AVO BIDDLE INSTRUMENTS

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Instruction Manual
AVTM 72-390Ja

For the

Versa-Cal® Calibrator

Catalog Number 720390 Series

AVO BIDDLE INSTRUMENTS

BLUE BELL, PA 19422 • (215) 646-9200

The Measure of Excellence in Electrical Testing...

The industry leader since 1895, AVO Biddle Instruments offers a comprehensive line of electrical test and measurement products, from portable instruments for use in the field to fully-integrated systems for high voltage systems testing. Biddle Instruments fulfills a range of requirements found in electric utility, large industrial, electrical apparatus manufacturing, military and governmental applications worldwide.

Portable Field Test Equipment

AVO Biddle's extensive product line includes its well-known portable field test equipment, including the MEGGER® family of Insulation Resistance Testers, which indicate the deterioration of electrical insulation; Ground Resistance Testers for installing and maintaining grounding systems; and equipment for locating faults in both power and communications cable.

Precision Test & Measurement Equipment

AVO Biddle operates a calibration lab traceable to the NIST to ensure the quality of its precision products. These include the DLRO® line of digital low resistance ohmmeters, and the Versa-Cal® line of thermocouple calibrators for process control applications.

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AVO Biddle is a leading supplier of equipment and systems for High Voltage Systems Testing applications, from rigorous QC testing of manufactured power cable to demanding R&D requirements in the Aerospace industry. This range of products includes fully-integrated systems for detecting minute levels of partial discharge to HV power supplies and DC dielectric, transformer turn ratio, and capacitance/dissipation factor test sets for use in the field testing of large power apparatus.

No matter whether it's a hand-held MEGGER Insulation Tester or a 750 kV Partial Discharge Detection System, Biddle Instruments backs it up with a full range of support services:

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Applications Assistance

Our Applications Engineers can demonstrate how Biddle instruments can fulfill your testing requirements. They can provide on-site demos, training or product presentations tailored to your application.

Customer Service

Contact one of Biddle's Customer Service Representatives for quick answers to your questions regarding where to buy, order entry, delivery, or warranty and repair information. They can also assist you in ordering replacement parts, accessories, operating/service manuals, and product/applications literature.

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Operating Instruction Manual 72-390Ja

for

Versa-Cal® Calibrator
Catalog Number 720390 Series

Read the entire manual before operating.
Antes de operar este producto lea este manual enteramente.

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

Section 1
Introduction

1.1 RECEIVING INSTRUCTIONS

Check the equipment received against the packing list to ensure that all materials are present. Notify Biddle Instruments of any shortage. Telephone (215) 646-9200.

Examine the equipment for possible damage received in transit. If any damage is discovered, file a claim with the carrier at once and notify Biddle Instruments or its nearest authorized sales representative giving a detailed description of the damage.

The Versa-Cal Calibrator has been thoroughly tested and inspected to rigid specifications before being shipped. It is ready for use when set up as indicated in this manual.

The complete instrument consists of the following:

- Main instrument (nameplate data on outside of case and inside of lid should match)
- Instruction manual and four test leads (in lid)
- Charger and RTD simulator (in storage compartment)

- Record the serial number of the calibrator and simulator here:

  Versa-Cal Calibrator: ______________________

  RTD Simulator: ______________________

Read this manual and become familiar with the functions of the calibrator, following the performance verification procedure in Section 6.

BEFORE INITIAL USE OF CALIBRATOR, CHARGE BATTERIES

Refer to Section 5 for battery charging procedure.

1.2 GENERAL INFORMATION

This manual gives instructions for the use of Versa-Cal Calibrator. The instrument is portable, lightweight, and self-contained. It operates on rechargeable batteries and is housed in a rugged, splash-resistant case. A storage compartment holds the charger and RTD simulator. Figure 1 shows Cat. No. 720390 calibrator with its accessories removed.

A "-47" suffix added to the catalog number denotes a 230-V charger. A 115-V charger is standard. The calibrator is designed, built, and tested to provide accurate calibrations in the field. Special features include built-in self-checking and traceability to the National Institute of Standards and Technology (NIST). The calibrator measures and simulates a wide range of measurement transducer output signals:

Figure 1: Cat. No. 720390, Accessories Removed

- Temperature from thermocouples.
- Millivolts from thermocouples (TC's) or other sources.
- Temperature from resistance temperature detectors (RTD's).
- Resistance in ohms of RTD's or other sources.
- Frequency in hertz from flowmeters, tachometers, etc.
- 100-V insulation test.

The calibrator meets standards for service in critical industries such as food, pharmaceutical, aerospace, and nuclear power. For example, in heat-treating aerospace components to MIL-H-6875H and SAE's AMS 2750, the calibrator qualifies for three levels of the calibration hierarchy, test instrument, secondary standard, and primary standard. Biddle Instruments uses in-house standards certified directly by NIST. Strict internal controls in accordance with MIL-STD-45662 are frequently monitored by industry and by government agencies.

1.3 FEATURES

1.3.1 Dual Input/Output Channels

Two sets of binding post terminals provide the capabilities for:

- Generating a calibrated output signal on one channel while measuring a different signal on the second channel.
- Supplying voltage to a strain-gauge-type transducer while measuring its millivolt output.
- Tracking or comparing two separate input sources.

1.3.2 Sensitive, Accurate Millivolt Measuring Circuit

This measuring system has the unusually wide range of 0.5 µV to 4 V, with very high input impedance. Careful electronic and thermal design provides for 0.005 percent full-scale calibration. The high sensitivity permits thermocouple measurements at temperature extremes (where thermocouple output falls as low as 1 or 2 µV per degree) while the wide range permits direct measurements from high-impedance transducers. Most thermocouple ranges may be displayed in 0.1°F increments and RTD temperatures in 0.01 degree increments without excessive test current.

1.3.3 Ten Thermocouple Types

The calibrator measures and simulates 10 thermocouple types (J, K, T, E, R, S, B, N, C, and NM). Other types are available by special order. The range mix can be changed either by the factory or by the user with a plug-in field kit.

1.3.4 Wide Range Reference Junction Compensation

This feature is fully specified. It enables the calibrator to remain accurate over a wide range of temperatures including severe temperature shock (step change).

High performance is obtained by use of a selected fast-response temperature sensor embedded in the brass binding posts at the reference junction of each connection channel. The binding posts are enclosed in a thermally isolated well.

1.3.5 Direct-Reading "Ice Bath" Mode for Thermocouple Measurements

The calibrator bypasses its reference junction compensation to display temperatures directly for thermocouple systems having an ice point reference junction. This provides a three to one improvement in calibrator accuracy for measurements of up to a few hundred degrees.

1.3.6 Three RTD Types, Three-Wire or Four-Wire Hookup

The calibrator measures and simulates platinum, nickel, and copper RTD types with resolution to 0.01 degree. Other RTD types are available by special order. Test current is well below recommended self-heating limits. An automatic zero check corrects for spurious electromotive forces (emf's). Special capabilities include displays to identify open leads and a routine for checking errors in three-wire installations caused by lead imbalance.

1.3.7 Precision Resistance Range

The calibrator simulates any RTD, thermistor, or other resistance up to 2000 Ω; measures to 4000 Ω; Cat. No. 720390 measures up to 40,000 Ω using voltmeter-ammeter hookup; and provides full resolution, 0.002 Ω, for 10 Ω sensors.

1.3.8 High-Capacity Battery Supply with Dry Cell Backup

High-efficiency electronics and a high-capacity battery combine to give normal service between charges of several weeks (up to 40 hours continuous). As a backup, ordinary dry cells can be used.

1.3.9 Quick-Set Calibration Output

Five quick-set push buttons are calibrated to five cardinal points of any output range; these push buttons can be set to cover any portion of any range using two independent pairs of COARSE and FINE wire-wound OUTPUT controls. The output is continuously measured by the display system.

1.3.10 Precision Frequency Measurement

The calibrator measures frequency by direct comparison to a precision temperature-stable quartz crystal. The system provides resolution to 0.01 Hz with a sampling time of only 0.1 second. Long-term accuracy approaches one least significant digit (lsd).

1.3.11 Insulation Test

The instrument applies 100 V dc to test for faulty insulation of thermocouples and RTD's.

1.3.12 Valuable Low Ranges

Full four-digit measurement resolution and excellent accuracy are provided for ranges of 0 to 1 mA, 0 to 1 V, 0 to 10 Ω, and others.

1.4 APPLICATIONS

- Calibrating control signals in dc mA, volts, or frequency ranges.
- Calibrating transmitters such as mV-to-current for which the calibrator supplies a calibrated input while accurately monitoring its output.
- Calibrating loggers, recorders, controllers, indicators, and other instruments of the digital, null-balance, or deflection type.
- Troubleshooting sensor circuits or control loops.
- Measuring temperature with thermocouples or RTD's.
- Comparing outputs of working and reference transducers, including thermocouples and RTD's.
- Measuring millivolts from high-impedance transducers up to 4000 mV.
- Measuring and simulating frequency-generating transducers such as flowmeters and event counters.
- Measuring millivolt-per-volt output of strain-gauge transducers.

Section 2
Safety

Safety is the responsibility of the user.

The Versa-Cal Calibrator has no unusual hazards; however, because of the unpredictable conditions that may occur in the equipment being tested, the user must be trained to recognize and protect against other hazards that may exist. The user should read and understand this manual, be alert to hazards, and take indicated precautions including the following specific instructions:

Explosion: Do not use the calibrator in, or connect it to, equipment located in an explosive atmosphere.

Environmental: In making connections, watch out for very hot or very cold or otherwise hazardous surfaces or atmospheres.

Electric Shock: Do not connect the calibrator to hazardous energized circuits. Do not touch energized circuits. Take special care of sensors situated in electrically heated furnaces, long leads whose path is unknown, or other circuits which might be accidentally energized by line voltage or other hazardous voltages. Watch for control loops having high supply voltages.

Use the battery charger in a dry indoor environment only. Protect it from physical damage. If charger needs repair, use a factory replacement.

General: Do not use the calibrator, test leads, and other accessories for any purpose or in any manner other than described herein.

Refer fuse replacement to qualified service personnel only. To avoid electric shock and fire hazard, use only the fuse specified in the parts list which is identical in respect to type, voltage rating, and current rating.

This instrument uses rechargeable batteries; replace only with nickel-cadmium batteries as specified in Section 3, Specifications. If zinc-carbon dry cells are used as a temporary emergency replacement, do not use the charger. Danger of explosion can result.

Observe all safety precautions as specified throughout this manual. The following warning and caution notices are used in this manual where applicable.

WARNING

Warning, as used in this manual, is defined as a condition or practice which could result in personal injury or loss of life.

CAUTION

Caution, as used in this manual, is defined as a condition or practice which could result in damage to or destruction of the equipment or the apparatus under test.

If unsure about safety, stop and get help.

Section 3
Specifications

3.1 MODES OF OPERATION

Selectable by rotary FUNCTION switch:

MEASURE A/MEASURE B: measures either of two input signals connected to in/out channels A and B. Any input signal can be measured on channel A; any TC or mV signal can be measured on channel B.

MEASURE A/OUTPUT B: simultaneously measures an input signal on channel A and generates an output signal on channel B. Channel B may be used instead to measure input signals.

OFF: turns power off, but battery may be charged.

3.2 METHODS OF GENERATING AND DISPLAYING OUTPUT SIGNALS

For signals except ohms/RTD, outputs are continuously generated at channel B terminals and displayed on demand by direct measurement. For ohms/RTD signals, outputs are generated by the RTD simulator which plugs into channel A terminals. A switch on the simulator provides for monitoring its setting on the display.

3.3 OVERALL RANGES OF SIGNALS MEASURED AND GENERATED

Type	Measure Mode Range	Output Mode Range
millivolts (mV)	-200 to 4000	-11 to 101
temperature from TC	10 TC types	10 TC types
resistance (Ω)	0.001 to 4000	9 to 2000
temperature from RTD	3 RTD types	3 RTD types
milliamperes (mA)	-60 to 60	0.0001 to 55 quick-set 4-20, 10-50
volts (V)	-40 to 40	0.0001 to 11 quick-set 2-10
frequency (Hz)	8.00 to 40,000	8.00 to 4000 quick-set 800-4000

3.4 CONTROLS FOR OUTPUTS EXCEPT OHMS/RTD

Each output signal can be quick-set by push button to any of five values fixed at 25 percent intervals over a commonly used standard range. Alternately, the end values can be adjusted to any desired setting with the intermediate values automatically at the 25 percent intervals. The controls function as follows:

FIXED RANGE quick-set outputs: five push buttons marked LO (0% RANGE) 25, 50, 75, and HI (100% RANGE). Trimmable as a group through ±1/4 percent of setting by a single one-turn control which has a calibrated position indicated by an index mark.

ADJUST (adjustable) outputs:

controls for setting HI (100% RANGE) point:

COARSE, 10-turn continuous control, covering fulloutput range.

FINE, 3-turn control, covers 1/350 of COARSE range.

controls for setting LO (0% RANGE) point:

COARSE, 10-turn control covering lower 25% of fulloutput range.

FINE, 1-turn control, covers 1/600 of COARSE range.

3.5 DETAILED PERFORMANCE

3.5.1 Thermocouple (TC) and Millivolt (mV) Ranges, Measure Mode

Table 1 shows the thermocouple and millivolt ranges, resolution, and limit of error in the measure mode.

TC/mV type selection: 12-position rotary switch

°C/°F selection: by slide switch

Reference junction compensation: basic accuracy when displaying temperature above ambient and with reference junction between 32 and 113°F:

Maximum error at stable ambient: 0.017 degree displayed per degree of reference junction deviation from 77°F (25°C) of which the first ±10°C effect is included in Table 1.

Temperature shock initial offset: 1 percent of ambient step change in still air.

Temperature shock recovery: offset drops by two-thirds in 30 minutes.

Accuracy in special cases:

Type C: for display above 1200°C multiply error and offset by 1.5.

For display of temperature below ambient, multiply the error and offset by the ratio of thermocouple mV per degree at ambient temperature to that at the displayed temperature.

Millivolts and type B: no compensation.

Ice bath mode: setting a slide switch located in the storage compartment bypasses automatic reference junction compensation. Instrument then displays correctly for external reference junction held at 32°F (0°C).

Thermometer mode: displays temperature of (-) binding post. Range 32 to 113°F; accuracy 0.2°F + 1.7 percent of deviation from 77°F.

Settling time to rated accuracy: 0.5 second after input change

Input resistance : >1000 MΩ

Source resistance effect: 2000 Ω causes less than one digit error on all ranges.

Table 1: Ranges, Resolution, and Limit of Error for Thermocouple and Millivolt Ranges, Measurement Mode

TC/mV TYPE Switch[4] Position	Type[1]	Range	Resolution and Repeatability	Limit of Error[3] 25±10°C, 1 Year
1	mV[2]	(±)0 to 20.030 mV	0.001 mV	±(0.03% rdng + 0.005 mV)
		(±)20 to 200.30 mV	0.01 mV	±(0.03% rdng + 0.02 mV)
		(+)200 to 4006.0 mV	0.1 mV	±(0.02% rdng + 0.2 mV)
2	J	-346 to +2192°F	0.1°F	±1°F
		-210 to +1200°C	0.1°C	±0.6°C
3	K	-328 to +2501°F	0.1°F	±1°F
		-200 to +1372°C	0.1°C	±0.6°C
4	T	Primary:		
		-339 to +752°F	0.1°F	±1°F
		-205 to +400°C	0.1°C	±0.6°C
		Extended:		
		-405 to -337°F	0.1°F	±10°F
		-243 to -205°C	0.1°C	±6°C
5	E	Primary:		
		-389 to +1832°F	0.1°F	±1°F
		-234 to +1000°C	0.1°C	±0.6°C
		Extended:		
		-422 to -389°F	0.1°F	±5°F
		-252 to -234°C	0.1°C	±3°C
6,7	R,S	-58 to +3214°F	1°F	±2°F
		-50 to +1768°C	1°C	±1°C
8	B	Primary:		
		1112 to 3308°F	1°F	±2°F
		600 to 1820°C	1°C	±1.5°C
		Extended:		
		680 to 1112°F	1°F	±3°F
		360 to 600°C	1°C	±2°C
9	N	+32 to 2372°F	0.1°F	±1°F
		0 to 1300°C	0.1°C	±0.6°C
10	C	Primary:		
		+32 to 2192°F	1°	±1°F
		0 to 1200°C	1°C	±1°C
		Extended:		
		2192 to 3812°F	1°F	±2°F
		3812 to 4200°F	1°F	±3°F
		1200 to 2100°C	1°C	±1.5°C
		2100 to 2315°C	1°C	±2°C
11	NM	0 to 2372°F	1°F	±3.5°F
		-18 to 1300°C	1°C	±2.3°C
12	Spare	-	-	-

[1] Thermocouple ranges are calibrated to International Practical Temperature Scale (IPTS) 1968. Symbols and curves are as defined by ANSI MC96.1, IEC 584-1/1977, ASTM E230/87, and other U.S. and international standards, except as noted in the following:

J - Iron-Constantan
K - Chromel-Alumel
T - Copper-Constantan
E - Chromel-Constantan
R - Platinum/13% Rhodium-Platinum
S - Platinum/10% Rhodium-Platinum
B - Platinum/30% Rhodium-PT/6% Rhodium
N - Nicrosil-Nisil per NBS (now NIST) Monograph 161 (14 gauge wire) and ASTM E230/1987.
C - Tungsten/5% Rhenium-Tungsten/26% Rhenium per Hoskins Mfg. Co. and ASTM E988/89. Symbol "C" is industry usage equivalent to W5.
NM - Nickel-Nickel/18% Molybdenum per General Electric Company table, using IPTS of 1927; symbol "NM" assigned by Biddle Instruments.

Other thermocouple types or earlier standard curves are supplied on request.

[2] Millivolt measure range has automatic range changes, with hysteresis, at ±20.03 mV and +200.3 mV.

[3] Limit of error includes linearization conformity, resolution, zero error, span error, noise, reference junction compensation, and calibration to NIST. For type B, assumes copper extension leads with reference junction temperature between 10 and 35°C (50 to 95°F). Linearization conformity to original source is within 0.2°F within primary thermocouple range, except 0.2°C for type B, and 1.1°C for type NM.

Applies to operation as directed after warm-up of 5 minutes (only 30 seconds for ranges with 1 degree or 0.01 mV resolution).

[4] In ice bath (ICE) mode, the limit of error reduces to the sum of the linearization conformity and the millivolt range errors.

Normal mode rejection: >50 dB at 50 or 60 Hz

Common mode rejection ratio:

Operating on batteries: not applicable

Operating on ac (charger on): >140 dB with 300-V isolation

CHECK TC/mV function: displays reading of a special internal reference voltage on any TC/mV range. The displayed reading can be compared with the recorded value marked on the label in the instrument lid.

Open input (thermocouple burnout) detection:

Timing: before each display update

Effect on reading: none unless input is open

Effect on source: circuit emits 30 nA for 0.1 second

Display: OP-LO replaces normal reading if open is detected.

3.5.2 Thermocouple (TC) and Millivolt (mV) Ranges, Output Mode

Range: same as measure mode, see Table 1, except for millivolts which is -11 to +101.

Display resolution, repeatability, and limit of error: same as measure mode, see Table 1.

Setting resolution: enables setting to full resolution of display.

Stability, mV: typically <20 ppm per ˚C and <5 µV in 1 hour.

Stability, TC: output, which includes the reference junction emf, shifts with the reference junction temperature; display indicates this correctly.

Output resistance:

10 or 25 Ω; supplied with 25 Ω; can bereduced to 10 Ω by jumping out overvoltage protectiondevice.
Quick-set FIXED RANGE values: +20, 40 60,80, 100 mV; accuracy: ±0.2 percent of setting.

3.5.3 Resistance and RTD Ranges, Measure Mode

Table 2 shows ranges, resolution, and limit of error for resistance and RTD ranges when the calibrator is in the measure mode.

Three-wire/four-wire selection: single panel control with markings of connections required.

Lead resistance effect:

- For four-wire hookup, a total resistance of either the C1-C2 lead pair or the P1-P2 lead pair of up to 100 Ω has no effect.

- For three-wire hookup, the same applies to the P1-C2 lead pair and the P1-P2 lead pair, but the total of the P1 lead and the unknown may not exceed the selected resistance range (400 Ω for all standard RTD ranges).

Spurious dc voltage effect: below 20 mV has no effect; above 20 mV causes display to show "HI E."

Detection of intermixed leads: diagnostic display prevents false readings; for three-wire hookup, display indicates single-pair interchange required to make correction.

Detection of open sensor or open lead or leads: diagnostic display prevents false readings; switch change locates fault.

Calibration check: 100-Ω resistor built into RTD simulator; checks 0°C point on 100-Ω RTD range to ±0.05°C.

3.5.4 Resistance and RTD Ranges, Output Mode (Using RTD Simulator)

Simulator internal resistors:

- Adjustable, RA, range 8.9 to 2000 Ω with settingresolution of 0.002 Ω
- Fixed standard, RS, 100 Ω nominal value, with effectivevalue depending on connection as follows:
  Displayed on calibrator, 4-wire: 100 Ω ±0.02 percent
  (A measured value is recorded on the check label.)
  Displayed on calibrator, 3-wire: 99.98 Ω ±0.02 percent
  Output to item under test, 4-wire: 101 Ω ±0.02 percent
  Output to item under test, 3-wire: 99.98 Ω ±0.03 percent

Simulator connections and switching:

Four banana plugs fit channel A binding posts
Three binding posts for connection to user's measuring instrument
Two-position switch connections:
Left: RA to output, RS to calibrator for display
Right: RS to output, RA to calibrator for display

Output limit of error: same as measure mode plus the following
In resistance, ±0.012 Ω
In temperature, Pt 100 Ω or Ni 120 Ω: ±0.03°C or 0.06°F
In temperature, Cu 10 Ω: ±0.3°C or 0.6°F
Maximum current recommended for simulator: 10 mA

Test of lead compensation on 3-wire instruments: 1 Ω ±0.5 percent is inserted in each output lead with the 100-Ω RS.

Table 2: Ranges, Resolution, and Limit of Error for Resistance and RTD Ranges, Measure Mode

RANGE Switch Setting	Test mA	Range[1]	Resolution	Limit of Error[2] 25±10°C, 1 Year 4-Wire	Add for 3-Wire
RES OHMS	0.5	0 to 40.060	0.001 Ω	±(0.03% + 0.003 Ω)	0.002 Ω
400 Ω		40 to 400.60 Ω	0.01 Ω	±(0.03% + 0.02 Ω)	0.02 Ω
RES OHMS	0.05	0 to 400.60 Ω	0.01 Ω	±(0.03% + 0.03 Ω)	0.02 Ω
4 kΩ		400 to 4000.0 Ω	0.1 Ω	±(0.03% + 0.2 Ω)	0.1 Ω
TEMP RTD	0.5	-200.00 to 157.00°C	0.01°C	±(0.03% + 0.15°C)	0.02°C
PT DIN		157.0 to 650.0°C	0.1°C	±(0.03% + 0.2°C)	0.02°C
100 Ω		-328.0 to 314.60°F	0.02°F	±(0.03% + 0.3°F)	0.04°F
		314.6 to 1202.0°F	0.1°F	±(0.03% + 0.4°F)	0.04°F
		73.00 to 430.00°K[3]	0.01°K	±(0.03% + 0.05°K)	0.02°K
		430.0 to 923.0°K	0.1°K	±(0.03% + 0.1°K)	0.02°K
TEMP RTD	0.5	(-)200.0 to 260.0°C	0.1°C	0.3°C	0.02°C
CU 10 Ω		(-)328.0 to 500.0°F	0.1°F	0.5°F	0.04°F
TEMP RTD	0.5	(-)70 to 270°C	0.01°C	0.25°C	0.02°C
NI 120 Ω		(-)94 to 518°F	0.02°F	0.5°F	0.04°F

[1] Description and source of RTD temperature curves (all conforming to IPTS-1968):
PT DIN 100 Ω: platinum, 100 Ω at 0°C, ±0.3850 percent per °C, to DIN

Standard 43760/1980, IEC 751/1983, BS 1904/1984 and ASTM E1137/1987.
CU 10 Ω: copper, 10 Ω at 25°C per Minco Products Inc. Table No. 16-9. R100/R0 = 1.4274 (U.S. industrial standard).
NI 120 Ω: nickel, 120 Ω at 0°C, ±0.672 percent per °C, per Minco Products Inc. Table No. 7-120. R100/R0 = 1.6720 (U.S. industrial standard).

[2] Limit of error covers A/D converter linearity, zero shift, span change, conformity, digital round-off, and noise, and applies with charger or lamp on or off after 5-minute warm-up; 3-wire limits are for matched lead resistance in P1 and C2. Conformity of linearization to original source is 0.005°C for PT DIN, 0.05°C for CU, 0.1°C for NI.

[3] °K (Kelvin) on special order only.

3.5.5 dc Control Loop Ranges (Volts and Milliamperes), Measure Mode

Table 3 shows ranges, resolution, and limit of error for dc control loop signals in the measure mode.

Table 3: dc Control Loop Ranges, Resolution, and Limit of Error, Measure Mode

RANGE Switch Setting	Range	Resolution	Limit of Error ±10°C, 1 Year
60 mA*	(±)0 to 2.0030 mA	0.1µA	±(0.04% rdng +0.001 mA)
	(±)2 to 20.030 mA	1 µA	±(0.04% rdng +0.002 mA)
	(±)20 to 60.00 mA	10 µA	±(0.04% rdng +0.02 mA)
40 V	(±)40.000 V	0.001 V	±(0.03% rdng +0.003 V)

* mA range has automatic range change at 2.0030 mA and 20.030 mA.

Input Impedance:

volts range: 2 MΩ ±1 percent
mA range: 85 Ω ±20 percent

3.5.6 dc Control Loop Ranges (Volts and Milliamperes) Measure Mode on Output Channel (Not on Cat. No. 720380)

As for Measure Mode except:

Input Impedance:

volts: 25 kΩ±1%
mA: less than 300 Ω

3.5.7 dc Control Loop Ranges (Volts and Milliamperes), Output Mode (Not on Cat. No, 720380)

Table 4 shows the ranges, resolution, and limit of error for dc control loop signals in the output mode.

Table 4: dc Control Loop Ranges, Output Mode

Switch Setting		Output	Quick-Set Outputs[2]	Display		
TYPE	mA Range	Range	FIXED RANGE	Range	Resolution	Limit of Error
mA	20	0 to 22	4, 8, 12, 16, 20	As in Measure Mode, see Table 3.		
mA	50	0 to 55	10, 20, 30, 40, 50	As in Measure Mode, see Table 3.		
V	-	0 to 11[1]	2, 4, 6, 8, 10	0 to 2.003[3]	0.0001	±(0.03% rdng + 0.0003)
				2 to 11.000	0.001	±(0.03% rdng + 0.002)

[1] Volts output can be adjusted to a few millivolts below zero.

[2] FIXED RANGE settings have an accuracy of ±0.2 percent of setting.

[3] Volts range has automatic range change at 2.003 V.

Regulation and Stability:
Maximum output change caused by any of the following influences is 0.1 percent of nominal range.

Full range load change
10°C change in ambient temperature
First minute of warm-up
8 hours after warm-up at constant ambient

Alternate Power Sources, mA Ranges:

Internal 30 V
External loop supply up to 60 V
Internal 30 V aided by external supply up to 60 V total

Output Ratings, mA Ranges:

Internal source voltage: 30 V ±5 percent no load, falling to 24 V at 50 mA

External voltage: 60 V maximum allowable

Maximum loop resistance depends on current setting and total loop voltage as shown in Figure 3.

Output Ratings, Voltage Ranges:

Rated load current: 20 mA

Short circuit protection: current limits at approximately 45 mA, no damage; thermal limiter requires up to 5 minutes to reset.

3.5.8 Frequency Ranges, Measure Mode (Not on Cat. No. 720380)

Table 5 shows ranges, resolution and limit of error of frequency ranges when in the measure mode.

Table 5: Frequency Ranges, Measure Mode

Switch Setting	Range*(Hz)	Resolution	Limit of Error 25±10°C, 1 Year
kHz	8 to 400.00	0.01	20 ppm+2 lsd
	400 to 4000.0	0.1	20 ppm+2 lsd
	4000 to 40000	1	20 ppm+2 lsd

*Automatic range changes at 400 and 4000 Hz.

Waveforms accepted: sine, square, pulse, contact closure, either polarity or ac.
Amplitude accepted: 0.1 to 100 V peak-to-peak
Input impedance: 10 kΩ in parallel with 4700 pF
Sampling period: 0.07 to 0.17 second
Abnormal conditions detected: no detectable signal, frequency over range

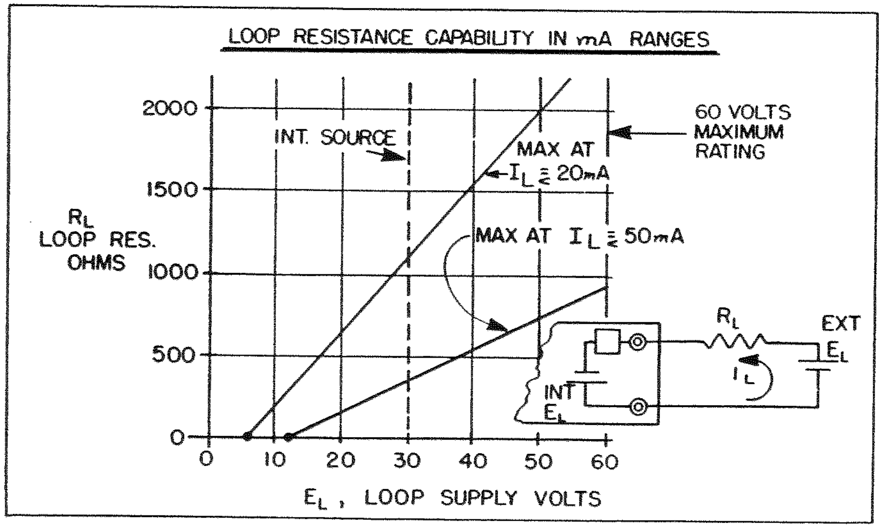

Figure 2: Loop Resistance Capability in mA Output Ranges

3.5.9 Frequency Ranges, Input Measurement on Output Channel

As in Measure Mode except input impedance is 3.3 K below 0.5 V input and less than 3.3 K above 0.5 V input; a dc bias voltage is applied to source.

3.5.10 Frequency Ranges, Output Mode (Not on Cat. No. 720380)

Range: 10 to 4000 Hz

Display resolution and limit of error: same as measure mode

Setting resolution: 0.04 Hz

Quick-set FIXED RANGE values: 800, 1600, 2400, 3200, 4000 Hz

Accuracy of FIXED RANGE values: 0.2 percent of setting ±6 Hz

Jitter: ±0.02 Hz

Output impedance: TTL compatible

Waveform: square, 0 to +5 V
(other wave shapes may be approximated by external networks)

3.5.11 Insulation Resistance Test

Range: 1 to 100 MΩ

Test voltage: 100 V dc at 100 MΩ

Resolution, percent of reading: 2 percent at midrange, falls to 10 percent at ends

Accuracy: 3 times resolution

Short-circuit current: 10 µA dc

Connections, settings, and display: set up and connect as for mA output with external supply; press momentary button (behind sliding cover, inside storage compartment); display reads µA (may be converted to MΩ using supplied table).

3.6 OTHER PERFORMANCE

3.6.1 Display (see Figures 3 and 4)

Type: transmissive/reflective liquid crystal display (lcd) with switched backlighting; main characters are seven segment, 0.4 in. (1 cm) high; auxiliary characters are 0.15 in. (0.38 cm) high

Lighting: three incandescent lamps behind display; controlled by LAMP push button, press to turn on, press again to turn off after 15-second delay. Lamps light briefly at power-up.

Digits: five with decimal point and (-) sign

Reading format: refer to Table 6.

Reading update rate: 2 per second for TC, mV, mA, V or F; 1 per second for RES and RTD

Diagnostic messages: see Figure 5.

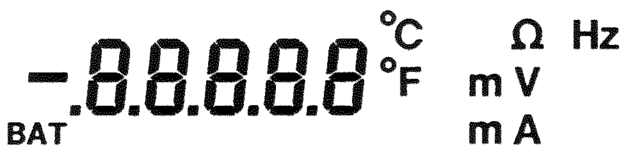

Figure 3: Calibrator Display, Shown Actual Size
(Ice and 3-Wire Indicators Not Shown)

Display	Indication
HI	Signal above range.
LO	Signal below range.
OP-LO	Open input (TC/mV).
-000-	Signal not perceptible (Hz).
OP L2	Open current lead C2 (ohms, RTD).
-POL	Potential leads crossed (ohms, RTD).
OP-E	Spurious voltage (ohms, RTD).
EE	A/D converter error.
BAT (NORMAL DISPLAY BLINKING)	Low batteries.
(BLANK DISPLAY)	Depleted battery.
(ALL SYMBOLS)	Turn-on display check.

Figure 4: Displays for Abnormal Conditions and Self-Testing

Table 6: Display Format

Measurement	Polarity	Display		Comment
		Numerals & Polarity[2]	Annunciator[4]	
TC, 0.1° Resolution	POS	2501.6	°C or °F	Fixed Ranges
(J, K, T, E, N)	NEG	(-) 389.0	°C or °F	Fixed Ranges; N positive only
TC, 1° Resolution	POS	3668	°C or °F	Fixed Ranges
R, S, B, C, NM)	NEG	(-) 47	°C or °F	Fixed Ranges; B, C positive only
mV, Low Range	POS	19.950	mV	Auto Range Change
(0 to ±20 mV)	NEG	(-)19.950	mV	Auto Range Change
mV Mid Range	POS	101.10	mV	Auto Range Change
(±20 to ±200 mV	NEG	(-)101.10	mV	Auto Range Change
mV High Range	POS	1000.1	mV	Auto Range Change
(+200 to +4000 mV)	-	-	-	-
VOLTS, Low Range Change	POS/NEG	/- 1.9002	V	Output Only; Auto Range
VOLTS, High Range	POS/NEG	/- 10.005	V	-
mA Low Range	POS/NEG	/- 1.5001	mA	Auto Range
mA Mid Range	POS/NEG	/- 20.030	mA	Auto Range
mA High Range	POS/NEG	/- 54.55	mA	Auto Range
OHMS, 400 Ω Low Range	POS/NEG	/- 40.010	Ω	0.5 mA, Auto Range[1]
OHMS, 400 Ω High Range	POS	395.73	Ω	0.5 mA, Auto Range
OHMS, 4 kΩ Low Range	POS/NEG	/- 398.72	Ω	0.05 mA, Auto Range[1]
OHMS, 4 kΩ High Range	POS	4000.2	Ω	0.05 mA, Auto Range

Table 6: Display Format (cont'd)

Measurement	Polarity	Display		Comment
		Numerals & Polarity[2]	Annunciator[3]	
RTD TEMP, PT or NI	POS/NEG	/- 170.05	°C or °F	-
RTD TEMP, CU	POS/NEG	/- 140.3	°C or °F	-
Frequency, Low Range	-	60.03	Hz	Auto Range
Frequency, Mid Range	-	4000.0	Hz	Auto Range
Frequency, High Range	-	40002	Hz	Measure Only, Auto Range

[1] Lowest OHMS ranges provide negative display for convenience in setting zero.

[2] (/-) indicates display may have either no symbol or a ().

[3] When controls are set to measure OHMS or RTD and HOOKUP switch is set to 3-WIRE, a symbol shows in the upper left corner of the display. When controls are set to display a thermocouple reading without reference junction compensation (ice or check modes), a blinking symbol shows in the upper right corner of the display.

3.6.2 Circuit Isolation

All circuits are isolated from the chassis except for one connection via a 0.01 µF, 1 kV dc capacitor. Channel A circuits are isolated from channel B circuits in all modes. Charger is transformer-isolated; charger withstands a 2500-V rms test, (4500 V for 230-V primary).

3.6.3 Overvoltage Performance

Without damage, 120 V dc or rms ac may be applied briefly between any two terminals with any switch setting.

3.7 POWER SUPPLY

Type: rechargeable battery and dc-dc converter with separate plug-in charger.

Battery type: five "C" size nickel-cadmium cells, button terminal (flashlight type).

Battery fuse: 2 A, 125 V axial lead

Replacement cells: Gates Energy Model G2000C (size KR 257/463 per ANSI C18.2 - 1984) or Saft Nicad type 2.0SC or equivalent.

Continuous operating time after full charge:

a. In measure mode or output mode lightly loaded, display lamp off: 30 hours

b. With output load of 12 mA with internal power source: 12 hours

c. Same as "a" but with display lamp on: 12 hours

d. Same as "b" but with display lamp on: 7 hours.

Charging: with FUNCTION switch set to OFF, 14 to 16 hours (charge may continue without damage)

with light load, a trickle charge is supplied

with medium load, charger supplies power indefinitely.

Battery life: at least 500 charge/discharge cycles

WARNING

Do not use the battery charger when using zinc-carbon dry cells.

Emergency operation on dry cells: nickel-cadmium cells may be replaced with zinc-carbon dry cells. Fresh alkaline "C" size cells such as Duracell type MN1400 or Eveready E93 (NEDA/ANSI 14A, IEC LR-14, military BA-3042/U) will give approximately three times the discharge time of freshly charged nickel-cadmium cells.

Low battery warning: lamp goes off, display blinks on and off and BAT message appears.

Depleted battery protection: instrument is shut down shortly after start of low battery warning. Warning time ranges from 5 to 10 minutes at maximum drain to 1 hour with minimum drain.

Charger: compact plug-in unit with 6-ft output cord; internal regulator maintains normal output against line voltage changes and tapers charge to minimize heating of instrument. Actual current flow is confirmed by an LED indicator. The 230-V charger has a two-wire line cord and no plug.

Power supply for charger: 50/60 Hz, 10 W maximum
115 V ±15 percent (Cat. No. without -47 suffix)
230 V ±15 percent (Cat. No. with -47 suffix)

3.8 ENVIRONMENTAL

3.8.1 Operating Temperature Range

14 to 113°F (-10 to 45°C)

3.8.2 Storage Temperature Range

-40 to 122°F (-40 to 50°C) with battery
-40 to 158°F (-40 to 70°C) without battery

3.9 PHYSICAL DATA

3.9.1 Dimensions

12 in. wide x 9-5/8 in. deep x 6-3/8 in. high (30 x 24.5 x 16.2 cm)

3.9.2 Weight

13 lb (6 kg)

3.9.3 Enclosure

Bright yellow 1/4-in. thick G.E. Noryl precision foam molded case, with hinged lid, carrying handle, and rubber feet. Lid is on sturdy 1/4-in. pin hinges with two heavy duty latches. Lid is captive, but easily removable. Lid includes label with reference check readings, holder for instruction manual, and retainer for test leads.

Fitted storage compartment 2-1/2 x 4 x 7 in. (6.3 x 10 x 18 cm) with hinged magnetic latch cover holds RTD simulator and charger.

Panel markings are chemical resistant white on black with color key to distinguish input and output controls.

Five-way binding posts, four for channel A and two for channel B, accept bare wire, lugs, or standard-size banana plugs.

3.10 SAFETY

The Versa-Cal Calibrator has been designed and manufactured to meet the requirements of ANSI C39.5-1974 specification "Electrical Safety Requirements for Electrical Measuring and Controlling Instrumentation" and IEC 348-1978.

3.11 ACCESSORIES INCLUDED

- RTD Simulator, Catalog No. 720980
- Charger
- Pair of 3-ft long test leads with banana plug at instrument end, test probe with a banana plug and slip-on clip at outboard end
- Pair of 1-ft long jumper leads with stackable banana plugs at each end
- Instruction manual
- Certificate of Calibration with traceability to NIST

3.12 OPTIONAL ACCESSORIES

- Soft pack carrying case, Catalog No. 218748
- Additional Operating Instruction Manual.
- Applications Manual
- Calibration/Maintenance Manual

Section 4
Description

4.1 CONTROLS, INDICATORS, AND CONNECTORS

4.1.1 Overall Description

Main panel controls are arranged in color-coded groupings for ease of operation. Figure 5 shows the calibrator panel controls and connectors. Controls situated inside the storage compartment are described in this section, but not shown in the figure. Controls and connectors on the RTD simulator module are shown in Figure 6. Control settings are stored by physical switch positions; all settings are visible at a glance and there is no need to reprogram when power is turned on.

Small slide switches, which resist accidental change, are used for seldom changed functions such as °C/°F and 3-WIRE/4-WIRE. For the major mode controls, which are usually set only once or twice during a setup, large, clearly marked rotary switches are used (FUNCTION, RANGE, and TYPE). For the most frequently used controls, DISPLAY CHANNEL A/B, OUTPUT % RANGE, etc., push-button arrays are used. A selected push button shows a bright color flag when pressed. Multi-turn continuous controls are used for output adjustment. These are long-life, wire-wound potentiometers with enough resolution to match the full sensitivity of the display and still enable rapid setting to new output values.

The custom lcd has a 40,000-count (4-3/4-digit) capacity and symbols showing units of measurement and diagnostic information. The alphanumerical characters are legible from a distance of 6 ft in all lighting conditions. In good working light, such as bench, desk, or outdoors, the display lamp should be left off to conserve battery. In poor lighting, the incandescent backlight maintains full visibility. The lamps are pre-aged for years of normal use. As a backup, when one lamp burns out, two other lamps remain to provide adequate light.

4.1.2 Functional Description

4.1.2.1 Channel A Input Connection Binding Posts

These four binding posts provide for measuring input signals as indicated by a green incoming arrow marked "A." All four posts are marked for resistance connection (C1, P1, P2, C2); a diagram on the panel shows the hookup for four-wire and three-wire input and the direction of test current flow. The two center binding posts accept two-wire inputs. A polarity mark (+) applies to all input types and a thermocouple diagram is color coded (negative lead red) to match the standard used for thermocouple extension lead wire.

4.1.2.2 Channel B Input/Output Connection Binding Posts

These two binding posts handle output signals as indicated by a yellow outgoing arrow. They also accept input signals of TC or mV type as indicated by the green incoming arrow marked "TC/mV." A (+) polarity

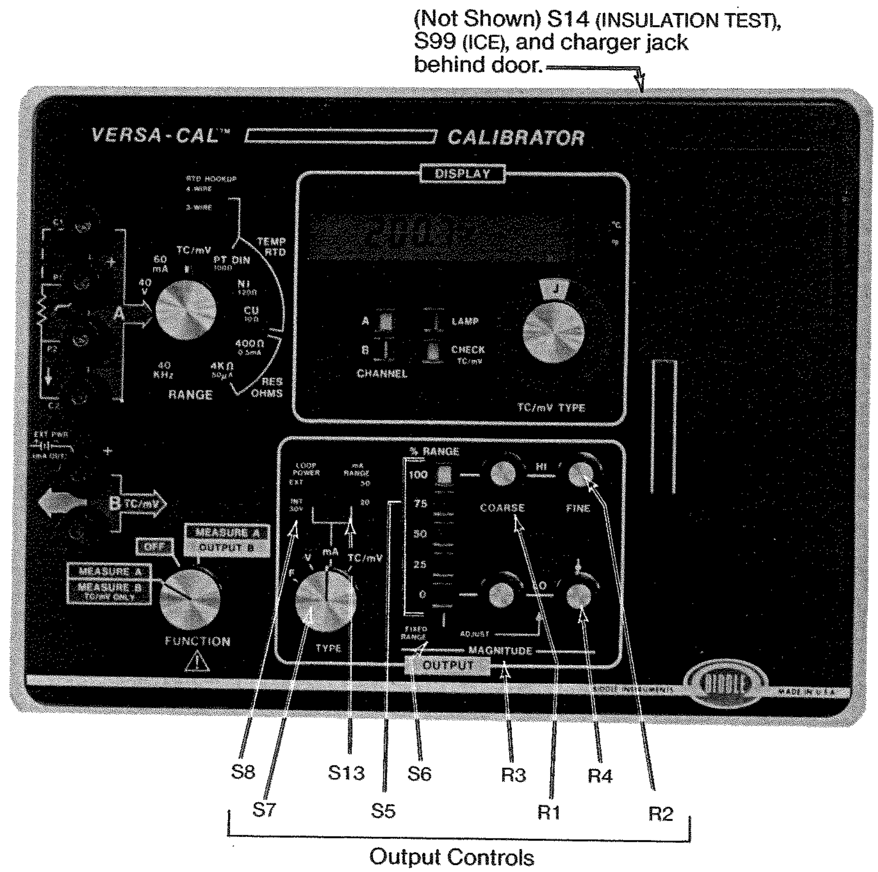

Figure 5: Cat. No. 720390 Panel

mark applies to all signals; in mA output mode it shows the terminal from which current flows with the calibrator viewed as a generator. A diagram on the panel shows the correct polarity for connecting an external mA loop power supply.

4.1.2.3 FUNCTION switch (S9)

This three-position rotary switch controls power on/off and selects measure (green) or output (yellow) for channels A and B.

FUNCTION Switch Setting	Power from Battery	Charger Current (if connected)	Channel A Connection	Channel B Connection
OFF	none	250 mA max; tapers to 160 mA	measure circuit selected by RANGE switch	open
MEASURE A/ MEASURE B	to measure and display circuits	100 mA	measure circuit selected by RANGE switch	to A/B switch open if not selected
MEASURE A/ OUTPUT B	to measure, display, and output circuits	150 mA (100 mA on 720380)	measure circuit selected by RANGE switch	to output circuit

4.1.2.4 RANGE Switch for Channel A (S2)

This switch selects the type of input signal to be measured and displayed on channel A. An unmarked spare position produces a display of 88888.

4.1.2.5 RTD HOOKUP Switch (S10)

When this switch is set to 3-WIRE, it disconnects the C1 binding post and routes test current to the P1 binding post instead. It also signals the microprocessor to use three-wire lead compensation.

4.1.2.6 DISPLAY CHANNEL A/B Switch (S1)

These two interlocked push buttons connect the selected channel for display. The selected push button latches down and shows a bright orange flag. If both push buttons are up, no input or output is connected for display.

4.1.2.7 DISPLAY LAMP Switch (S12)

This single-latching push button, when pressed, switches on the backlighting for the display and shows an orange flag. When pressed again, this push button switches off the backlighting after about 30 seconds.

4.1.2.8 CHECK TC/mV Switch (S11)

This single-latching push button, when pressed (orange flag), disconnects any external signal to the measuring system and connects instead a stable 5-mV check signal. This can be measured and displayed on any mV or TC range, and the reading compared to the factory readings recorded on a label in the lid. Other controls must be set to give a TC/mV display.

4.1.2.9 TC/mV TYPE Switch (S3)

This switch selects thermocouple type or millivolts (uncompensated) to be displayed. A thermocouple selection causes display in degrees of temperature, normally with automatic reference junction compensation. An unmarked spare position produces a display of 88888.

4.1.2.10 °C/°F Switch (S4)

This slide switch selects units for all temperature displays.

4.1.2.11 OUTPUT TYPE Switch (S7)

This four-position rotary switch selects the type of output signal to be generated on channel B.

4.1.2.12 mA LOOP POWER Switch (S8)

This slide switch selects between internal power supply and external power supply for dc current loop output signals. When this switch is set to INT 30V, an internal 30-V supply is connected in the loop being tested, making the calibrator a complete constant-current generator. When this switch is set to EXT, the instrument simulates a typical transmitter in that it supplies no power to the loop but works with an external loop power supply. The polarity for the external supply is marked at the channel B binding posts.

4.1.2.13 mA RANGE Switch (S13)

This slide switch selects nominal operating range of output current, either 4 to 20 mA or 10 to 50 mA.

4.1.2.14 OUTPUT MAGNITUDE Controls

FIXED RANGE/ADJUST slide switch (S6)
% RANGE, five interlocked push buttons (S5)
100% (HI) COARSE and FINE controls (R1, R2)
0% (LO) COARSE and FINE controls (R3, R4)

These controls set the magnitude of the output signal. Five equally spaced output values are always available by pressing one of the % RANGE push buttons (yellow flag will show). The full span covered by the % RANGE push buttons can be set in one of two ways depending on the setting of slide switch S6.

a. When slide switch S6 is set to FIXED RANGE and the 0% (LO) FINE control is set to its index mark, the push buttons provide factory-adjusted, quick-set outputs. These outputs can be trimmed slightly by the 0% (LO) FINE control. The other three controls have no influence.

b. When slide switch S6 is set to ADJUST, the user controls the outputs provided by the five push buttons. Any output in the available range can be obtained by pressing the 100% (HI) push button (yellow flag will show) and adjusting the HI COARSE (10-turn) and FINE (3-turn) controls. Any output in the lower quarter of the available range can be obtained by pressing the 0% (LO) push button and adjusting the LO COARSE (10-turn) and FINE (1-turn) controls. After setting a 100% value and a 0% value in this way, outputs spaced at four equal increments are obtained by pressing the 25, 50, or 75% push buttons.

4.1.2.15 ICE Switch (S99)

This slide switch, situated in the storage compartment, when set to ICE, bypasses thermocouple reference junction compensation and modifies all thermocouple displays to show temperature based on an ice-bath reference junction.

4.1.2.16 INSULATION TEST Switch (S14)

This momentary push button, situated behind a protective sliding cover in the storage compartment, applies a 100-V, 10 ±A source to the channel B binding posts for use in testing insulation resistance. This switch functions only when other controls are set to output mA.

4.1.2.17 CHARGER Jack

This jack, situated in the storage compartment, accepts plug on low-voltage output cord of charger.

4.1.2.18 RTD Simulator (see Figure 7)

4.1.2.18.1 RA Controls (Set of 3)

These controls, marked COARSE, MEDIUM, and FINE, are adjustable resistors connected in series to make up resistance R_A.

4.1.2.18.2 Banana Plugs (Set of 4)

These plugs provide for connection to the calibrator channel A for display of R_A or a separate 100 Ω standard resistor, R_S.

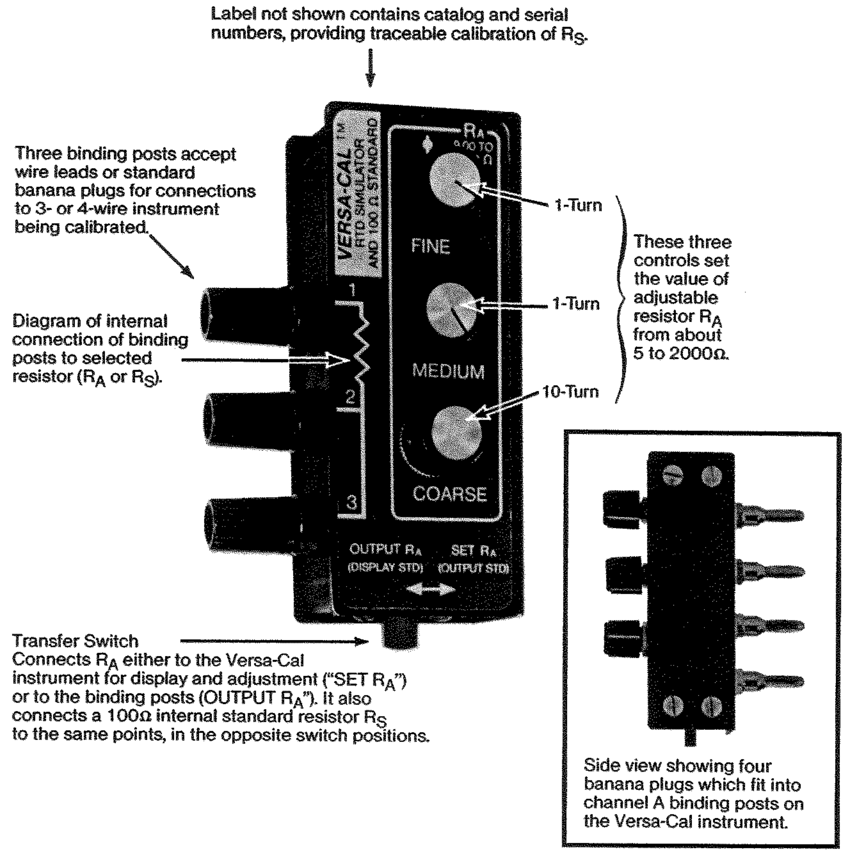

Figure 6: RTD Simulator Controls and Connectors

4.1.2.18.3 Output Binding Posts (Set of 3)

These binding posts provide for connection to the instrument under test. A diagram on the simulator shows internal connections to RA or RS.

4.1.2.18.4 Transfer Switch

This slide switch connects RA and RS alternately to binding posts or banana plugs.

4.1.2.19 Charger

The 120-V version of the charger is shown in Figure 1. The 230-V version has a two-wire line cord and no plug. A red LED indicator lamp confirms the actual flow of current.

4.2 BLOCK DIAGRAM

Figure 8 shows a simplified block diagram of the calibrator. The measuring system is built around a microprocessor with a crystal clock and a large memory chip. The microprocessor controls two separate measuring systems: a 4000-mV, 40,000-count A/D converter with a 6-V reference zener diode and, in the calibrator, a 40,000-Hz frequency measuring system.

The output system is isolated and consists of a second reference voltage, operational amplifiers, and manually adjustable resistors which generate a stable signal. This signal is converted to output over the selected range and may be set to one part in 100,000. Output for resistance consists of an adjustable resistor which can be alternately measured on the item under test and displayed on the calibrator.

Separate power sources supply the various sections of the circuit. These are isolated, as shown in the figure, to prevent external ground loops or unexpected loading of user equipment when both input/output channels are connected.

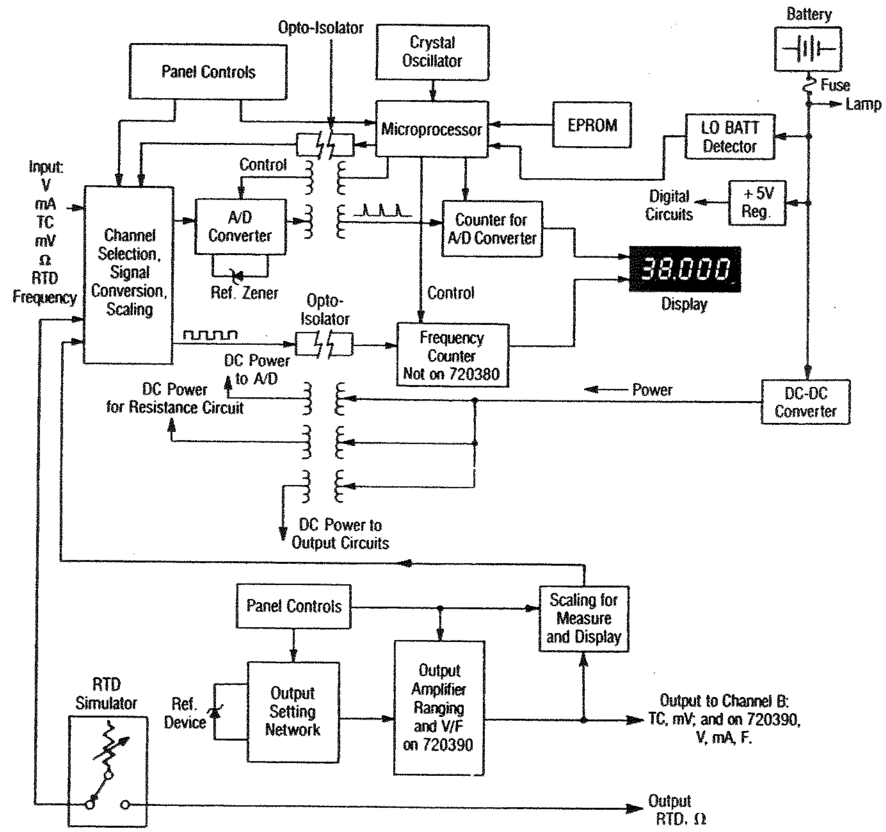

Figure 7: Calibrator, Simplified Block Diagram

Section 5
Operation

5.1 PREPARATION FOR USE

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage.

Before operating for the first time, the user should become familiar with the normal operation of the calibrator by using the verification procedures of Section 6. Be sure to read, understand, and follow the safety precautions in Section 2, Safety.

5.1.1 Power Supply

The calibrator can be operated from the battery continuously at any load and from the charger continuously at light or medium loads and intermittently at maximum load. However, when the battery is needed for field work, plan ahead to have it charged. When operating steadily from line voltage, periodically run down the battery and recharge it; this will prevent loss of capacity.

5.1.2 Working Position

When the case is opened, the lid may be left attached or removed and set aside. To remove the lid, set the instrument horizontally with lid fully open; push down on the outer edge of the lid until the lid falls free at hinge. To replace the lid, set the instrument vertically and push the lid down into the hinge until it snaps into place. Figure 1 shows the various operating attitudes. In addition, the calibrator may be placed horizontally on the ground with the lid fully open or partially open (use a pencil to prop up the lid and effect a sunshade).

5.1.3 Selection of Test Leads

The banana plug leads supplied with the calibrator are for use on the volts, mA, frequency, and the highest mV range only. For work on thermocouple ranges use only thermocouple leads or thermocouple compensated leads (unless using the ice bath mode). For work on the lower millivolt ranges (up to 200 mV) use only copper leads. The copper leads may be tinned or silver plated or bare. Any clips or terminals must also be copper and may be plated or bare.

5.1.4 Turn-on Precautions

To protect the calibrator and any connected equipment against accidental misconnection, make a habit of leaving the calibrator off until all connections are made and the entire setup checked.

Keep the OUTPUT controls at a well-protected, low-power setting when not actually using the output mode. For example:

- TYPE at TC/mV
- MAGNITUDE at FIXED RANGE with 0% push button pressed
- LOOP POWER at EXT.

5.2 GENERAL OPERATION

5.2.1 Display Lamp

Use the lamp when available lighting is poor. The lamp lights automatically for a few seconds at turn-on. To switch the lamp on, press the LAMP button; the orange flag will show. To switch it off, press the LAMP button again; the lamp extinguishes after approximately 30 seconds.

5.2.2 Battery Charge Conservation

To conserve battery charge, turn off the calibrator when not in use. Use the MEASURE A/MEASURE B function whenever output is not required. Switch off the display lamp when not needed. The freshly charged battery will operate the calibrator for a week or two. Set up a regular schedule for battery charging to suit individual usage needs. Use this guide to the approximate relative battery drain of various operations:

Measure only operation, basic drain:	100%
Lamp on, adds:	200%
Output mode, no output, adds:	50%
Full output (on 720390 only), 50 mA, adds:	800%

When the battery charge runs low, the "BAT" symbol appears, the lamps extinguish, and operation becomes intermittent (blinking display). This conserves the little remaining charge. In no less than 5 minutes (up to 1 hour if operating at a light load), the instrument will shut down completely. The duration of the blinking period will be longer if the load is reduced after blinking starts.

Important: Switch off as soon as the blank display is seen.

5.2.3 Battery Charging

WARNING

Use the charger in a dry indoor environment only.

1. Remove the charger from the storage compartment and plug its output cord into the jack in the storage compartment. Note that a room temperature environment is recommended for full service life.

2. Plug the charger into a standard ac power outlet having the rating marked on the charger. The 230-V charger has a two-wire line cord; a plug meeting local standards must be added.

When the charger is connected, its red LED lamp will light indicating that the charger is delivering current to the calibrator. If the LED does not light, check the power supply line and the charger plug and jack. If the LED flashes only briefly as the charger is plugged into the power line, check the calibrator jack or inside the calibrator for an open cable connector.

3. Charge for 14 to 16 hours, at 60 to 90°F (18 to 32°C), with the calibrator power off, for a full charge.

4. After charging, replace the charger in the storage compartment. The charger may left plugged into the charger jack if regular use is expected, but should be unplugged before long-term storage to prevent any battery drain into the charger.

5.2.4 Troubleshooting

If the instrument does not operate as expected, look for low battery indications and recharge if necessary. If low battery is not the problem, perform the performance verification procedures of Section 6 and check connections and control settings.

Some specific symptoms with possible causes (and corrections):

TC display about 25°C (50°F) too low. Short reads 0°C/32°F instead of room.	ICE switch set to ICE. (Reset to normal.)
One type of output will not run up. Milliamp Measure (Channel A) limits current to a milliamp or less.	Overvoltage tripped protective device. (Disconnect from overvolt source and wait a few minutes for device to recover.)
Locked display: TC or mV: "Check" reading Volts or mA: 0.5 or 0.05 Ohms or RTD: 0.0 Ω or "LO" (RTD)	CHECK TC/mV button is depressed. Reset to normal.
Strange unstable display of volts or millivolts or TC, on input measurement.	Very large overvoltage. In mV or TC, >±11 V. In volts, >±110 V.

5.3 MAKING MEASUREMENTS OTHER THAN RESISTANCE

5.3.1 To Measure a Single Input Signal

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage.

1. Connect input to channel A binding posts (+) to P1, (-) to P2.

2. Select type of input on channel A RANGE switch.

3. If displaying temperature, set °C/°F switch.

4. If input is TC or mV, make selection on TC/mV TYPE switch.

5. If input is TC, select normal or ICE mode on ICE switch (in storage compartment).

6. Press CHANNEL A push button at display.

7. Set FUNCTION switch to MEASURE A/MEASURE B. Display will briefly show the test pattern, then show the measured quantity with automatic ranging. Fault conditions will be indicated by display:

HI	Overrange positive
LO or OP-LO	Overrange negative
OP-LO	Open input (TC/mV only)
-000-	Frequency underrange or too weak (720390only)
EE	Malfunction
BAT; blinking	Low battery
blank display	Depleted battery

5.3.2 To Measure Two Input Signals (Fig. 8)

If one or both of the signals are TC or mV, proceed as follows:

1. Connect one TC/mV signal to channel B and the second signal (any type) to channel A.

2. Proceed as in paragraph 5.3.1 using the CHANNEL A or B push buttons to select the A or B input for display.

3. If the two input signals are of different types or ranges, reset the appropriate switches when changing channel.

5.4 To Generate a Calibration Output

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage.

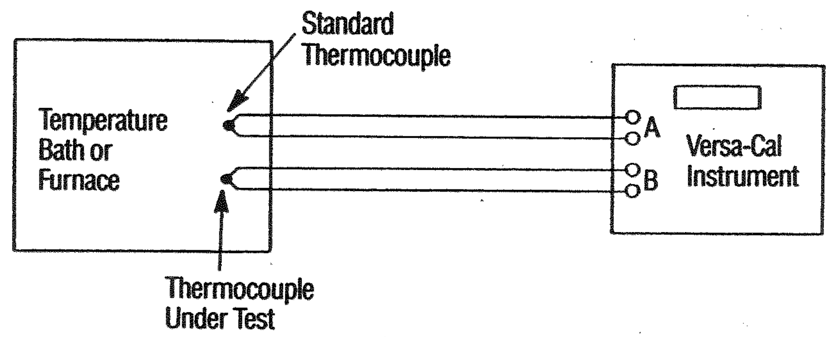

Figure 8: Measuring Two Input Signals

Available ranges of output signal are:

TC	all measured ranges
mV	(-)11 to (+)101 mV

1. Connect circuit or instrument to be tested to channel B.

2. If TC is to be selected, set the °C/°F switch.

3. Set TC/mV TYPE switch to desired setting.

4. Press CHANNEL B push button at display.

5. Set the FUNCTION switch to MEASURE A/OUTPUT B. Display will briefly show test pattern, then show the output quantity set on the ADJUST controls.

6. Adjust the COARSE and FINE controls to the desired output value.

5.4.2 To Generate an Output While Measuring an Input (Fig. 9)

1. Connect and set up channel B for output as described in paragraph 5.4.1.

2. Connect and set up channel A for measurement as previously described.

3. Set the FUNCTION switch to MEASURE A/OUTPUT B .

4. Press the CHANNEL A or B push button to show the desired signal, B for the output being supplied and A for the signal being measured by the calibrator.

5. Adjust the output to achieve the desired value on the display.

6. Switch the display from A to B as desired. The output on channel B remains steady regardless of A or B selection.

5.5 CALIBRATION OUTPUT (TC/mV, mA, V, F)

5.5.1 To Generate a Calibration Output of Any Single Value

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage.

1. Connect circuit or instrument to be tested to channel B.

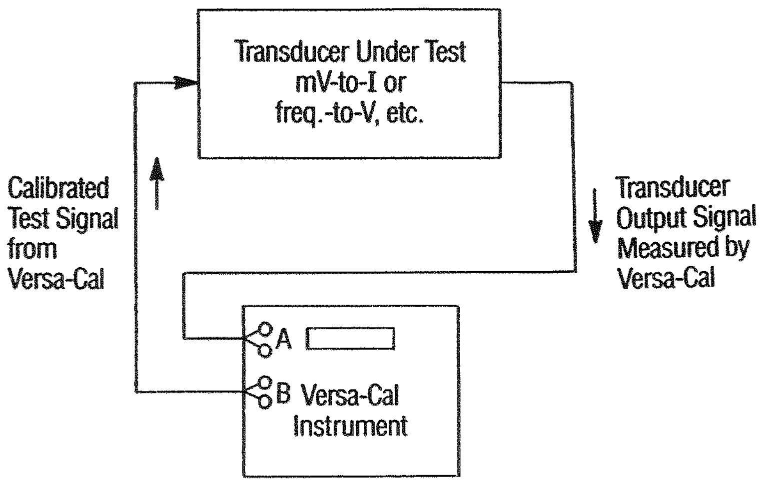

Figure 9: Test Setup for Simultaneous Input/Output

NOTE

If mA loop power is supplied by the external circuit (as when the calibrator is used to simulate a transmitter) connect with the loop supply polarity as shown on the panel sketch, and set the LOOP POWER switch to EXT. To use the internal power supply, set the LOOP POWER switch to INT 30V. If unsure of the external circuit, try EXT first to avoid accidental damage.

2. Set the OUTPUT TYPE switch as desired.

3. If TC is selected, set the °C/°F switch.

4. If mA is to be generated, set the mA RANGE switch to 20 for 4 to 20 mA or less, or to 50 for 10 to 50 mA. Set the LOOP POWER switch as described in the note to step 1 of this procedure.

5. If output is TC or mV, set TC/mV TYPE switch to desired setting.

6. Press CHANNEL B push button at display.

7. Double check the setup to be sure that the connected circuit can withstand the output to be applied.

8. Set the MAGNITUDE slide switch to ADJUST.

9. Select either the 0% or 100% push button to activate the LO or HI

pair of COARSE and FINE adjusters. The HI controls cover the entire available ranges, but are quicker to use.

10. Set the FUNCTION switch to MEASURE A/OUTPUT B. The display will briefly show a test pattern, then will show the output quantity set on the MAGNITUDE controls. Adjust as desired.

5.5.2 To Use Fixed-Range, Quick-Set Output Values

1. Perform steps 1 through 7 of the preceding procedure.

2. Set the MAGNITUDE slide switch to FIXED RANGE.

3. Set the LO FINE control to the index dot.

4. Press one of the five % RANGE push buttons. The corresponding output as shown in Table 7 will be generated. The output is accurate enough for most calibrations. Its exact value is shown on the display.

5. Set the FUNCTION switch to MEASURE A/OUTPUT B. The display will briefly show a test pattern, then will show the output quantity set on the MAGNITUDE controls.

6. To bring an output to its round-number value, adjust the LO FINE control. The other controls have no effect.

7. To check several of the cardinal points on the selected range, press some or all of the % RANGE push buttons, as needed.

8. Return the LO FINE control to the index dot.

Table 7: Fixed Range Output Values

TYPE	Output Value for % RANGE Push Buttons					Units
	0%	25%	50%	75%	100%	
mV	20	40	60	80	100	mV
V	2	4	6	8	10	V
mA 20	4	8	12	16	20	mA
mA 50	10	20	30	40	50	mA
F	800	1600	2400	3200	4000	Hz
TC:J*	730	1350	1940	HI	-	°F
K	950	1820	HI	HI	-	°F
T	HI	HI	HI	HI	-	°F
E	585	1030	1480	HI	-	°F
R	3100	HI	HI	HI	-	°F
S	HI	HI	HI	HI	-	°F
B	HI	HI	HI	HI	-	°F
N	1120	2040	HI	HI	-	°F
C	2040	HI	HI	HI	-	°F
NM	860	1560	2180	HI	-	°F

* The thermocouple fixed range outputs are the temperature equivalents of the 20 to 100 mV values, plus the ambient temperature (at the calibrator binding posts). The table shows approximate values in °F for an ambient of 77°F (25°C). For equivalent °C values, set the °C/°F switch to °C.

5.5.3 Automatic 0 to 100% Cycling

To obtain an automatic cycle between 0 and 100% values, trip all five OUTPUT % RANGE push buttons up. The output will automatically transfer every 10 seconds.

5.5.4 To Set Other Quick-Set Output Values

1. Perform steps 1 through 10 of paragraph 5.5.1 with the 0% push button pressed.

2. With the 0% push button pressed, adjust LO COARSE (10-turn) and LO FINE (1-turn) controls for the desired low-end scale display. Now the intermediate points will fall at 25, 50, and 75% points between the ends, accurate to ±0.05 percent of the total span. In the case of thermocouple calibrations, the intervals are equal in millivolts, but slightly unequal in °C or °F; however, the displayed values are correct and can be used as-is for calibration or can be trimmed to a nearby round number, if desired.

3. Press the 100% push button and adjust HI COARSE (10-turn) and HI FINE (3-turn) controls to get the desired full scale output on the display. The LO and HI settings do not interact.

5.6 TO DISPLAY THERMOCOUPLE TEMPERATURE USING AN ICE BATH REFERENCE AND THE VERSA-CAL ICE MODE

This procedure applies to both measuring temperature from thermocouples and to simulating thermocouples using the calibration output. Copper leads are used between the calibrator and the reference junction which is held at 32°F (0°C) by an ice bath or equivalent. Modify the standard procedure as follows:

1. Locate the ICE slide switch inside the storage compartment and set it to ICE (toward the back of the instrument). All thermocouple temperature displays in both measure and output modes will be correct if the external reference junction is at 32°F (0°C). A blinking symbol shows in the upper right corner of the display, warning that automatic reference junction compensation is not functioning.

2. Return the ICE switch to its normal position (toward the front of the instrument) when not using ice bath.

5.7 RTD AND OHMS OPERATIONS

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage.

5.7.1 Resistance Thermometer (RTD) and Resistance (Ohms) Measurement

1. Connect the resistor or RTD under test to the channel A binding posts as shown on the panel. To make a two-wire connection use the accessory jumpers to connect C1 to P1 and C2 to P2. For a three-wire RTD, omit connection to C1. For a three-wire RTD whose leads are not identified, refer to step 6 to obtain the correct hookup.
2. Set RTD HOOKUP switch to 3-WIRE or 4-WIRE according to number of connections made. When switch is set to 3-WIRE, a symbol shows in the upper left corner of the display as an alert that only three wires are being used.

3. Set channel A RANGE switch to desired RTD or OHMS range.

4. Set °C/°F switch; press CHANNEL A push button.

5. Set FUNCTION switch to MEASURE A/MEASURE B. The display will show a test pattern for 2 or 3 seconds, then display the reading.

If there is a steady display including the desired units (°C/°F, ohms), the reading is accurate. If not, there is probably a misconnection. The display will identify this and other problems. See Table 8. To use Table 8, find the display along the top and your setup on the left side. The box at the meeting of column and row identifies the abnormal condition. If the display indicates an abnormal condition, switch the calibrator off briefly, then on, to get the best diagnostic information.

If you change connections while measuring in three-wire mode, wait 6 seconds before reading to be sure that a full clean test cycle has occurred.

6. To find the correct hookup for a three-wire RTD when the leads are not marked:

a. Select any arrangement for a trial hookup and read on the 4000-Ω range. If a steady up-scale reading is obtained, the connection is correct.

b. If a steady negative reading occurs, interchange the P1 and C2 leads. This connection will be correct.

c. If the first trial gives a reading close to 0.0 Ω, interchange the P1 and P2 leads. This connection will be correct.

If this procedure fails to find a good reading, there is a defect in the sensor.

7. To check for open RTD leads:

a. With RTD connected, set channel A RANGE switch to TC/mV. A reading close to zero millivolts or ambient temperature shows that neither the sensor nor leads P1 or P2 are open.

b. Change the channel A RANGE switch to the OHMS or RTD range wanted. A reasonable up-scale reading indicates that all leads are checked.

Table 8: Special Abnormal-Condition Displays for RTD/OHMS.
Displays and Abnormal Conditions Indicated.

Hookup & Range	-POL	LO	(-) Ohms or (-)HI	Approx. 0.0	HI	OPL2	Quite Noisy	OP-E
3-Wire RTD	Spurious Voltage	Crossed P1 & P2, P1 & C2	—	—	Open Rx, Open P1, Open All; Spurious Voltage	Open C2	Open P2	Spurious Voltage >20 mV
3-Wire OHMS	—	—	Crossed P1 & C2; Spurious Voltage	Crossed P1 & P2	Open Rx, Open P1, Open All; Spurious Voltage	Open C2	Open P2	Spurious Voltage >20 mV
4-Wire RTD	Crossed P1 & P2 or other Open P1	Open C1 Crossed C1/P2, C2/P1	—	—	Open Rx	Open C2	—	Spurious Voltage >20 mV; Open Rx, Open P1, Open P2, Open all
4-Wire OHMS	—	—	Crossed P1 & P2 or other	Open C1; Crossed P1/C2 or C1/P2 or other	Open Rx, Open P1	Open C2	Open P1	Spurious Voltage >20 mV; Open Rx, Open P1, Open P2, Open all

5.7.2 To Calibrate Four-Wire, 100-Ω Platinum RTD Instruments

1. Plug the RTD simulator into channel A binding posts with its three binding posts to the left.

2. Connect the item under test to the three binding posts on the simulator using four wires. Connect one pair of wires (current and potential) to binding post 1, the other pair to binding posts 2 and 3.

3. Set the transfer slide switch on the simulator to the right. This connects a fixed 101-Ω standard resistor Rs to the output binding posts. The item under test should read 2.60°C (36.68°F).

4. Set the calibrator to measure 4-wire PT DIN 100 Ω RTD. It now reads the resistance (called R_A) established by the three controls on the simulator.

5. Adjust these controls for the up-scale calibration point on the item under test, as follows:

   a. Set the MEDIUM and FINE one-turn controls to their midpoints (lines on knobs vertical).

   b. Adjust the COARSE control close to the desired final setting.

   c. Adjust the MEDIUM control closer.

d. Adjust the FINE control to the precise setting wanted.

6. Set the transfer slide switch on the simulator to the left. This connects the adjustable resistor RA to the item under test. The item under test should now read the value just established for RA.

7. Alternate the output between the up-scale point and the RS point for checking and adjusting the item under test by setting the transfer slide switch.

5.7.3 To Calibrate Three-Wire, 100-Ω Platinum RTD Instruments

1. Connect directly to the item under test using three leads of low matched resistance (same gauge and length).

2. Plug the RTD simulator into the channel A binding posts with its three binding posts to the left. Connect the three leads from the item under test to the simulator binding posts as though to an RTD, following the sketch on the simulator panel. If the item under test has one terminal marked to distinguish it from the other two, connect this terminal to binding post 1 on the simulator; connect the other two terminals to simulator binding posts 2 and 3.

3. If calibration must be made on a system with poor or unknown lead compensation, use only the adjustable resistor R_A, not the 100-Ω standard R_S. Refer to paragraph 5.7.4.

4. Set the transfer slide switch on the simulator to the right. This connects a fixed 99.98-Ω standard resistor to the output binding posts (through three matched 1-Ω lead resistors). The item under test should read (-) 0.05°C (31.91°F).

5. Perform steps 4 through 7 of paragraph 5.7.2.

6. To check lead compensation (recommended) perform the procedure of paragraph 5.7.4.

5.7.4 Testing Lead Compensation of Three-Wire, 100-Ω Platinum RTD Instruments

In this test, the RTD simulator offers a 99.98-Ω resistor to the IUT, both with and without a matched set of three 1-Ω lead resistances. A significant difference between the two readings on the IUT shows that its lead compensation is wanting.

1. Connect the simulator to the IUT, using any set of leads meeting specifications for the IUT.

NOTE

For high precision IUT's (able to resolve 0.01 Ω or 0.025°C or 0.05°F), there is a best choice of connections to simulator binding posts 2 and 3. To find it, make a trial connection and read R_S on the IUT. Interchange the leads at simulator binding posts 2 and 3 and read R_S again. Use the connection which gave the higher reading.

2. Read the standard (R_S) on the 400-Ω, 3-wire range of the calibrator (99.98 Ω nominal).

3. Switch R_A to the calibrator and adjust R_A for the same reading as R_S.

4. Read both R_A and R_S on the three-wire IUT. Table 9 shows the effectiveness of the IUT lead compensation.

Table 9: Effectiveness of IUT Lead Compensation

Difference Between R_A and R_S Readings on IUT			
OHMS	°F	°C	Effectiveness (%)
0.00	0.00	0.00	100 (perfect)
0.01	0.05	0.025	99
0.02	0.1	0.05	98
0.05	0.22	0.12	95
0.1	0.45	0.25	90
0.2	0.9	0.5	80
1	4.5	2.5	0

Normally, at least 95 percent effectiveness would be expected, but the acceptable level depends on the specifications for the IUT and the actual resistances of the installed leads.

5. If the compensation is not adequate, correct the IUT or leads as needed before proceeding.

5.7.5 To Calibrate Instruments Having Other RTD and Ohms Ranges

Use the procedures given for 100 Ω PT (DIN) calibrations, modifying as follows:

1. If the 100 Ω RS is not a useful value, use a second setting of RA in its place.

2. For RTD types not specifically selectable on the panel, use tables supplied by the RTD manufacturer to find resistance at key temperatures. Use the OHMS ranges of the calibrator to set the simulator.

5.8 INSULATION RESISTANCE TEST

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage. Disconnect all electronic or other sensitive devices. This is a 100-V test.

1. Connect channel B to the circuit to be tested, for example, from RTD or thermocouple to protecting tube, ground, or shield. Plug in a temporary jumper across the channel B binding posts .

2. Press the CHANNEL B display push button. Set for mA OUT and EXT LOOP POWER. Set the FUNCTION switch to MEASURE A/OUTPUT B.

3. Briefly press the INSULATION TEST push button situated behind a sliding cover in the storage compartment. This is a preliminary check of the function and safety of the test. A good instrument will show between (-) 0.0080 and (-) 0.0120 mA. If this short-circuit check is OK, remove the jumper.

4. Press the INSULATION TEST push button, and read the output current. The insulation resistance can be obtained from the following:

Display mA (-)	Insulation Resistance (MΩ)	Typical Insulation Quality
Below 0.0010	Above 100	Excellent
0.0020	50	Good
0.0040	25	Fair
0.0060	10	Fair
Above 0.0080	Below 5	Poor

5. Always reposition the sliding cover after performing this test.

Section 6
Performance Verification

6.1 INTRODUCTION

This section contains procedures which verify that the Versa-Cal is performing its essential functions. These procedures use independent internal sources and measuring circuits to cross-check calibration.

Use these procedures:

- On first receiving the calibrator, to check its condition and to become familiar with its normal operation.
- As needed to verify performance or refamiliarize the user.
- Before taking the calibrator to remote work places.
- On the job, to resolve questionable results.

The procedures are not detailed; consider them as a checklist. Follow the instructions for operation presented in Section 5 to perform all steps correctly. Proceed carefully.

6.2 PROCEDURES

6.2.1 General

1. At each turn-on, the display lamp lights for a few seconds. Check for light from all three bulbs.

2. Watch for battery failure (blinking display, "BAT" symbol). If the charging is suspect, make sure the LED current indicator lights.

6.2.2 Basic TC/mV Measuring System CHECK Function

1. Press CHANNEL A push button and select °C and TC/mV for display.

2. Press CHECK TC/mV push button.

3. Check mV and any TC type of interest against number on label in lid. This checks most of the basic system used in measuring all functions except frequency. The check reading tolerances, at 25 ±10°C ambient, are as follows:

mV	±0.012 mV
Types J, E	±0.3°C
Types K, T	±0.4°C
Type N	±0.5°C
Types R, S, B, C, W, NM	±2°C

6.2.3 Millivolt Zero and Reference Junction Compensation, Channels A and B; Ice Bath Mode

1. Set up in a location protected from heat, cold, and wind.

2. Connect copper jumpers (pre-1982 pennies will do) across both mV input channels. Place a soft cloth over the binding posts.

3. Display mV; readings of channel A and B should match and settle near zero mV.

4. Display TC type T; channel A and B readings should match.

5. With ICE switch at normal position, display should show room temperature as measured by a thermometer at the binding posts. With ICE switch at ICE position, display should show 32.0°F or 0.0°C, with symbol blinking in upper right corner.

6.2.4 Channel B, mV Measure and Output

1. Jumper channel A to channel B using copper leads and matching polarities.

2. Set to output mV; adjust output to levels of interest, for example, 1, 10, 100 mV. Channel B reading should match channel A reading. Output range should cover -11 to +101 mV.

6.2.5 Volts

Switch output to volts. Adjust output to approximately 3 V, reading channel B. Read channel A in millivolts; readings should match. Read channel A in volts, this also should match but with one decade less resolution.

6.2.6 Milliamperes

Switch output to mA, with internal supply. Output 1, 10, 50 mA. Channel A and B readings should match.

6.2.7 Frequency

WARNING

Before connecting to any circuit, make sure that the circuit is not energized with a hazardous voltage.

1. Remove jumpers. Find a source of power line frequency, such as the secondary of a power transformer, isolated from the power line, of a volt or a few volts. Connect it to channel A and set to read frequency. Do not plug directly into power outlet. Reading should be 60.00 (or 50.00) ±0.10 Hz.

2. Disconnect from this source and connect channel A to B as in step 6.2.4, step 1. Output 10, 100, and 1000 Hz. Channel A and B readings should match.

6.2.8 Summary

If the checks so far are good, it is very likely that all the ranges checked are quite accurate. This is because they have been checked against either the millivolt check reading or the power line 60 Hz. Channels A

and B have checked each other as to their separate milliamp shunts, voltage dividers, and reference junction compensators.

6.2.9 Fixed Outputs

This test is somewhat coarse but it is completely independent of the calibrations already checked. Run through the mV, mA, and F outputs with FIXED RANGE values (LO FINE control at dot) of 0% and 100% at least. Display on channel B.

These should all fall within approximately 0.2 percent of setting (for frequency 0.2% +6 Hz). This checks the main measuring ranges against the FIXED outputs. Should any of the earlier Volts or mA checks of A versus B show a large discrepancy, this check against the fixed outputs should show which channel is in error.

6.2.10 Insulation Test

Set up and test as in paragraph 5.8 with no test item connected. The short circuit reading should be as in paragraph 5.8, step 3. The open circuit reading should be between +0.0003 and -0.0005 mA. The open circuit reading can be read as a correction to actual test readings.

6.2.11 RTD and OHMS, Measure

1. Plug the RTD simulator into channel A binding posts and set the transfer slide switch on the simulator to OUTPUT RA (DISPLAY STD).

2. Set RTD HOOKUP switch to 4-WIRE and read on the RTD or OHMS ranges of interest. The expected results are:

400-Ω range:	100.00 ±0.05 Ω (close to the calibrated value marked in the calibrator lid)
4000-Ω range:	100.00 ±0.10 Ω
PT DIN 100 Ω RTD:	0 ±0.15°C, 32 ±0.25°F
NI 120 Ω RTD:	-29.1 ±0.2°C, -20.4 ±0.4°F

3. Change RTD HOOKUP switch setting to 3-WIRE and read on the 400-Ω range. The reading should be approximately 0.02 Ω less than the four-wire reading. Symbol shows at upper left of display.

4. To check the CU 10 Ω RTD range, after the 100 Ω checks of step 2, refer to paragraph 6.2.12.

6.2.12 RTD and OHMS Output

After performing the steps in paragraph 6.2.11, check the range of the adjustable resistance (RA), about 5 to 2000 Ω, by moving the transfer switch to "SET RA" and adjusting RA to any settings of interest. To check the CU 10 Ω Measure range, set RA to approximately 10 Ω and switch range to CU 10 Ω. Any stable reading about 25°C confirms the accuracy of this range, assuming that the steps in paragraph 6.2.11 have been completed.

To check the actual output, unplug the simulator and wire its three output terminals using leads of equal length to channel A as follows:

Terminal 1 to Versa-Cal P1 and C1

Terminal 2 to Versa-Cal P2

Terminal 3 to Versa-Cal C2

Set the transfer switch to OUTPUT STD and read on the 400-Ω range. The readings should be:

4-wire	101.00 ±0.05 Ω
3-wire	99.98 ±0.08 Ω

Set the transfer switch to OUTPUT RA and confirm the range settings as above and check at approximately 100 Ω that the three-wire reads about 0.02 Ω less than four-wire.

Paragraphs 6.2.11 and 6.2.12 check the accuracy of all OHMS and RTD calibration outputs.

Section 7
Maintenance and Repair

7.1 REPAIRS

Repairs listed in this section are the only ones to be attempted by the customer. Electronic circuit repairs should not be attempted.

WARNING

> Do not attempt to repair the charger because repair may degrade its electric shock protection performance. Obtain a new charger from the factory.

Biddle Instruments offers a complete repair service and recommends that its customers take advantage of this service in the event of equipment malfunction. Equipment returned to the factory for repair should be shipped prepaid and insured and marked for the attention of the Repair Department. Please indicate all pertinent information including problem symptoms and attempted repairs. The catalog number and serial number of the instrument should also be specified.

7.2 GAINING ACCESS

Only persons skilled in maintenance of precision electronic devices should perform this procedure. Ensure that the calibrator is disconnected from all voltage sources before it is opened for maintenance or repair. An antistatic workplace must be used.

1. Set the instrument upside down on a table and pry off the four rubber feet. Using a 1/4-in. screwdriver with a shaft length of at least 3 in., loosen the screw under each foot.

2. Lift the case away from the works, being careful not to break the two cables. Disconnect ice switch cable P16 and charging cable P13.

3. The chassis with its bottom shield cover plate may now be gently rested on the bench with any side down except the battery end.

4. Reassemble by reversing the disassembly procedures.

7.3 BATTERY REPLACEMENT OR DRY CELL SUBSTITUTION

Open the instrument as in 7.2, snap out the five nickel-cadmium cells, and replace them with a new set. Polarities are shown on the bracket.

Check operation and reassemble.

Emergency use of dry cells instead of Ni-Cd:

WARNING

> The charger must not be connected when dry cells are installed. To prevent this from happening, remove the charger and set it aside with the nickel-cadmium cells. Place a warning tag on it or on the instrument.

Replace the Ni-Cd cells with five size "C" dry cells (alkaline type for longest service).

7.4 BATTERY FUSE REPLACEMENT

WARNING

> To avoid a fire hazard, use only the fuse specified in the parts list which is identical in respect to type, voltage rating, and current rating.

The only fuse in the instrument is in the battery circuit. It is designated F1.

The fuse is on the battery assembly, soldered in place between the two middle cells. Test it with instrument power off and if necessary remove it and replace with the fuse listed in the Field Replaceable Parts list, Section 8.

7.5 OTHER PARTS REPLACEMENT

7.5.1 Hinge Parts

The case hinge consists of the molded latch piece, spring, and special screw.

1. Remove the case lid by positioning the lid fully open and, in one motion, pressing the lid firmly past the fully open position. The lid should free from the hinge.

2. Replace any hinge parts necessary.

3. Replace the case lid by holding the lid at a 90° angle to the case and positioning the lid hinge part at the mouth of the case hinge part. Firmly and crisply strike the lower part of the lid using the heel of your hand or make a fist and strike hammer style.

7.5.2 Friction Adjustment on Output Control Knobs

The COARSE controls on main chassis and RTD simulator include a compressing washer to provide stable settings. When replacing these knobs, place the washer under the knob and push down gently on the knob while tightening the set screw to achieve a firm but smooth control action.

7.6 PREPARATION FOR STORAGE AND SHIPMENT

7.6.1 Storage

Remove batteries and unplug the charger before long-term storage (one year or more).

7.6.2 Shipment

Pack the instrument in a carton (original shipping carton if available) with adequate dunnage in accordance with best commercial practice. Seal the carton with waterproof tape.

Section 8
Field Replaceable Parts

Designation	Description	Quantity 720390	Quantity 720380	Biddle Part No.
Accessories:				
-	Battery charger (115V)	1	1	27365-3
-	Battery charger for 720390-47(230V)	1	1	27365-4
-	Jumper lead (12 in., stacking banana plugs) red (Pomona Part No. B-12-R)	1	1	22945-1
-	Jumper lead (12 in., stacking banana plugs) black (Pomona Part No. B-12-B)	1	1	22945-2
-	Test lead, 30 in. with probe & clip one end, red	1	1	22946-1
-	Test lead, 30 in. with probe & clip one end, black	1	1	22946-2
-	RTD simulator, complete	1	1	720980
Case and lid parts:				
-	Case & lid assy, complete	1	1	27362-1
-	Case w/o lid	1	1	25763-1
-	Catch, molded, for latch	2	2	25613-2
-	Spring, torsion, for latch	2	2	25613-5
-	Pin for latch	2	2	25613-4
-	Spring, compression, for hinge	2	2	25613-3
-	Latch piece, molded, for hinge	2	2	25613-6

Designation	Description	Quantity 720390	720380	Biddle Part No.
-	Screw for hinge, #6, 1/2 in., steel	2	2	1303-116
-	Lid assy w/o label, manual or test leads	1	1	27512
-	Velcro (hook) patch ´ x 1	1	1	22918-3
-	Velcro (loop strap)	1	1	27689
-	Range label	1	1	27506
-	Handle, case	1	1	23103
-	Screw for handle, #4-24 x 3/8 in., self-tap	2	2	1303-140
-	Lock washer, ext tooth, #4	2	2	4X11
-	Bumper, rubber	8	8	5591-1
-	Screw (panel/case) bind.hd 8-32 x 1-3/4 in.	4	4	8X2128
-	Lock washer, split, #8 (panel/case)	4	4	8X18
Accessory compartment parts:				
P16	ICE switch with 2-wire cable & plug	1	1	27050-16
-	Screw for P16, steel bd hd,#2-56 x ¨ in	2	2	2X2104
-	Lock washer for P16, ext tooth, #2	2	2	2X11
-	Nut for P16, #2	2	2	2B00N
P13	Charger jack & cable assy	1	1	27050-13
-	Foam Insert, 3 x 2 x 1 in. with cutouts	1	1	27688-1
-	Foam Insert, 3 x 3-5/16 x ´ in.	1	1	27688-2

Designation	Description	Quantity 720390	720380	Biddle Part No.
-	Foam Insert, 3 x 2-3/4 x ¨ in.	1	1	27688-3
-	Set of 3 labels for partition (ICE,etc)	1	1	27756
Panel parts:				
-	Knob, pointer with white line (for S2)	1	1	14877-2
-	Knob, with marked skirt (for S3)	1	1	14877-16
-	Knob, black line on inlay (for S9, S7)	2	1	14877-17
-	Knob, short skirt (for adj res)	3 (R1-3)	2 (R1,2)	14877-20
-	Wave washer for R1 and R3	2	1	6274-10
-	Knob, short skirt with white line(for R4)	1	0	14877-19
-	Compartment door assy & hinge (kit)	1	1	29790
-	Marked overlay	1	0	27099
-	Marked overlay	0	1	27096
RTD simulator parts:				
-	Marked Overlay	1	1	27522
R3, R4	Pot., 10Ω, 1 turn WW Clarostat Series 49 3/8-in. shaft length	2	2	22671-5
-	Knob for R3, R4, with line	2	2	14877-9
R5	Pot., 2 kΩ, 10 turn WW, Spectrol Model 536, 11/32 in. shaft length	1	1	27357-7
-	Knob for R5	1	1	14877-15
-	Wave washer for R5	1	1	6274-9

Designation	Description	Quantity 720390	Biddle Part No.
R1	Resistor, 4 Ω, 1%, 1/25 W, WW	1	10027-156
R2	Resistor, 20 Ω, 1%, MF, RN60	1	12026-103
Internal parts:			
F1	Fuse (battery), 2 A/125 V axial leads, Littlefuse #251.002	1	125421-5
B1	Battery cell, C size Ni-Cd	5	527359

REFERENCES

1. Biddle Instruments Manual 72-35T entitled "Thermocouple Temperature -Millivolt Conversion Tables for TC Types B, E, J, K, R, S, and T." Manualcontains millivolt tables in 1-degree increments, plus other useful data onthese couples and their extension wires (Tables based on Reference 2).

2. NBS Monograph 125. Contains emf tables and much detailed background on derivation of tables, mathematical representations, uses and precautions for the various materials. Covers types B, E, J, K, R, S, and T, to IPTS 1968.

3. NBS Monograph 161. Contains similar data for Nicrosil-Nisil (Type "N").

   NBS Monographs 125 and 161 are available from Superintendent of Documents, US Government Printing Office, Washington, DC 20402. (Monograph 125 is SD Catalog No. CDE13.44.125).

4. ANSI MC96.1 "American National Standard for Temperature Measurement Thermocouples." Covers wire coding, limits of error, selection, installation, and tables on popular thermocouples, revised 1982. (Also available from ISA, and supersedes several ISA RP documents.)

Available from American National Standards Institute, Inc. 1430 Broadway, New York, NY 10018.

5. ASTM Number STP470B "Manual on the Use of Thermocouples in Temperature Measurement." Published in 1981; 258 pages, hard cover. An excellent reference with chapters on Principles, Materials, Designs, Measurements, Reference Junction, TC Calibration, Installation Effects, Cryogenics, and Uncertainty of Measurements.

6. ASTM Standard E-563 "Preparation and Use of Freezing Point Baths," brief outline with many references. Coverage similar to Chapter 7 of Reference 5.

ASTM publications are available from American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

7. Kinzie, Paul A., "Thermocouple Temperature Measurement." John Wiley, New York, 1973; 278 pages, hard cover. A compendium of information on thermocouple types, common and uncommon, with information and references on each. Some 142 are covered; with even more mentioned briefly; 20 are mentioned as being in common use in the United States.

8. Benedict, Robert P., "Fundamentals of Temperature, Pressure and Flow Measurements," John Wiley, New York, 1969; 353 pages, hard cover. Third Edition, 1984, 532 pages. Covers basics, calibration and special measurement problems. Engineering text by a practicing engineer and teacher.

9. Caldwell, Frank R., "Temperatures of Thermocouple Reference Junctions in an Ice Bath," Journal of Research of the NBS Vol 69C, No. 2; April-June 1965. (Reprinted in NBS Special Publication 300, Volume 2 "Temperature" p. 256). Effects of immersion depth, wire size, insulation thickness, and glass tube size on errors.

10. Kerlin and Shepard, "Industrial Temperature Measurement," Instrument Society of America, 282 pages, 1982.

The best reference we know of on the subject. Written at an engineering level for practical use. Topics include calibration and accuracy, field problems, causes and corrections of errors.

11. Anonymous, "Resistance-Temperature Tables for Resistance Thermometers," Minco Products, Inc., Application Aid No. 7, 1983. Includes 1°C and 1°F tables for platinum 0.3926, 0.3850, and 0.3911; nickel, nickel-iron, and copper; also thermocouples J, K, T and E.

12. Anonymous, "Resistance Thermometry, Principles and Applications of Resistance Thermometers and Thermistors." Minco Products Inc., Application Aid No. 187, 12 pages, 1986. Excellent brief coverage of curves, error sources and sensor designs for metal RTD's, and comparable data on thermistors.

13. ASTM Standard E-1137, "Standard Specification for Industrial Platinum Resistance Thermometers". Covers all aspects of performance and testing. Specifies 100 ohms, ‡ = 0.00385, curve matches DIN 47360/1980 and IEC 751/1983. Gives table at 2°C intervals.

14. ASTM Standard E230-87, "Temperature-EMF Tables for StandardizedThermocouples." Tables and equations E = f(T) for types J, K, T, E, R, S, B,N, taken from references 2 and3, based on IPTS 1968.

15. ASTM Standard E988-89, "Standard Temperature-EMF Tables for Tungsten-Rhenium Thermocouples." Tables and equations for 3% and 5% Rhenium types.Developed from manufacturers' data, based on IPTS 1968.

GLOSSARY

⚠	Use only in accordance with Instruction Manual (used on instrument panel)
IPTS	International Practical Temperature Scale
IUT	instrument under test
lcd	liquid crystal display
lsd	least significant digit
NIST	National Institute for Standards and Technology formerly the National Bureau of Standards
RJC	reference junction compensation
rms	root mean square
RTD	resistance-temperature detector
SAE	Society of Automotive Engineers
TCR	temperature coefficient of resistance
thermocouple	a pair of dissimilar conductors so joined at two points that an electromotive force is developed by the thermoelectric effects when the junctions are at different temperatures.

WARRANTY

Products supplied by Biddle Instruments are warranted against defects in material and workmanship for a period of one year following shipment. Our liability is specifically limited to replacing or repairing, at our option, defective equipment. Equipment returned to the factory for repair, must be shipped prepaid and insured. This warranty does not include batteries, lamps, or other expendable items, where the original manufacturer's warranty shall apply. We make no other warranty. The warranty is void in the event of equipment abuse (failure to follow recommended operating procedures) or failure by the customer to perform specific maintenance as indicated in this manual.