OPERATOR'S MANUAL

SIMPSON THERM-O-METER

MODELS 388 AND 388-3L

SIMPSON ELECTRIC COMPANY

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Area Code 312, Telephone 379-1121
In Canada, Bach-Simpson, Ltd., London, Ontario

FIGURE 1. THE SIMPSON THERM-O-METER MODEL 388

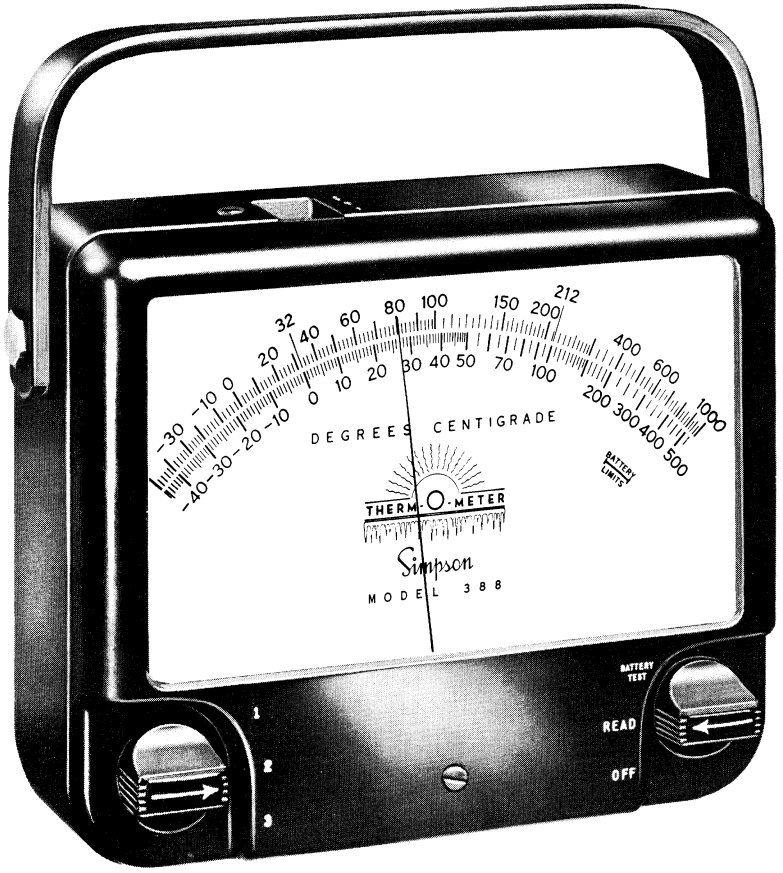

FIGURE 2. THE SIMPSON THERM-O-METER MODEL 388-3L

SECTION I

DESCRIPTION

MODELS 388 AND 388-3L

1. GENERAL

SELF CONTAINED

SIMPSON THERM-O-METERS MODELS 388 and 388-3L are self contained electrically operated temperature indicators. They are very convenient to use for any application of a wide range thermometer. The temperature is indicated on a large 7-inch meter in degrees Fahrenheit and Centigrade. The standard range for these instruments includes temperature indications from −50° F to +1000°F (−40°C to +500°C). Kelvin scale markings are available on special order.

INDICATES TEMPERATURE IN ENCLOSED SPACE

The measured temperature is that which affects the tip of an 8-foot lead which is connected to the instrument. Thus, the Simpson Therm-O-Meter is especially adapted for indicating the temperature within an enclosed space. Place the lead tip within the enclosed space and keep the indicating meter out where it may be read conveniently.

FOR CONTINUOUS OR SPOT CHECKS

The Simpson Therm-O-Meter may be used as a continuous indicator over a long period of time, or it may be used to spot-check a temperature at any time. There is a very short lag in time from when the tip is exposed to the temperature to be measured to when that temperature is correctly indicated on the meter.

2. PHYSICAL

TWO MODELS AVAILABLE

This book covers the use of two models (388 and 388-3L). They are similar in construction and application. Each Model is furnished with a single lead. The Model 388-3L has provisions for three leads, with a switch to connect any of the three at a time. Additional accessory leads are available (see pages 24-27).

FOR THREE LEADS WITH SELECTOR SWITCH

The Model 388-3L, with three leads, is convenient to use where there are several locations in the same vicinity for which the temperatures are to be checked. All three leads can be attached to the instrument at the same time. The selector switch in the lower left corner of the front panel determines which of the three leads is connected to the meter circuit. By switching back and forth between the three indications, the operator can observe simultaneous temperatures at all these sources with the single instrument. This is especially valuable for laboratory control apparatus, production equipment, and many types of experimental applications.

SINGLE LEAD MODEL

The Model 388 is similar in appearance to the Model 388-3L, but it accomodates only a single lead. There is no selector switch in the lower left corner of its front panel. In all other respects the two models are the same.

POLARIZED PLUGS AND JACKS

Both models use plug-in leads, with jacks placed on the top of the instrument. The plugs and jacks are polarized; that is, they fit together only one way. This is necessary because the polarity of the attached leads is important to the correct indication on the meter.

COMPENSATING CIRCUIT SWITCH

There is a compensating circuit switch in the lower right corner of the front panel on either model. It has no effect on current from the thermocouple lead circuit. The switch controls the circuit which compensates meter current to correct for meter temperature variations away from 80° F. This switch has three positions, marked OFF, READ, and BATTERY TEST.

OFF POSITION

When the switch is set at OFF, the compensating battery circuit is opened, and the meter circuit does not receive any correction voltage from it. However, if there is any temperature difference between the two ends of the thermocouple lead (when it is plugged in), the lead will furnish a voltage which will deflect the meter pointer away from 80° F.

READ POSITION

With the compensating switch in the READ position, the compensating battery circuit will correct the meter reading for the actual temperature of the instrument. The meter will respond to the combined voltages from the thermocouple lead and the compensating circuit.

BATTERY TEST POSITION

With the compensating switch held in the BATTERY TEST position, you can check the condition of the battery which is furnishing compensating voltage. There is a range of indications on the meter which shows whether the battery is satisfactory.

> NOTE: When you test the battery voltage, either place the lead tip near the plug at the top of the meter case, or substitute 2.9 ohms of resistance for the lead. The lead resistance must be in the circuit in order to obtain a satisfactory indication, but the thermocouple lead must not furnish any voltage at this time or it will affect the meter reading.

LENGTH & UNKINKED LEAD IMPORTANT

Both models are identical in size. They measure 7-15/16" x 6" x 2-15/16". Each weighs 3 lbs. One thermocouple lead is furnished with each instrument. The standard lead is 8 feet long, with a polarized plug on one end and an exposed and welded thermo-junction at the other. Keep the lead wound in a flat coil shape when it is not in use. DO NOT KINK THE LEAD OR CUT OFF ANY UNUSED EXCESS, as this will affect the resistance of the lead and the accuracy of the instrument.

3. ELECTRICAL

LEAD DESCRIPTION

The lead which is furnished with each instrument is eight feet long and is made up of two wires with fiberglass insulation. The wires are made of two different metals, one iron and the other constantan, and are joined together and welded at the tip. This is what is known technically as a thermocouple or thermo-junction. A temperature difference between the two ends of this lead develops a D.C. voltage difference between the iron and the constantan. When the temperature at the tip is higher than the temperature at the plug end of the lead, the voltage at the plug is positive on the iron wire and negative on the constantan wire. When the two ends are at the same temperature, there is no voltage difference between the wires. When the temperature at the tip is lower than at the plug end, the voltage at the plug is negative on the iron wire and positive on the constantan wire. As the temperature difference increases, the voltage increases between the wire. It is this voltage which is applied to the indicating meter circuit to deflect the pointer and indicate the temperature. Additional accessory leads are available (see pages 24-27).

ZERO POSITION IS 80 DEGREES F

With the compensating switch in the lower right corner at OFF, and the lead tip and the plug and meter all at the same temperature, there is no voltage generated in the thermocouple lead to send current through the meter. The pointer will not be deflected from its zero current indication point at 80° F on the dial. To correct the meter reading, set the compensating switch at READ. This connects a compensating circuit which will correct the meter indications and show the actual temperature.

NOTE: The lead must be plugged in, even though it is not furnishing any voltage to the meter circuit, because its resistance (2.9 ohms) is a part of the circuit through which the compensating current will pass.

COMPENSATING CIRCUIT

The patented compensating circuit is powered with a dry cell battery. There is a bridge network inside the case through which the battery current will pass. When the bridge temperature is 80° F., it is electrically balanced so there will be no difference in voltage between the two points where the meter is connected. Any variation in temperature away from 80° F. will change the resistance of a thermistor and unbalance the bridge. The polarity and amount of voltage difference between the two contacted points will send current through the meter to deflect it in the direction and amount necessary to correct the meter indication.

NORMAL OPERATION

In normal operation, the meter is placed in any convenient location where the temperature is between 60° and 100° F (15° and 39° C). The lead tip is placed in a position to assume the temperature to be measured; this may be inside a furnace, in a freezer, under the surface of a liquid, or wherever a temperature is to be measured. Then, with the compensating switch set at READ, there will be a current through the meter due to both the thermocouple and the compensating circuit. The result will show the temperature present at the tip of the lead.

4. ABNORMAL TEMPERATURE OPERATION BELOW 60° F OR ABOVE 100° F

If the instrument is placed in a temperature below 60° or above 100° F., it will operate, but the compensating circuit will not fully correct for the instrument temperature. Errors in indications will be in proportion to the number of degrees the instrument is operated from the normal operating range of 60° to 100° F. For example, an instrument operating at a temperature of approximately 40° (which is 20° lower than the normal operating temperature range) may indicate an error of approximately 3° to 6°, or if operating at 0° temperature (which is 60° below the normal operating range) an error of 15° or more could be expected.

LARGE TEMPERATURE DIFFERENCE

When transferring the Therm-O-Meter from one location to another where there is a large difference in temperature, it is necessary for the meter to stabilize to the new temperature environment before attempting to make accurate measurements. This may take from a few minutes to an hour or more, depending upon the temperature difference involved and the accuracy required.

5. ACCURACY 1½ SCALE DIVISIONS

(ON FAHRENHEIT DEGREES SCALE)

When the instrument leaves the factory, it is capable of indicating any temperature within its range accurate to within 1½ scale divisions. To duplicate this accuracy, the instrument must be held in a horizontal position. Since the scale is not linear, a

scale division represents a different number of degrees for various temperature ranges. Consult the dial scale in the vicinity of each reading to determine the number of degrees per scale division in that area. This changes from 2° to 5° to 10° to 25° F as you go across the scale.

DECREASING BATTERY TERMINAL VOLTAGE

The accuracy of the compensating circuit depends on the terminal voltage of the dry cell battery. As the battery ages, its internal resistance increases and its terminal voltage decreases. For a quick check of the battery condition, there is a third position of the compensating switch, marked BATTERY TEST. The operator should turn the switch to this position periodically to check the battery condition. When the meter indication is not within the BATTERY LIMITS area on the dial, replace the battery. See Section 3, Maintenance, for more detailed information.

CALIBRATING CONTROL

There is a removable snap type button which covers an access hole through the top of the instrument case near the lead jack. When this is removed, there is access to a screwdriver-adjusted variable resistor inside the case. This resistor, used for calibrating the instrument, is shown in the schematic diagram, figure 3, as R8. Do not change the setting of this resistance except during calibration. See the instructions in Section III.

SECTION II

OPERATING INSTRUCTIONS

1. PRELIMINARY STEPS

BATTERY TEST

Before each use, or at least once a day for a Therm-O-Meter which is in constant use, check to see that the dry cell battery inside the case of the instrument tests within its proper limits. Have a thermocouple lead plugged in, and place its tip near its plug so both ends come to the same temperature and the lead does not furnish any deflecting voltage. Turn the compensating switch in the lower right corner of the instrument to its BATTERY TEST position. This is a spring loaded position; that is, the switch will remain in that position only as long as it is held there. Check the meter indication. The pointer will be within the area designated as BATTERY LIMITS if the battery has enough strength to be used for the compensating circuit. When the indication drops below the limits, the terminal voltage is too low. Replace the battery when this condition is noted.

ZERO ADJUSTER

To check for correct zero setting, remove the lead (or leads) from the instrument and turn the compensating switch to its OFF position. The meter should now indicate 80° F. If it does not, correct it by turning the zero adjuster screw directly under the meter window.

CONNECT THE LEAD (OR LEADS)

For the Model 388, insert the lead plug into the jack on the top of the meter case. It fits only one way. For the Model 388-3L, connect one, two, or three leads into the jacks on the top of the meter case as desired for the application.

POSITION THE TIP (OR TIPS)

For the Model 388, place the tip in the area where temperature is to be measured. This may be in air or other gas, in a solid material, or under the surface of a liquid. For best results, be sure to have at least two inches of the end of the lead in the measured temperature. For the Model 388-3L, place each of the lead tips in the area where it is to measure a temperature and note the lead which is to be identified with each switch position – 1, 2, and 3.

2. OPERATION

COMPENSATING SWITCH AT READ POSITION

After the battery voltage has been checked and the leads have been connected to the meter, proceed to read the temperatures at the tips. Set the compensating switch at READ and allow time for the pointer to steady its indication. Then read the indicated temperature in degrees Fahrenheit or Centigrade.

SELECTOR SWITCH (MODEL 388-3L)

For the Model 388, there is only one test lead connection, and the temperature indicated is that for the tip of the single lead.

For the Model 388-3L, use the switch in the lower left corner of the front panel to select between the temperatures at the tips of the associated leads. For example, when the switch is set at 1, the temperature will be that of the tip of lead 1. When the switch is set at 2, temperature is indicated for the tip of lead 2. For the #3 position, the lead 3 tip temperature is indicated.

SET SWITCH AT OFF

Between readings, return the compensating switch to OFF. This will assist the battery to retain a longer use life, because the battery does not have to furnish current through any circuit when the switch is set at OFF.

METER READINGS WITH SWITCH OFF

Note that the meter may read some temperature other than 80° F, if there is a lead connected to the instrument and the switch is set at OFF. It will not be a corrected temperature. The reason why there may be some variation in the meter indication is that the thermocouple develops voltage whenever there is a temperature difference between the two ends of the lead. This voltage causes current to flow through the meter circuit and the pointer will be deflected as long as this condition remains. When both ends of the lead are at exactly the same temperature, so no voltage is developed, the normal meter indication with the compensating switch set at OFF is 80° F.

EMERGENCY USE WITH LOW BATTERY VOLTAGE

When battery voltage indicates below the normal range, the Model 388 or 388-3L can be used to measure temperatures, provided

the meter temperature is known. Use the normal operating procedure, but leave the compensating switch at OFF. Read the meter indication, and then correct the reading by adding or subtracting the difference between the meter temperature and 80° F. If the meter temperature is higher than 80° F, add the difference to the reading. If the meter temperature is lower than 80° F, subtract the difference from the reading. The equivalent Centigrade temperature for 80° F is 26.7° C; use this in place of 80° to correct for meter readings made on the Centigrade scale.

> NOTE: To read the temperature in a liquid, submerse the lead tip at least two inches in the liquid. After the temperature has been measured, wait until the tip and insulation are thoroughly dry before reading a "dry bulb" temperature; indications are lower while evaporation is taking place.

SECTION III

MAINTENANCE

1. THERMOCOUPLE LEAD

CARE OF LEAD

The thermocouple lead is made of two wires, one iron and the other constantan, with spun glass insulation covering each wire and another layer covering the pair. The lead length is approximately 8 feet overall, and should remain that length to produce accurate temperature indications. The lead resistance is a part of the circuit resistance through the indicating meter, so any change in length will change the electrical resistance in the meter circuit, and change the resulting temperature and battery test indications.

USING DAMAGED LEAD

If the lead tip has been damaged by continued application of high temperatures, so the insulation has melted away, the lead may still be used; be sure the two wires are separated from each other except where they are welded together to form the junction.

ROLL THE LEAD CAREFULLY

When the lead is not in use, keep it rolled in a flat coil to prevent accidental damage. Do not kink the lead with a sharp bend. The two metals of which the wires are made are somewhat brittle, and will either break at the sharp bend, or will partially break and increase lead resistance.

2. BATTERY

ACCURACY DEPENDENT ON BATTERY VOLTAGE

The battery which is used in the Models 388 and 388-3L is a 1.5 volt dry cell, No. 2, Size D. As mentioned earlier, the battery strength will decrease over a period of time. When the terminal voltage decreases, the amount of compensating current will decrease correspondingly. To maintain the desired accuracy of indications, be sure the battery condition is within the established tolerance which will provide the right amount of temperature correction on the meter.

CONNECT LEAD DURING BATTERY TEST

To check the battery, connect a thermocouple lead to the meter circuit and place its thermo-junction in the center eyelet of the thermocouple plug. If necessary, wait for the two ends of the lead to come to the same temperature.

SET SWITCH AT BATTERY TEST

Turn the compensating switch in the lower right corner of the instrument to BATTERY TEST. The meter pointer will deflect to indicate the terminal voltage available from the dry cell. There is a special scale on the dial marked BATTERY LIMITS. When the pointer shows that the terminal voltage has reduced below the allowable limit, replace the dry cell with a fresh one.

BATTERY REPLACEMENT

To replace the battery, remove the four screws through the back of the case and pull the case straight back from the front panel.

Do not pull the case at an angle. The battery is located in a compartment inside the instrument which is especially designed to hold it and contact its two terminals. To remove the battery, pull it straight out of the compartment. When replacing, be sure to observe polarity; the raised center cap of the battery must be at the end of the compartment where there is a + mark, and the base where there is a − mark. After the battery has been replaced. put the case back in place over the instrument. Be careful, as before, to slide it on straight, and not at an angle.

3. CALIBRATION PROCEDURE – GENERAL

PARTS REPLACEMENT

Whenever any resistors or other parts (except the battery) are replaced in the Therm-O-Meter, recalibrate the instrument with the standard factory procedure. There are several steps in the complete calibration procedure, and several special items are essential.

TEMPERATURE CONTROLLED ROOM OR CABIENT

To duplicate factory accuracy, the instrument and its lead must be placed into either a room or a cabinet in which the temperature is controlled. The required temperatures are exactly 80° F, and approximately 60° F and 100° F, and these need to be held constant through periods of two or more hours. Another item which will be required is a container of ice water which is at least 50% ice at the time it is used. A third item is a container of water which is boiling at the time it is used. If these items are not available, either follow the procedure as closely as possible, with the understanding that accuracy will probably

be affected, or return the instrument to the nearest Simpson Repair Station for calibration. A list of these Repair Stations is included at the rear of the manual.

COMPARE TO STANDARD THERMOMETERS

For best accuracy, use two standard thermometers for comparison of indications. Tape one to the meter cover to read the instrument temperatures in the cabinet or room at 60°, 80°, and 100° F. Place the other standard thermometer in the same position as the lead tip to check temperatures from 32° to 212° F. Calibration accuracy of the Simpson Therm-O-Meter will be determined by the accuracy of the standard thermometers.

AVOID TOUCHING INSTRUMENT OR LEAD

Do not handle the instrument or the lead unnecessarily during the calibration procedure. Body temperature is different from any of the controlled temperatures to which the instrument and lead are subjected, and will cause a temperature variation each time you touch them.

CALIBRATION PROCEDURE

1. Set meter zero adjuster in the front panel of the instrument.

   A. Set compensating switch at OFF.
   B. Remove the lead (or leads) from the jack on the top of the Therm-O-Meter.
   C. Use a small screwdriver to turn the zero adjuster (slotted bakelite button), at the center below the dial, slowly in either direction until the meter pointer rests over 80° F

on the dial. This is the pointer position for zero current through the meter.

2. Balance the bridge in the compensating circuit.

   A. Connect a lead to the instrument. For the Model 388-3L, set the switch in the lower left corner of the front panel to connect the lead for the instrument circuit.
   B. Place the instrument and the lead in a temperature controlled cabinet or room set for exactly 80° F. Allow one to two hours for the entire instrument and the lead to become stabilized at this temperature.
   C. Set the compensating switch at READ. Observe the meter indication. It should read 80° F.
   D. If it does not read 80° F, remove the back cover and use a screwdriver to adjust potentiometer R2, located two inches from the bottom edge of the panel, until the meter indicates correctly.

3. Adjust the compensating circuit sensitivity.

   A. Leave the instrument and lead as they were for step 2.C above. Increase the controlled temperature to about 100° F. Allow one to two hours for the instrument and lead to be stabilized at this temperature.
   B. Observe the meter indication. It should be equal to that on the standard thermometer which is affected by the same controlled temperature.
   C. If necessary, adjust the potentiometer located closest to the battery (R9) with a screwdriver to correct the temperature indication on the Therm-O-Meter.
   D. Reduce the controlled temperature to about 60° F. Allow one to two hours for the instrument and lead to become stabilized at this temperature.

   E. Observe the meter indication again. It should be the same as that shown on the standard thermometer which is affected by the same controlled temperature.
   F. If necessary, compromise the setting of potentiometer R9 to average the 60° F accuracy with that at 100° F.

4. Final calibration; setting calibration resistor.

   A. Stabilize the instrument and lead at room temperature, between 75° F and 85° F.
   B. Place the end of the lead in the mixture of ice water. Place at least two inches of the end of the lead in the water. Stir the water to maintain a constant temperature and measure it with the standard thermometer at the point where the sensing end of the lead is submersed.
   C. Adjust the calibrating resistor, R8, located near the lead jack, until the meter reads the same as the standard thermometer. This will be near 32° F, but may vary one to two degrees due to barometric pressure and impurities in the water and the ice.
   D. Remove the lead and the standard thermometer from the ice water and transfer them to the container of boiling water.
   E. After the temperature indications have been stabilized, compare the meter indication with the thermometer reading. They should read the same temperature. If there is any difference, readjust calibrating resistor R8 to average the accuracy for ice water and boiling water.

There is no adjustment for the battery test circuit. A fresh dry cell should cause the meter to indicate within the upper two thirds of the BATTERY LIMITS area when the thermocouple lead is plugged in and the thermocouple tip and the meter are at the same temperature.

4. REPLACEMENT PARTS

Symbol	Description	Simpson Part No.
R1	Thermistor, approximately 1000 ohms at 80° F	1-113771
R2	Potentiometer, 400 ohms	1-113774
R3	Resistor, 680 ohms ±1%, ½ w	1-115243
R4	Resistor, 510 ohms ±1%, ½ w	1-115242
R5	Resistor, 510 ohms ±1%, ½ w	1-115242
R7	Resistor, N.T.C., 2.75 ohms at 80° F	1-112271
R8	Potentiometer, 100 ohms	1-114224
R9	Potentiometer, 1000 ohms	1-114525
R10	Resistor, 100 ohms ±1%, ½ w	1-114091
S1	Switch, compensating	1-115245
S2	Switch, circuit selector (Model 388-3L only)	1-116645
	Knob, switch, with white arrow	1-115334
	Case back, machined (Model 388 only)	3-320135
	Case back, finished (Model 388-3L only)	3-330075
	Thermistor clamp	3-160064
	Thermistor holder	3-160065
	Jack assembly (Model 388-3L only)	10-890189
	Temperature probe, standard type	0190
	Temperature probe, Surface type	0187
	Temperature probe, Rugged Service type	0496

Figure 3 is a schematic diagram which shows the circuits for both models of the Simpson Therm-O-Meter. The circuit at the left is for the Model 388, and the circuit at the right is for the Model 388-3L.

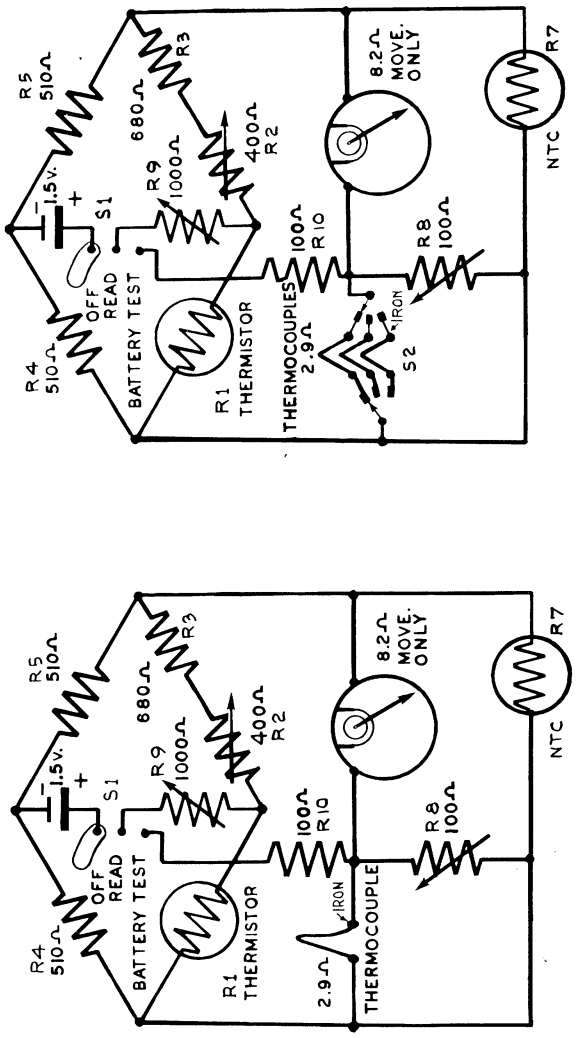

FIGURE 3. SCHEMATIC DIAGRAM FOR SIMPSON THERM-O-METERS, MODELS 388 AND 388-3L

SECTION IV

SUPPLEMENTARY INFORMATION

WET BULB TEMPERATURES

The Simpson Therm-O-Meter is a very convenient instrument to use for measuring wet bulb temperatures. Wrap some string or wicking around the end of the test lead and dip it in water to wet it thoroughly. Then swing it back and forth gently to evaporate water from the lead tip. Since the instrument remains in a stationary position, you can read the exact wet bulb temperature while continuing to swing the lead tip. Be careful to prevent kinking the lead as it is swung back and forth.

> NOTE: After making a wet bulb reading, remove the string wrapping and dry the lead tip thoroughly before attempting to make a dry bulb reading. If any moisture remains on the lead tip or in the insulation, this will lower the dry bulb reading.

ACCESSORIES

There are several accessory items which are available to aid you in getting the best service from your Simpson Therm-O-Meter. See them at your Parts Jobber.

Additional standard type thermocouple leads can be obtained for use with either model Therm-O-Meter. Specify standard leads with Simpson Part Number 0190. See figure 4.

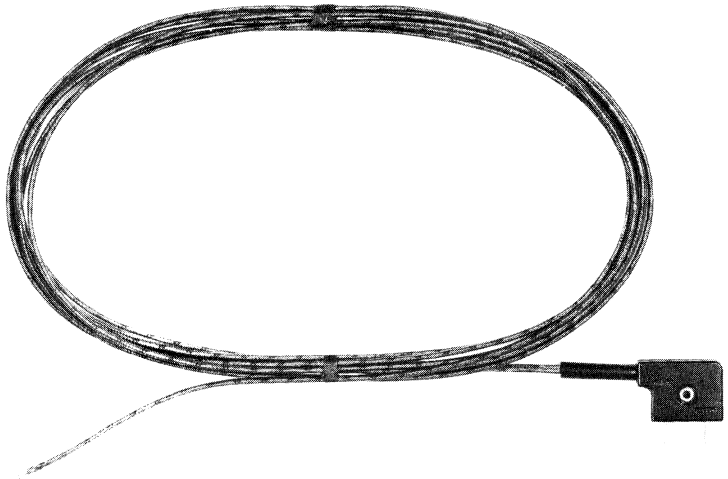

FIG. 4 STANDARD TYPE THERMOCOUPLE LEAD MODEL 0190

SURFACE TEMPERATURE PROBE

A special type of lead is available to use in measuring a surface temperature, such as the outer wall of a container. This lead is 7 feet long. The sensing tip is enclosed in a bakelite sleeve and a teflon insulator. A small copper contactor is imbedded in the end of the plastic, and transmits the heat back to the thermocouple junction inside the insulator. The other end of this lead is fitted with a plug to fit the regular jack. For this surface temperature probe, specify Simpson Part Number 0187. Surface Temperatures up to 1000° F. can be measured with this probe. probe.

The Surface Temperature Probe is constructed so that surrounding temperature has no influence on the couple and thus provides a temperature reading of the surface only. See figure 5.

To use--plug the connector into the Model 388 or 388-3L. Hold the tip of the probe against the surface to be measured for 10 to 20 seconds, or until the meter pointer comes to a complete rest; then read the temperature.

CAUTION: The material supporting the sensing element in this probe softens at temperatures in excess of 600° F. Apply only light pressure----only enough to maintain contact with the surface being checked----to avoid distortion and damage to the probe, when making measurements at temperatures above 600° F.

In addition, probe life is shortened by exposure to temperatures above 600° F. Estimated minimum probe life and recommended maximum continuous usage time are shown below.

Temperature	Maximum Continuous Usage Recommended	Probable Probe Life
700° F.	2 hrs.	5000 hrs.
800° F.	15 min.	100 hrs.
900° F.	3 min.	1 hr.
1000° F.	1 min.	.5 hr.

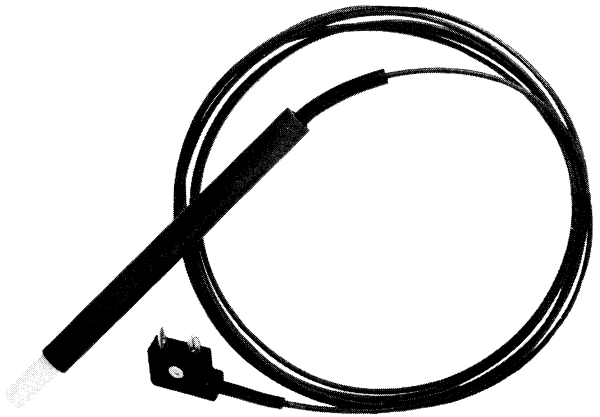

FIG. 5 SURFACE TEMPERATURE PROBE MODEL 0187

RUGGED SERVICE LEADS

In many applications, particularly where abrasion of the insulation can occur, the life of the standard lead will be relatively short. For these applications, a lead having a flexible steel jacket has been designed. Temperature measurements can be continuously monitored within the maximum limits of this tester without any detrimental effects to the steel jacketed leads. For this rugged service lead, specify Simpson Part Number 0496. See figure 6.

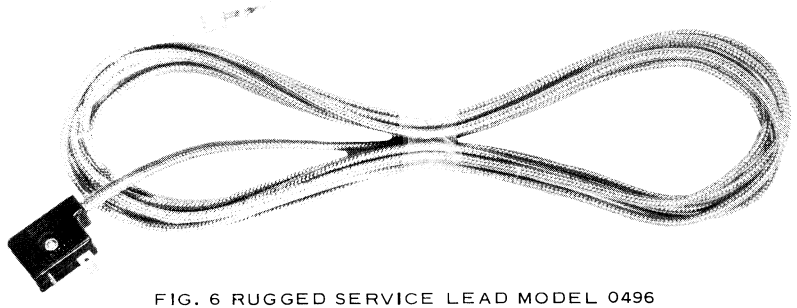

FIG. 6 RUGGED SERVICE LEAD MODEL 0496

INSTRUMENT PROTECTION

To protect your instrument, there is an Ever-Redy style vinyl carrying case into which you can place the instrument and test lead. You can leave the instrument in the carrying case while it is being used to read temperatures. The case protects the instrument from damage when it is in use as well as when it is stored. Specify Simpson Case Number 5262.

SIMPSON WARRANTY REPAIR STATIONS AND PARTS DEPOTS

Arizona, Phoenix 85016 Metercraft Inc. 3308 N. 24th St.	Area Code 602 279-6249
California, San Diego 92111 Meter Master, Inc. 8139 Engineer Road	Area Code 714 278-2200
California, Glendale 91201 JSD Engineering Company 6915 San Fernando Road	Area Code 213 849-6187
California, Los Angeles 90022 Meter Master, L.A. Div. of Kierulff Electronics, Inc. 5645 East Washington Blvd.	Area Code 213 685-7313
California, Mountain View 94041 Kierulff/Metermaster 2484 Middlefield Road	Area Code 415 968-6292
California, San Francisco 94105 Pacific Electrical Instrument Lab. 111 Main Street	Area Code 415 421-7185
Canada, London, Ontario Bach-Simpson Ltd. 1255 Brydges Street P.O. Box 484	Area Code 519 451-9490
Colorado, Denver 80223 Meter-Master Instrument Service 2145 S. Kalamath Street	Area Code 303 934-4601 934-8614
Connecticut, New Haven 06511 Kaufman Instrument Labs Inc. 810 Dixwell Avenue	Area Code 203 776-7201
Florida, Miami 33136 Florida Precision Instrument Corp. 800 N.W. 7th Avenue	Area Code 305 374-1731
Florida, Orlando 32806 Electro Tech Inc. 307 - 27th Street	Area Code 305 423-5589
Georgia, Atlanta 30310 Electro-Tech Inc. 690 Murphy Ave. S.W.	Area Code 404 758-7205
Hawaii, Honolulu 96817 Electronic Systems Inc. 1622-26 Silva Street	851-457 811-132
Illinois, Chicago 60625 A & M Instrument, Incorporated 4801 North Ridgeway Avenue	Area Code 312 539-4460
Illinois, Chicago 60644 Pacific Indicator Company 5217 W. Madison Street	Area Code 312 261-1330
Illinois, Chicago 60644 Simpson Electric Company 5200 W. Kinzie Street	Area Code 312 379-1121
Kansas, Shawnee Mission 66205 Sturtz Instrument Co. 4705 Mission	Area Code 913 236-4705
Louisiana, New Orleans 70115 Industrial Instrument Works 3305 Tchoupitoulas Street	Area Code 504 895-5621
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Minnesota, Minneapolis 55411 — Area Code 612
Instrumentation Services Inc. — 521-8803
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Electro-Tech Equipment Company — 675-2400
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333 Vestal Parkway East
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North Carolina, Charlotte 28206 — Area Code 704
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Pioneer Standard Electronic, Inc.
314 Leo Street

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Tri State Instrument Lab. — 936-0489
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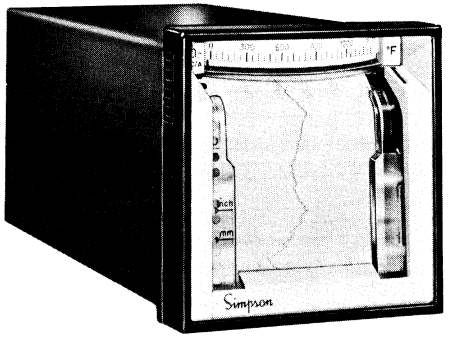

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