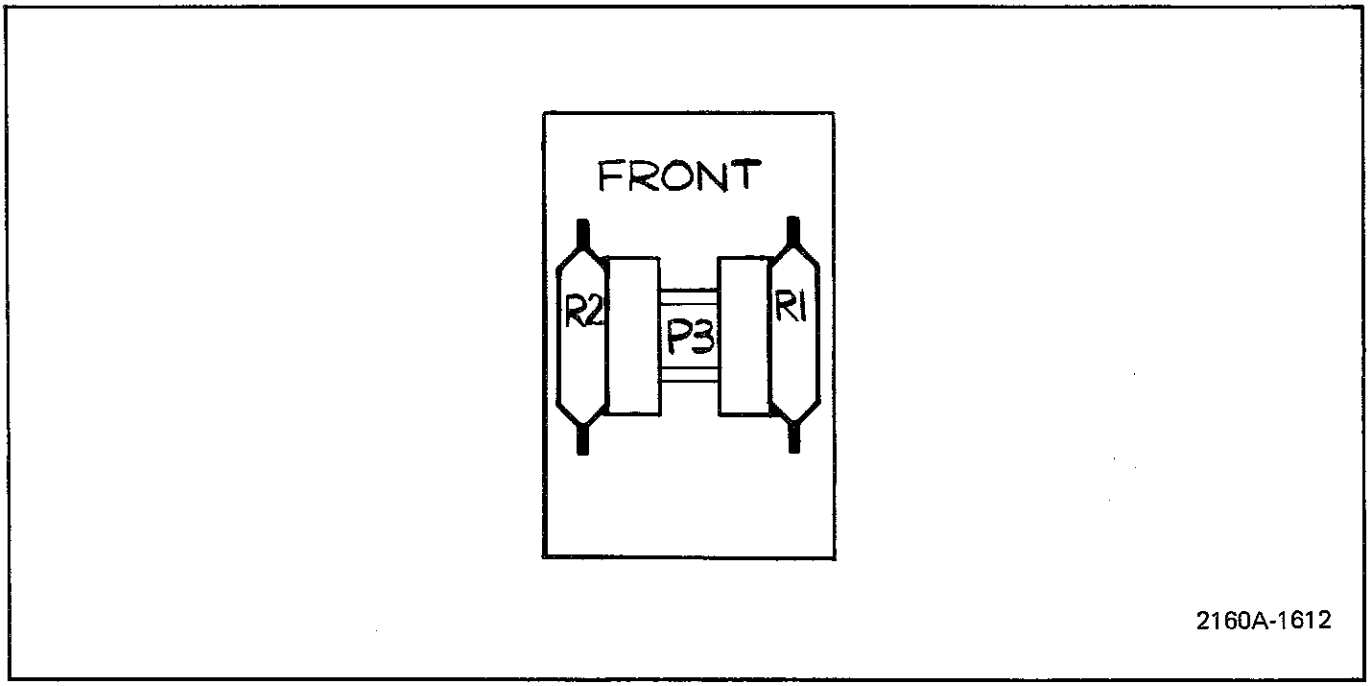


Figure 8-4. A4 Type Select PCB Assembly

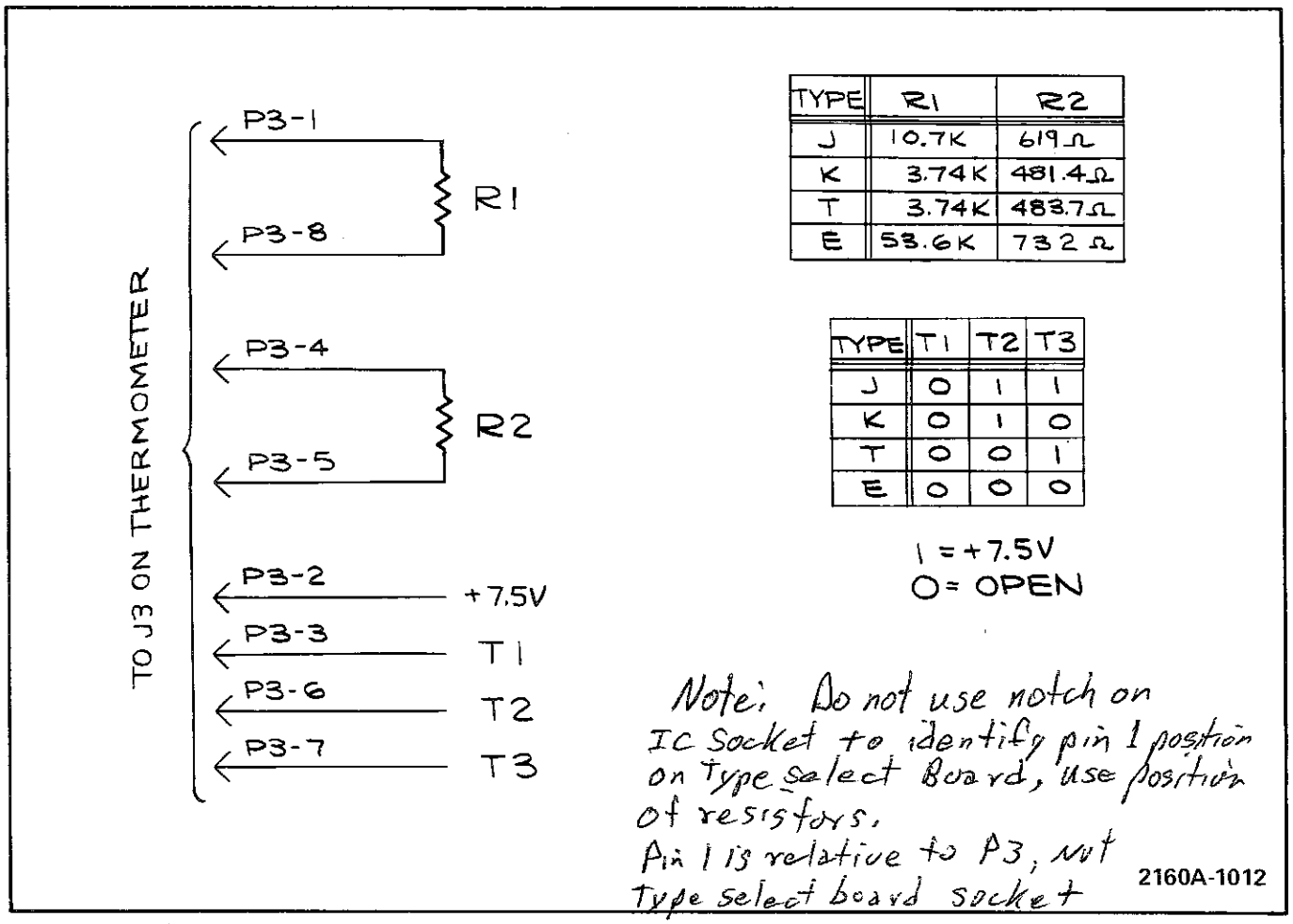
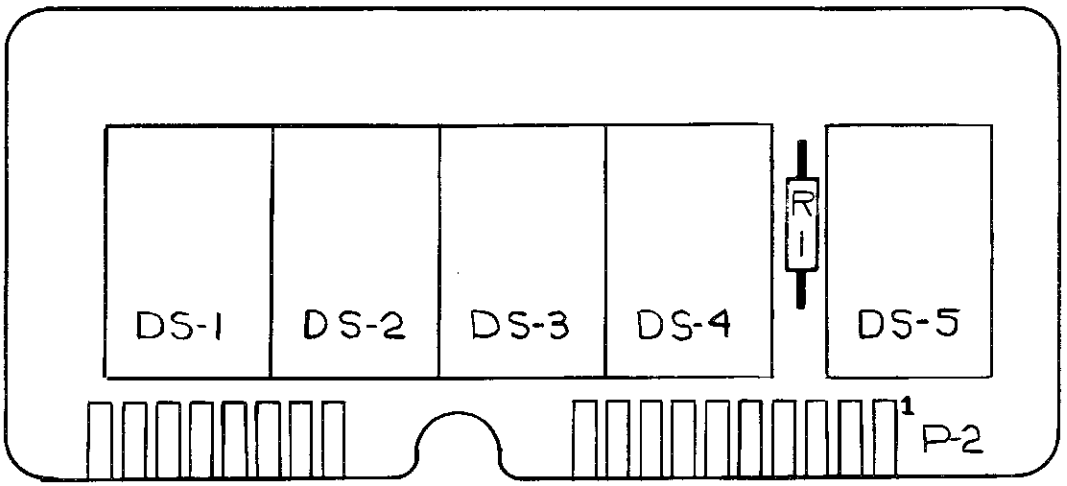


Figure 8-4. A4 Type Select PCB Assembly (cont)



2165A-1603

Figure 8-5. A5 Display PCB Assembly

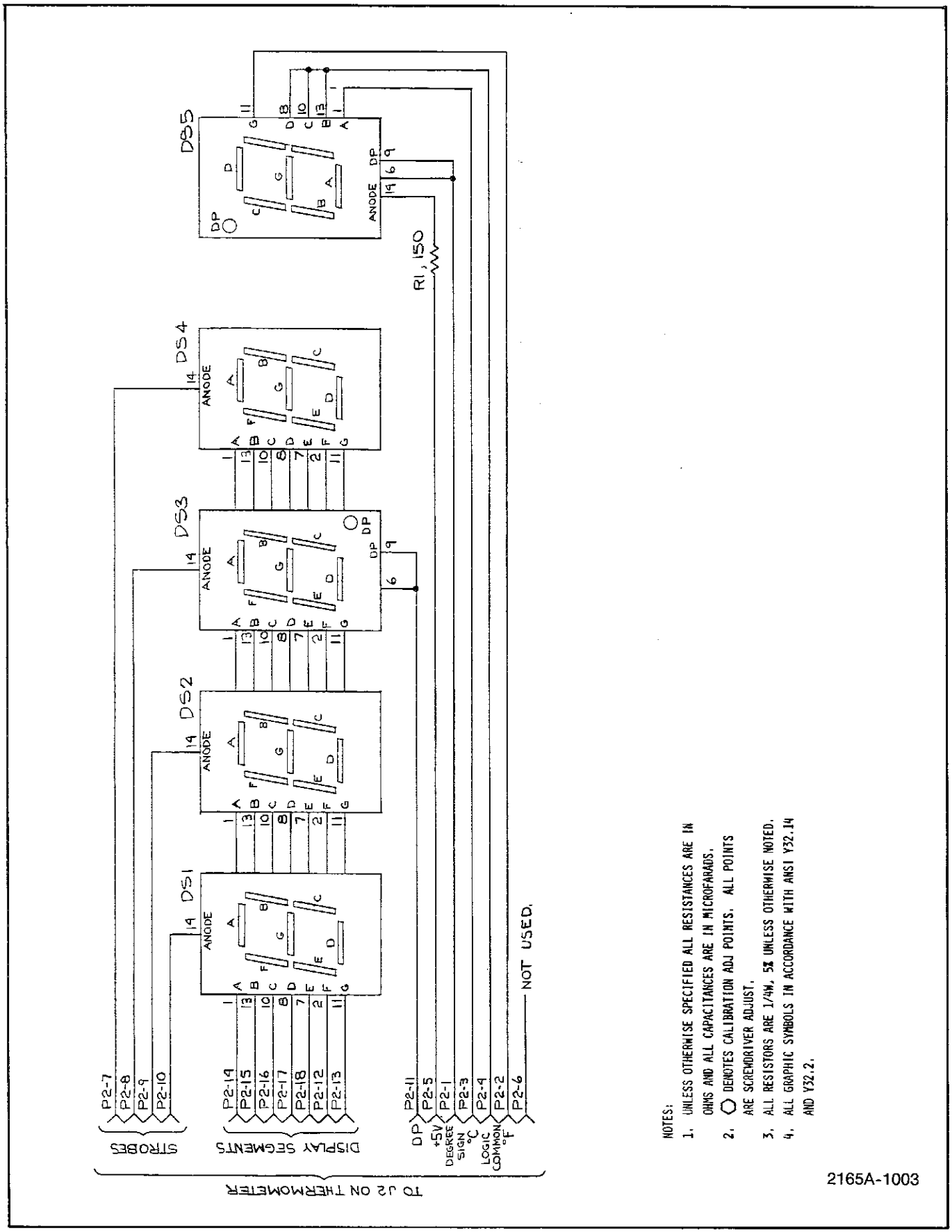
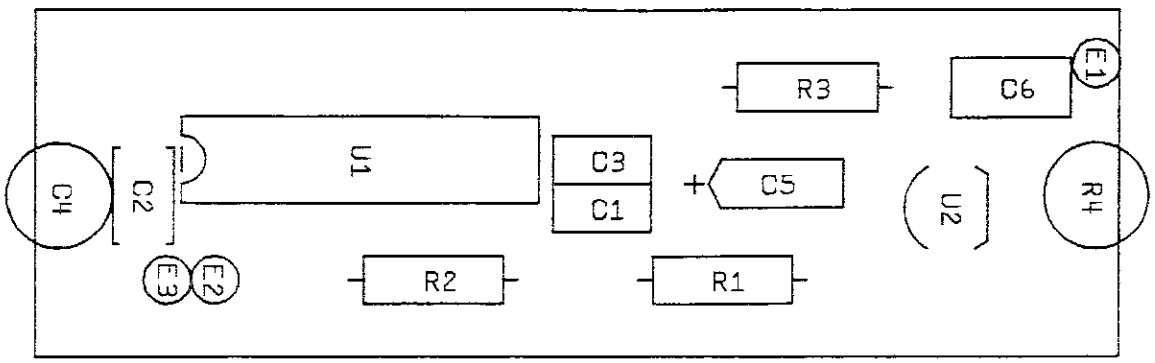
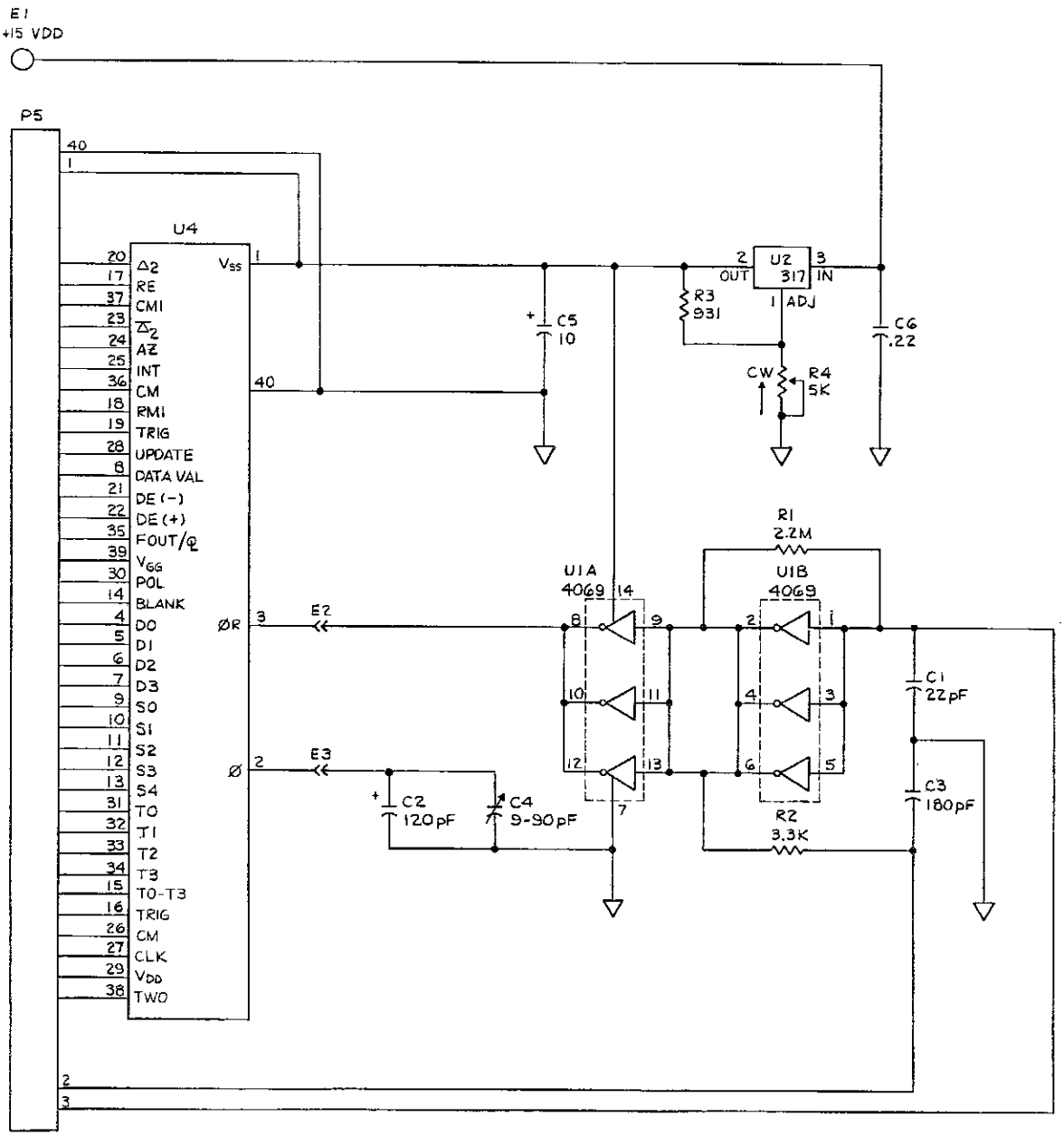


Figure 8-5. A5 Display PCB Assembly (cont)



2160A-1622

Figure 8-6. A6 Oscillator Regulator PCB Assembly



NOTES: UNLESS OTHERWISE SPECIFIED.

1. ALL RESISTANCES ARE IN OHMS.
2. ALL CAPACITANCES ARE IN MICROFARADS.

REFERENCE DESIGNATION	
LAST USED	NOT USED
C6	
R4	
U4	U3
P5	P1-4
E3	

2160A-1022

Figure 8-6. A6 Oscillator Regulator PCB Assembly (cont)