INSTRUCTION MANUAL

B&K PRECISION TP-28

TEMPERATURE PROBE

SPECIFICATIONS

TEMPERATURE	
Fahrenheit Range	-58° to +302°.
Celsius Range	-50° to +150°.
Sensitivity	10 mV per °C or °F, switch-selectable.
Resolution	0.01° (with adequate voltmeter sensitivity).
Accuracy	±1.7°C or ±3°F.
Settling Time	10 seconds for stated accuracy (in immersion) for temperature change of 100°C.
GENERAL	
Meter Requirements	Analog or digital. Input impedance in excess of 10 kΩ. Voltage ranges must cover 0 to 3 volts DC (voltage is negative for temperatures below zero).
Maximum Voltage	500 volts between probe tip and circuit low.
Battery	9-volt transistor battery; Eveready type 216 or equivalent (not supplied).
Battery Life	120 hrs., continuous.
Low Battery Indicator	Meter continuously indicates high negative reading (approximately -100°C or F).
Size	8.75 x 5 x 2.8 cm (3½ x 2 x 1-1/8").
Cable Length	122 cm (4').
Weight	142 g (5 oz.).

B&K PRECISION DYNASCAN CORPORATION

INTRODUCTION

The TP-28 Temperature Probe is a temperature-sensitive voltage generator that converts almost any digital or analog voltmeter into an electronic thermometer. The probe produces 0 volts at 0° (a switch selects your choice of °C or °F), and increases linearly at 10 millivolts positive per degree, for temperatures above 0°; 10 millivolts negative per degree for temperatures below 0°. This provides a direct temperature reading from a voltmeter. For example, +1.425 volts = 142.5°, -0.227 volts = -22.7°, etc. The unit measures the temperature at the tip of the probe. It therefore can be used to measure atmospheric temperature, can be immersed to measure the temperature of liquids, or held against a part for surface temperature measurement.

VOLTAGE READING RANGES						TEMPERATURE, ° C or ° F, Switch-Selectable
Digital Voltmeter		Analog Voltmeter				
1-Volt	10-Volt	0-.5 Volt	0-1 Volt	0-1.5 Volt	0-3 Volt or 0-5 Volt	
	03.02				3.02	302°
	02.50				2.50	250°
	02.12				2.12	212°
	02.00				2.00	200°
1.999					1.99	199.9°
1.500				1.50	1.50	150.0°
1.000			1.00	1.00	1.00	100.0°
0.500		.500	0.50	0.50		50.0°
0.320		.320	0.32	0.32		32.0°
0.250		.250	0.25	0.25		25.0°
0.100		.100	0.10	0.10		10.0°
0.000		0.00	0.00	0.00		0.0°
-0.100		-.100	-0.10	-0.10		-10.0°
-0.250		-.250	-0.25	-0.25		-25.0°
-0.500		-.500	-0.50	-0.50		-50.0°
-0.580			-0.58	-0.58		-58.0°
Approximately -1 volt						Replace battery

°F

°C

The probe covers the temperature range of -50° to +150°C or -58° to +302°F and will settle to a new reading within 10 seconds for a change of temperature from 0° to 100°C (in liquid immersion, about 30 seconds for surface measurements). The probe can be used with any digital or analog voltmeter with an input impedance of 10 kΩ or greater. The meter should offer good accuracy and resolution in the 0- to 3-volt ranges. A 3½ digit digital multimeter such as the **B & K-PRECISION** Model 2800, 2810 or 2830 is an ideal companion for the temperature probe. All temperatures within the probe's range, except those above 199.9°F, can be read on the 1-volt range with 0.1° resolution. When used with an auto-polarity digital multimeter, the negative sign is automatically displayed for temperatures below 0°. The dual banana plug of the probe inserts directly into the test lead jacks of many meters.

APPLICATIONS

The TP-28 has many applications in electronics. It can monitor the ambient temperature at various points within a cabinet of operating equipment, and within temperature chambers during environmental tests. It can be used in the design lab to verify designs. It can measure the surface temperature of individual components such as transistors, integrated circuits, resistors, and transformers. Case temperatures can be used to evaluate biasing. Heat dissipation qualities of heat sinks and components can be evaluated as conservative or marginal. The probe can be used to determine oscillator temperature/frequency drift and measure temperature compensation parameters.

The temperature probe provides a voltage proportional to temperature which may be applied to a chart recorder for long-term temperature measurements.

The TP-28 also is a valuable instrument for electronics troubleshooting. It can locate "hot spots" caused by shorts or partial shorts. Lack of heat indicates inoperative components. It can test thermal devices. An incoming inspection department could use the probe to test temperature-related specifications of components. In quality control, measurement of temperature difference between a transistor case and its heat sink checks the quality of heat transfer workmanship.

The probe also has several non-electronic applications such as measuring the temperature of walls, floors, and ceiling to determine where additional insulation is needed, locating cold air leaks, and measuring the temperature of liquids such as water and solutions used in photo processing.

SAFETY PRECAUTIONS

1. The TP-28 is often used to measure temperatures in "live" equipment and the probe tip may be placed directly onto electrically hot conductors up to 500 volts. In any equipment where high voltage is present, use caution to prevent bodily contact with any point that could result in electric shock.

2. The TP-28 may be used to measure surface temperatures up to 302°F. Avoid touching hot surfaces which could result in serious burns.

3. When measuring the temperature of hot liquids, handle carefully to avoid spilling that could result in scalding.

OPERATING INSTRUCTIONS
(Refer to Fig. 1)

1. The TP-28 is shipped without a battery so that a fresh battery can be installed when you are ready to use the unit. Install a 9-volt transistor battery as shown in Fig. 3.

2. Connect the TP-28 to the voltage measurement jacks of a digital or analog voltmeter, observing polarity. For temperatures below zero, a negative voltage is generated. Digital voltmeters with automatic polarity indicator will automatically display a (-) sign. For other meters, use polarity reversal switch, zero center scale, or reverse polarity of connections.

3. Set the meter to measure DC volts (see Hint No. 1 for range selection tips).

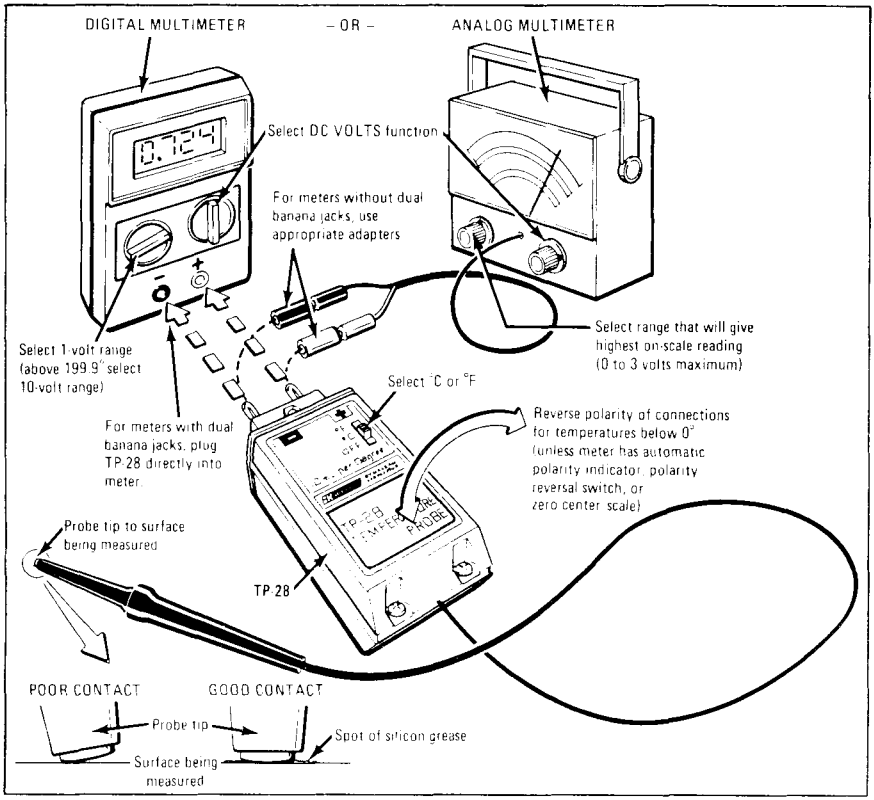

Fig. 1. Typical operation.

4. Turn on the TP-28 by setting the OFF-°C-°F switch to the °C position for Celsius temperature readings or to the °F position for Fahrenheit temperature readings.

5. Place the tip of the probe where it is desired to measure temperature. Place at desired point for air temperature measurement, immerse tip for liquid

measurement, or hold against surface for surface temperature measurement. Allow reading to stabilize at the new temperature.

6. For surface measurements:
   a. Be sure surface is clean.
   b. Hold probe tip at right angle to surface for maximum surface contact.
   c. Apply a drop of silicon grease at point of measurement for good heat transfer.

7. Read temperature from meter. Each 10 millivolts equals 1 degree (see table on inside of front cover).

8. Place OFF-°C-°F switch in OFF position to conserve battery life when the TP-28 is not in use.

HINTS AND KINKS

1. METER CONSIDERATIONS

a. The voltmeter must have a minimum input impedance of 10 kΩ *on the range selected*. All digital multimeters, FET multimeters, and VTVM's have a much higher input impedance than 10 kΩ and are desirable. Most good quality VOM's have a sensitivity of at least 20 kΩ per volt, and even on a 0.5-volt range presents 10 kΩ input impedance. Low cost VOM's should be examined to make sure they meet this requirement. A 10 kΩ per volt meter may be used on 1-volt and higher ranges, but not on a 0.5-volt range (presents 5 kΩ impedance).

b. A 3½-digit digital multimeter will provide 0.1° resolution on the 1-volt range for all temperatures from -50° to +150°C and from -58° to 199.9°F. Temperatures from 199.9° to 302°F can be measured on the 10-volt range with 1° resolution.

c. For best accuracy and resolution on analog meters, use the range that will give the highest meter deflection without exceeding full scale The TP-28 generates 3.02 volts maximum at 302°F.

d. The TP-28 generates positive voltage for all temperatures above 0°, and negative voltages for temperatures below 0°. A digital multimeter with automatically display a minus (-) sign for negative temperatures is preferred. A digital or analog meter with a polarity reversal switch or an analog meter with a zero center scale also is fairly convenient. For other meters, the polarity of connections between the TP-28 and the meter *must be reversed for temperatures below zero.*

e. Total accuracy of a reading must include the accuracy of the meter plus the accuracy of the temperature probe. For best total accuracy, use a high-accuracy meter.

f. For meters with dual banana jacks, plug the TP-28 directly into the meter. For meters with any other type jacks, use suitable adapters.

2. Low battery voltage in the TP-28 is indicated by a continuous high negative reading (approximately -100°C or F). Replace the battery as shown in Fig. 3.

3. Do not attempt to measure temperatures higher than 150°C (302°F). Damage to the probe tip may occur. The main body of the TP-28 may be used in ambient temperatures of 0° to +50°C.

4. For temperature chamber measurements, the probe should be placed inside the chamber and the meter left outside for ease of reading, and to keep the meter in a stable ambient temperature. The small diameter cable is very flexible and can easily be run through most door gaskets or access hole gaskets without disturbing the air seal.

5. When measuring the surface temperature of small components, remember that the probe will have some heat sinking effect and reduce the temperature somewhat below the normal operating temperature of the device.

6. The probe is made of Valox 420-SEO, which is impervious to most chemical solutions. Before using the probe in solvents, verify chemical reaction properties if possible. Otherwise, watch closely for possible damage to the probe.

THEORY OF OPERATION
(Refer to Fig. 2)

Operation of the TP-28 Temperature Probe is based upon the linear temperature coefficient of a semiconductor diode junction when forward biased with a constant current. The temperature sensor located in the tip of the probe is such a semiconductor junction. The forward voltage across the junction varies linearly with temperature. This voltage is amplified and scaled to produce a DC output voltage of 10 millivolts per degree, with separate scaling components for °C or °F.

Constant current source IC2B applies a constant current of 0.2 milliamp over the entire temperature range through temperature sensor Q1. This low current value assures negligible internally generated heating of the sensor. The voltage across the sensor junction is applied to amplifier IC1C. An offset voltage is also applied to the amplifier from the 0°C calibration pot. This offset voltage is adjusted so that the output reference voltage across the (+) and (-) terminals is 0 millivolts with the probe tip immersed in a 0°C liquid. The gain of amplifier IC1C is adjusted with the 100°C calibration pot so that the output is 1000 millivolts with the probe immersed in a 100°C liquid. Because of the linear characteristic, calibration performed at one low temperature point and one high temperature point calibrates the probe for its entire temperature range.

For the °F scale, an additional offset voltage is applied to the (-) output terminal so that the total output reference voltage is 320 millivolts (32°F reading) with the tip of the probe still immersed in the 0°C liquid. This offset voltage is derived from a 2.5-volt reference voltage established by IC2B and zener diode IC3. This is divided down to 1.5 volts across buffer IC1A, adjusted

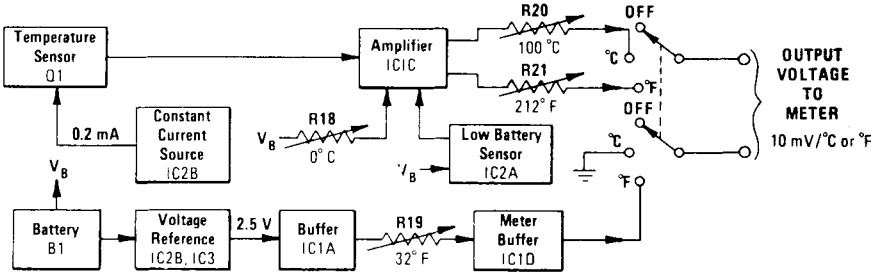

Fig. 2. Model TP-28 block diagram.

with the 32°F calibration pot, and applied to the output terminal through meter buffer IC1D. The gain of IC1C is increased by selection of the 212°F calibration pot, which adjusts the high temperature calibration point for 2120 millivolts (212°F reading) with the probe tip immersed in the 100°C liquid.

Power is provided by an internal 9-volt transistor battery. Diode D1 provides reverse polarity protection. Low battery sensor IC1A toggles when battery voltage becomes too low for continued accuracy, applying an offset voltage that will drive amplifier IC1C to its negative limit. This results in an output voltage of about -1000 millivolts, regardless of the temperature, an unmistakable indication to the operator that battery voltage is low. Total battery drain is only about 2 milliamps when the unit is operating. Low power consumption circuitry gives long battery life; at least 120 hours continuous, and several months for typical intermittent use.

MAINTENANCE AND CALIBRATION

DISASSEMBLY

Access to circuits in the main housing for battery replacement, calibration adjustments, or troubleshooting and repair is obtained by removing the three screws as shown in Fig. 3. To remove the circuit board from the housing (also illustrated in Fig. 3) spread the housing slightly at the retaining clips so that the board can be lifted out.

BATTERY REPLACEMENT

The TP-28 may be powered by any 9-volt transistor battery. When battery voltage gets too low for continued operation, the meter will continuously read a high negative value of about -100°C or F. The battery location is shown in Fig. 3; disassemble the main housing for access. Be careful not to accidentally move the calibration adjustments when removing or replacing the battery. Remove a discharged battery immediately to prevent leakage and corrosion. Remove the battery if the TP-28 is to be stored or not used for a long period.

BASIC TROUBLESHOOTING CHECK LIST

If the TP-28 does not operate normally, be sure to make the following checks before assuming there is a defective component, etc:

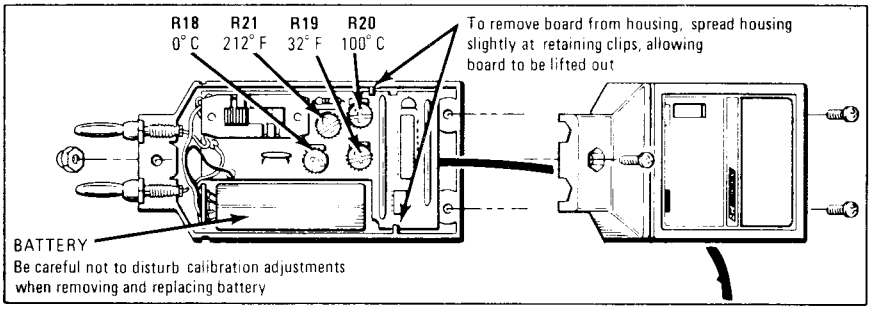

Fig. 3. Disassembly, battery location, and calibration adjustments location.

1. Is a battery installed in the TP-28?

2. Is the meter set to measure DC voltage? Is a 3-volt or lower range selected?

3. Is there a good electrical connection between the TP-28 and the voltmeter?

4. Is the meter okay? Does it measure other DC voltages normally?

5. If the meter continuously reads a high negative value (around -100°C or F), replace the battery with a known good battery. The cable from the main housing to the probe should also be examined for possible damage; a broken conductor will give the same symptom as a low battery.

If these steps do not correct the problem, the unit may be returned for service as instructed under "WARRANTY SERVICE INSTRUCTIONS."

TROUBLESHOOTING AND REPAIR

The following list of normal test conditions may be used for comparison to measurements obtained from your unit to help isolate the cause of a malfunction:

1. Total battery current should be about 2 milliamps.

2. Probe tip current should be 0.1 milliamp.

3. Voltage across zener diode IC3 should be 2.5 volts (can be measured across resistor network RN2, pins 8 to 9).

4. Current through zener diode IC3 should be 0.5 milliamp.

5. Voltage across resistor network RN2, pins 6 to 7, should be 1.5 volts.

CALIBRATION ADJUSTMENTS

The unit was accurately calibrated at the factory before shipment. Recalibration should be attempted only if repairs have been made which may affect calibration accuracy or you have reason to believe the unit is out of

calibration. If the tip is replaced, the unit must be recalibrated. **CALIBRATION ADJUSTMENTS MUST BE PERFORMED IN THE SEQUENCE LISTED.**

1. Disassemble the main housing of the unit for access to the calibration adjustments (refer to Fig. 3 for location of adjustments).

2. Connect the probe to an accurate DC voltmeter (0.5% accuracy or better for DC voltage ranges).

3. Set OFF-°C-°F switch to the °C position.

4. Prepare a mixture of crushed ice with just enough cold water to make a liquid ice water bath. Stir thoroughly to chill to 0°C (32°F). Immerse the probe tip about an inch into the ice water bath, using the probe to constantly stir the mixture. Adjust R18 for 0°C reading on voltmeter (0.000 ±.001 V).

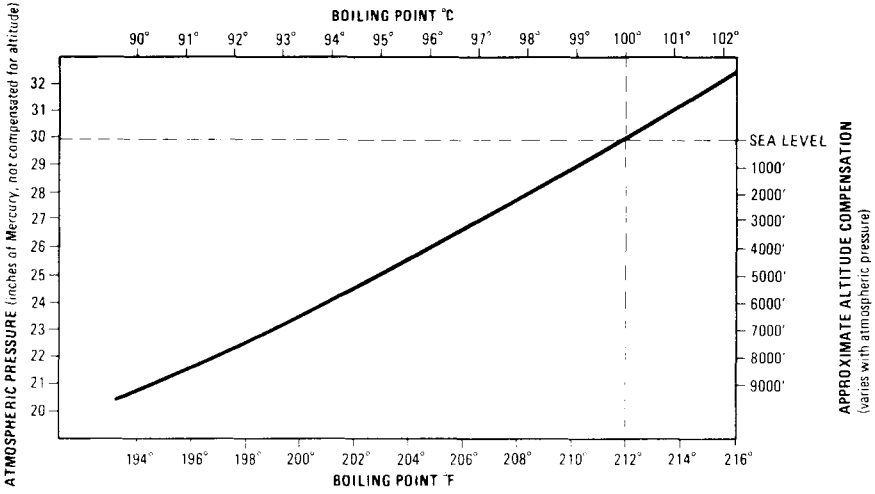

Fig. 4. Boiling point vs. altitude and atmospheric pressure.

5. Select the °F position and adjust R19 for 32° reading (+0.320 ±.001 V) with the tip still immersed in stirred ice water bath.

6. Prepare container of boiling water and measure temperature with calibrated thermometer. If a calibrated thermometer is not available, Fig. 4 may be used to approximate the boiling point, but calibration will be less accurate. Remember that water boils at 100°C (212°F) only at sea level with a standard atmospheric pressure of 29.9 inches of Mercury. The boiling point decreases with altitude and varies from hour to hour with atmospheric pressure changes. If a calibrated thermometer is used, do not allow it to touch the container which holds the boiling water, since it will be considerably hotter.

7. Return the OFF-°C-°F switch to the °C position and immerce the probe tip about an inch into the boiling water. Adjust R20 (the 100°C potentiometer) for the same temperature reading on the voltmeter as obtained from the calibrated thermometer in °C. For temperature of exactly 100°C adjust for reading of 1.000 +0/-.005 volt.

8. Again select the °F position and immerse the probe tip into the boiling water. Adjust R21 (the 212°F potentiometer) for the same temperature reading on the voltmeter as obtained from the calibrated thermometer in °F. For temperature of exactly 212°F, adjust for reading of 2.12 +0/-.01 volt.

WARRANTY SERVICE INSTRUCTIONS

1. Refer to the MAINTENANCE section of your B & K-Precision instruction manual for adjustments that may be applicable.

2. If the above-mentioned procedures do not correct the problem you are experiencing with your unit, pack it securely (preferably in the original carton or double-packed). Enclose a letter describing the problem and include your name and address. Deliver to, or ship PREPAID (UPS preferred) to the nearest B & K-Precision authorized service agency (see list enclosed with unit).

If your list of authorized B & K-Precision service agencies has been misplaced, contact your local distributor for the name of your nearest service agency, or write to:

Service Department

B & K-Precision Product Group
DYNASCAN CORPORATION
2815 West Irving Park Road
Chicago, Illinois 60618

LIMITED ONE-YEAR WARRANTY

DYNASCAN CORPORATION warrants to the original purchaser that its B & K-PRECISION product, and the component parts thereof, will be free from defects in workmanship and materials for a period of one year from the date of purchase.

DYNASCAN will, without charge, repair or replace, at its option, defective product or component parts upon delivery to an authorized B & K-PRECISION service contractor or the factory service department, accompanied by proof of the date of purchase in the form of a sales receipt.

To obtain warranty coverage, this product must be registered by completing and mailing the enclosed warranty registration card to DYNASCAN, B & K-PRECISION, P.O. Box 35080, Chicago, Illinois 60635 within five (5 days) from the date of purchase.

Exclusions: This warranty does not apply in the event of misuse or abuse of the product or as a result of unauthorized alterations or repairs. It is void if the serial number is altered, defaced or removed.

DYNASCAN shall not be liable for any consequential damages, including without limitation damages resulting from loss of use. Some states do not allow limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific rights and you may also have other rights which vary from state to state.

For your convenience we suggest you contact your B & K-PRECISION distributor, who may be authorized to make repairs or can refer you to the nearest service contractor. If warranty service cannot be obtained locally, please send the unit to B & K-PRECISION Service Department, 2815 West Irving Park Road, Chicago, Illinois 60618, properly packaged to avoid damage in shipment.

B+K PRECISION DYNASCAN CORPORATION

6460 West Cortland Street • Chicago, Illinois 60635

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SCHEMATIC DIAGRAM AND PARTS LIST

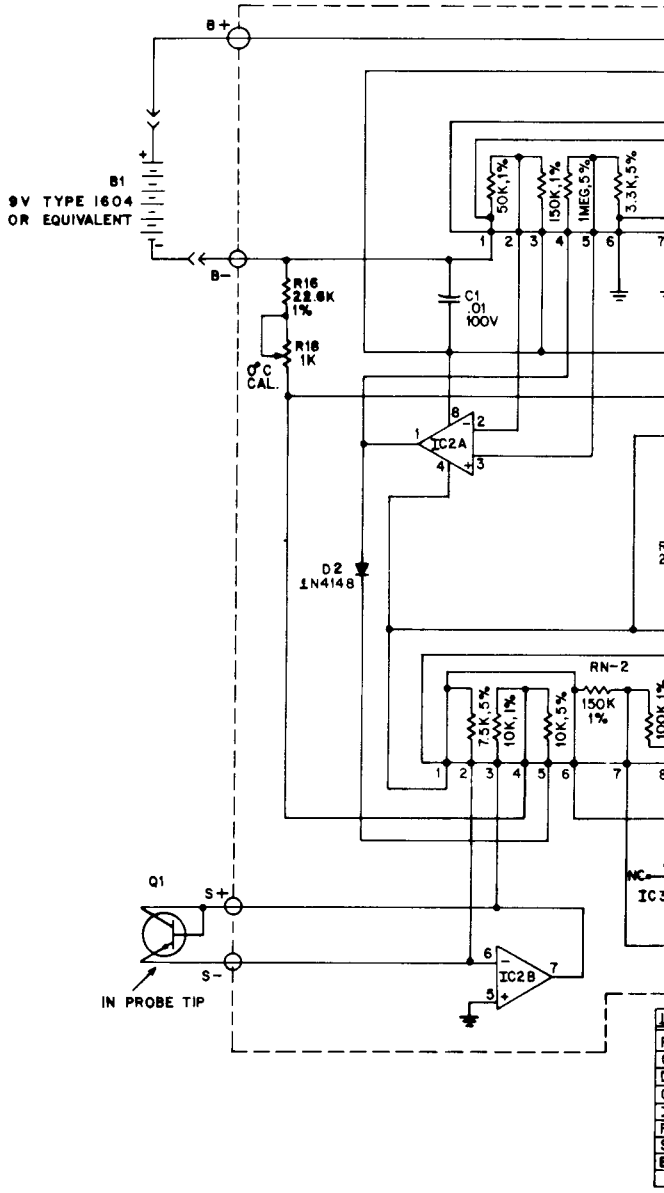
B&K PRECISION **TP-28**

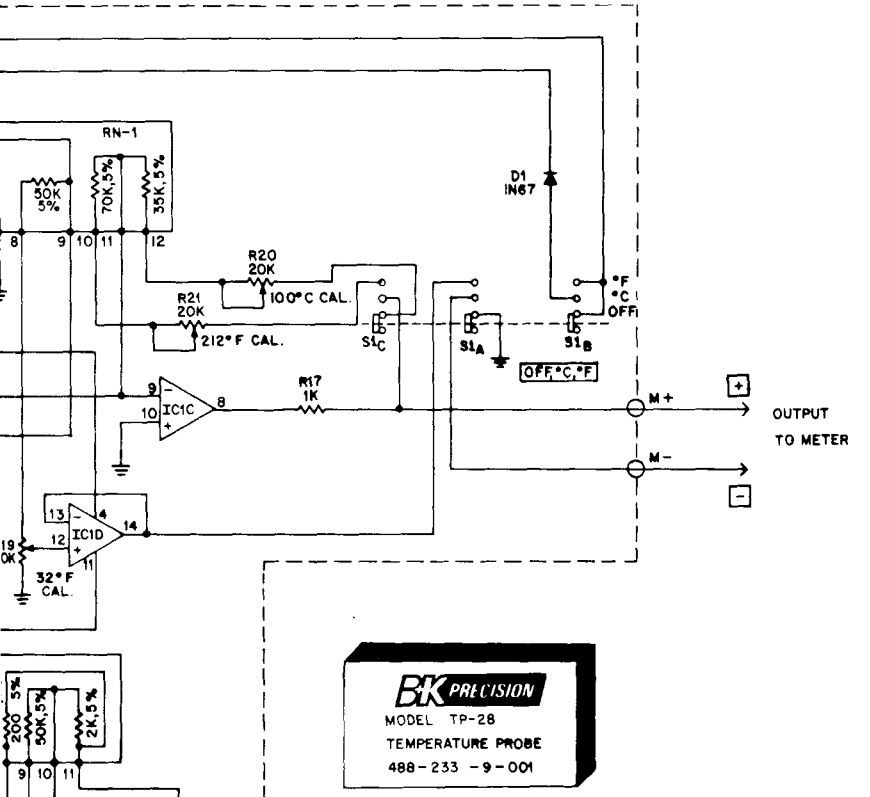
TEMPERATURE PROBE

PARTS LIST
488-233-9-002

SCHEMATIC SYMBOL	DESCRIPTION	B & K-PRECISION PART NO.
	RESISTORS	
R16	22.6KΩ, ¼W, 1% Metal Film	015-141-2-262
R18	Trimpot, 1KΩ	010-011-9-001
R19, 20, 21	Trimpot, 20KΩ	010-009-9-001
	NETWORKS	
RN-1	Resistor Network	012-019-9-001
RN-2	Resistor Network	012-020-9-001
	CAPACITORS	
C1	.01μF, 100V, +80, -20% Disc Ceramic	020-101-9-001
	DIODES	
D1	1N67 Germanium	150-008-9-001
D2	1N4148 Silicon	151-038-9-001

COMPOSITE
499-154-9-001


B+
B1
9V TYPE 1604
OR EQUIVALENT
B-
R16
22.6K
1%
R18
1K
°C
CAL.
C1
.01
100V
50K,1%
150K,1%
1MEG,5%
3.3K,5%
IC2A
D2
1N4148
RN-2
7.5K,5%
10K,1%
10K,5%
150K
1%
Q1
S+
S-
IN PROBE TIP
IC2B
NC
IC3



B&K PRECISION
MODEL TP-28
TEMPERATURE PROBE
488-233-9-001

NOTES: (UNLESS OTHERWISE SPECIFIED)

1. ALL RESISTORS ARE 1/4W, 5%, DEPOSITED CARBON.
2. ALL CAPACITORS ARE SHOWN IN MICROFARADS.
3. TITLES IN RECTANGLES DENOTE PANEL CONTROLS.
4. IC3 IS A PROGRAMABLE ZENER USED AS A 2.5V ±4% REFERENCE
5. S1 SHOWN IN THE OFF POSITION.

AST NUMBER	NOT USED
21	
1	
2	
1	
C3	
N2	

SCHEMATIC SYMBOL		B & K-PRECISION PART NO.
	INTEGRATED CIRCUITS	
IC1	324, Quad Op-Amp	307-060-9-001
IC2	358, Dual Op-Amp	307-134-9-001
IC3	LM336, 2.5V Programmable Zener Diode	307-142-9-001
	SWITCHES	
S1	3P3T, Slide Switch	084-061-9-001
	MISCELLANEOUS	
	Inlay, Front	260-150-9-001
	Inlay, Rear	260-151-9-001
	Case	380-300-9-001
	Probe Tip and Cable Assembly	520-032-9-001
	Cover, Slide Switch	763-108-9-001
	Battery Connector	771-030-9-001
	Banana Plug	775-049-9-001

NOTE: Standard value resistors are not listed. Values may be obtained from schematic diagram. Minimum charge $5.00 per invoice. Orders will be shipped C.O.D. unless previous open account arrangements have been made or remittance accompanies order. Advance remittance must cover postage or express charges. Specify serial number when ordering replacement parts.

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