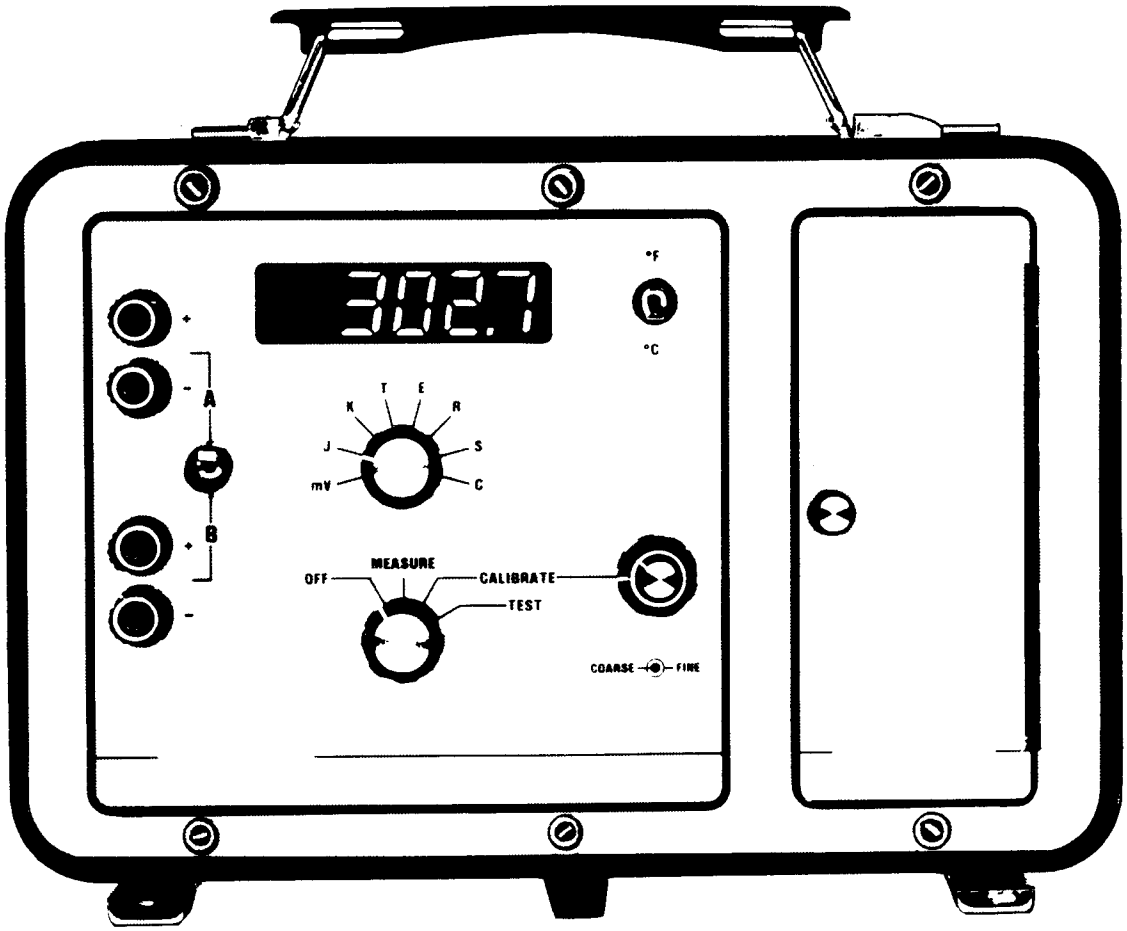
OMNICAL 4A and OMNICAL 8A

Temperature Calibrators



OMEGA®

An OMEGA Technologies Company

Operator's Manual
M0118/0693

OMEGA® ...Your Source for Process Measurement and Control

TEMPERATURE

- Thermocouple, RTD & Thermistor Probes, Connectors, Panels & Assemblies
- Wire: Thermocouple, RTD & Thermistor
- Calibrators & Ice Point References
- Recorders, Controllers & Process Monitors
- Infrared Pyrometers

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- Load Cells & Pressure Gauges
- Displacement Transducers
- Instrumentation & Accessories

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- Turbine/Paddlewheel Systems
- Totalizers & Batch Controllers

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- Benchtop/Laboratory Meters
- Controllers, Calibrators, Simulators & Pumps
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SECTION 1 INTRODUCTION

1.1 GENERAL DESCRIPTION

This manual contains operating and maintenance instructions, as well as a description of the principles of operation, of the OMNI-CAL™ Portable Digital Thermocouple Instrument Calibrator. The information covers all models of the instrument, including the basic equipment and its available options and accessories.

The manual, insofar as practicable, is a complete User Guide, providing step-by-step instructions for operating the OMNI-CAL™ in each of its designed functions and with each of the built-in thermocouple data conforming programs. The publication also includes instructions for the use of standard NBS Millivolt Tables so that calibration of thermocouple sensors not incorporated in the OMNI-CAL™ design ranges (such as the type B thermocouple) can be performed by table lookup from its OMNI-CAL™ measured voltage output. Calibration of thermocouple types in common use including the type C very high temperature sensor, can be performed by simple, direct reading measurements made with the OMNI-CAL™ instrument.

The OMNI-CAL™ is a microprocessor based, laboratory grade, field portable, digital calibrator, thermometer, and voltmeter. It is packaged in a rugged metal case, and it is especially designed for multifunction use in the harsh environments of the process and service industries.

The OMNI-CAL™ operates in any of four front panel selected functions:

1. As a thermometer (FUNCTION = MEASURE), providing direct °F or °C readout of a connected thermocouple.
2. As a calibrator (FUNCTION = CALIBRATE), providing precise voltage outputs equivalent to the tabular values expected from a selected thermocouple at a settable temperature, or a settable voltage from −12 to +80 mV.
3. As a voltmeter (FUNCTION = MEASURE, RANGE = mV), providing 4½ digit readout of a ± 101 mV range input, with microvolt resolution and automatic polarity indicated in the display.
4. As a self tester (FUNCTION = TEST), providing an overall system performance check, assuring a valid calibration. Appropriate microprocessor generated error messages are displayed for malfunctions that may occur during other functional use.

The OMNI-CAL™ is available as a 4-range or 8-range model, and each may be supplied for either 110 or 220 V ac recharging power sources. Each model is configured for the mV RANGE selection, thus providing the millivoltmeter and direct settable voltage functions. The 4-range model provides for three thermocouple ranges (J, K, T), while the 8-range model provides for seven thermocouple ranges (J, K, T, E, R, S, C), in addition to the mV range.

Measurements and calibration outputs for front panel selected thermocouple types are automatically corrected for reference junction offsets. Direct millivoltmeter measurements and settable direct reading calibration voltage outputs are provided without reference junction compensation.

Front panel displays are presented on large, 0.31″ (8 mm) high, LEDs. The decimal point is positioned automatically, and the minus (−) polarity sign is displayed for any negative value; the plus (+) polarity sign is understood for any positive value. The digital display is actually 7 positions: five decade positions are available for the 4½ digit value; the decimal point is incorporated to the right within one of these positions; the polarity sign (when appropriate) is always positioned to the far left; the symbol F, C, or E is displayed at the far right, as annunciators for Fahrenheit, Celsius, or emf (millivolts), respectively.

Error messages of HIGH, LO, OPEN, or ERROR are respectively displayed when the temperature is above full scale, the temperature is below full scale, an open thermocouple lead is detected (or less than minus 101 mV), or when a voltage greater than 101 mV is applied to the input terminals.

1.2 MECHANICAL DESCRIPTION

The OMNI-CAL™ is assembled in a rugged metal carrying case, whose bottom half forms the instrument case, and whose lid may be used as a tilt stand support arrangement for easy viewing. See Figure 1-1. There are no rear panel connections, indicators, or controls.

The instrument is battery powered, and is supplied with a rechargeable NiCad battery pack and an integral battery charging circuit. The recharger line cord is attached to the instrument and is stored in the front panel storage compartment. The OMNI-CAL™ may be ordered for either 110 or 220 V ac recharging source power.

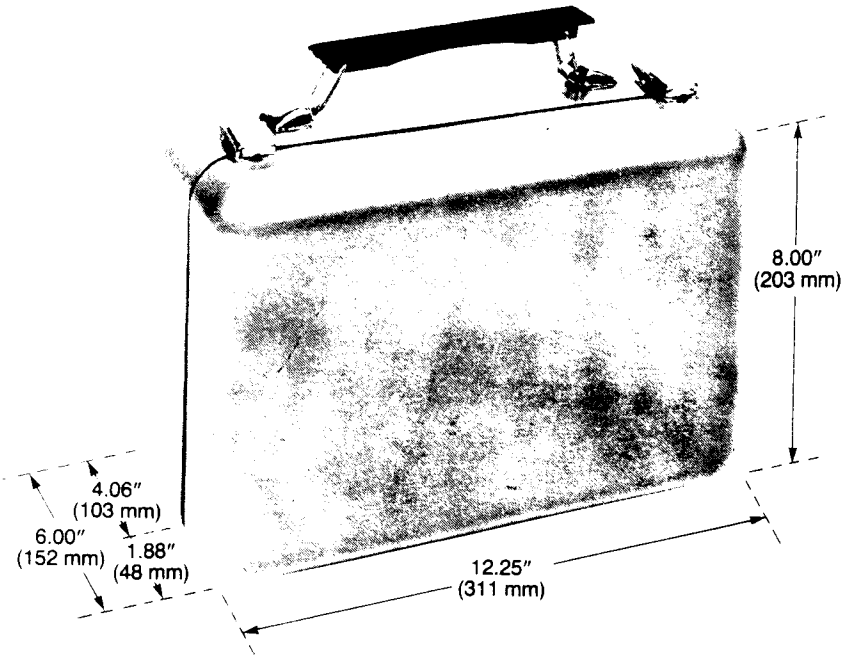

Figure 1-1. Carrying Case and Dimensions

A fully charged battery pack will deliver typically 8 continuous operating hours while 14 to 16 hours (when not in use) are required for full battery recharge. (The instrument may be operated while the batteries are being recharged.) The batteries are rated for a minimum of 1000 charge/discharge cycles.

The OMNI-CAL™ front panel is made of a stain and impact resistant thermoplastic, consistent with the instrument's intended use as a Calibrator/Thermometer in harsh field environments. The hinged lid is deep enough so that OMNI-CAL™ accessories and documentation may be carried within the case without requiring additional storage space. A summary operation instruction label is affixed to the inner lid surface, for ready field use and reference.

1.3 FUNCTIONAL DESCRIPTION

1.3.1 General

Under microprocessor control, the OMNI-CAL™ "reads" the front panel selected FUNCTION and RANGE switches and sets up the instrument to MEASURE, CALIBRATE, or TEST for the selected thermocouple (where appropriate). Figure 1-2 is a greatly simplified block diagram that illustrates the multifunction capabilities of this compact instrument. As shown in the illustration, the displayed value is derived from any one of several selectable inputs to the analog to digital (A/D) chain. The front panel FUNCTION select switch determines whether the A/D input will be the signal connected to the front panel terminals from some temperature sensor, or a voltage derived from one of three internal sources. The front panel RANGE switch setting causes the microprocessor to calibrate the digitized signal in terms of the stored thermocouple tabular data and in °F or °C, as selected by a front panel switch, or in units of millivolts when no thermocouple range has been selected.

In the measurement function, the signal connected to the input terminals is connected to the A/D chain. If a thermocouple range has also been selected, the signal from a reference junction sensor is also connected to the A/D chain.

In the calibration function, a settable voltage, whose value is similarly scaled, converted, and displayed is connected internally to the front panel terminals. If a thermocouple range has also been selected, the output voltage is conformally mapped by the microprocessor and compensated for the reference junction voltage.

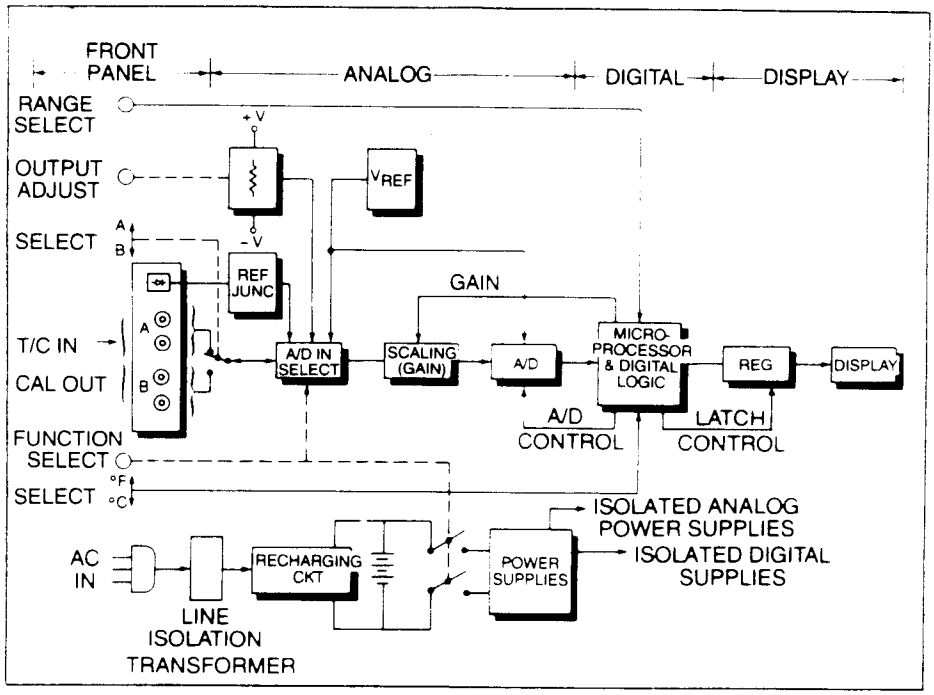

Figure 1-2. System Block Diagram

In the self test function, an internal precision reference voltage is similarly scaled and converted. (It is not connected to the terminals for external use, however.) As for the other functions, if a thermocouple range has also been selected, the converted value is conformally mapped for the particular thermocouple and compensated for the reference junction voltage value as well. Its digital value is displayed, and the reading may be compared with the value established at the factory final test and calibration. Because the test signal is processed through the complete chain as for any measurement or calibration function, the self test exercises all of the components that are included in the normal operation.

Error messages are displayed if the performance does not meet preprogrammed requirements. If an open sensor lead (or open thermocouple or a voltage input more negative than minus (–) 101 mV) is detected, the message OPEN is displayed. If the input value exceeds the preprogrammed full scale range for the selected thermocouple, the message HIGH or LO appears for the appropriate direction in which the signal exceeds the limits. If the input exceeds the maximum full scale range of 101 mV, the message ERROR is displayed.

1.3.2 The Two Conversion Cycle

The digital display is updated twice a second for nine successive updates of the selected input signal to the A/D conversion chain. In the tenth 500 millisecond interval, only the output of the reference junction sensor is connected to the A/D chain. Its value is digitized and stored to be applied in the next nine display updates.

During each 500 millisecond period, the OMNI-CAL™ performs two analog to digital conversions. In the first such conversion, lasting 200 milliseconds, the instrument makes a conversion with a minimum amplifier gain of 20. The microprocessor examines the result of that conversion and then sets the gain at 20, 50, 70, or 200 so that the next conversion will occur with a scaling for the greatest possible resolution of the displayed result. In effect, the OMNI-CAL™ autoranges before every measurement or calibration, and updates its cold junction reference compensation every 5 seconds.

1.4 APPLICATIONS

In Section 3 of this manual you will find detailed instructions for each of the following application areas.

1. Measuring temperature with a thermocouple in the OMNI-CAL™ range.
2. Measuring temperature with a thermocouple not in the OMNI-CAL™ range.
3. Calibrating thermocouple type recorders, indicators, or controllers.
4. Checking thermocouples.
5. Checking mV type recorders, indicators, or controllers.
6. Using the OMNI-CAL™ as a general purpose millivolt digital voltmeter.

SECTION 2 INSTALLATION

This Section contains information on the installation, setup and preoperation check of the OMNI-CAL™ prior to its use as a Calibrator/Thermometer. The information includes instructions for unpacking and repacking the instrument. This Section also includes information about the front panel operating controls and indicators and general information about the instrument's use. This information should be read carefully before attempting to use the OMNI-CAL™ on site.

2.1 UNPACKING

The instrument is placed in a waterproof plastic wrapper, securely fitted between molded foam shock isolators and placed with the documentation in its shipping carton. You will find the documentation inside the shipping carton.

1. OMNI-CAL™ (Thermocouple Instrument Calibrator)*
2. Certificate of Calibration
3. Factory Test Data Sheet (Part of the Certificate of Calibration)
4. Operators Manual

*Battery pack and fuse are installed in the instrument. The recharger line cord is attached, and is located in the front panel accessed storage compartment.

Remove the PACKING SLIP and use to check off actual equipment received. If you have any questions on your shipment please call OMEGA's Customer Service Department.

NOTE

If any part is damaged, a claim should be filed with the carrier. Save all containers for inspection.

Retain the packing material for reshipment. When shipping OMNI-CAL™, use foam shock isolators and pack in original shipping carton, if available. If original shipping material is no longer available, use some shock isolators, such as bubble plastic, and wrap securely within a suitable carton.

2.2 OMNI-CAL™ SETUP

The instrument is shipped in a complete configuration. The battery pack is installed, and it was shipped in a fully charged condition. To assure that the batteries will be operational after any prolonged shelf life, or after any extensive shipping interval, charge the batteries for a period of 15 hours. After an initial warmup period of 1 minute for 1° resolution measurements (15 minutes for 0.1° resolution measurements), the instrument is ready for operation. Refer to Section 3 for detailed operating instructions.

2.3 OPERATING CONTROLS AND INDICATORS

Figure 2-1 illustrates the front panel features, and includes a brief description of the operating controls and indicators. Table 1 is a schematic composite of a number of possible display formats, illustrating the location of decimal point, polarity sign, and annunciator codes. The illustration also indicates the location and appearance of possible error messages.

2.4 INPUT TERMINALS/ACCESSORIES

The standard binding posts provide complete flexibility in making connections to the OMNI-CAL™. A terminal pair is spaced for simple banana jack connection, as well as the spade lug, single jack, or wire lead connection to the individual binding post. The availability of 2 pairs of the binding posts provide maximum flexibility for measurement and calibration.

The binding post connections are thermally coupled to an internal sensor to provide the input for the automatic Cold Junction Compensation (CJC) in the OMNI-CAL™. The reference junction temperature compensation is scaled for any one of the selected thermocouple ranges, and is therefore effective in the MEASURE, CALIBRATE, or TEST functions when a thermocouple type is selected. The CJC is NOT included when the mV range is selected in any one of these functions.

To expedite the measurement and calibration operations, an optional thermocouple adaptor plug may be used for quick connect/disconnect of thermocouple units. The color-coded adaptor plugs are available in standard or miniature sizes and are pre-wired with short lengths of appropriate flexible thermocouple leads terminated at the other end in lugs. An optional instrument service cable is also available, providing a 6 ft. length of flexible, paired thermocouple leads.

The accessory adaptor plugs and instrument service cables supplied for types R and S are fabricated of copper vs. copper alloy #11, which is only useful at ambient temperatures up to 302°F (150°C).

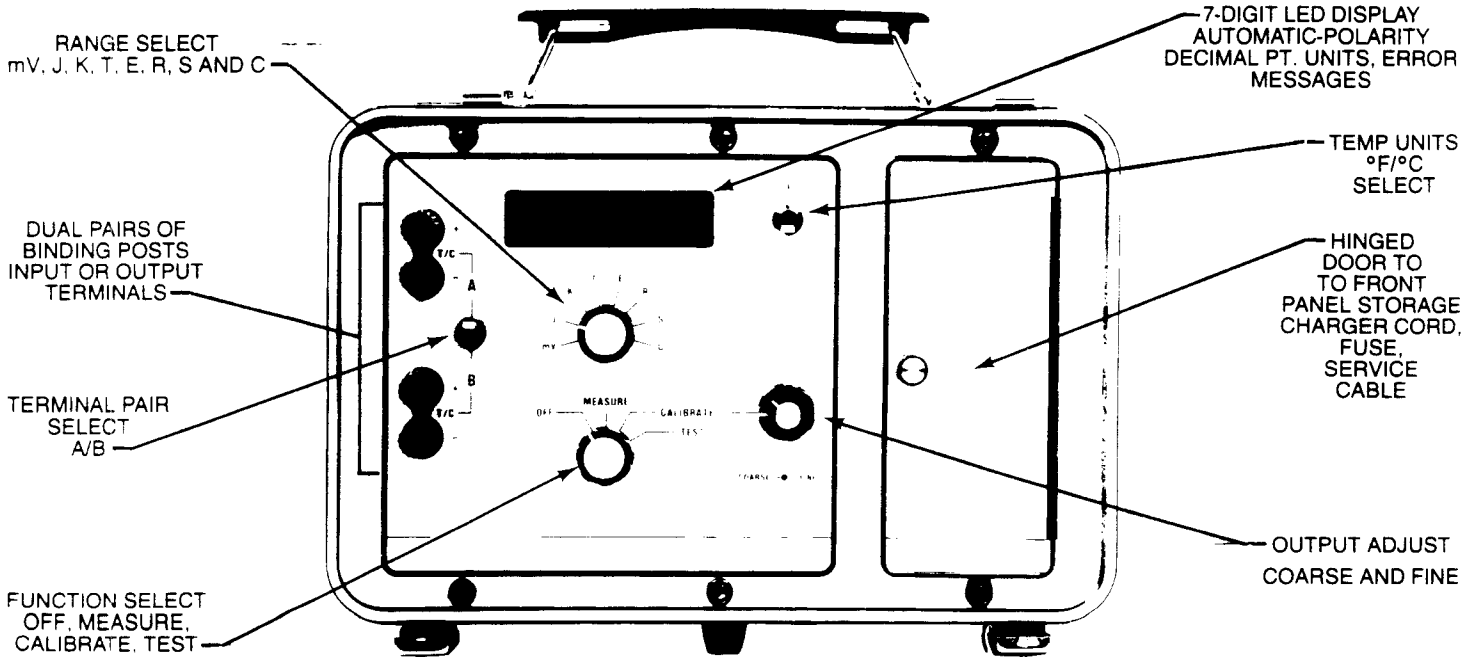

Figure 2-1. OMNI-CAL™ Front Panel Features

TABLE 1

OMNI-CAL™ DISPLAY FORMATS

250.0 F -40.0 F	Measures temperature directly from thermocouple types J, K, T, & E, with resolution of 0.1°F and 0.1°C.
231.5 C - 50.0 C	Measures temperature directly from thermocouple types R, S, & C with resolution of 1°F and 1°C.
20.000 E -20.000 E	Measures ±20mV signals with resolution of 0.001mV (1μV)!
10.000 E -10.000 E	Measures ±20mV to ±101.1mV signals with resolution of 0.01mV.
H I GH LO OPEN Error	Automatically indicates faults: temperature above or below the calibrated instrument range, or... open thermocouple or... input signal greater than 101.1mV.

2.5 PRE-OPERATIONAL TESTS

To obtain the maximum benefits when using your OMNI-CAL™, observe the following precautions and perform a simple self test of the instrument.

1. Set up for use in as draft-free an ambient as possible.
2. Allow at least 1 minute for warmup before making measurements of 1° resolution thermocouples or 0.01 mV resolution voltages. Allow 15 minutes for 0.1° thermocouple or 0.001 mV resolution ranges.
3. Operate on battery power, whenever possible.

Before each CALIBRATE/MEASUREMENT operation:
The °F, °C switch must be placed in °C position.

1. Select the TEST FUNCTION.
2. Rotate the RANGE selector through its eight range positions, starting with mV.
3. For each RANGE position, the display value should be within the limits shown on the calibration label located on the inside case cover.

Note that a full display appears momentarily after each range selection. Check the lighting of each of the 7 segments and decimal point that should appear in each of the 7 digits. Display reads 8.8.8.8.8.8.8.

A blinking display indicates a low battery voltage. You have 10 minutes of continued in-spec OMNI-CAL™ performance from the time the display starts blinking until the battery pack MUST be recharged. At the end of the 10 minute interval, the OMNI-CAL™ is automatically programmed to stop its operation.

Start the recharge cycle as soon as possible after observing a low battery indication. OMNI-CAL™ operation may be continued, if necessary, during the recharge operation.

If your OMNI-CAL™ will not operate in the battery mode after several attempts at charging, it may be necessary to replace your battery pack.

This section includes step by step instructions for using OMNI-CAL™ in the Measure, Calibrate, and Test functions. You will learn how to use your OMNI-CAL™:

1. As a Field Calibrator/Simulator, to calibrate analog and digital thermocouple instruments, including panel meters, indicators/controllers, chart recorders, data loggers, thermocouple amplifiers, linearizers and bridges, X-Y plotters, millivoltmeters, VCOs, etc.
2. As an Indicator of wide temperature ranges from seven (7) basic thermocouple types incorporated in the memory of OMNI-CAL™.
3. As a millivolt generator for calibrating other than thermocouple instruments.
4. As a precision millivoltmeter, for precision measurements of low level signals from a variety of transducers and signal sources.
5. As a precision comparator, to compare two thermocouples or other signal sources.
6. As a calibrator of thermocouples, when used with a precision controlled temperature bath, such as "hi-temp" sand bath, 32°F ice bath, temperature controlled oil bath, cryostat, and freeze point standard.
7. As a digital thermometer, to measure ambient temperature and special reference junction temperatures when used with a calibrated thermocouple.
8. As a laboratory instrument, performing all the functions noted in steps 1 through 7 and especially useful where precision temperature measurements and calibrations with 0.1° resolution and conformity are required.
9. As a self testing and diagnostic tool, indicating open thermocouples, or thermocouple signals above or below the range of specified thermocouples.

These applications are illustrated in the figures that follow, showing site hookups, including the use of accessory leads, adaptors, and external equipment.

In the lid of each OMNI-CAL™ is a decal (4 or 8 range) giving abbreviated operating instructions in each of the three modes of OMNI-CAL™ operation: Measure, Calibrate, Test. These decals also contain a listing of the various thermocouple types, their operating range in °F or °C, and the factory recorded test readings at 25°C ± 10°C for each of the input ranges (mV as well as thermocouples).

3.1 THERMOCOUPLE WIRES

In making measurements where additonal wire must be connected to the thermocouple leads, care must be exercised in selecting these wire types, not only when they are claimed to be of the same composition as the thermocouple involved, but, also of their "quality". Performance results where high precision is required, and in circumstances where some type of thermocouple wire leads are added to the original installation, should be reviewed carefully for the impact of the choice of the additional wire leads. Call OMEGA ENGINEERING for assistance if required.

The quality of thermocouple wire is established by the limits of error to be expected in its use. There are three recognizable levels of quality:

Special Grade
Standard Grade
Extension Grade

The error limits determining the grade quality differ from thermocouple type to thermocouple type, reflecting the degree of difficulty in maintaining the precise levels of purity of the metals used. Table 2 summarizes the error limits for Special and Standard grades, while extension grade wire is characterized by limits of error exceeding those in Table 2. Errors up to ±8°F may be experienced when using extension grade thermocouple wire for J and K thermocouples.

TABLE 2

LIMITS OF ERROR FOR THERMOCOUPLES[1]: REFERENCE JUNCTION 0°C

Thermocouple Type	Temperature Range °C	Temperature Range °F	Limits of Error[2] Standard (Whichever is greater)	Limits of Error[2] Special (Whichever is greater)
T	0 to 350	32 to 662	±1.0°C or ±0.75%	±0.5°C or .4%
J	0 to 750	32 to 1382	±2.2°C or ±0.75%	±1.1°C or .4%
E	0 to 900	32 to 1652	±1.7°C or ±0.5%	±1.0°C or .4%
K	0 to 1250	32 to 2282	±2.2°C or ±0.75%	±1.1°C or .4%
R or S	0 to 1450	32 to 2642	±1.5°C or ±0.25%	±0.6°C or .1%
B	800 to 1700	1472 to 3092	±0.5%	Not Estab.
C*, G*, D*	0 to 425	32 to 797	±4.5°C	Not Estab.
	425 to 2320	797 to 4208	±1.0%	Not Estab.
	Sub-Zero Range[3]			
T	−200 to 0	−328 to 32	±1.0°C or ±1.5%	Not Estab.
E	−200 to 0	−328 to 32	±1.7°C or ±1.0%	Not Estab.
K	−200 to 0	−328 to 32	±2.2°C or ±2.0%	Not Estab.

*Not ANSI symbol

[1]ANSI MC 96.1 (1975) These limits are given only as a guide for discussion between purchaser and supplier

[2]The limits of error of the thermocouples and extension wires are based on a Reference Junction temperature of 32°F (0°C). Does not include use or installation errors.

[3]Due to the characteristics of the materials, sub-zero limits of error for type J thermocouples are not listed.

3.2 AS A FIELD CALIBRATOR/SIMULATOR, CALIBRATING THERMOCOUPLE TYPE INDICATORS, RECORDERS, AND CONTROLLERS

When the thermocouple type is within the OMNI-CAL™ ranges (See Figure 3-1.)

1. Disconnect the thermocouple leads from the instrument to be calibrated.
2. Use the appropriate thermocouple type and quality grade leads to connect the instrument to an OMNI-CAL™ terminal pair.
3. Select the CALIBRATE function.
4. Select the appropriate OMNI-CAL™ RANGE.
5. Use Coarse and Fine OUTPUT ADJUST controls for a 0° display value.
   Select temperature unit °F/°C as used in the instrument being calibrated. If the instrument being calibrated does not include a zero value in its Full Scale Range, set up the minimum value that can be displayed (or indicated).
6. Adjust the instrument ZERO for 0° (or minimum value) instrument display (or indication).
7. Use OMNI-CAL™ OUTPUT ADJUST controls for an Instrument Full Scale Range output value.
8. Adjust the Instrument RANGE (GAIN or SPAN) control for equal instrument display (or indication).

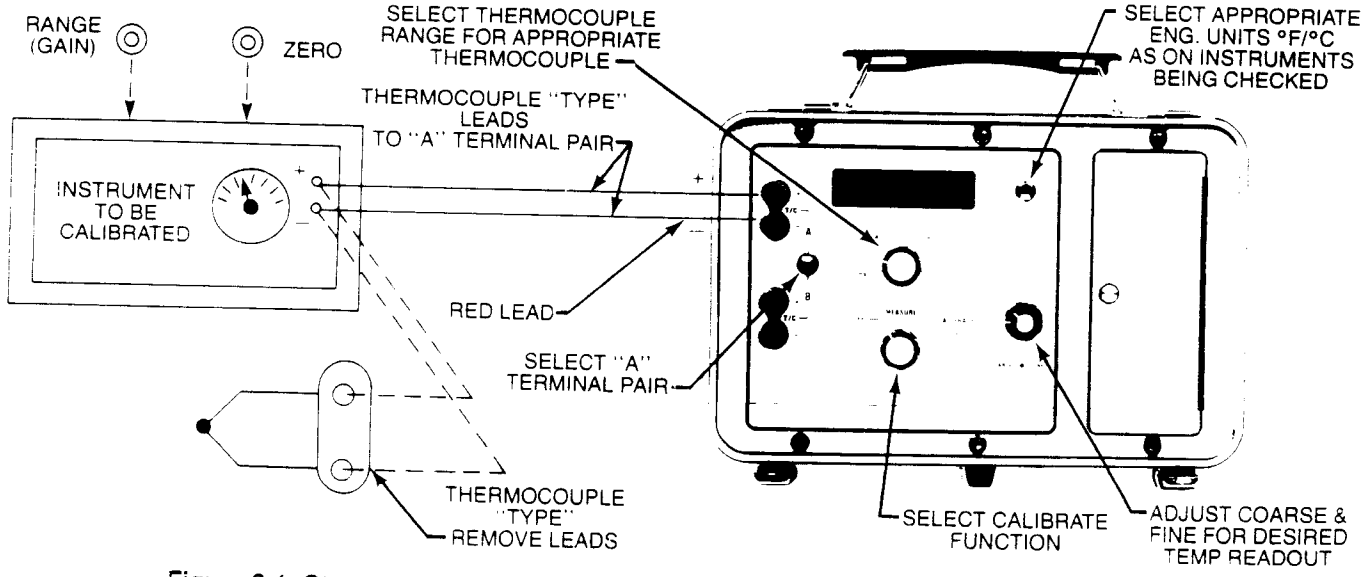

Figure 3-1. Standard OMNI-CAL™ Setup for Temperature Measurements

3.3 AS AN INDICATOR OF TEMPERATURES WITH THERMOCOUPLES IN THE OMNI-CAL™ RANGE

This procedure is applicable to circumstances where the thermocouple is of the type shown on the front panel RANGE selection (7 basic types or 3 basic types). See Figure 3-2.

1. Use special or standard thermocouple leads to connect to the thermocouple input terminals of OMNI-CAL™. You may use either pair of thermocouple terminals. See Table 3.

CAUTION

Observe care in connecting proper polarities. The red thermocouple lead is to be connected to the negative binding post terminal; connect the other lead to the positive terminal.

2. Turn the A/B channel select switch to the connected terminal pair. (Figure 3-2 indicates connection to the "A" terminal as an example only.)
3. Rotate the RANGE selector switch to the appropriate thermocouple type.
4. Rotate the FUNCTION selector switch to the MEASURE function.
5. Select the desired temperature units, °C/°F.
6. Read the temperature in the display. The value has been compensated automatically for the reference junction temperature.

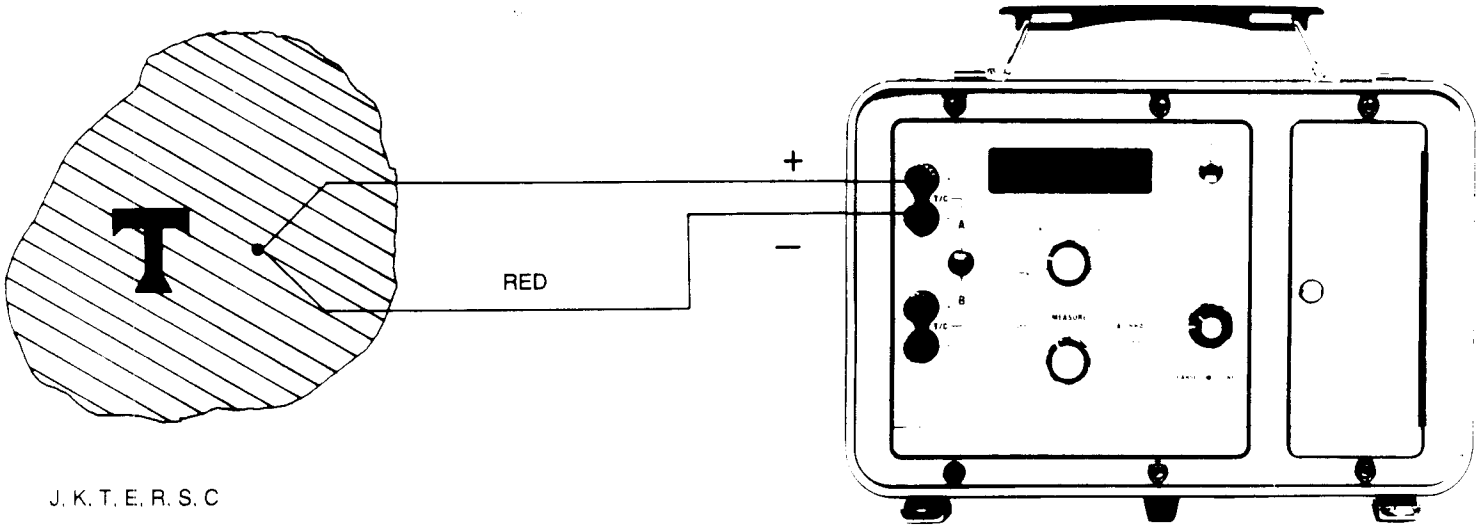

Figure 3-2. Temperature Measurement with OMNI-CAL™

TABLE 3

THERMOCOUPLE LEAD COLOR CODES (ANSI)

Type	Plus(+)	Minus(−)
T	Blue	Red
J	White	Red
E	Purple	Red
K	Yellow	Red
R, S	Black	Red
B	Green	Red

3.4 AS A MILLIVOLT GENERATOR FOR CALIBRATING VOLTAGE MEASURING/DISPLAY INDICATORS

When used in the CALIBRATE FUNCTION and mV RANGE, the OMNI-CAL™ provides a precision millivolt range calibration signal that may be used as a standard input to calibrate such devices as X-Y plotters, strip chart recorders, data loggers, etc. See Figure 3-3.

Replace the normal millivolt level input to the instrument to be calibrated with the output of the OMNI-CAL™.

Adjust the OMNI-CAL™ output with the Coarse and Fine controls for the desired valve as indicated in the display.

Adjust the instrument GAIN for the proper indicated value.

3.5 AS A PRECISION MILLIVOLTMETER, MEASURING THERMOCOUPLES NOT COVERED IN THE OMNI-CAL™ RANGE OR OTHER TRANSDUCERS

The OMNI-CAL™ is a convenient field portable device for measuring the outputs of transducers such as pressure gages, flowmeters, level indicators, force indicators, etc., where such outputs are in the millivolt level.

Merely connect the output of such devices to the OMNI-CAL™, and operate the OMNI-CAL™ in the MEASURE FUNCTION and mV RANGE. (The reference junction temperature compensation is removed from the measuring circuit in the mV RANGE.)

Consult available tables of emf vs. temperature to convert the millivolt readings to appropriate engineering units.

Where temperature vs. emf tabular data is available, the OMNI-CAL™ may be used to convert precision measurements of thermocouple outputs into values of temperature when the thermocouple is not one of those in the OMNI-CAL™ memory. See Figure 3-4.

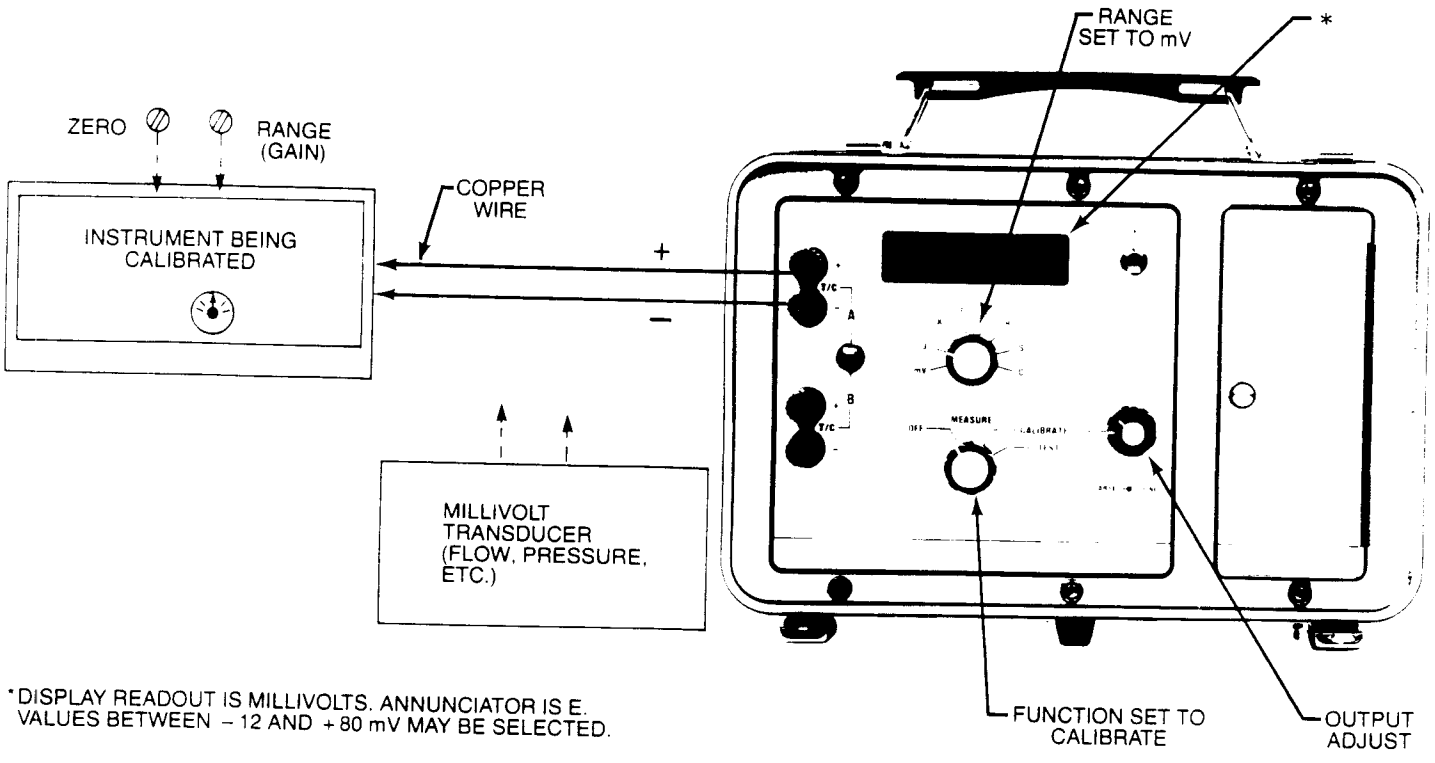

Figure 3-3. Calibrating mV Measuring/Display Indicators

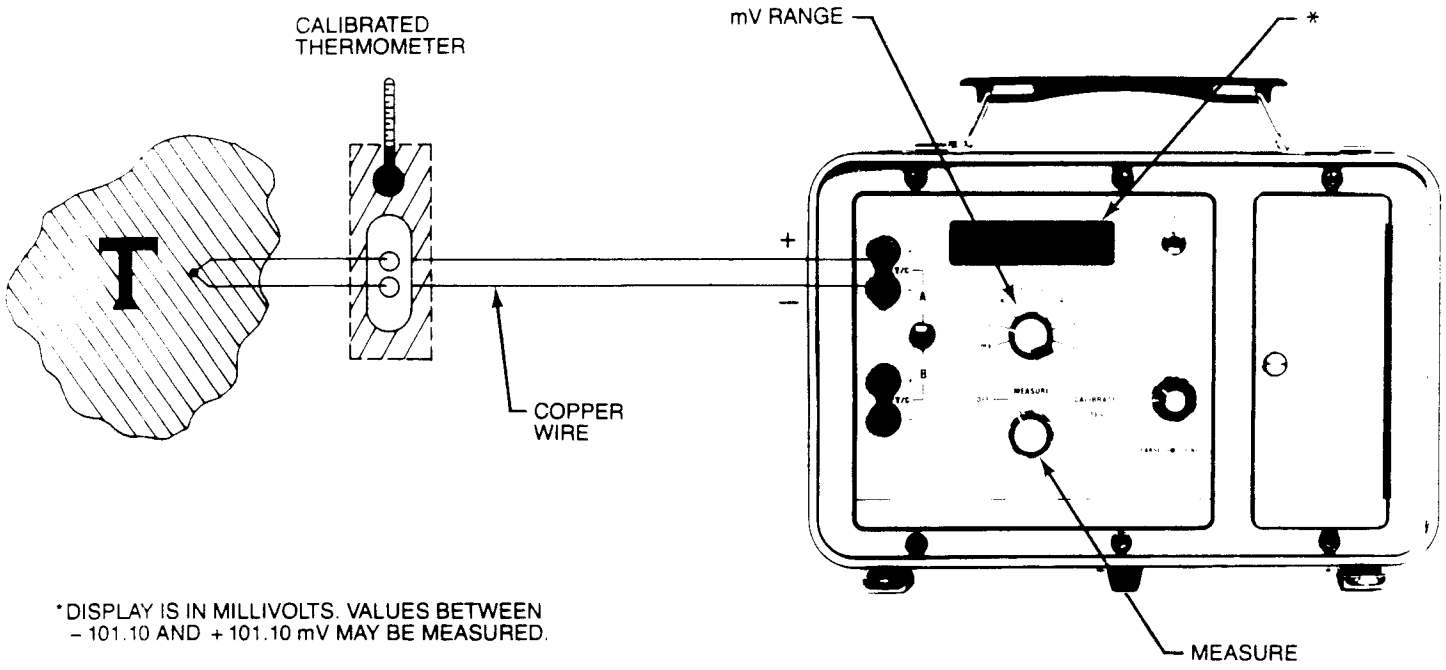

Figure 3-4. Temperature Measurement via mV Function

1. Connect the transducer reference terminals to OMNI-CAL™ with copper leads.

CAUTION

Observe the proper polarity being sure to connect the negative thermocouple terminal to the negative binding post terminal.

2. Use a calibrated thermocouple (See Paragraph 3.8) or thermometer to measure the temperature of the reference junction (where the copper leads are connected to the transducer leads). The other input binding posts of the OMNI-CAL™ may be used with the calibrated thermocouple to obtain the reference junction temperature with minimum additional operations.
3. Select the OMNI-CAL™ MEASURE function.
4. Select the OMNI-CAL™ mV range.
5. Read the millivolt value on the OMNI-CAL™ display. Record.
6. Use an approved tabular listing of transducer temperature vs. voltage and convert the values recorded in steps 2 and 6 as shown in the sample below.

Assume the use of thermocouple type B. Tables for this type are available in NBS Monograph 125. Catalog Number OP-3 available from OMEGA Press.

Assume reference junction temperature is 65°F in step 2. Look up the tables, and obtain the equivalent millivolt value for 65°F:

65°F = – 0.003 mV

Assume a millivolt display value of 0.549 in step 5.

Since the reference junction temperature is above the table reference point of 32°F, add the two values algebraically:

– 0.003 mV
+ 0.549 mV
+ 0.546 mV

....the true 32°F (0°C) reference junction compensated voltage.

Look up the tables to obtain the temperature for 0.546 mV:

It is between 635 and 636°F.
The temperature is 635.5°F.

3.6 AS A PRECISION COMPARATOR, COMPARING TWO THERMOCOUPLES OR OTHER SIGNAL SOURCES

a. When both thermocouple elements are of the same type:

1. Connect each to a pair of binding post terminals, using the same type and quality grade of thermocouple leads.
2. Select the OMNI-CAL™ MEASURE function.
3. Select the OMNI-CAL™ RANGE type for the thermocouple involved.
4. Be sure the thermocouple probes are as close together as possible in the heat source. Tight contact of the two probes is preferable, if obtainable.
5. Alternately select input terminal pair A, or B.
6. Read and record the alternate displays. Remember that the OMNI-CAL™ goes into a display test mode with each new selection, before the measured value appears.

b. When the thermocouple units are not among those in the OMNI-CAL™ Range:

1. Connect the thermocouple leads to copper extension wires. These connections form the reference junction. Immerse the reference junction in an ice bath which is maintained at 32°F (0°C) by using crushed ice and water and stirring thoroughly. See Figure 3-5.

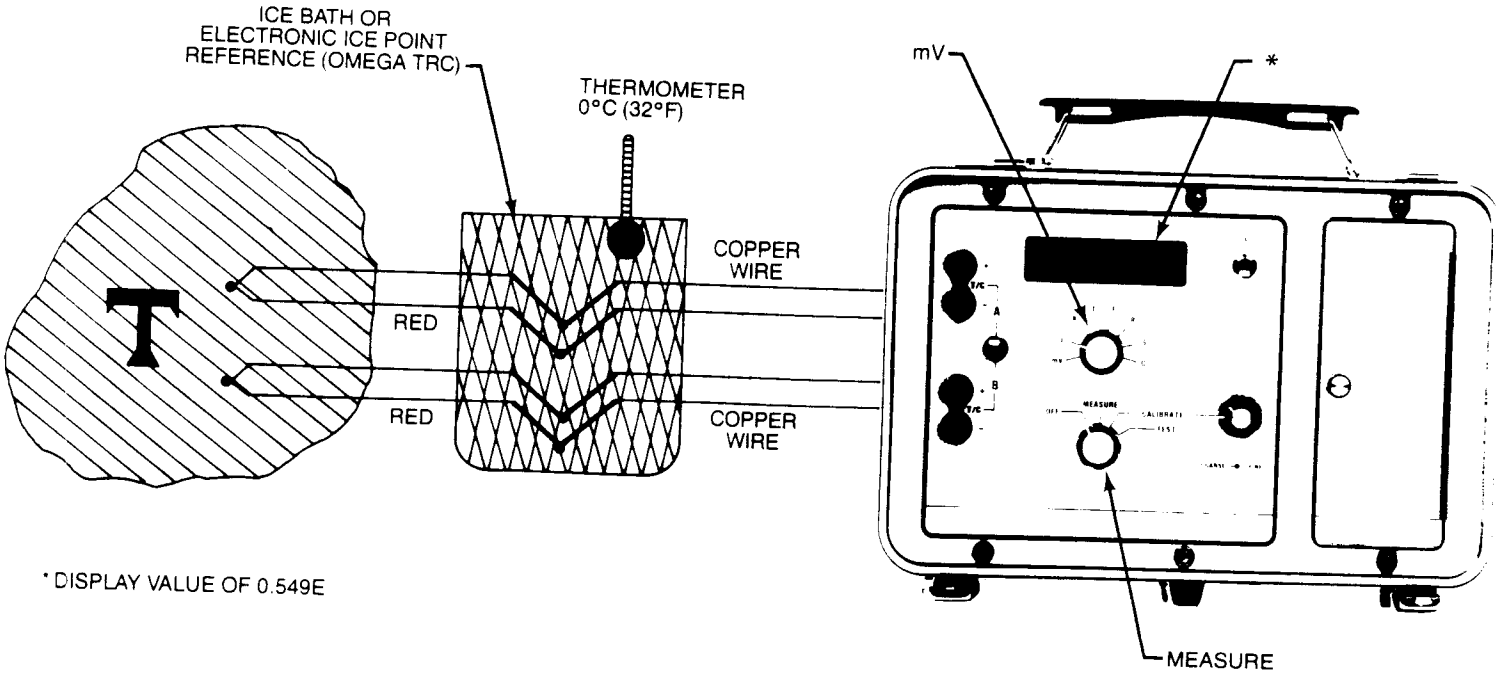

Figure 3-5. Comparing Thermocouple Performance

2. Connect the reference junction ice point to the OMNI-CAL™. Observe the proper polarities; red lead to negative terminal.
3. Select OMNI-CAL™ MEASURE function.
4. Select OMNI-CAL™ mV range.
5. Select alternate OMNI-CAL™ input terminals A, or B.
6. Read and record the alternate display values.

c. When different thermocouple types are to be compared:

1. Both are among the OMNI-CAL™ ranges; follow procedure 3.6 a above, but select the appropriate thermocouple range type corresponding to the thermocouple connected to the input when A/B selection is made.
2. At least one is not among the OMNI-CAL™ ranges. follow the procedure in paragraph 3.6 b, but use the different electronic ice point adaptors for each thermocouple element. Compare mV display values.

3.7 AS A CALIBRATOR OF THERMOCOUPLES, USING PRECISION TEMPERATURE BATHS

The OMNI-CAL™ is a laboratory grade instrument. Its accuracy as a precision indicator and its display resolution make it suitable for laboratory calibration of thermocouples (whether or not they are within the OMNI-CAL™ memory). To accomplish the procedure described in this paragraph, one or more of the precision temperature baths shown in Figure 3-6 must be available.

1. Immerse the thermocouple in the precision temperature bath, whose temperature is known to an accuracy of ±0.01°C to ±0.1°C.
2. Select the appropriate thermocouple type RANGE. Select the MEASURE function. If the thermocouple is not among the OMNI-CAL™ ranges, select the mV RANGE.
3. Read the sensed temperature (or the millivolt value).
4. Record the difference between the value of the Precision Temperature Bath and the measured value on the display.
5. Calculate the instrumentation error as the root sum square of the possible error introduced by the OMNI-CAL™ for the thermocouple type and temperature range (See Section 6) plus the error introduced by the thermocouple wire (See Paragraph 3.1) plus the inaccuracy of the temperature bath.

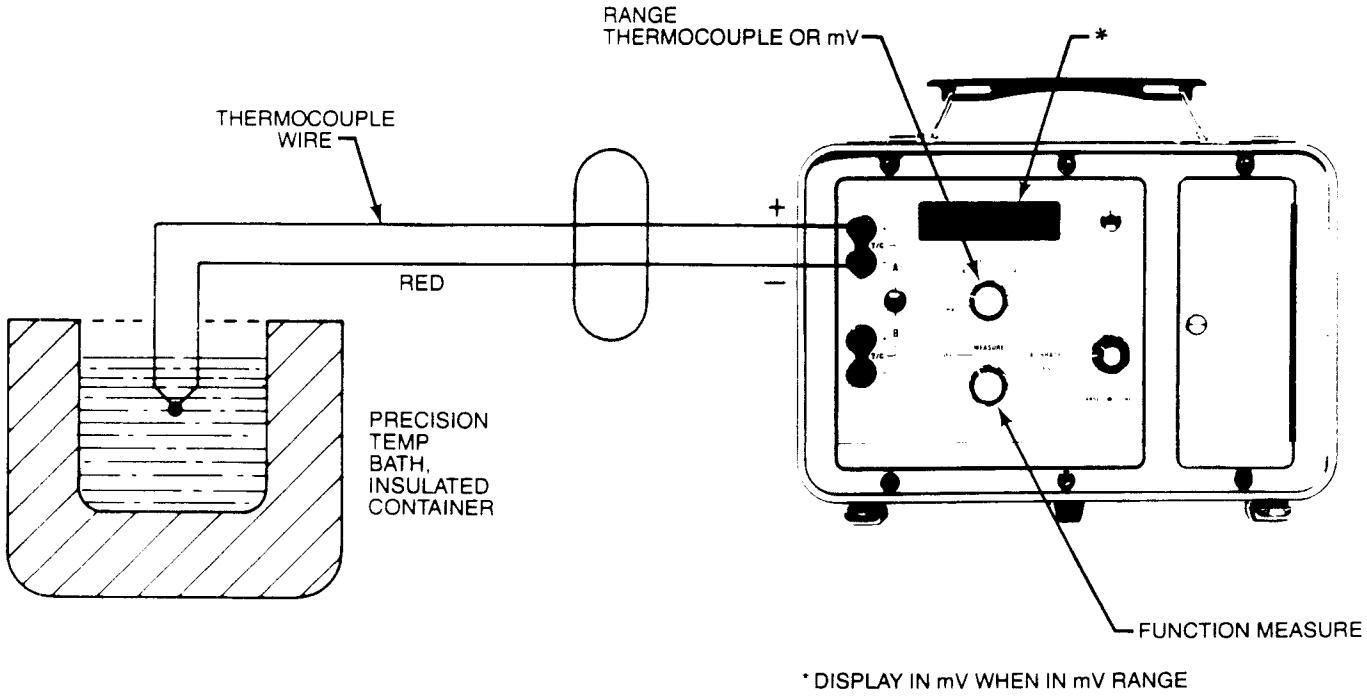

Figure 3-6. Calibrating Thermocouples in Precision Temperature Baths

3.8 AS A PRECISION DIGITAL THERMOMETER USING CALIBRATED THERMOCOUPLES

The precision and accuracy of the OMNI-CAL™ make it possible to perform temperature measurements with a Special Grade thermocouple with an accuracy up to this time unavailable for field instruments.

(The accuracy of the precision thermocouple may be checked by using the procedure of the previous paragraph.)

Use the OMNI-CAL™ in the MEASURE function and select the RANGE of the thermocouple in use.

Determine the possible error of the measurement by calculating the root sum square of the errors determined from the table of Limits of Error for the thermocouple used plus the error of the OMNI-CAL™ as determined from the specifications.

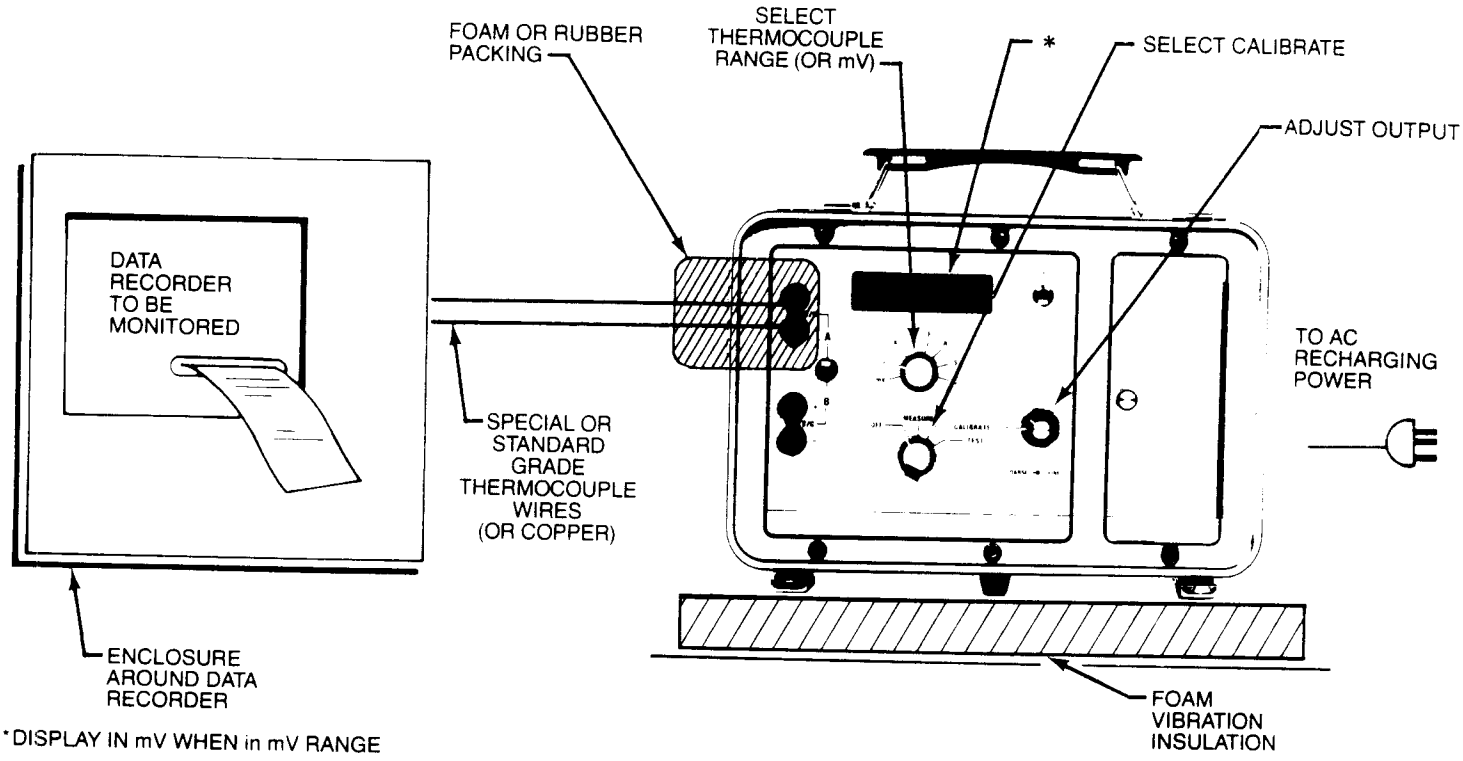

Figure 3-7. Calibrating Thermocouple Type Indicators, Recorders, and Controllers in the Laboratory

3.9 AS A LABORATORY INSTRUMENT, WHERE HIGH PRECISION TEMPERATURE CALIBRATIONS ARE REQUIRED.

The OMNI-CAL™ is particularly well suited for laboratory use where very precise temperature calibrations (±0.1°) are to be made. See Figure 3-7.

1. Connect the temperature measuring device (chart recorder, indicator, controller, data logger, etc.) to the OMNI-CAL™.
2. Use the OMNI-CAL™ in its recharging mode (the battery life is typically 8 hours when fully charged).
3. Place the thermal measuring equipment in a protected enclosure to insure the absence of draft induced changes in ambient temperature.
4. Pack the OMNI-CAL™ input terminals in a foam rubber packing to maintain an insulated reference junction environment.
5. Set up the OMNI-CAL™ for the appropriate RANGE and CALIBRATE function.
6. Adjust the OMNI-CAL™ output for the desired reading. Operate the OMNI-CAL™ as for normal procedures.
7. Because of the precision of OMNI-CAL™, you can now detect small temperature variations of 0.1° in process recording, monitoring, and controlling instruments.

3.10 AS A SELF TESTING DIAGNOSTIC TOOL

The OMNI-CAL™ may be used as a troubleshooting tool in installations where malfunctioning thermocouples are suspected.

Merely connect the suspect thermocouple (or other millivolt transducer) to the OMNI-CAL™ and set the front panel controls for the appropriate RANGE (thermocouple type or mV) and MEASURE.

The OMNI-CAL™ will display an appropriate error message if the transducer has an open lead or if the output exceeds the high or low levels of the specified component. Refer to Table 1.

3.11 SPECIAL APPLICATIONS

For the petrochemical and pipeline industries, where intrinsic safe operation is required, the OMNI-CAL™ may be used with an approved barrier system without serious degradation of performance in either the measurement or calibration mode.

OMNI-CAL™ OPERATION

MEASUREMENT MODE

1. Connect the thermocouple leads or millivolt input leads to either the A or B set of input binding post terminals. Set the channel A/B input selector switch accordingly. Connect the red thermocouple lead to the minus (–) terminal for thermocouple temperature measurements. Use copper leads for millivolt measurements.
2. Set function selector to MEASURE.
3. Set RANGE selector to mV or to the thermocouple type attached to the OMNI-CAL™.
4. Select °F or °C for the temperature readout desired.
5. Readout displays measurement value. Readout displays °F or °C for temperature* and E for millivolts. Allow one minute warm-up for one degree resolution and a fifteen minute warm-up for tenth degree resolution.

CALIBRATE MODE

1. Disconnect the signal or sensor leads from the input of the instrument to be calibrated.
2. Connect the OMNI-CAL™ to the input of the instrument to be calibrated using thermocouple wire of the same type as the calibration: use copper leads for millivolt calibration. See step 1 of MEASUREMENT MODE.
3. Set the function selector to CALIBRATE.
4. Set the RANGE selector for the thermocouple type required for the thermocouple calibration, or to mV for millivolt calibrations.
5. Select °F or °C for thermocouple calibrations.
6. Adjust the COARSE and FINE controls of the OUTPUT ADJUST potentiometer for the thermocouple calibration temperature * or millivolt calibration voltage desired as defined by the display.
7. Readout and warm-up per step 5 of MEASUREMENT MODE.

TEST MODE

1. Set function selector to TEST.
2. Set °F or °C selector to °C.
3. Readout will be per the TEST READING of the below table (input leads need not be disconnected).

DIAGNOSTICS

1. Display reads OPEN for an open input, sensor burnout, or millivolt readings below – 101.1 mV.
2. Display reads HI or LO for temperatures outside the measurement range (see Operating Range Table
3. Display reads ERROR for millivolt inputs greater than + 101.1 mV.
4. A flashing display indicates a low battery condition.

OPERATING RANGE

Range*	ANSI Alloy	ANSI Color	°F	°C	Resolution	Test Readings at 25 ± 10°C	
mV	Copper/Copper	—	± 101.1 mV		.001/.01**	mV***	± 0.012 mV
J	Iron/Constantan	White/Red	– 346 to 2192	– 210 to 1200	0.1	J	± 0.3°C
K	Chromel/Alumel	Yellow/Red	– 328 to 2501	– 200 to 1372	0.1	K	± 0.4°C
T	Copper/Constantan	Blue/Red	– 405 to 752	– 243 to 400	0.1	T	± 0.4°C
E	Chromel/Constantan	Purple/Red	– 422 to 1832	– 252 to 1000	0.1	E	± 0.3°C
R	Pt/Pt 13% Rhodium	Black/Red	– 58 to 3214	– 50 to 1768	1.0	R	± 2°C
S	Pt/Pt 10% Rhodium	Black/Red	– 58 to 3214	– 50 to 1768	1.0	S	± 2°C
C	W5Re/W26Re	—	+ 32 to 4200	0 to 2315	1.0	C	± 2°C

Model

Serial Number

NOTE: Read Instruction Manual for further operational details.

*Per ANSI Standards, IPTS-68 and NBS Monograph 125.

**0.001 mV from – 30 mV to + 20 mV.

***Enter Test Readings from inside cover of your unit.

SECTION 4 ADJUSTMENTS AND CALIBRATION

4.1 RECALIBRATION

Recalibration of your OMNI-CAL™ should not be required for one year. Refer to the following procedures when required.

4.1.1 Setup

The calibration should be performed where there is relatively calm ambient air flow at 73°F ± ½°F (±23°C ± ½°C). It is desirable to create a "Calibration Box" of some foam plastic, in which the assembly may be placed while performing the calibration procedure, and where the ambient air temperature may be controlled within the specified tolerance. Connections at the front panel terminals should be shrouded in plastic foam, such as you will find on the inner connections to the analog assembly.

WARNING

During this procedure, voltage potentials of 120 V ac (or 240 V ac) will be accessible.

4.1.2 Equipment Required

1. Precision, adjustable voltage standard, ±110 mV, 0.01% accuracy, 1 μV resolution.
2. Ice point reference, 32.0 ± 0.1°F; OMEGA Model TRC-III equivalent.
3. T Thermocouple, calibrated to ±0.1°F at 75°F.
4. Power Supply, adjustable 5 to 7 volts, 0.5 amperes.
5. Digital Voltmeter, 5 to 7 volts, 0.01 volt resolution, 0.1% accuracy.
6. Oscilloscope, 5 MHz bandwidth.

4.2 PREAMP AND SCALING CALIBRATION PROCEDURE

4.2.1 Setup (Figures 4-1 and 4-2)

1. Disconnect the battery cable from connector J4 on the power supply card.
2. Connect the power supply to the same connector. Refer to the connector pin terminals as shown in Figure 4-1.

CAUTION

Reversed power supply voltages may cause failure of the power supply printed circuit board.

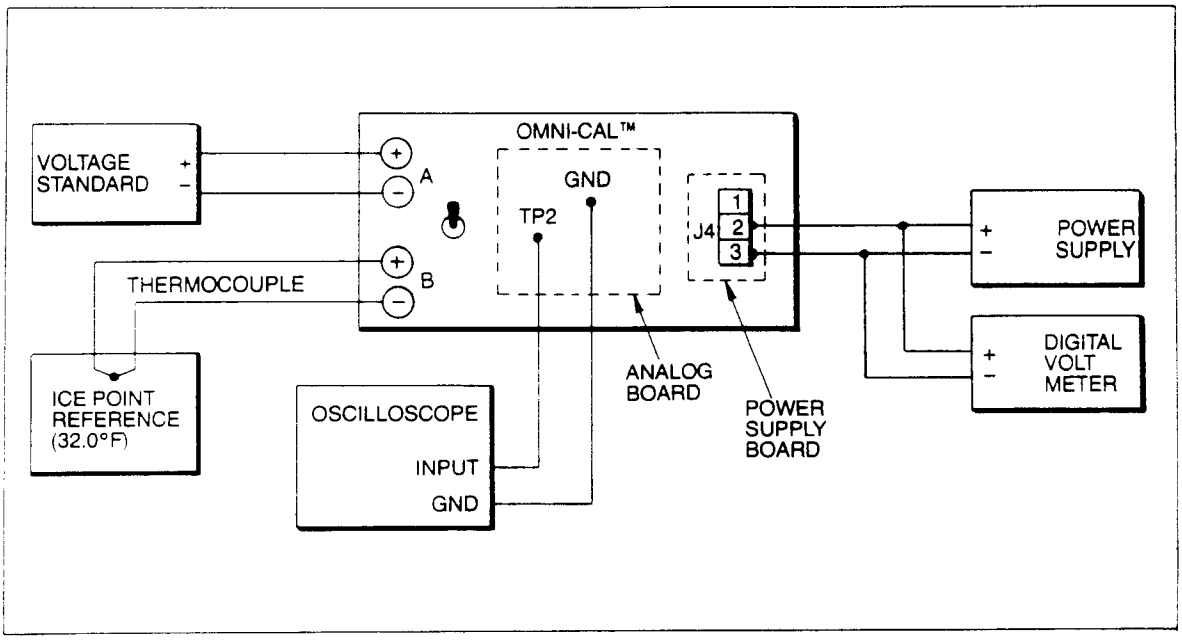

Figure 4-1. Recalibration Setup

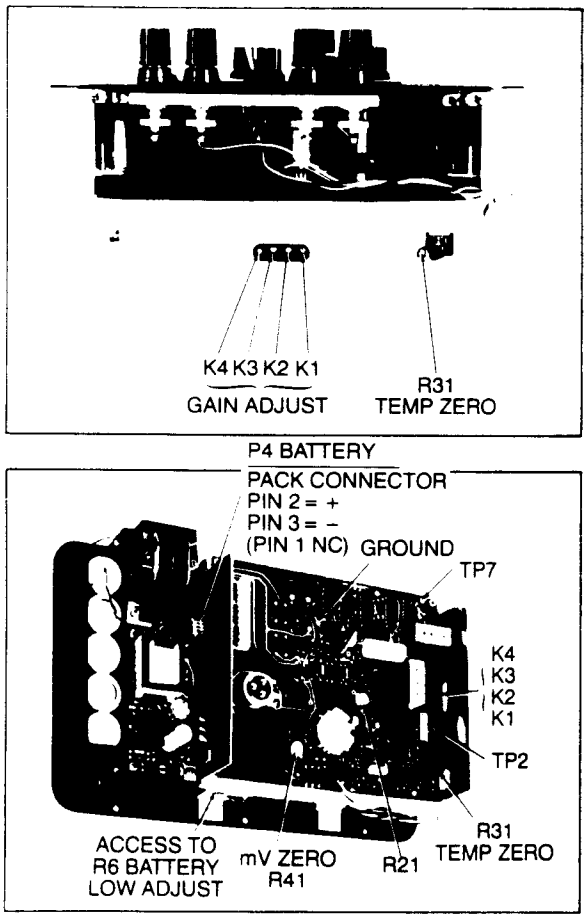

Figure 4-2. Recalibration Adjustments

3. Set the power supply to +6.2 volts.
4. Connect the voltage standard to the input terminals, using copper wires. Shroud the connections with a foam rubber or plastic insulating material for best calibration accuracy.
5. Set the voltage standard for an output of 0.00 mV.
6. At the OMNI-CAL™ front panel, select mV RANGE and MEASURE function.
7. Connect the oscilloscope ground lead to the GND test point on the analog assembly card. See Figure 4-2.
8. Set the oscilloscope sweep to 10 milliseconds per division.
9. Set the oscilloscope for free running or automatic triggering.
10. Connect oscilloscope vertical input to the preamp output at TP2.

4.2.2 Preamp Zero Offset Adjust (R21)

Allow the instrument to warm up for at least 30 minutes before making any adjustments to the calibrating controls.

Observe the waveform on the oscilloscope. Adjust the preamp offset (R21) for approximately straight, zero voltage trace (within ± 1 cm) with scope sensitivity of 0.1 V/cm.

NOTE

Once every five seconds there will be a positive pulse of about 3 V. This is the output of the reference junction sensor, and it should be ignored.

Disconnect the oscilloscope.

4.2.3 Amplifier Gain (Scaling) (K1, K2, K3, K4)

Set the voltage standard to the values shown in Table 4. Adjust the indicated control until the display on the OMNI-CAL™ is the value indicated in Table 4.

TABLE 4

AMPLIFIER GAIN

Voltage Standard (mV)	Adjust	Display Value
0.000	R41(mV zero)	0.000
+15.000	K4	15.000
+40.000	K3	40.000
+70.000	K2	70.000
+90.000	K1	90.000

Set the voltage standard to the values shown in Table 5. Observe the displayed values for each setting. Check to see that the displayed values are within the tolerance specified in Table 5. If a value exceeds the tolerance shown in Table 5, then adjust the indicated control to balance the error between positive and negative inputs (half the indicated error).

TABLE 5

AMPLIFIER TOLERANCES

Voltage Standard (mV)	Tolerance (mV)	Display Adjust
−15.000	±0.002	K4
−40.000	±0.010	K3
−70.000	±0.010	K2
−90.000	±0.010	K1

4.2.4 Reference Junction Calibration

1. Remove the voltage standard input to the OMNI-CAL™.
2. Connect a calibrated thermocouple to the input. Shroud the connection in foam rubber or plastic insulation for best calibration accuracy.
3. Select the appropriate thermocouple RANGE on the front panel. Select °F display units.
4. Place the thermocouple in the Ice Point Reference. As an alternate procedure, use an ice bath (water + ice) and stir thoroughly until the bath is "air saturated". Allow 5 minutes for stabilization.
5. Adjust TEMP ZERO (R31) control for a displayed value of 32.0°F (0°C). Recall that this temperature is updated only once every 5 seconds. Therefore, be sure that the effect of the adjustment of R31 has had a five second opportunity to affect the displayed value before readjusting the potentiometer.

4.2.5 Low Battery Sense Calibration

1. Adjust BTRY LOW (RG) control on the digital card fully counterclockwise. See Figure 4-2.
2. Set the adjustable power supply voltage to 5.90 volts.
3. Slowly turn R6 clockwise until the display starts to blink.

Verify the proper action of this function, as follows:

1. Increase the power supply voltage until the display stops blinking (DO NOT EXCEED 7 VOLTS).
2. Slowly decrease the power supply to the value where the display starts to blink. Measure the power supply voltage. It should be within ±0.03 volts of 5.90 volts.

Remove the voltage standard connection.

Replace the connector J4 on the power supply card.

Replace the assembly in the case. Reverse the procedure described above for removal. Do not re-fasten with the six screws until the TEST function in the next paragraph is completed.

4.2.6 Test Function

Place the instrument in battery operation, and let warm up for at least 30 minutes.

Select the TEST function.

Select the thermocouple ranges for the instrument, and verify that the displayed value is within the limits shown in Table 6. Repeat the calibration procedure if the results do not fall within the limits shown in Table 6.

TABLE 6

THERMOCOUPLE RANGES

Range	Value
mV	4.450 to 5.550 mV
J	185 to 221°F
	84.9 to 105.2°C
K	227 to 275°F
	108.6 to 135.5°C
T	218 to 258°F
	103.7 to 126.7°C
E	161 to 191°F
	71.8 to 88.6°C
R	928 to 1108°F
	498 to 598°C
S	971 to 1135°F
	522 to 631°C
C	530 to 630°F
	277 to 337°C

4.3 BATTERY PACK REPLACEMENT (See Figure 4-2)

When your OMNI-CAL™ unit will no longer operate in the battery mode, replace the battery pack, following the procedure described in paragraph 4.3.1.

4.3.1 Access to Battery Pack

1. Unplug ac power cord.
2. Remove 6 screws on front panel.
3. Slip assembly out of case.
4. Disconnect ground wire from the case.

4.3.2 Replacement

1. Unplug battery cable J4 on power supply board.
2. Remove the four screws that attach holder to power supply assembly.
3. Replace the battery pack with a 5 cell unit.
4. Be sure to maintain proper polarities of solder terminals.
5. Reassemble unit by following the steps above in reverse order.

SECTION 5 REFERENCE DATA

Reference Data A

DEFINITIONS

Cryogenic - Very low temperatures; used in reference to liquified gases such as LOX (– 297°F) and LN2 (– 320°F). Requires use of high resistance Platinum RTDs (500, 5,000 ohms), gold Chromel thermocouples or low temperature thermistors.

DIN Std. - A European Temperature Standard. DIN 43710 establishes thermocouple curves.

Duplex Sensor - A dual thermocouple usually isolated from each other and in the same housing or sheath.

Freeze Point Std. - Provides known reference temperatures, the freezing points of metals. They are usually not monitored by a reference thermometer since the pure metal samples are certified. Typical examples:

Metal	Freezing Points °C	°F
Tin	231.97	449.55
Zinc	419.58	787.24
Aluminum	660.37	1220.67

Kapton - A DuPont Company Polyimide insulation material; Radiation Resistant, Maximum Temperature 285°C. Used for high temperature lead wire insulation for RTDs and thermocouples.

Mineral Insulated - A term used to express a swaged or drawn thermocouple construction where a mineral oxide insulation, usually magnesium oxide or aluminum oxide, is densely compacted in a sheath for rugged, bendable, high temperature sensor construction.

O. D. (Tubing vs. Pipe) - Outside diameter, the proper way to size thermocouple sheath tubing vs. inside diameter used for pipe sizing.

Platinel - A special high output/high temperature platinum alloy thermocouple (Trademark of Englehard Industries). Has an emf output of 0-51 mV over span of 32°F to 2372°F. Composition is gold, platinum and palladium. Usual diameter is 0.020″ per lead.

Reference Junction - The other junction (usually at ice point) to which the measuring thermocouple junction is compared. The output voltage of a thermocouple is approximately proportional to the temperature difference between the measuring (hot) junction and the reference (cold) junction.

Response Time - (Time constant of a sensor). The time necessary for the sensor to reach 63.2% of step change in temperature with the sensor in water at a velocity of three (3) Ft/Sec, transverse to the sheath.

Teflon/Tefzel - Medium temperature wire insulations useful to 500°F and 390°F respectively. Tefzel has some radiation resistance.

Thermocouple - Two dissimilar metals with a voltage output proportional to temperature. ANSI types:

			Temperature (max.)
	J	Iron-Constantan (Copper-Nickel)	32° to 1382°F
	K	Chromel-Alumel (NiCr vs. NI-Al)	– 328° to 2282°F
	T	Copper-Constantan (Copper-Nickel)	– 328° to 662°F
	E	Chromel-Constantan (NiCr vs. Cu-Ni)	– 328° to 1652°F
	R	Platinum-vs. Plat. 13% Rhodium	32° to 2642°F
	S	Platinum vs. Platinum 10% Rhodium	32° to 2642°F
	B	Plat. 6% Rhodium vs. Plat. 30% Rhodium	32° to 3092°F
(Non-ANSI):	C	W 5% Rhenium vs. W 26% Rhenium	32° to 4208°F

Thermowell - The pressure vessel into which a thermocouple is inserted for easy removal and/or replacement purposes.

TEMPERATURE DEFINITIONS SUPPLEMENT

OFHC - Oxygen free high conductivity copper, one leg in type T thermocouples, the other leg being an alloy of approximately 60/40 copper nickel.

Alloy 11 - An alloy of copper with addition of approximately 0.5% nickel. Used with pure copper as compensating lead wire for Platinum/Platinum-Rhodium thermocouples types R and S.

Nicrosil/Nisil - Thermocouple improvements on type K to eliminate the instability caused by high temperature drift and short term changes in emf in the 250-550°C range. Data available in NBS Monograph 161. Composition is:

	Nicrosil	Nisil
Chromium	14.2%	
Silicon	1.4%	4.4%
Nickel	Balance	Balance

Nicrosil/Nisil are useful from 32° to 2372°F (0° to 1300°C), where the emf output is about 47.5 mV.

Limits of Error - The deviation in degrees or % of Standard or Special Grade D thermocouples in emf outputs from an ideal calibration. This tolerance or calibration normally applies only from 0°C up to the maximum temperature for each thermocouple. Sub-zero limits require special calibrations.

Junction-Forming - The means of forming the electrical contact between the two wires of a thermocouple. Methods include:

Type E - Soft or silver soldering for low temperature operation.

Type J, K, T - Gas Welding; the wires are twisted together through two or three turns, held vertically in a vise and joined by fusion with a gas flame (using only borax as a flux).

Reference Data B

HIGH TEMPERATURE THERMOCOUPLES (OVER 2000°F)

Thermocouple	Maximum Temperature °F	°C	Composition
R	3214°F	1768°C	Pt13Rh/Pt
S	3214°F	1768°C	Pt10Rh/Pt
B	3308°F	1820°C	Pt6Rh/Pt30 Rh
G***	4200°F	2315°C	W/W-26Re
C***	5000°F	2760°C	W5Re/W-26 Re
D***	4352-5072°F	2400-2800°C	W3Re/W-25 Re
Platinel**	2372°F	1300°C	Gold-Plat.-Palladium
Nicrosil/Nisil (N)	2372°F	1300°C	Nicrosil/14.2% Cr 1.4% Si/Bal Ni Nisil/4.4% Si/Bal Ni
K	2501°F	1372°C	NiCr/NiAl
PlMo	2900°F	1600°C	Platinum-Molybdenum
PL20Rh/PL40Rh	3272-3362°F	1800-1850°C	Platinum-Rhodium
Iridium vs.*_____ Iridium-Rhodium	3632°F	2000°C	Iridium-Rhodium

*40, 50 or 60%

**Platinel is a registered trademark of Englehard Industries.

***Not ANSI Symbol.

SECTION 6 SPECIFICATIONS

TYPES, RANGES & RESOLUTION:	See Table 7
REFERENCE JUNCTION COMPENSATION:	Automatic 0.017°/degree from 590 to 95°F (150 to 35°C)
ZERO STABILITY:	0.2 μV ½°F (RJC)
RANGE TEMPCO:	15 ppm/°C typical
OVERLOAD PROTECTION:	120 V dc or 120 V ac rms, continuous
INPUT IMPEDANCE:	100 MΩ or greater, during measurement interval
RANGES, RESOLUTION, & ACCURACY:	See Table 8
RANGE TEMPCO:	Same as thermocouple inputs
OVERLOAD PROTECTION:	Same as thermocouple inputs
RANGE:	− 12 mV to + 80 mV
RESOLUTION:	1 μV (typical)
SOURCE IMPEDANCE:	40Ω
NORMAL MODE REJECTION:	50 dB @ 50/60 Hz
COMMON MODE REJECTION:	140 dB with 300 V ac isolation for recharge mode
BATTERY MODE:	8 hours continuous operation minimum for NiCad battery pack
BATTERY LIFE:	Minimum 1,000 charge/discharge cycles
RECHARGE MODE:	14 to 16 hours for full charge. Instrument can be operated continuously and indefinitely while on recharge.
RECHARGE SOURCE:	110 V ac or 220 V ac, ± 20%, 47 to 400 Hz. Includes line cord for specified power source. Externally accessible fuse
OPERATE POWER:	1.5 watts (Battery Mode)
PRIMARY/SECONDARY TRANSFORMER ISOLATION:	1400 V ac
WEIGHT:	9.5 lb (4.3 kg)
DIMENSIONS:	H: 8″ (203mm) x W: 12.5″ (317mm) x D: 6″ (152 mm)
OPERATING TEMPERATURE:	14° to 104°F (− 10° to + 40°C)
STORAGE TEMPERATURE:	− 40° to + 140°F (− 40° to + 60°C)
RELATIVE HUMIDITY:	0-90% noncondensing
MOISTURE SEAL:	O-ring sealed waterproof case; splashproof panel

VIBRATION:	Each unit vibrated at 5g for 30s
EMI/RFI:	Shielding on six sides in standard metal case
BURN-IN:	100 hrs min (without batteries), with temperature cycles from 32° to 130°F, (0° to 54°C) plus power ON/OFF cycles
CALIBRATION:	NBS traceable. Detailed certificate of conformance shipped with each unit.
SAFETY:	Meets requirements of ANSI C39-5-1974 for Electrical Safety
RANGE SELECT:	Rotary switch, four or eight ranges
FUNCTION SELECT:	Rotary switch, four position: OFF, MEASURE, CALIBRATE, and TEST
°F/°C SELECT:	Toggle switch, two position: °F or °C
OUTPUT ADJUST (CALIBRATE FUNCTIONS ONLY):	Dual concentric potentiometer for coarse and fine adjustment of output (and of corresponding display)
CHANNEL A/B SELECT:	Toggle switch, two position
DISPLAY TYPE:	Seven digit, seven segment planar, red LED display, 0.30″ (8 mm) high
DISPLAY READOUT UNITS:	°F or °C for temperature, E for millivolts
LOW BATTERY:	Display blinks during a 10 minute warning period, then the unit powers down and the display turns off
POSITIVE TEMPERATURE OVERRANGE:	"HIGH"
NEGATIVE TEMPERATURE OVERRANGE:	"LO"
OPEN THERMOCOUPLE INPUT:	"OPEN"
OVERRANGE MV INPUT:	"ERROR"
DISPLAY TEST:	Display reads all "8s" when unit is turned on or range is changed

Notes to Specifications

1. *Outside of this range (i.e., from − 10°C to + 15°C ambient, and from + 35°C to + 40°C ambient), maximum reference junction error is ± 0.035/degree.*

2. *Range tempco applies from 14° to 104°F (− 10° to 40°C) ambient.*

TABLE 7

RANGE, RESOLUTION, CONFORMITY, ACCURACY & STABILITY OF THERMOCOUPLE MEASUREMENT AND SIMULATION FUNCTIONS[1] (ALL VALUES IN DEGREES)

Thermocouple Type (metals)	Scale	Temperature Range[2]	Resolution	Conformity[3]	RSS Calibration Accuracy[4]	Overall Accuracy 1 year[5]
J	°F	−346 to +2192	0.1	±0.2	±0.29	±1
(Fe/CuNi)	°C	−210 to +1200	0.1	±0.1	±0.17	±0.6
K	°F	−328 to +2501	0.1	±0.2	±0.33	±1
(NiCr/NiAl)	°C	−200 to +1372	0.1	±0.1	±0.19	±0.6
T	°F	−337 to + 752	0.1	±0.2	±0.25	±1
(Cu/CuNi)		−405 to − 337	0.1	±9.2	±9.11	±10
	°C	−205 to + 400	0.1	±0.1	±0.15	+0.6
		−243 to − 205	0.1	+5.1	±5.10	±5.6
E	°F	−389 to +1832	0.1	±0.2	±0.27	±1
(NiCr/CuNi)		−422 to − 389	0.1	±5.0	±4.81	±5
	°C	−234 to +1000	0.1	±0.1	±0.16	±0.6
		−252 to − 234	0.1	±2.8	±2.71	±2.8
R	°F	−58 to +3214	1	±0.2	±0.76	±2
(Pt13Rh/Pt)	°C	−50 to +1768	1	±0.1	±0.65	±1.1
S	°F	−58 to +3214	1	±0.2	±0.61	±2
(Pt10Rh/Pt)	°C	−50 to +1768	1	±0.1	±0.54	±1.1
C	°F	+32 to +2192	1	±0.2	±0.68	±1
(W5Re/W26Re)		+2192 to +3812	1	±0.2	±0.84	±2
		+3812 to +4200	1	±0.2	±0.97	±3
	°C	0 to +1200	1	±0.1	±0.56	±0.6
		+1200 to +2100	1	±0.1	±0.62	±1.1
		+2100 to +2315	1	±0.1	±0.69	±1.7

TABLE 8

RANGE, RESOLUTION, AND ACCURACY OF mV MEASUREMENT AND SOURCE FUNCTIONS

Voltage Range [6]	Resolution	RSS Calibration Accuracy[4]	Overall Accuracy 1 year[5]
−20.000 mV to +20.000 mV	0.001 mV	±(0.005% of reading +2 digits)	±(0.03% reading +5 digits)
−101.10 mV to −20.00 mV; +20.00 mV to +101.10 mV	0.01 mV	±(0.01% of reading +1 digit)	±(0.03% reading +2 digits)

Notes to Tables 7 and 8

1. *For unlisted thermocouples, such as types B, W, Nicrosil/Nisil, gold/chrome, etc., use the OMNI-CAL™ millivolt range and appropriate mV vs. T tables (NBS Monographs, etc.).*
2. *For thermocouple calibrate functions, the output range is − 12 mV to + 80 mV, with resolution and accuracy per the corresponding temperatures shown.*
3. *Data conformity to ANSI Spec MC 96.1-1975. See Table 7 for equivalent standards.*
4. *Traceable to NBS. RSS = root sum squares: the square root of the sum of the squares of all the error contributions involved.*
5. *Instrument at 25°C ± 2°C.*
6. *For mV MEASURE operation, the instrument autoranges. For mV source operation (CALIBRATE function), the output range is − 12 mV to +80 mV with resolution and accuracy per Table 8.*

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MADE IN USA

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OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that our customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

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BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, YOU MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OUR CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

FOR WARRANTY RETURNS, please have the following information available BEFORE contacting OMEGA:

1. P.O. number under which the product was PURCHASED,
2. Model and serial number of the product under warranty, and
3. Repair instructions and/or specific problems you are having with the product.

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1. Your P.O. number to cover the COST of the repair / calibration,
2. Model and serial number of the product, and
3. Repair instructions and/or specific problems you are having with the product.

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