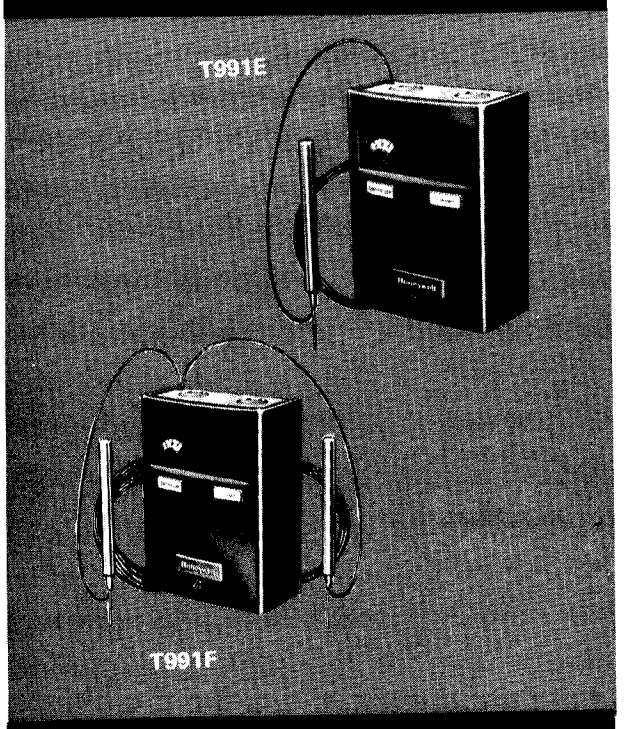
Honeywell

PROPORTIONING TEMPERATURE CONTROLLERS

THE T991E,F PROPORTIONING TEMPERATURE CONTROLLERS WITH END SWITCH PROVIDE ON-OFF AND MODULATING CONTROL OF LIQUID OR AIR TEMPERATURES IN BOILERS, STORAGE TANKS, OR AIR DUCTS.

- T991F dual bulb model provides automatic reset of the control point as the outdoor air temperature changes.
- For use with series 90 (modulating) actuators or motors.
- Series 40, spst, line voltage end switch cycles burner off and on when low fire position exceeds firing requirements, or turns burner on prior to modulating control on temperature fall.
- Rugged, heavy-duty potentiometer assembly has increased resistance to vibration to allow use of T991 with V9055 Modulating Gas Valve Actuator.
- Liquid-filled, remote bulb, temperature sensing element (T991F element has 2 bulbs).
- Capillary tubing allows remote mounting of sensing element; available in various lengths as a special option.
- Sensing bulb can be directly immersed in a liquid or mounted in an immersion well for boiler or storage tank applications, or duct-mounted for warm air applications.
- T991F outdoor bulb can be mounted in an outdoor duct, or outdoors with a bulb shield.
- Mounting accessories are available for all applications.
- Set point adjusting screw on front of case.
- T991 can be mounted in any position.



T991E,F

Form Number 60-2176—5

J.B.
REV. 7-78 (.12)

SPECIFICATIONS

IMPORTANT

THE SPECIFICATIONS GIVEN IN THIS PUBLICATION DO NOT INCLUDE NORMAL MANUFACTURING TOLERANCES. THEREFORE, THIS UNIT MAY NOT MATCH THE LISTED SPECIFICATIONS EXACTLY. ALSO, THIS PRODUCT IS TESTED AND CALIBRATED UNDER CLOSELY CONTROLLED CONDITIONS, AND SOME MINOR DIFFERENCES IN PERFORMANCE CAN BE EXPECTED IF THOSE CONDITIONS ARE CHANGED.

MODELS:

T991E Proportioning Temperature Controller–provides on-off and modulating control of liquid or air temperatures in boilers, storage tanks, or air ducts. Includes end switch that can be used as a burner controller; cycles burner on and off *above* high temperature (low fire) end of proportioning range.

T991F Dual Bulb Proportioning Temperature Controller–same as T991E except with 2 sensing bulbs to provide automatic reset of the control point as the outdoor air temperature changes.

POTENTIOMETER: Single; 135 ohms resistance; wiper moves toward "W" end on temperature rise.

END SWITCH: Series 40, line voltage, spst (single-pole, single-throw), snap-acting. Operates *above* high temperature (low fire) end of proportioning range.

"Make" point on temperature fall–adjustable, 1 to 4 F [0.6 to 2.2 C] above high end of proportioning range (factory-set at 1 F [0.6 C] above proportioning range).

Breaks at "make" point *plus* differential on temperature rise.

Differential–4 F [2.2 C], fixed, additive.

ELECTRICAL RATINGS:

Proportioning Controller–low voltage (24V ac) series 90 only.

End Switch–

VOLTAGE	FULL LOAD (amperes)	LOCKED ROTOR (amperes)
120V ac	2.6	15.6
240V ac	1.3	7.8

2 amperes at 24V ac.

TEMPERATURE RANGE: See SCALE RANGE in Table I.

PROPORTIONING (THROTTLING) RANGE: 11 F [6 C], fixed. Set point is at *center* of proportioning range (see Fig. 13).

MAXIMUM AMBIENT OPERATING TEMPERATURE (CONTROLLER CASE): 125 F [52 C].

MAXIMUM SAFE BULB TEMPERATURE: See Table I.

MAXIMUM STORAGE TEMPERATURE (T991F only): 132 F [56 C].

TABLE I–TEMPERATURE RANGES

MODEL	SCALE RANGE		MAXIMUM SAFE BULB TEMPERATURE	
	FAHRENHEIT	CELSIUS	F	C
T991E1018[a]	160 to 260[a]	71 to 127	280	138
T991E1026	0 to 100	-18 to +38	125	52
T991E1034	55 to 175	13 to 79	200	93
T991F1009	70 to 140[b]	21 to 60[b]	265[c]	129[c]

[a] With mechanical stop, factory-set at 240 F [116 C].

[b] Indoor set point.

[c] Indoor bulb temperature plus outdoor bulb temperature must not exceed 265 F [129 C].

(continued on page 3)

ORDERING INFORMATION

WHEN PURCHASING REPLACEMENT AND MODERNIZATION PRODUCTS FROM YOUR TRADELINE WHOLESALER OR YOUR DISTRIBUTOR, REFER TO THE TRADELINE CATALOG OR PRICE SHEETS FOR COMPLETE ORDERING NUMBER, OR SPECIFY–

1. **Order number.**
2. **Temperature range (T991E only).**
3. **Accessories, if required.**
4. **Special options, if required.**

IF YOU HAVE ADDITIONAL QUESTIONS, NEED FURTHER INFORMATION, OR WOULD LIKE TO COMMENT ON OUR PRODUCTS OR SERVICES, PLEASE WRITE OR PHONE:

1. **YOUR LOCAL HONEYWELL RESIDENTIAL DIVISION SALES OFFICE (CHECK WHITE PAGES OF PHONE DIRECTORY).**
2. **RESIDENTIAL DIVISION CUSTOMER SERVICE**
   HONEYWELL INC., 1885 DOUGLAS DRIVE NORTH
   MINNEAPOLIS, MINNESOTA 55422 (612) 542-7500

(IN CANADA–HONEYWELL CONTROLS LIMITED, 740 ELLESMERE ROAD, SCARBOROUGH, ONTARIO M1P 2V9)
INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD.

RESET RATIO (T991F only): 1:1 (ratio of change in outdoor air temperature to change in control point of the heating medium).

TEMPERATURE SENSING ELEMENT: Liquid-filled, remote bulb, copper (T991F has 2 bulbs).

SENSING BULB SIZE: Length – 4-3/16 inches [106.4 mm]; diameter – 1/2 inch [12.7 mm].

MAXIMUM SENSING BULB PRESSURE: 50 psi [344.7 kPa] for direct immersion.

CAPILLARY MATERIAL: Copper.

CAPILLARY LENGTH:
T991E–5 feet [1.5 metres].
T991F–indoor, 10 feet [3.0 metres]; outdoor, 30 feet [9.1 metres].

WIRING KNOCKOUTS: Four, 7/8-inch [22.2 mm] diameter knockouts for 1/2 inch conduit (2 in the top and 2 in the bottom).

CONTROLLER MOUNTING: Three slotted holes in back of case (see Fig. 1).

SENSING BULB MOUNTING:
In boilers or storage tanks–immersion well (Fig. 2) or capillary compression fitting (Fig. 3).
In air ducts–capillary holder (Figs. 4-6).
Outdoor bulb (T991F only)–bulb shield (Figs. 7-8).

DIMENSIONS: See Fig. 1.

WEIGHT: T991E–2 lb [0.91 kg]; T991F–2.5 lb [1.13 kg].

FINISH: Gray cover, zinc-plated case.

APPROVALS:
UNDERWRITERS LABORATORIES INC. LISTED: File No. E4436, Guide No. XAPX.
CANADIAN STANDARDS ASSOCIATION CERTIFIED: File No. LR1620, Guide No. 400-E-0.

ACCESSORIES:

1. Immersion Well Assembly, to protect sensing bulb from mechanical or chemical damage when mounting in a boiler or storage tank; copper; 4-3/4 inch [120.7 mm] insertion length; includes 112721 Tube Clip for clamping capillary tube to immersion well–
–Part No. 112622AA, 1/2-14 NPT external threads on spud.
–Part No. 112630AA, 3/4-14 NPT external threads on spud.

2. Capillary Compression Fitting, to provide seal-off when mounting sensing bulb directly in a boiler or storage tank; brass; rated at 50 psi [344.7 kPa] water pressure or 15 psi [103.4 kPa] air pressure for sealing off sensing tube–
–Part No. 104484A, 1/2-14 NPT external threads on spud.
–Part No. 104484B, 3/4-14 NPT external threads on spud.

3. 107324A Capillary Holder, for mounting sensing bulb in an air duct; 8-3/8 inches [212.7 mm] long.

4. 34886A Bulb Shield, for mounting sensing bulb outdoors.

5. 105900 T-Strap, for clamping sensing bulb to a pipe or similar mount.

6. 120650 Tube of Heat Conductive Grease, for reducing response time when mounting sensing bulb in immersion well.

7. 801534 Calibration Wrench.

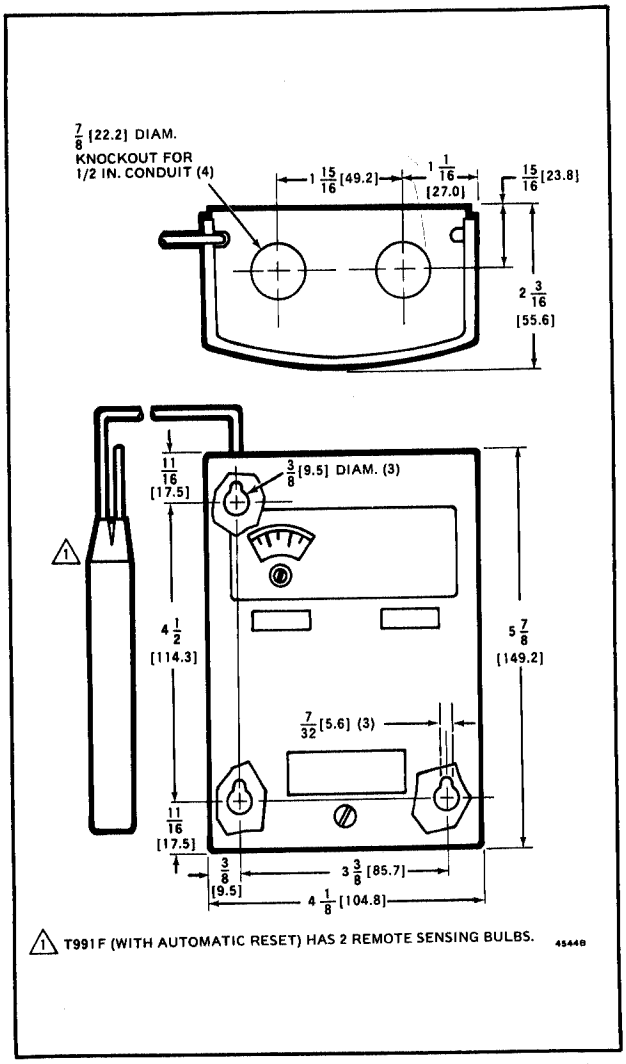


FIG. 1–APPROXIMATE DIMENSIONS OF THE T991E AND F PROPORTIONING TEMPERATURE CONTROLLERS, IN INCHES [MILLIMETRES IN BRACKETS].

INSTALLATION

WHEN INSTALLING THIS PRODUCT. . .

1. Read these instructions carefully. Failure to follow them could damage the product or cause a hazardous condition.
2. Check the ratings given in the instructions and on the product to make sure the product is suitable for your application.
3. Installer must be a trained, experienced, service technician.
4. After installation is complete, check out product operation as provided in these instructions.

CAUTION

1. Disconnect all power to the controller before beginning installation to prevent electrical shock and equipment damage.
2. All wiring must comply with applicable local electrical codes, ordinances, and regulations.
3. The potentiometer (B, R, and W terminals) must be connected only to a low voltage (24 volts ac), series 90 device.
4. Loads connected to the end switch must not exceed those listed in the SPECIFICATIONS section.

IMPORTANT

1. Before using this controller in a new boiler installation, consult the boiler manufacturer.
2. Do not bend the capillary tubing into a radius of less than 1/2 inch [12.7 mm]. Repeated bending of the capillary will "work harden" the tubing, causing it to become brittle and break. Do not pull on the capillary at the controller.
3. Make sure excess wire and capillary tubing does not interfere with the end switch linkage.

LOCATION

The T991 case may be mounted in any convenient position on a flat surface, such as a wall or panel, where the ambient temperature does not exceed 125 F [52 C]. If the mounting surface is hot or cold, insulate the case from it by insulation material (such as a wooden board), or offset the case to allow a space for air circulation. The location selected should be vibration free.

The capillary tube allows remote mounting of the sensing bulb(s). The length of tubing on the bulb(s) may limit the choice of locations. *Sharp bends or kinks in the capillary tubing could seriously affect the operation or calibration of the controller, and must be carefully avoided.* Excess tubing should be carefully coiled and left beside the T991.

The sensing bulb(s) must be located where the maximum ambient temperature will not exceed the maximum safe bulb temperature listed in Table I in the SPECIFICATIONS section. The bulb(s) should be located where it is exposed to the average temperature of the controlled medium.

MOUNTING THE CONTROLLER

Refer to Fig. 1 for location of the 3, slotted mounting holes. Remove the cover from the controller and fasten the case securely to a flat surface. The controller may be mounted in any position.

MOUNTING THE SENSING BULB IN A BOILER OR STORAGE TANK

The manufacturer of a boiler or storage tank usually provides a tapping for insertion of the sensing bulb. Follow the manufacturer's instructions if available. If the boiler or tank is filled, drain it until the level of the liquid is below the tapping in the boiler or tank. Remove the plug from the tapping, and screw the spud of the immersion well or compression fitting into the tapping. A reducer fitting may be necessary to adapt the spud to the tapping. Make sure the well or fitting is screwed in tightly to prevent leakage. Install the sensing bulb and controller. Then refill the boiler or tank. *Do not try to tighten the well or fitting in the tapping by turning the controller.*

USE OF AN IMMERSION WELL (FIG. 2)

An immersion well (separable well) is used to protect the sensing bulb from mechanical or chemical damage, and to permit easy removal of the bulb from the liquid without having to drain the boiler or tank. In addition, it provides a tighter fitting than other mounting methods. An immersion well is very desirable for mounting the bulb in an agitated liquid.

The immersion well must be mounted where it is always exposed to the circulation of the liquid under control, but it must never be located close to a hot or cold inlet or steam coil.

The use of an immersion well more than doubles the response time compared to that for a bare bulb. Therefore, the well must fit the bulb snugly. It may be desirable to fill the space between the bulb and the well with a heat-conductive compound. The use of a heat-conductive grease will reduce the response time to about 1-1/2 times that for a bare bulb.

TO INSTALL AN IMMERSION WELL:

1. Drain the system.
2. Screw the spud of the immersion well into the boiler or tank tapping (or reducer fitting, if one is required).

3. Insert the sensing bulb into the well until it bottoms.

4. If desired, fill the space between the bulb and the well with heat-conductive grease (Part No. 120650).

5. Fit the tube clip over the capillary tubing and clip it onto the end of the spud.

6. Coil excess capillary tubing at the T991 case.

7. Refill the system and check for leaks.

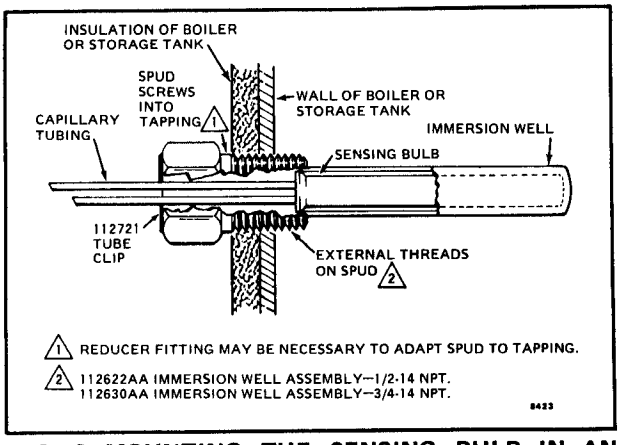


FIG. 2—MOUNTING THE SENSING BULB IN AN IMMERSION WELL.

USE OF A CAPILLARY COMPRESSION FITTING (FIG. 3)

A capillary compression fitting can be used to form a positive seal in applications where the bulb can be immersed directly in the liquid without danger of mechanical or chemical damage.

TO INSTALL A CAPILLARY COMPRESSION FITTING:

1. Drain the system.

2. Screw the spud of the compression fitting into the boiler or tank tapping (or reducer fitting, if one is required).

3. Run the capillary tubing through the packing nut.

4. Slide the sensing bulb completely through the spud.

5. Place the composition disc and 4 slotted brass washers on the capillary tubing in the order shown in Fig. 3.

6. Slide the disc and washers into the spud, and tighten the packing nut.

7. Coil excess capillary tubing at the T991 case.

8. Refill the system and check for leaks.

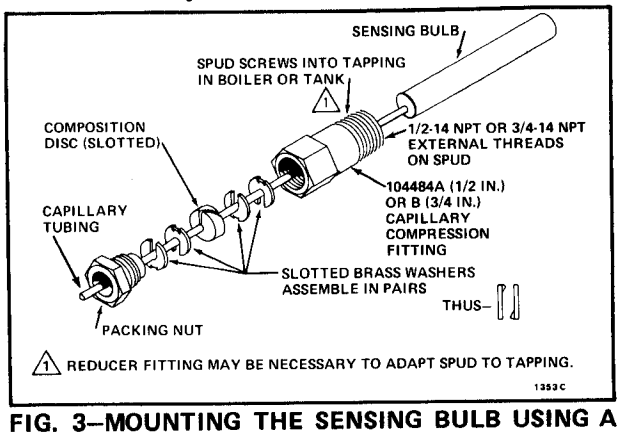


FIG. 3—MOUNTING THE SENSING BULB USING A CAPILLARY COMPRESSION FITTING.

MOUNTING THE SENSING BULB IN AN AIR DUCT

The sensing bulb should be located where air of average temperature can circulate freely around it. Avoid mounting the bulb close to hot pipes, cooling coils, the combustion chamber, and other places where the air temperature is not representative.

USE OF A CAPILLARY HOLDER (FIGS. 4-6)

A capillary holder and plate assembly is used to support and protect the capillary and bulb in the duct, and to prevent excessive air leakage. The holder should be long enough to hold the bulb in freely circulating air, away from the duct wall. If it is too long, it may easily be broken off to the proper length.

TO INSTALL A CAPILLARY HOLDER:

1. Drill a 3/4 inch [19.1 mm] hole in the wall of the duct to admit the sensing bulb and capillary holder.

2. Using the holder plate as a template, mark and drill holes for the 2 mounting screws.

3. Break off the capillary holder to the desired length (Fig. 4).

NOTE: The capillary holder should be long enough to hold the sensing bulb in freely circulating air, away from the duct wall.

4. Place the capillary tubing in the bulb holder channel, and pinch the top edges of the holder together at each segment (Fig. 5).

5. Insert the bulb and holder into the controlled area through the hole prepared in step 1 (Fig. 6, page 6).

6. Fasten the holder plate to the duct wall with the 2 mounting screws furnished.

7. Coil excess capillary tubing at the T991 case.

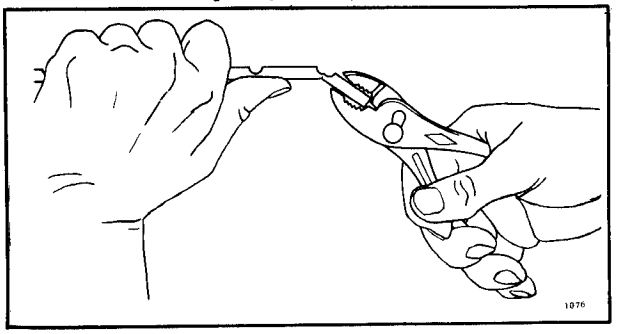


FIG. 4—SHORTENING THE CAPILLARY HOLDER.

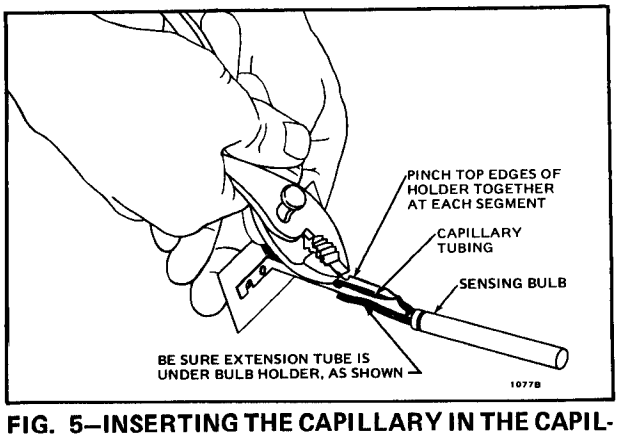


FIG. 5—INSERTING THE CAPILLARY IN THE CAPILLARY HOLDER.

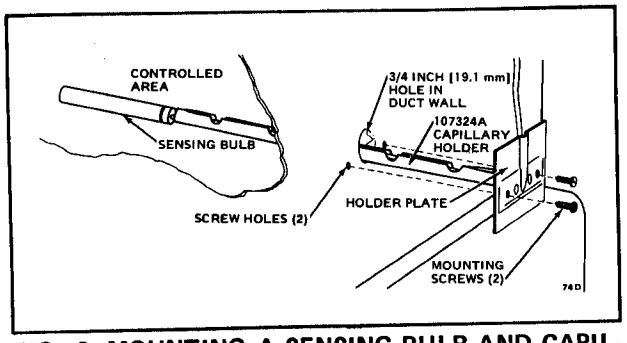


FIG. 6–MOUNTING A SENSING BULB AND CAPILLARY HOLDER IN AN AIR DUCT.

MOUNTING THE OUTDOOR SENSING BULB (T991F ONLY)

To obtain automatic reset of the control point, the outdoor sensing bulb on the T991F must be mounted in an outdoor air duct or outdoors. It can be mounted in an air duct using a capillary holder (Figs. 4-6). To mount it outdoors, use a bulb shield to protect the bulb from damage.

NOTE: The outdoor bulb is the one with the longest capillary (30 feet [9.1 metres]).

USE OF A BULB SHIELD (FIGS. 7-8)

The bulb should be mounted under the shield in a horizontal position on the outside of the building where it will be exposed to representative air temperature, but not to direct sunlight. (However, for structures with large glass areas which absorb more radiant heat from the sun, it may be preferable to mount the bulb where it will be exposed to the same heating effect.) It should be mounted high enough so that it cannot be covered with snow, ice, leaves, or other debris, and so it cannot be tampered with. Vents from the building should be avoided.

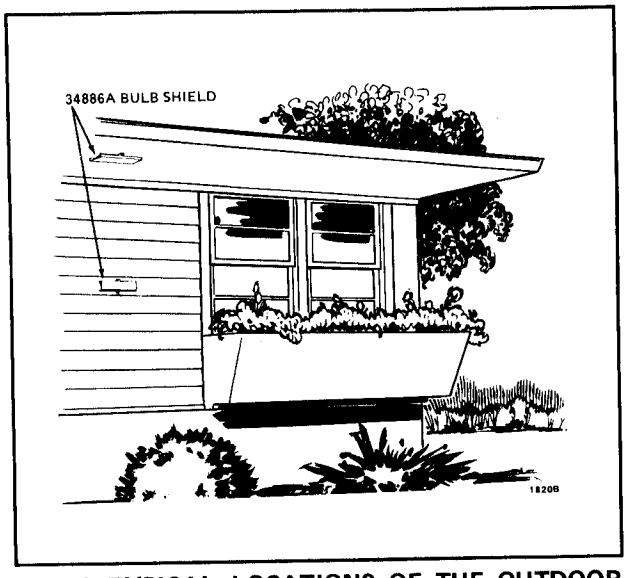


FIG. 7–TYPICAL LOCATIONS OF THE OUTDOOR BULB SHIELD.

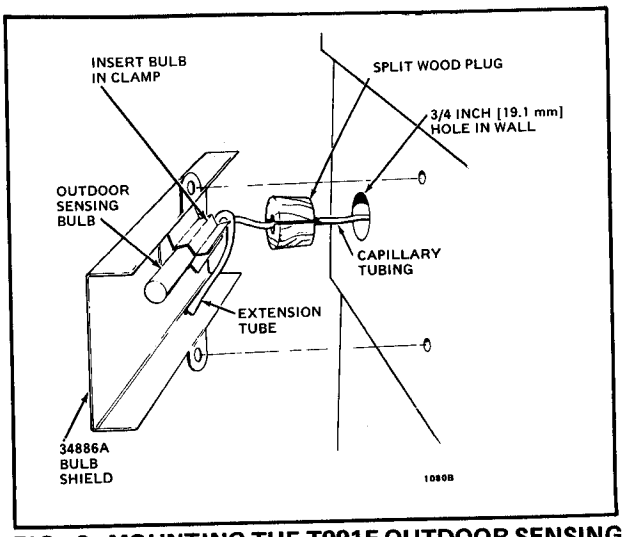


FIG. 8–MOUNTING THE T991F OUTDOOR SENSING BULB OUTDOORS USING A BULB SHIELD.

WIRING

Disconnect the power supply before making wiring connections to prevent electrical shock and equipment damage. All wiring must comply with applicable electrical codes, ordinances, and regulations. If using the T991 with a flame safeguard control, use moisture-resistant No. 14 wire suitable for at least 167 F [75 C] for a primary control (such as an RA890), or for at least 194 F [90 C] for a programming control (such as an R4140). *For high temperature installations,* use moisture-resistant No. 14 wire selected for a temperature rating above the maximum operating temperature.

The internal schematic is shown in Fig. 9. A typical flame safeguard application is shown in Fig. 10. A typical *fuel-saving* application of the T991F Dual Bulb Proportioning Temperature Controller is shown in Fig. 11. Also refer to instructions furnished by the system equipment manufacturer. In a replacement application, make sure the T991 is wired into the system to operate the same way as the old controller. *When wiring the T991, make sure excess wire and capillary tubing does not interfere with the end switch linkage.*

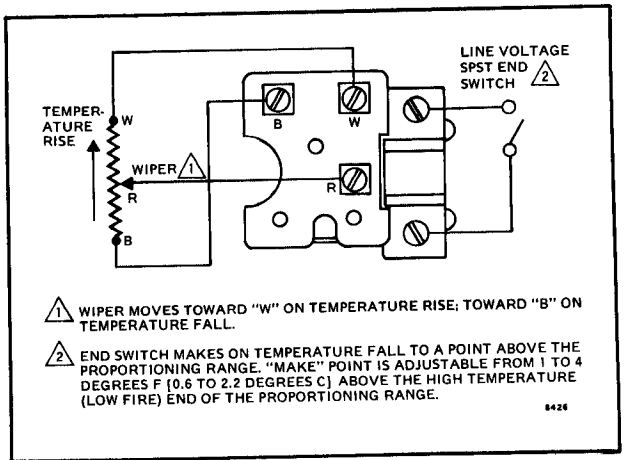


FIG. 9–INTERNAL SCHEMATIC OF A T991E OR F PROPORTIONING TEMPERATURE CONTROLLER.

COMBINATION ON-OFF AND FIRING RATE CONTROL USING A T991E OR F (FIG. 10)

For economy, it may be desirable to use the *same* controller to turn the burner on and off, and also to regulate the firing rate. A T991E or F can be used to accomplish these functions.

Fig. 10 shows a T991E or F connected directly to a V9055 Modulating Fluid Power Gas Valve Actuator to regulate the firing rate. When the temperature is warm enough, the end switch will be open so the RA890 will not be energized and the burner will be shut down. When the temperature falls, the end switch makes, energizing the RA890 and starting the burner. When the pilot flame is detected, internal switching applies power to terminal 5 of the RA890, energizing the V9055 actuator.

The temperature is still above the proportioning range of the temperature controller, so its wiper will be all the way over to the W end of the potentiometer. The actuator and main valve will be at the low fire position (closed or nearly closed). If the temperature continues to fall until it is within the proportioning range of the temperature controller, the controller will regulate the position of the actuator and main valve, and thus modulate the firing rate. If the temperature rises too high, even with the system at low fire, the end switch will break, de-energizing the RA890 and shutting down the burner.

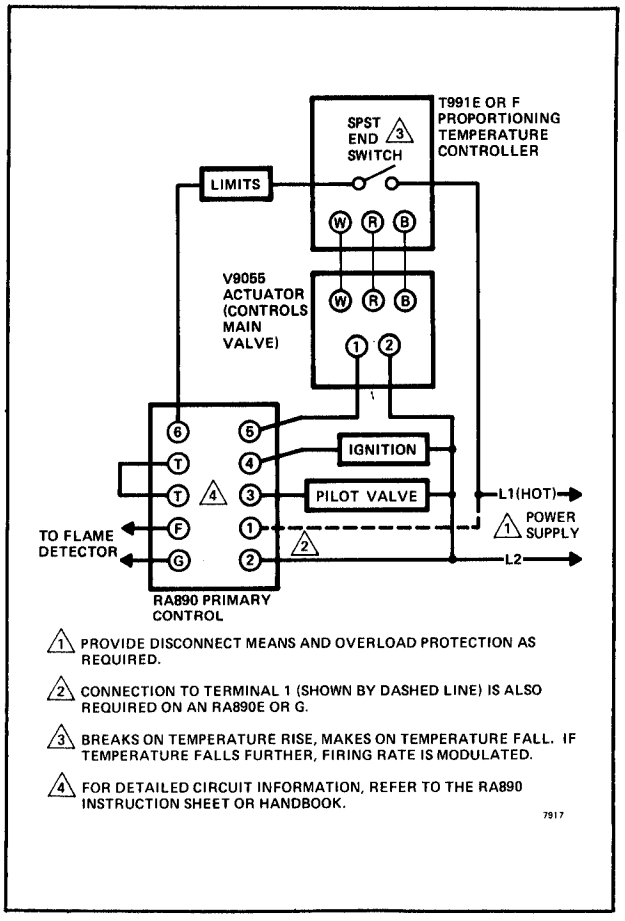


FIG. 10—TYPICAL FLAME SAFEGUARD APPLICATION OF A T991E OR F—PROVIDING COMBINATION ON-OFF AND FIRING RATE CONTROL.

AUTOMATIC RESET OF BOILER WATER TEMPERATURE USING A T991F (FIG. 11)

The T991F Dual Bulb Proportioning Temperature Controller can be used to save fuel by proportioning the firing rate and providing automatic reset of the boiler water temperature.

Fig. 11 shows a T991F connected directly to a V9055 Modulating Fluid Power Gas Valve Actuator to regulate the firing rate. The connections are similar to Fig. 10 except that the end switch is connected in the low voltage circuit of the RA890 instead of in series with the limits. An RA890H, J, or K must be used in this application.

Operation is the same as that described for Fig. 10 except for automatic reset of the control point. When the outdoor temperature falls, the control point temperature will be automatically increased. The boiler water temperature will increase to take care of the increased heating load. When the outdoor temperature rises again, the boiler temperature will decrease automatically.

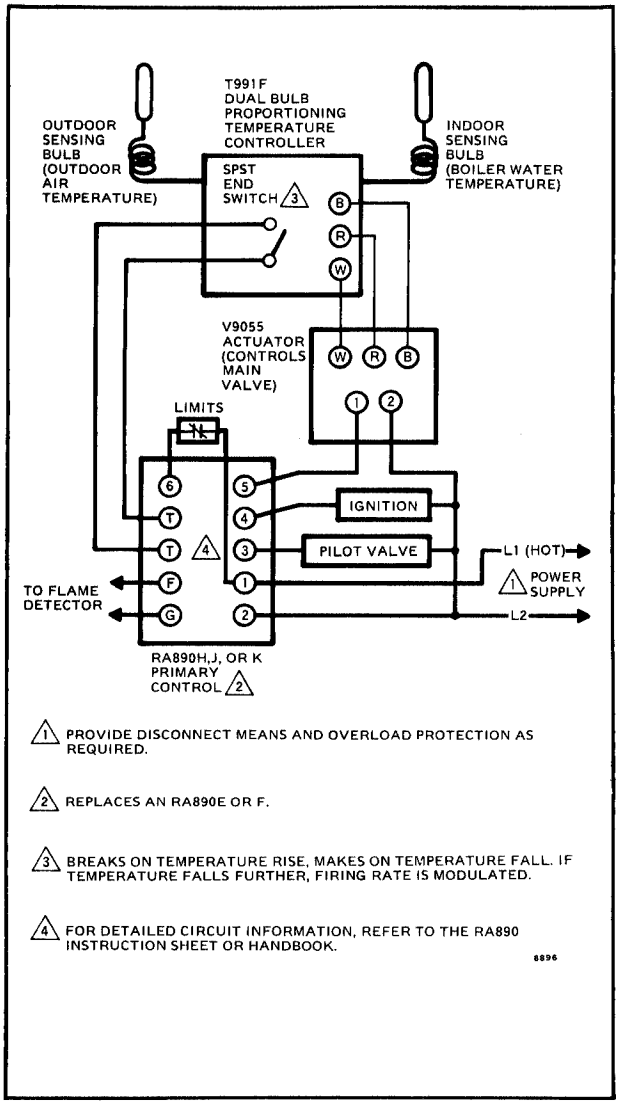


FIG. 11—TYPICAL FUEL-SAVING APPLICATION OF A T991F—PROPORTIONED FIRING RATE AND AUTOMATIC RESET OF BOILER WATER TEMPERATURE.

SETTING AND CHECKOUT

CAUTION

Disconnect all power to the controller before removing the cover, adjusting the end switch, or checking out the controller internally. With power connected, line voltage may be present at the end switch terminals.

IMPORTANT

Before changing the prescribed set point on an existing boiler installation, consult the boiler manufacturer.

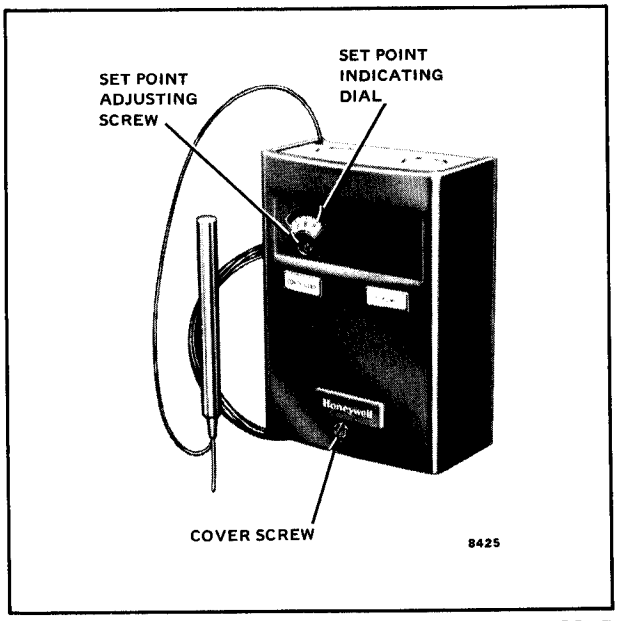


FIG. 12–ADJUSTING THE SET POINT ON A T991E OR F.

SETTING THE T991E OR F

SET POINT (FIG. 12)

Adjust the set point for the desired operating temperature by turning the set point adjusting screw on the front of the case until the desired value is reached on the set point indicating dial. The set point is calibrated to be at the center of the proportioning range (Fig. 13).

On a T991F, this set point will be the control temperature of the heating medium (e.g., boiler water) when the outdoor air temperature is at 70 F [21 C]. For the standard reset ratio of 1:1, if the outdoor air temperature falls 10 degrees F [5.6 degrees C] below 70 F [21 C], the temperature of the heating medium will increase 10 degrees F [5.6 degrees C] above the set point.

From an economical standpoint, it is desirable to operate the heating equipment at a minimum temperature when the weather is mild, and to operate near full capacity when the most severe weather is encountered. Therefore, the T991F should ordinarily be set near the low end of the operating range.

If in doubt as to the correct initial temperature set point, it is better to start on the low side of the range and increase the setting; a need for additional heat is easily detected. Too high an initial set point is difficult to detect, reduces economy, and results in poor control.

PROPORTIONING (THROTTLING) RANGE

The proportioning range (Fig. 13) is *not* adjustable. It is fixed at 11 degrees F [6 degrees C], so it extends 5.5 degrees F [3 degrees C] above and below the set point.

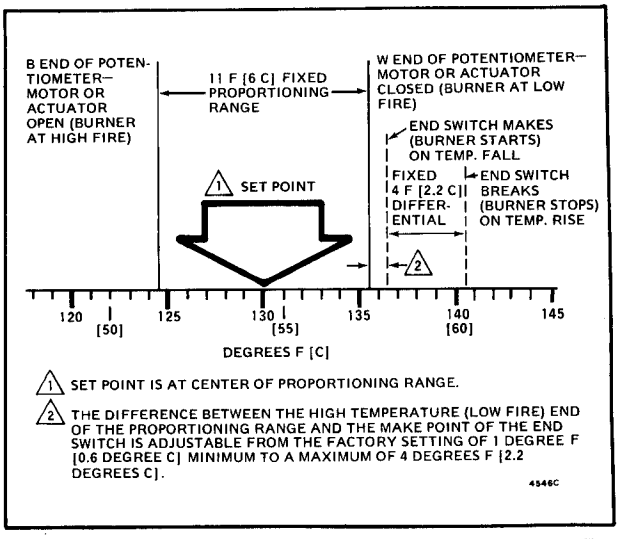


FIG. 13–OPERATING POINTS OF A T991E OR F.

END SWITCH ADJUSTMENTS

To adjust the end switch, *disconnect all power* to the T991, loosen the cover screw (Fig. 12), and remove the cover. The adjustment screw is on the side of the switch below the terminals.

END SWITCH "MAKE" POINT (FIG. 14)

On a T991E or F, the temperature difference between the high temperature (low fire) end of the proportioning range and the point at which the end switch makes is adjustable. It can be increased from the factory setting of 1 degree F [0.6 degree C] minimum to a maximum of 4 degrees F [2.2 degrees C] by turning the end switch adjustment screw (Fig. 14) counterclockwise ↶

(backing the screw out), but *no more than 1/16 of a turn at one time. Do not turn the adjustment screw clockwise* ↶ .The end switch will not operate properly if the adjustment screw is turned clockwise past the factory-set position.

CAUTION

Do NOT turn the end switch adjustment screw counterclockwise ↷ more than 1/16 of a turn at one time. *Do not turn the adjustment screw clockwise* ↶ . If the adjustment screw is turned in a clockwise direction beyond the factory-set position, the end switch *will not* cycle the burner properly.

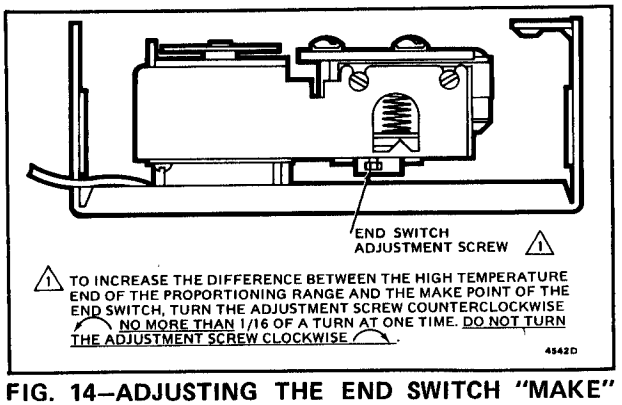


FIG. 14–ADJUSTING THE END SWITCH "MAKE" POINT.

END SWITCH DIFFERENTIAL

The end switch differential between its make and break points is *not* adjustable. It is fixed at 4 degrees F [2.2 degrees C].

CHECKOUT

After the controller has been installed, wired, and set, it should be tested with the system in operation. First allow the system to stabilize. Then observe the operation of the controller while raising and lowering its set point. Temperature should increase when the set point is raised and decrease when the set point is lowered. Use accurate temperature testing equipment when checking out the controller. Do not rely on inexpensive gauges. The controllers are carefully calibrated at the factory.

CHECKING THE PROPORTIONING ACTION

Make sure the modulating motor or modulating valve actuator reaches the low and high fire positions at the proper points. If the motor or actuator runs in the proper direction when the set point is adjusted, it can be assumed that the controller is operating properly. If it runs in the wrong direction, reverse the B and W wires. Observe the action of the motor or actuator to see if it stabilizes.

If the proportioning controller is suspected of operating improperly, it may be further checked as follows (Fig. 15):

1. *Disconnect all power to the controller,* loosen the cover screw (Fig. 12), and remove the cover.
2. Disconnect the wires from the controller.
3. Connect an ohmmeter between controller terminals B and W to measure the resistance of the potentiometer in the controller. The ohmmeter should read about 135 ohms.
4. Connect the ohmmeter between controller terminals W and R and raise the set point of the controller at least 6 degrees F [3.3 degrees C] above the actual temperature being measured. The ohmmeter should read the full value of the potentiometer measured in step 2 (135 ohms).
5. Slowly lower the set point of the controller while observing the ohmmeter reading. The resistance should drop to zero at some set point below the actual temperature.
6. An approximation of the proportioning range can be made by observing the change in set point required for a resistance change from zero to full value.

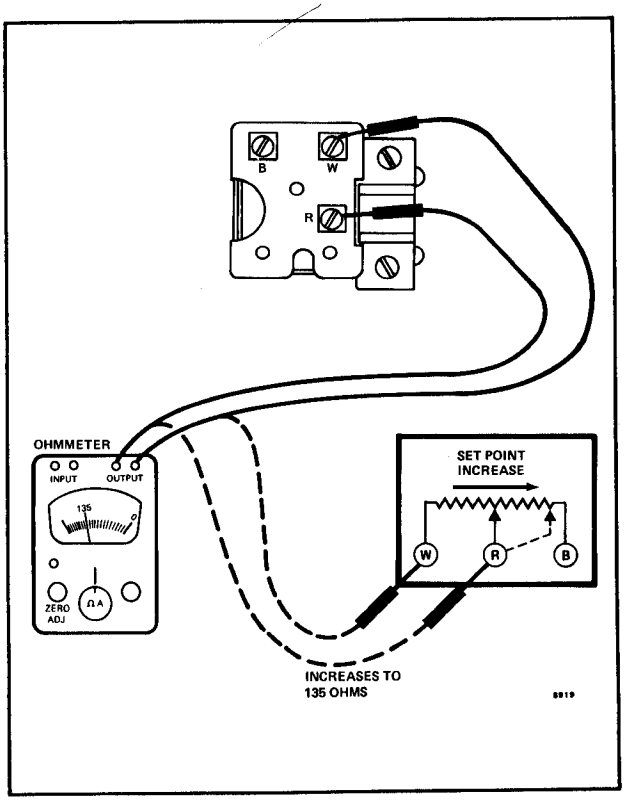


FIG. 15–CHECKING THE PROPORTIONING RANGE.

CHECKING THE END SWITCH

Make sure the end switch makes and breaks at the proper points. Be sure to consider the differential. If the controller is suspected of operating improperly, it may be further checked as follows (Fig. 16):

1. *Disconnect all power to the controller,* loosen the cover screw (Fig. 12), and remove the cover.
2. Disconnect the wires from the controller.
3. Connect an ohmmeter between the end switch terminals.
4. Lower the set point of the controller at least 14 degrees F [8 degrees C] below the actual temperature being measured. The switch should break (the ohmmeter should read infinity).

(continued on page 10)

5. Raise the set point of the controller more than the differential (at least 5 degrees F [3 degrees C]). The switch should make (the ohmmeter should read zero).

6. An approximation of the differential can be made by observing the change in set point required for a resistance change from zero to infinity.

CAUTION

Do not put the system into service until you have satisfactorily completed all applicable tests described in this CHECKOUT section, in the CHECKOUT section of the applicable instruction sheet for the flame safeguard control, and any others required by the burner manufacturer.

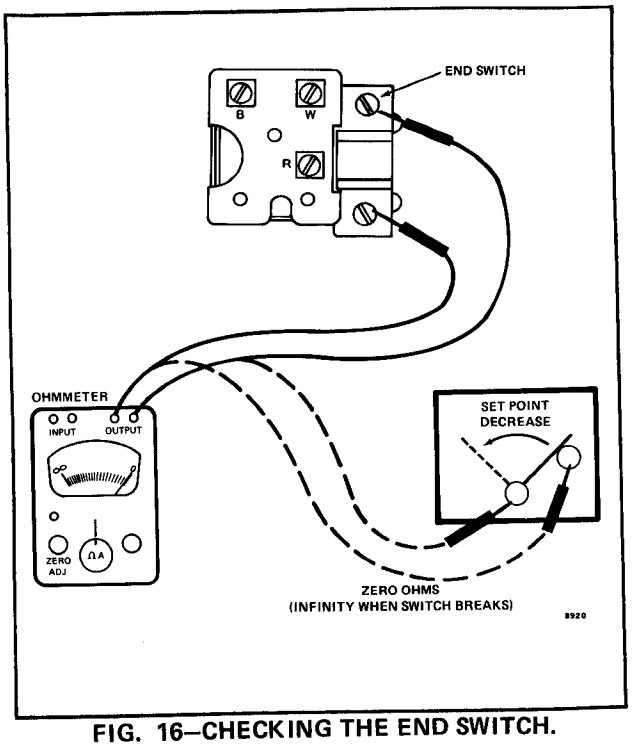


FIG. 16–CHECKING THE END SWITCH.

CALIBRATION

CAUTION

1. Disconnect all power to the controller before beginning a calibration check. With power connected, line voltage may be present at the end switch terminals.
2. Disconnect all controlled equipment before beginning a calibration check.

The T991 is carefully calibrated at the time of manufacture and will maintain adjustment for years of normal service. Poor control can be the result of many factors, and field recalibration is not recommended. If reason exists for verifying calibration, this can be performed with reasonable accuracy with a good thermometer and an ohmmeter.

T991E CALIBRATION CHECK AND ADJUSTMENT (FIG. 17)

1. Determine the temperature as accurately as possible at the sensing bulb. If it is not possible to determine the temperature accurately, remove the bulb and immerse it in water at a temperature near the midrange of the T991E temperature dial.

NOTE: Allow the bulb to remain in the water for a minimum of 15 minutes. Then determine the water temperature with an accurate thermometer.

2. *Disconnect all power to the controller,* loosen the cover screw (Fig. 12), and remove the cover.

3. Connect an ohmmeter between terminals R and W of the T991E.

4. Rotate the T991E temperature dial clockwise ↷, if necessary, to obtain a zero (0) reading on the ohmmeter.

5. Rotate the dial counterclockwise ↶, simulating a temperature fall, until the ohmmeter reads 67.5 ohms.

6. Note the dial reading of the T991E. If it differs from the bulb temperature, recalibrate the controller as follows.

7. Determine the number of degrees difference between the T991E dial reading and the bulb temperature.

8. Insert the calibration wrench (accessory, Part No. 801534) into the slots of the dial. Rotate the dial until the tabs of the wrench drop into the slots of the calibration nut under the dial.

9. Note the dial reading at this point. Turn the dial *and* the nut together up or down the number of degrees that the T991E dial reading differs from the thermometer reading (step 7).

FOR EXAMPLE: Turn the dial from 45 to 65 degrees if the bulb temperature is 20 degrees higher than the dial reading.

10. Check the calibration by repeating steps 1 through 6.

11. If the T991E is still out of calibration, repeat the recalibration procedure.

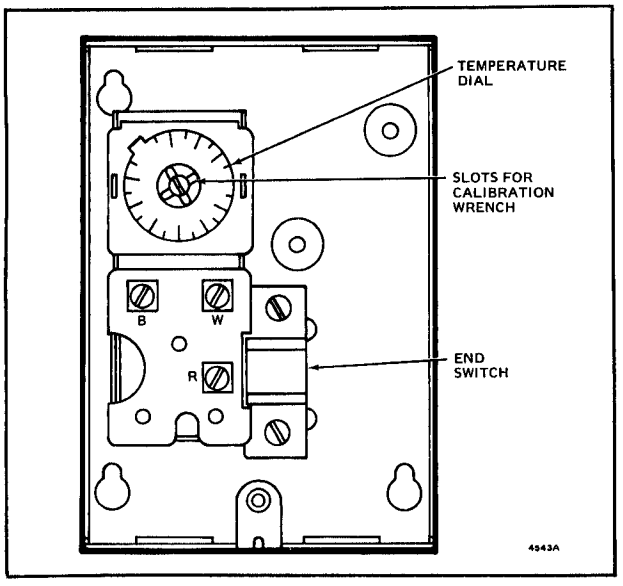


FIG. 17–INTERNAL VIEW OF A T991E OR F.

T991F CALIBRATION CHECK AND ADJUSTMENT (FIG. 17)

IMPORTANT

Calibration must be performed at an outdoor air temperature of 70 F [21 C] or below.

1. Determine the outdoor air temperature as accurately as possible at the *location of the outdoor bulb.* Subtract this temperature from 70 F [21 C] (the calibration reference point of the T991F) to find the DIFFERENCE TEMPERATURE.

2. Multiply the DIFFERENCE TEMPERATURE by the RESET FACTOR (see table below) to find the amount of shift, or "reset," in the control point.

RESET RATIO	RESET FACTOR
1:1	1.00
1:1.5	1.50
1.5:1	0.67
3.5:1	0.29

3. Determine the temperature of the heating medium at the indoor bulb and subtract the amount of the control point reset (step 2) to find the THEORETICAL SET POINT.

NOTE: An alternative to performing steps 1 through 3 is to place both bulbs in a 70 F [21 C] water bath. Leave them in the water bath for at least 15 minutes before proceeding.

4. *Disconnect all power to the controller,* loosen the cover screw (Fig. 12), and remove the cover.

5. Connect an ohmmeter between terminals R and W of the T991F.

6. Rotate the T991F temperature dial clockwise ↷, if necessary, to obtain a zero (0) reading on the ohmmeter.

7. Rotate the dial counterclockwise ↶, simulating a temperature fall, until the ohmmeter reads 67.5 ohms.

8. Note the dial reading of the T991F. If it differs from the THEORETICAL SET POINT (or the temperature of the water bath), recalibrate the controller as follows.

9. Determine the number of degrees difference between the T991F dial reading and the THEORETICAL SET POINT (or the temperature of the water bath).

10. Insert the calibration wrench, Part No. 801534, into the slots of the dial. Rotate the dial until the tabs of the wrench drop into the slots of the calibration nut under the dial.

11. Note the dial reading at this point. Turn the dial and the nut together up or down the number of degrees that the T991F dial reading differs from the THEORETICAL SET POINT (or the temperature of the water bath) in step 9.

FOR EXAMPLE: Turn the dial from 45 to 65 degrees if the THEORETICAL SET POINT or the temperature of the water bath is 20 degrees higher than the dial reading.

12. Check the calibration by repeating steps 1 through 8.

13. If the T991F is still out of calibration, repeat the recalibration procedure.

OPERATION

PROPORTIONING RANGE

The T991E and F Proportioning Temperature Controllers have a *fixed* proportioning range of 11 degrees F [6 degrees C]. The proportioning range (also called throttling range) extends 5.5 degrees F [3 degrees C] on both sides of the set point (Fig. 13).

Temperature variations cause the liquid in the sensing bulb(s) to expand or contract. This change is transmitted to the diaphragm in the case by the capillary tubing. The potentiometer wiper (R terminal) is operated by the diaphragm through an adjustable parallel lever arrangement. When the diaphragm moves, the wiper moves across the windings in the potentiometer (Fig. 9). This varies the resistance between R and B, and R and W. The resulting circuit unbalance drives a modulating motor or modulating valve actuator and regulates the firing rate.

As the temperature rises, the wiper will move toward the W end of the potentiometer, driving the motor or actuator toward its closed position and decreasing the firing rate. As the temperature falls, the wiper will move toward the B end, driving the motor or actuator toward its open position and increasing the firing rate. Thus, a change in the temperature will cause modulation of the firing rate to compensate for the change and keep the temperature nearly constant at the set point.

(continued on page 12)

The proportioning range is the difference in temperature represented by the total potentiometer resistance. When the potentiometer wiper moves all the way to the W end, the motor or actuator will be fully closed and the burner will be at low fire. This will occur when the controlled temperature rises 5.5 F [3 C] above the set point. Similarly, when the potentiometer wiper moves all the way to the B end, the motor or actuator will be fully open and the burner will be at high fire. This will occur when the controlled temperature falls 5.5 F [3 C] below the set point.

For example, in Fig. 13, the set point is at 130 F [54.4 C]. The controller will modulate between its fully open (high fire) position at 124.5 F [51.4 C] and its fully closed (low fire) position at 135.5 F [57.5 C].

END SWITCH

The spst end switch in a T991E or F can be used as an operating controller to shut down the burner when the temperature is warm enough, and to start the burner when the temperature falls through the differential. It can also be used as a high limit to shut down the burner if the temperature gets too high. If the temperature falls into the proportioning range of the controller, the firing rate of the burner will be modulated, as described previously.

For example, in Fig. 13, the burner will be shut down when the temperature rises to 140.5 F [60.3 C]. When the temperature falls 4 degrees F [2.2 degrees C] through the differential of the end switch to 136.5 F [58.1 C], the burner will be started again. If the temperature continues to fall below 135.5 F [57.5 C], the firing rate of the burner will be modulated.

AUTOMATIC RESET OF THE CONTROL POINT (T991F ONLY)

The T991F Dual Bulb Proportioning Temperature Controller monitors the outdoor temperature to determine the need for a change in indoor temperature. The T991F automatically adjusts the control point of the furnace or boiler to compensate for a change in the outdoor temperature. Automatic reset results in a more consistent comfort level in the living space.

The sensing element of a T991F consists of a single powerhead to which 2 remote, liquid-filled, sensing bulbs are connected by capillary tubing. The capillaries for the 2 bulbs are interconnected at the powerhead, so the diaphragm responds to both bulbs at the same time. To keep the diaphragm position constant, the total volume of liquid in the system must remain constant. If the temperature at one of the bulbs falls, the volume of liquid in the bulb contracts. Therefore the volume of liquid in the other bulb must expand the same amount to keep the diaphragm position constant. This requires a rise of temperature at the second bulb, resulting in an automatic increase of the control point of the temperature controller without readjusting the set point. This change in the control point is called *reset*.

In a typical heating system, reset is used to maintain boiler water at the desired temperature. The controller set point is adjusted for a relatively low boiler temperature during mild weather. When the outdoor temperature falls, the boiler temperature will be increased automatically to take care of the increased heating load. When the outdoor temperature rises again, the boiler temperature will decrease automatically. This enables the temperature controller to be set at the minimum required temperature and left there, while still allowing the system to provide enough heat for the most severe weather conditions. By keeping the boiler water temperature low, boiler standby heat loss and transmission loss from piping are reduced. The possibility of overheating the controlled space is minimized. Also, since the circulator pump runs longer, expansion and contraction noises are much less of a problem.

In a normal application, one bulb monitors the temperature of the outdoor air, and the other monitors the temperature of the heating medium (usually boiler water). If the temperature of the outdoor air falls, the temperature of the heating medium must rise to a new control point, and vice versa. The relationship between these two temperatures is expressed as a *reset ratio.*

RESET RATIO = CHANGE IN TEMPERATURE OF THE OUTDOOR AIR : CHANGE IN CONTROL POINT TEMPERATURE OF THE HEATING MEDIUM.

FOR EXAMPLE:

2:1

CHANGE IN OUTDOOR TEMPERATURE : CHANGE IN CONTROL POINT

In this example, if the outdoor temperature falls 2 degrees, the control point increases 1 degree.

This is an *inverse* ratio—when the outdoor air temperature falls, the control point rises (and vice versa).

The table below shows the change in theoretical control point that would result from a change in outdoor air temperature of 20 degrees F [11 degrees C].

RESET RATIO	SHIFT IN CONTROL POINT (NOMINAL)	
	F	C
1:1.5	30	17
1:1	20	11
1.5:1	13	7
3.5:1	6	3

When the sensed outdoor temperature is *below* 70 F [21 C], each degree of fall causes a related *increase* in control point above the dial-indicated set point temperature. Thus, on a controller with a reset ratio of 1:1, an outdoor temperature of 50 F [10 C] will cause a reset of 20 degrees F [11 degrees C]. The control point will be 20 degrees F [11 degrees C] higher than the set point temperature indicated on the scale.

SERVICE INFORMATION

CAUTION

1. Only qualified service technicians should attempt to service or repair flame safeguard controls and burner systems.
2. Disconnect all power to the controller before removing the cover. With power connected, line voltage may be present at the end switch terminals.

MAINTENANCE

The cover of the controller should be in place at all times to protect the internal components from dirt, dust, and physical damage. Routine maintenance should consist of occasional inspection and blowing or brushing away any accumulated dirt and dust. To ensure proper functioning of the controller at all times, an operational check of the entire system should be performed during routine maintenance checks.

Occasionally, mishandling of the controller may cause a malfunction. A gradual change of control point may occur because of a very small leak in the thermal system. This is most likely to be caused by bending the capillary tubing too sharply, or too close to a joint. Aging at the factory would have revealed the leak if it had been present at the time of assembly. If the tubing is squeezed so hard or bent so sharply that its bore is completely closed up, the controller will, of course, be rendered entirely inoperative. Deforming the sensing bulb(s) will change the volume, resulting in a shift in calibration. These types of malfunctions should be looked for during maintenance. Controllers should be handled carefully at the time of installation, during actual use, and during maintenance.

CLEANING THE POTENTIOMETER WINDINGS OR WIPER

Occasionally, the windings or wiper on the potentiometer may need cleaning. Use *only* Honeywell pressurized contact cleaner, Part No. 132569. Honeywell's chemical analysis laboratory has found this cleaner to be acceptable for this task. Directions for using this cleaner are printed on the can.

IMPORTANT

1. Use only Honeywell contact cleaner, Part No. 132569, to clean the potentiometer windings or wiper. Do not use any other type of contact cleaner.
2. Use utmost care to avoid bending the wiper or damaging the windings.
3. Do not use an abrasive or a burnishing tool to clean the potentiometer windings or wiper.
4. Do not use hard paper, such as a business card, to clean the potentiometer windings or wiper.

Do not use other types of contact cleaners. Honeywell's chemical analysis laboratory tested other pressurized type contact cleaners but did not approve them for these reasons:

1. The solvents could deteriorate plastic parts and wire insulation.
2. The cleaners leave an oily residue which will collect dust and dirt. The residue will also break down to form various carbonaceous products. Either result will cause early failure of the potentiometer.

Do not use an abrasive (sand paper stick, file, etc.) or a burnishing tool to clean the potentiometer windings or wiper. Use of an abrasive loosens fine particles which adhere to the surface of the windings or wiper, thus increasing the resistance between the windings and the wiper.

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