JAMES G. BIDDLE CO.
Plymouth Meeting, Pennsylvania 19462

Printed in U.S.A.

File 4630 5 10/71 W

72-311J

INSTRUCTIONS FOR PORTABLE MILLIVOLT POTENTIOMETER/ CALIBRATOR

Catalog No. 72-311

August 1971

JAMES G. BIDDLE CO.
Plymouth Meeting, Pennsylvania 19462

(5) Rotate the Function Selector Switch to the mV OUTPUT position.

(6) Convert the temperature setting to be checked to the equivalent millivolt value using the proper temperature millivolt conversion table.

(7) Rotate the EMF measuring dials to the millivolt value obtained in step 6.

(8) Depress and lock down the DET key.

(9) Balance the instrument being checked and observe the reading.

NOTE: a. By repeating the above procedure at various temperature settings, a series of correction factors may be obtained.

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a. Measure the reference-junction temperature at the terminals of the instrument to be checked with a mercury-in-glass thermometer. If copper extension leads are used, the reference junction will be located at the point where the extension leads are connected to the thermocouple.

b. Convert the reference-junction temperature reading to millivolts by referring to the appropriate table in Thermocouple Temperature-Millivolt Conversion Table 60-35T (or NBS Circular 561).

c. Rotate the Function Selector Switch to the SET COMP position.

The Potentiometer features manual reference-junction compensation for measurement of thermocouple emf's, which, after being set, permits direct millivolt readings of temperature equivalents above or below the reference-junction temperature.

A battery operated solid state constant voltage supply furnishes the current to the Potentiometer measuring circuit and also functions as the instrument reference voltage. The current is automatically maintained precisely at the proper value, without adjusting any controls, when the instrument is switched to any operating position. The voltage supply also eliminates the generally used "standard cell" which is far more susceptible to voltage change due to vibration, mechanical shock, operating position, temperature variation, accidental shorting or excessive current drain.

The Potentiometer can be operated at temperatures as low as -30°C (-22°F) and as high as 60°C (140°F). For operation below -30°C (-22°F) special low temperature batteries are required.

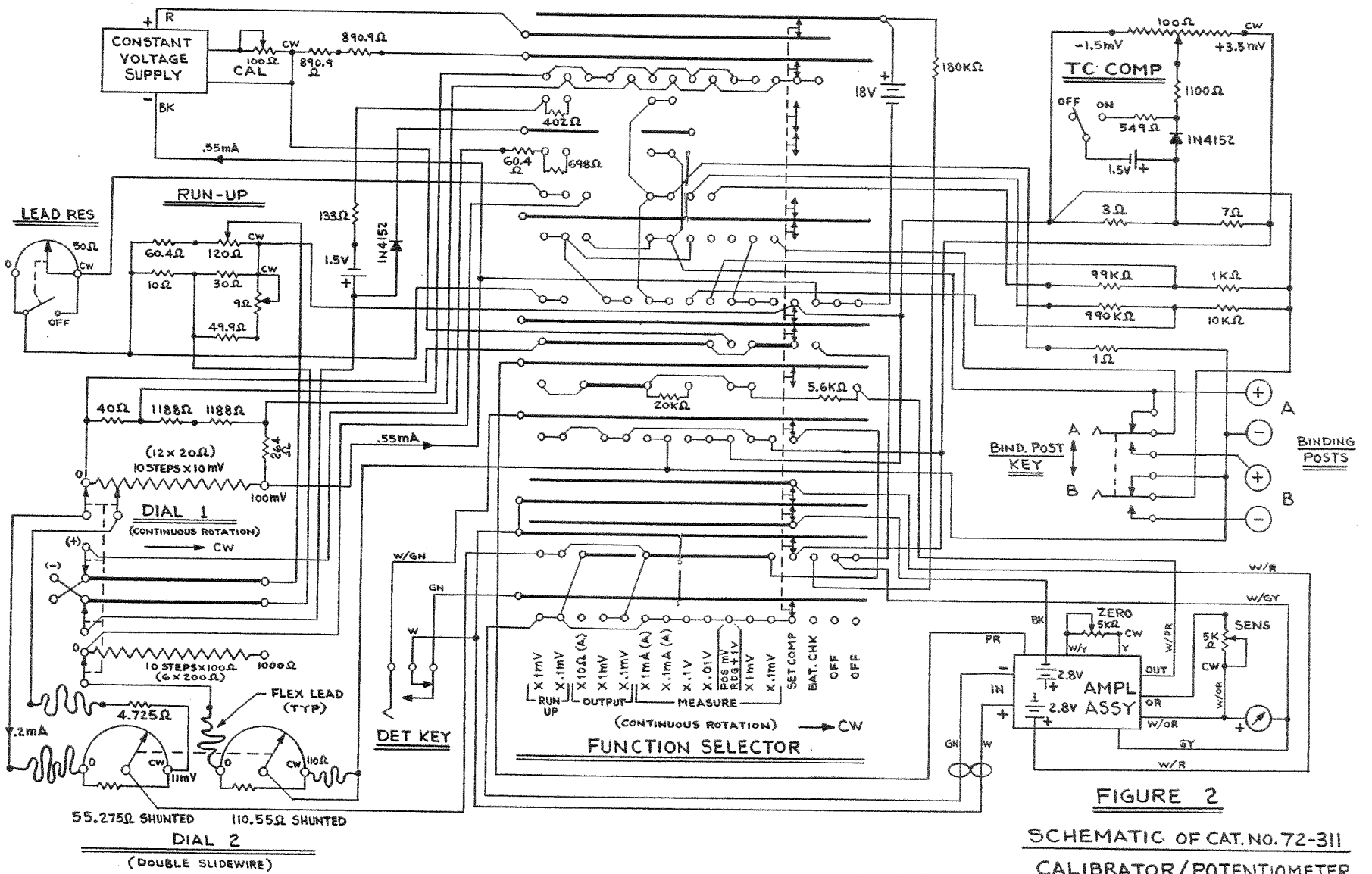

FIGURE 2

SCHEMATIC OF CAT. NO. 72-311 CALIBRATOR/POTENTIOMETER

60K55

d. Adjust the LEAD RES (Ω) knob to cause a correct reading of the instrument being checked.

e. Depress the DET key to be sure that the millivoltage provided by the RUN-UP is still correct. If a re-adjustment of the RUN-UP is necessary, repeat steps 4 and 5.

f. Using a check point of 20% of the instrument scale, repeat steps (b), (c), and (d). If the instrument reading is correct, the setting of the LEAD RES (Ω) dial is equivalent within 1 ohm to the external resistance required by the instrument.

The above method is recommended only as a means of determining the probable standard millivoltmeter lead resistance required.

F. CHECKING STANDARD CELLS OR EQUIVALENT ZENER-DIODE VOLTAGE SUPPLIES

(1) Connect the standard cell to the desired EMF binding posts (A or B) using copper wire and observing proper polarity.

(2) Set the Binding Post Selector Switch to position A or B corresponding to the EMF binding posts in use.

(3) Rotate the Function Selector Switch to the 1V + POS mV position.

(4) Adjust the meter pointer to electrical "0" if required, as described in section 5B.

(5) Rotate the 2 EMF measuring dials to the EMF value, in excess of 1 volt, marked on the standard cell.

(6) Tap the DET key and note the meter pointer deflection. If the deflection is to the right, the EMF dial settings are too high; if to the left, too low.

(7) Increase or decrease the setting of the last EMF measuring dial as dictated by step 6 and adjust for null meter deflection.

(8) The potentiometer reading is a direct indication of the EMF of the standard cell. Since no current is drawn from the voltage source by the Potentiometer, no measuring error is introduced.

G. MEASUREMENT OF EMF ABOVE THE POTENTIOMETER RANGE

Voltages up to 11.1 V d.c. can be measured with a total limit of error of ±(0.1% of reading + 2 millivolts).

(1) Connect the source of voltage to be measured to the desired EMF binding posts (A or B) using copper wire and observing proper polarity.

(2) Set the Binding Post Selector Switch to position A or B, corresponding to the EMF binding posts in use.

(3) Rotate the Function Selector Switch to the appropriate V MEASURE range.

X.01 multiplier for -0.11 V to 1.11 V
X.1 multiplier for -1.1 V to 11.1 V

(4) Rotate the EMF dials to the approximate setting for voltage to be measured.

(5) Depress the DET key and readjust the EMF measuring dials for null meter deflection.

(6) The Potentiometer reading indicates the source EMF value as it appears at the EMF Binding Posts.

NOTE: Measurements made on the V MEASURE ranges are not potentiometric measurements and do load the voltage source to some degree. The current drawn from the source is approximately 10 μa, at full scale, on both ranges.

H. CALIBRATION OF D.C. VOLTMETERS (UP to 11.1 V FULL SCALE)

(1) Connect a stable, adjustable voltage supply to the desired EMF binding posts (A or B), with the voltmeter to be calibrated in parallel. Use copper wire for connections and observe proper polarity of all connections.

(2) Set the Binding Post Selector Switch to position A or B corresponding to the EMF binding posts in use.

(3) Rotate the Function Selector Switch to the appropriate V MEASURE position.

(4) Rotate the EMF measuring dials to the voltage setting that corresponds to that point on the voltmeter scale which is to be calibrated. (Refer to step G3).

(5) Adjust the stable power supply to obtain a pointer deflection to the desired point on the voltmeter scale.

(6) Depress the DET key and readjust the EMF measuring dials, if necessary, to obtain a null meter balance.

(7) The correction for this point on the meter scale is the true voltage reading minus the voltmeter reading.

I. MEASUREMENT OF CURRENT

Direct currents of up to 111 milliamperes can be measured with a total limit of error of ±(0.1% of reading + 20 μa).

(1) Connect a current source to the "A" EMF binding posts, using copper wire and observing proper polarity.

CAUTION: Be sure that there is sufficient resistance in the current source circuit to limit the current to levels acceptable to the current ranges of the 72-311.

(2) Set the Binding Post Selector Switch to position A, corresponding to the EMF binding posts in use.

(3) Rotate the Function Selector Switch to the appropriate mA MEASURE position.

X.1 range for -1.1 to 11.1 ma
X1 range for -11 to 111 ma

(4) Rotate the EMF measuring dials to the approximate setting for current to be measured.

(5) Depress the DET key and readjust the EMF measuring dials for null meter deflection.

(6) The Potentiometer reading indicates the value of current flowing through the 72-311 shunt circuit.

J. CALIBRATION OF D.C. MILLIAMMETERS (UP to 111 ma FULL SCALE)

(1) Connect the 72-311 and the milliammeter under test as indicated in Figure 5.

(2) Set the Binding Post Selector Switch to position A.

(3) Rotate the Function Selector Switch to the appropriate mV MEASURE position. (Refer to I3).

(4) Rotate the EMF measuring dials to the current setting that corresponds to that point on the milliammeter scale which is to be calibrated.

(5) Adjust the current source to obtain a pointer deflection to the desired point on the milliammeter scale.

(6) Depress the DET key and readjust the EMF measuring dials, if necessary, to obtain a null meter balance.

(7) The correction for this point on the meter scale is the true current reading minus the milliammeter reading.

K. COMPARISON OF RESISTORS

(1) Connect a four terminal reference resistor, a four terminal unknown resistor, a stable current adjusting rheostat and a stable battery or power supply as shown in Figure 6. For maximum accuracy it is recommended that the value of the reference resistor and unknown resistor be approximately the same.

(2) Set the Binding Post Selector Switch to select the pair of binding posts connected to the reference resistor.

(3) Set the Function Selector Switch to the mV MEASURE range.

(4) Rotate the 2 EMF Measuring Dials to the desired setting, corresponding to the approximate voltage drop across the reference resistor.

(5) While tapping the DET key, adjust the current adjusting rheostat or adjustable current supply to obtain, as nearly as possible, a null meter balance.

(6) Depress the DET key and readjust the last EMF Measuring Dial to obtain a final null meter balance.

(7) Rotate the Binding Post Selector Switch to the other pair of binding posts (those connected to the unknown resistors).

(8) While tapping the DET key, rebalance the 2 EMF Measuring Dials to obtain a null meter balance.

(9) The value of the unknown resistor is found from the following equation:

Unknown resistor value =

$$\frac{\text{EMF Dial reading of unknown R}}{\text{EMF Dial reading of reference R}} \times \text{reference R value}$$

L. TEMPERATURE MEASUREMENT USING A RESISTANCE THERMOMETER

(1) Connect a four terminal reference resistor, a four terminal resistance thermometer, a stable current adjusting rheostat and a stable battery or power supply as shown in Figure 6. For maximum accuracy, the reference resistor should have a value approximately equal to that of the resistance thermometer.

(2) Set the Binding Post Selector Switch to select the pair of binding posts connected to the reference resistor.

(3) Set the Function Selector Switch to the mV MEASURE range.

(4) Rotate the 2 EMF Measuring Dials to the desired setting corresponding to the approximate voltage drop across the reference resistor, based on the recommended resistance thermometer current.

(5) While tapping the DET key, adjust the current adjusting rheostat or adjustable current supply to obtain, as nearly as possible, a null meter balance.

(6) Depress the DET key and readjust the last EMF Measuring Dial to obtain a final null meter balance.

(7) Set the Binding Post Selector Switch to connect the other pair of binding posts (those connected to the resistance thermometer).

(8) While tapping the DET key, rebalance the 2 EMF Measuring Dials to obtain a null meter balance.

(9) The resistance value of the resistance thermometer is found from the following equation.

Resistance of resistance thermometer =

$$\frac{\text{EMF Dial reading of res. thermometer}}{\text{EMF Dial reading of reference R}} \times \text{reference R value}$$

NOTE: The external circuit current should be periodically monitored when following the temperature changes of a resistance thermometer. The frequency with which this current will require adjustment depends upon the stability of the current supply, the resistance change of the resistance thermometer and the measurement precision required.

M. GENERATING A RESISTANCE TO SIMULATE A RESISTANCE THERMOMETER

(1) Make necessary connections to the "A" EMF binding posts using copper wire.

(2) Set the Binding Post Selector Switch to position A.

(3) Rotate the Function Selector Switch to the X10Ω OUTPUT position.

(4) Rotate the EMF measuring dials to the desired resistance value. (Rdg. X 10 = ohms).

The resistance appearing at the "A" binding posts and corresponding to the setting of the EMF dials X10, may be used as a substitute for an actual resistance thermometer when making a function check or calibration check of a resistance thermometer measuring instrument.

N. THE 1V + POS mV RANGE AS A VOLTAGE SOURCE

This range is indicated in the specifications (Section 2) as a measuring range and was designed primarily for that purpose. However, an output voltage equal to 1V + the EMF dial settings is available at the binding posts when the Function Selector Switch is set to the 1V + POS mV position.

The voltage output is accurate only when supplying a null type instrument which draws no current from the Potentiometer. The detector is not disconnected from the circuit on this range as on true OUTPUT ranges, and some detector interaction may be observed when supplying an EMF to another instrument. The meter pointer will return to "0" when the second instrument is truly at null balance.

NOTE: Current drawn from the 72-311 during that time which is required to balance a null balance type instrument, will not affect the final accuracy of the output voltage. Recovery from such loading is instantaneous.

7. MAINTENANCE

A. GENERAL

With normal use the only maintenance required will be replacement of the batteries and an occasional cleaning and lubrication of the slide wire after long periods of disuse. Instruments having only periodic use should have their measuring dials rotated several times over their full travel previous to making a measurement.

B. REMOVAL OF POTENTIOMETER FROM CASE

(1) Remove the four panel screws.

(2) Carefully lift the instrument from the case.

(3) Replace the Potentiometer in the case by reversing the procedure described above.

C. BATTERY REPLACEMENT

Replace the measuring circuit battery when the meter pointer deflection is below the green line (less than 8 divisions) when checking the battery as described in section 5C.

The compensator circuit battery should be replaced when the compensator millivolt range becomes appreciably less than that specified or the voltage setting begins to change rapidly, requiring frequent adjustment of the compensator control.

Replace the null detector batteries when the meter pointer cannot be adjusted to "0" as described in section 5B. The battery compartment is in the bottom of the instrument. Remove the panel assembly from the case as described in section 7B.

The battery requirements and their connections are as follows:

(1) Measuring Circuit: Two 9-volt Burgess #M6 dry cells (NEDA 1605) connected in series to give 18 volts.

Red lead connection to 18 volt positive (+) terminal.
Black lead connection to 18 volt negative (-) terminal.

(2) Compensator Circuit: One 1-1/2 volt "D" size cell.

White/red lead connection to 1-1/2 volt positive (+) terminal.
Gray lead connection to 1-1/2 volt negative (-) terminal.

Proper polarity is marked on battery holder.

(3) Run-Up Circuit: One 1-1/2 volt "D" size cell.

Red leads (2) connection to 1-1/2 volt positive (+) terminal.
Black lead connection to 1-1/2 volt negative (-) terminal.

Proper polarity is marked on battery holder.

(4) Null Detector: Two 2.8 or 2.7 volt mercury batteries (Mallory TR132, TR132H, TR132R, NEDA 1200).. Four 1.4 or 1.35 volt mercury batteries (Mallory RM1, RM1R, NEDA 1100) may be used for replacement, or two 4.2 volt mercury batteries (Mallory TR-133, NEDA1306M) may also be used (with one cell removed from each) if more readily available.

Proper polarity is marked on battery holders.

NOTE: Incorrect installation of the null detector batteries, defective batteries, or failure to make contact with the battery holders will cause the meter pointer to deflect violently off scale or result in failure of the pointer to move when the ZERO control is rotated with the Function Selector Switch set at any X.1 MEASURE or the SET COMP position.

D. SLIDE WIRE

The need for slide wire cleaning is indicated by erratic deflection of the meter, when smooth slide wire rotation is applied, while at or near meter null balance when measuring with the DET key depressed. Rotate the slide-wire dial several times over its full travel in order to break through the oxidation on the slide wire surface. If the meter still deflects erratically proceed as follows:

(1) Remove the Potentiometer from the case as described in section 7B.

(2) Clean the slide wire surface by rubbing briskly with a soft cloth moistened with Naphtha, Chloroethylene, Benzene, Alcohol or other volatile petroleum solvent. Dry with soft cloth. Lubricate by rubbing lightly with a soft cloth sparingly impregnated with petroleum jelly or white vaseline.

(3) On severely oxidized slide wires, not cleanable by step 2 above, polish gently with crocus cloth uniformly over the full length of the slide wire, then repeat step 2 above.

(4) Replace the Potentiometer in the case as described in section 7B.

E. PUSH KEYS

Failure of the push keys to make contact will be indicated by the failure of the meter pointer to deflect when an unbalance is known to exist.

Key contacts may be cleaned by inserting a thin strip of bond paper or business card between the contacts and applying pressure to the contacts by depressing or releasing the key button as required while withdrawing the paper. Repeat three of four times, or as necessary.

F. AMPLIFIER ASSEMBLY

Due to solid-state construction, no maintenance of the amplifier assembly is required under normal use other than battery replacement which is described in section 7C. After several years, however, it may be necessary to re-adjust the amplifier zero balance circuit to compensate for long term drift voltages beyond the range of the ZERO control. If the meter cannot be adjusted to "0" as described in section 5B, proceed as follows:

(1) Remove the Potentiometer from the case as described in section 7B.

(2) Rotate the Function Selector Switch to the COMP SET position and the SENS control to the extreme clockwise position.

(3) Rotate ZERO control to extreme clockwise position then extreme counterclockwise position and observe meter pointer deflection. The pointer should normally deflect half scale in both directions.

(4) If deflection of meter pointer remains to the right side of "0" (or barely to the left side of "0") when ZERO control is fully counterclockwise, total resistance of RT + RT' must be increased approximately 100 ohms for each division of correction desired. If meter pointer remains to the left side of "0" (or barely to right side of "0") when ZERO control is fully clockwise, total resistance of RT + RT' must be decreased.

(5) Remove the three screws which hold the amplifier assembly in place then carefully roll back the amplifier assembly so that the circuit side of the printed circuit card is exposed. Locate RT + RT' by the PC markings.

(6) Increase or decrease the total value of RT + RT' as required, using metal film resistors. (Approx. 100Ω for each meter division).

G. METER

Failure usually occurs by suspension breakage due to a severe shock. If broken, meter pointer will not deflect when an unbalance is known to exist. To replace, disconnect wires from meter terminals, then remove ring nut holding meter in place. Install new meter. Connect White/Gray wires to positive (+) terminal and remaining wires to negative terminal.

H. CONSTANT VOLTAGE SUPPLY

Due to solid-state construction no maintenance of the voltage supply is required under normal use other than battery replacement which is described in section 7C. A screwdriver adjusted rheostat permits the

reference voltage to be readjusted, if necessary, to compensate for long term drift voltage. Refer to section 9 for Calibration Check.

NOTE: The constant voltage supply is protected against damage resulting from inadvertent reverse connection of the 18 volt battery.

I. MEASURING CIRCUIT

Calibration and repair of the measuring circuit should only be attempted in the laboratory under controlled conditions. For those operations not described above, or the replacement of parts not listed below (section 8), it is recommended that the instrument be returned to the factory.

8. FIELD REPLACEABLE PARTS LIST

PART NO.	QUANTITY/INSTRUMENT	DESCRIPTION
11874	1	Meter
11166-2	4	Binding Posts (Superior #DF31BC)
4690-12	1	Knob, Function Switch (Buckeye PS-70PL-2)
13084	1	Knob, first EMF dial
4690-16	1	Knob, second EMF dial (Buckeye PS-175)
4690-15	2	Knob, ZERO, SENS, and RUN-UP (PS-50/70C-3-5)
4690-14	1	Knob, LEAD RES (Ω) (PS-50-TSL)
4690-11	1	Knob, TC COMP (PS-50-2)
11357-3	1	Push Key, DET
11357-4	1	Push Key, BIND. POSTS
13045	2	Battery, 9 volts Burgess M6, Eveready 266, NEDA 1605)
8857	2	Battery, 1-1/2 "D" size cell
11892	2	Battery, 2.8 volt, mercury (Mallory TR132, TR132R, TR132H, NEDA 1200)
11990-1	1	Case

For replacement of parts not listed, return to factory.

9. OPERATIONAL CHECK

Connect a Standard Cell of known value to the EMF binding posts (A or B) of the 72-311 and set the Binding Post Selector Switch to the corresponding position. Set the Function Selector Switch to the 1 V + POS mV position and measure the value of the Standard Cell. (See Section 2B for Limit of Error statements). If it is found that the Potentiometer does not agree with the known Standard Cell value, the Potentiometer current must be adjusted until the EMF dial readings of the 72-311 Potentiometer are in agreement with the known Standard Cell value.

The adjustable trimming resistor for setting the Potentiometer current to its exact value, is located on the chassis of the 72-311, directly beneath the meter.

Refer to section 7B for removal of the instrument from its case.

10. ACCESSORIES

A mercury-in-glass thermometer is necessary for measuring the ambient temperature, when making thermocouple temperature measurements using Reference Junction Compensation. (Section 5D). Clips are provided in the lid of the 72-311 Calibrator for convenient storage of such a thermometer.

The following Arthur H. Thomas thermometers are satisfactory for this purpose:

Cat. No.	Range
9608-B	0 to +105°C (1°/DIV)
9609-B	+30 to 220°F (2°/DIV)

The following Fisher Scientific Company thermometers are also satisfactory for this purpose:

Cat No.	Range
15-021B	-10 to +110°C (1°/DIV)
15-021C	-130 to +120°F (2°/DIV)
15-021D	+30 to 220°F (2°/DIV)

All of the above thermometers are provided with a protective metal tube with pocket clip.

1. Meter
2. Zero & Sens (Dual)
3. TC Compensation
4. Function Switch
5. Run-up Coarse & Fine (Dual)
6. Lead Resistance
7. Measuring Dial 1 (Step Switch)
8. Measuring Dial 2 (Slidewire)
9. Detector Key
10. Bind. Post Selector
11. Bind. Posts (4)

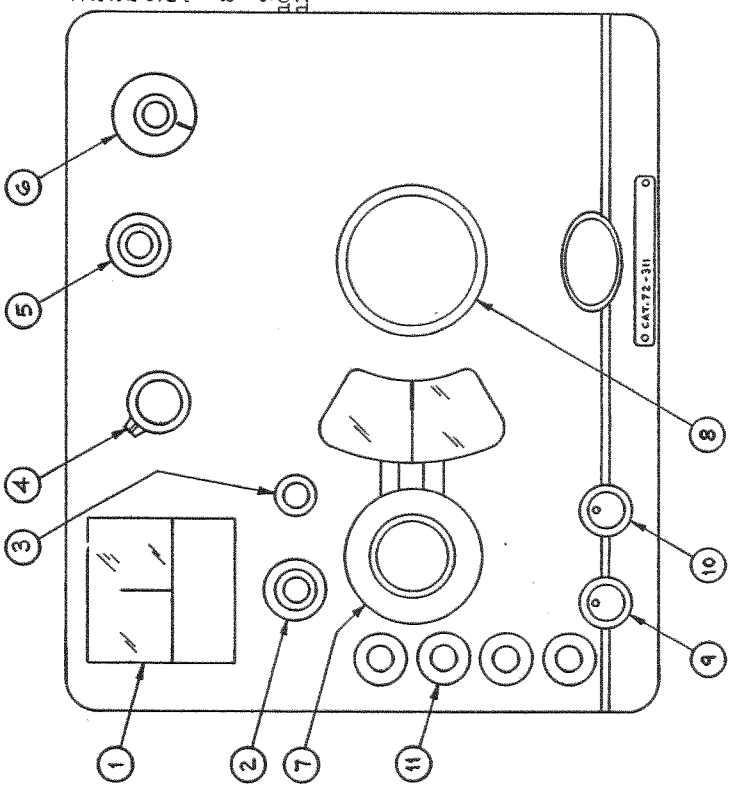

FIGURE 1 CAT. NO. 72-311 Calibrator/Potentiometer Front Panel

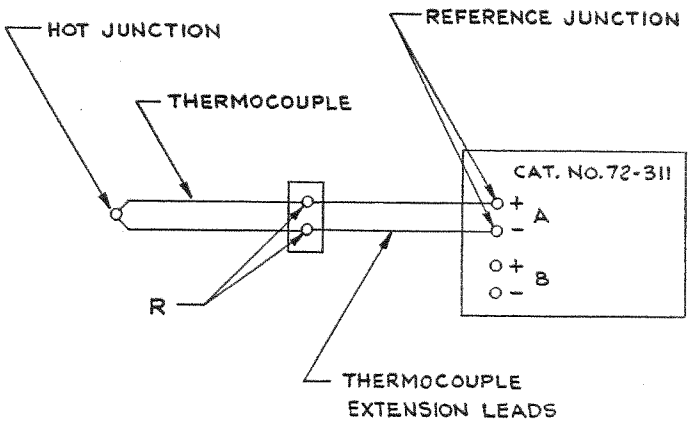

FIGURE 3 - Temperature Measurement with a Thermocouple

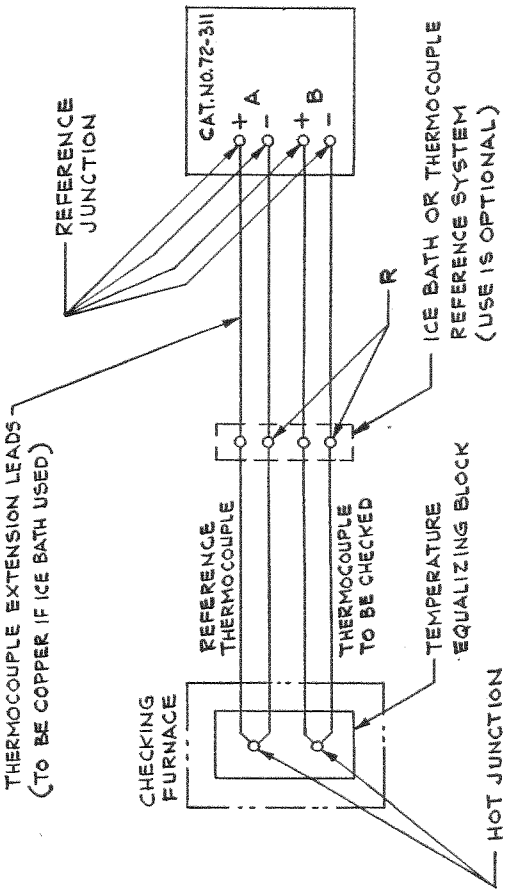

FIGURE 4 - Checking Thermocouples

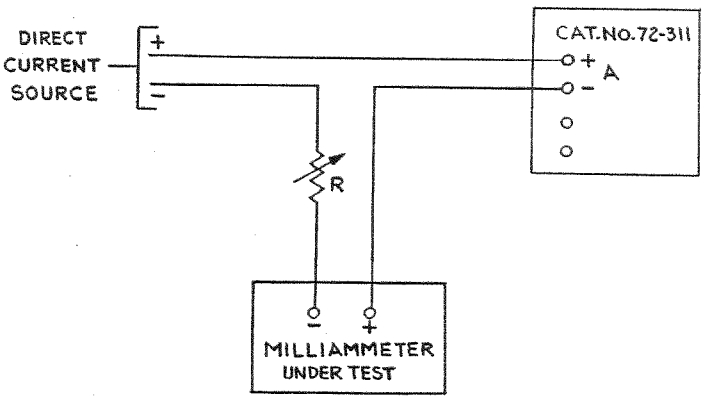

FIGURE 5 - Calibration of Milliammeter

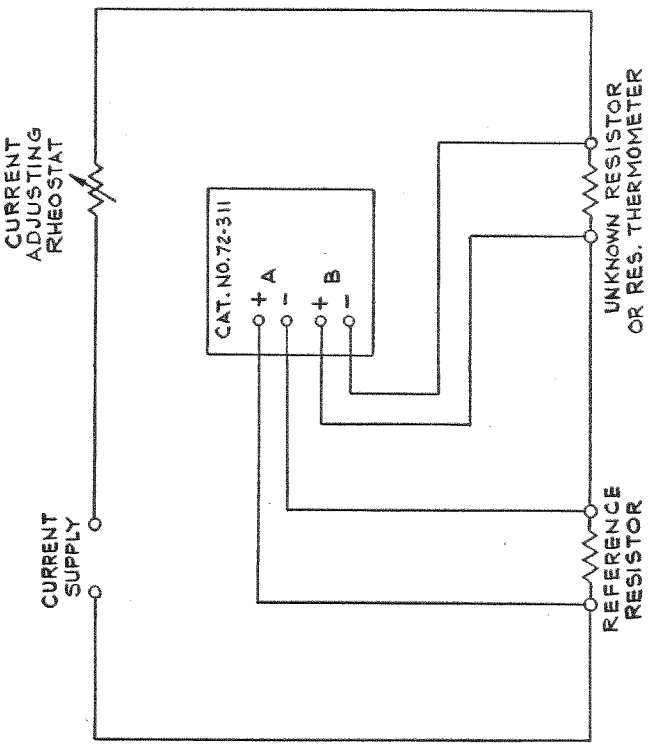

FIGURE 6 - Comparison of Resistors or Temperature Measurement using Res. Thermometer