FENWAL® TEMPERATURE CONTROLS CATALOG 780

Headquarters, Ashland, Massachusetts

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

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TEMPERATURE CONTROL SELECTOR CHART

DEGREES °F

2500
2000
1500
1000
700
600
500
400
300
200
100
0
−100
−200

Bi Metal Snap Disc Thermostat	Differential Expansion Thermoswitch Controller	Surface Mounting Thermoswitch Controller	Liquid Expansion Thermoswitch Controller	Liquid Expansion 400 Line
FEATURES Nonadjustable set point. Close tolerance. Up to 12 amp output.	**FEATURES** Adjustable set point. 0.1°F sensitivity. Slow make-break. Rugged construction.	**FEATURES** Small size, low cost. 10 amp output/120 VAC adjustable set point.	**FEATURES** Single or dual snap switch. Travelling or Independent Differential.	**FEATURES** Single or dual snap switch. Travelling or Independent Differential.
UL Component Recognition.	Various head styles. ⅝" cartridge. 10 amp output. High Temperature Models available.	Surface mounting brackets available. UL Component Recognition.	**UL Component Recognition. CSA Certified.**	Dual scale (°F & °C). 4 Bulb styles. Pneumatic and Proportioning models available.
	UL Component Recognition. CSA Certified.			15 amps output. UL Listed and CSA Certified.
 PROBE TYPE	 			 NONINDICATING FM APPROVED HIGH LIMIT  INDICATING
 SURFACE MOUNT				
Page 17	Page 11-13	Page 14-15	Page 18-20	Page 21-26
Price Range				
$5-$20	$28-$63	$5-$8	$29-$56	$120-$232

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TEMPERATURE CONTROL SELECTOR CHART

DEGREES F

	Thermistor Sensing		Thermocouple Sensing		
	Series 194	Series 551	Series 550	Series 550	Series 543
2500	**FEATURES** ON/OFF or Proportioning • SPDT or DPDT relay rated at 10 amps or SPDM rated at 25 amps or	**FEATURES** ON/OFF or Proportioning Control Modes • SPDT or DPDT relay rated at 10 amps or DC out-	**FEATURES** Time proportionning. 7 segment LED display of process & controller set point. Uses standard type J or K thermocouples.	**FEATURES** DIN-Sized. Non-indicating. Deviation or Full scale indicating. Analog or Digital. SPDT or DPDT	**FEATURES** Surface mounting or Custom installation. SPDT or DPDT relay output rated up to 25 amps.
2000	DC output for solid state relays. Field selectable voltage inputs (120, 208, 240 VAC). Sensor lead break	put for solid state relays. Field selectable voltage inputs (120, 208, 240 VAC). Sensor lead break		relay rated at 10 amps or DC output for solid-state relay. UL Component Recognition. Single or dual point.	Field selectable voltage inputs.
1500	protection. UL Component Recognition.	protection. Large variety of thermistor probes			
1000	Excellent control over limited temperature ranges.	available. UL Component Recognition.			
700		Excellent control over temp. ranges from −50 to 750°F.			
600					
500					
400	REMOTE MULTI-POINT METER				FM APPROVED HIGH LIMIT
300	TRIAC OUTPUT		DIGITAL INDICATING		CONTROLLER
200					
100	RELAY OUTPUT			ANALOG INDICATING	
0					
−100					
−200	Page 29-32	Page 27-28	Page 27-28	Page 27-28	Page 33-34
	Price Range				
	$52-$92	$234-$302	$405	$85-$229	$92-$131

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how to get better TEMPERATURE CONTROL

This catalog discusses the various considerations in designing a thermal system, suggests how they can be applied, and outlines some practical rules for designers.

1. What is a Heated System?

There are four elements in a heated system, all of which contribute in some way to control performance.

A. *Work (or Load):* The material or product which must be maintained at a controlled temperature. The heat demand of the work may be steady; that is, the same material must be held at constant temperature for a prolonged period, such as a culture in an incubating oven. More commonly, the heat demand of the work is variable and cyclic; that is, cold material periodically enters the system, absorbs heat, is removed and replaced by another batch of cold material. An example of a variable system is a molding press which receives a batch of cool plastic, forms, cures and ejects it and repeats the cycle several times a minute.

B. *Heat Source:* The device which delivers the heat used by the system. The source may be electrical heaters, oil and gas-fired heaters, or any other source. The process may be exothermic; i.e., generate its own heat.

C. *Heat Transfer Medium:* The material which transmits the heat from the heat source to the work. The material may be a solid, liquid, or gas. Its transfer characteristics play a large part in determining how fast temperature changes are transmitted through the system and, consequently, how closely the system can be controlled.

D. *Controller:* The instrument which controls the heat flow on the basis of the discrepancy between the sensed temperature and the controller's set point.

2. A Practical Approach to Accuracy

The user of a thermal system is interested in one basic question: is the temperature control accurate enough to operate his product or process satisfactorily? Control requirements are far less stringent in a waffle iron than in a crystal oscillator oven. Maintaining exact temperature in a wax applicator tank is less critical than in a laboratory viscosimeter. The point is that exact control of a system takes time, care and money. Moreover, it takes highly sensitive measuring instruments and indicators—and frequent recalibration in service—to tell just how good the control is. Eliminating the last degree or fraction of a degree of temperature deviation is costly and should be done only for sound practical reasons.

Nonetheless, good control *is* attainable with standard instruments. To be sure, control will be no better than the capabilities of the controller, but unless the system is designed as an entity, there is little assurance that the controller *can* deliver what the user expects of it.

3. What Affects Control Accuracy?

System bandwidth and constancy of mean temperature are the overall measures of control accuracy. They are affected by many factors:

1. Temperature Gradients—the range of temperature variation throughout the system at any given instant
2. Thermal Lag—the time delay for a temperature change in one part of the system to be felt in other parts of the system (See page 5).
3. Location of the Controller's Sensing Element—its placement relative to heat source and load (See page 5).
4. Response Speed and Sensitivity of the Controller—these and other characteristics make up inherent controller accuracy. They determine how well it is suited for a given application (See page).
5. Heat Balance—the capacity of the heat source in relation to heat demand from the work, plus heat losses. Improper balance can destroy control (See page).

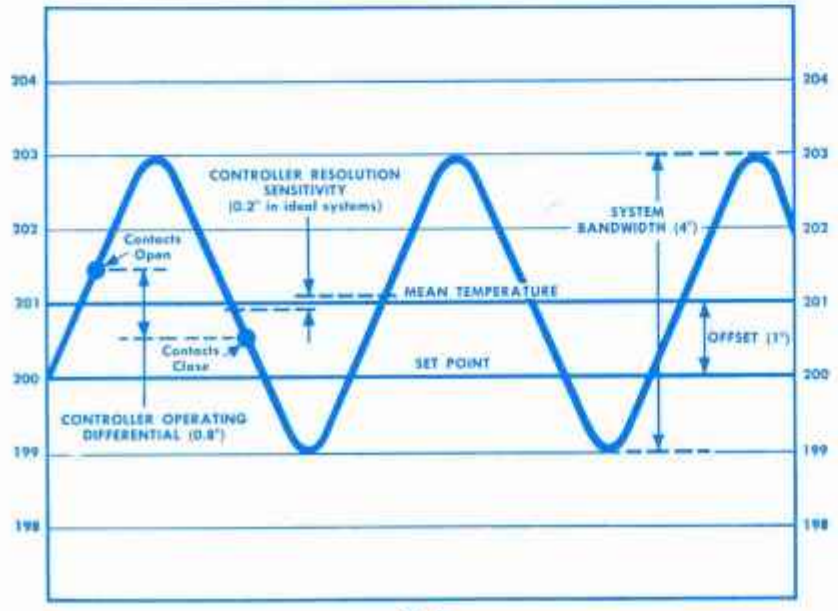


Fig. 1

How the Rest of the System Affects Control Accuracy

1. Thermal Gradient

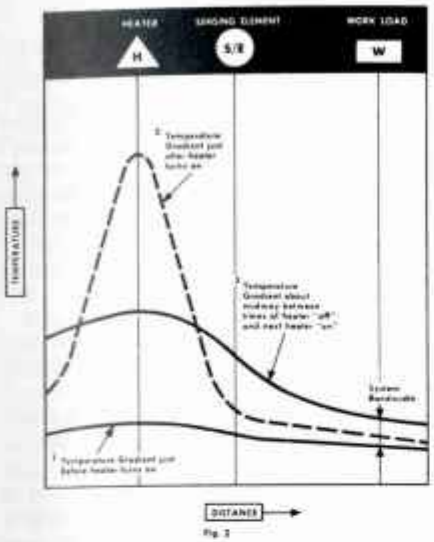
If you were to measure the temperatures in a thermal system at some instant, starting at the heater and progressing outwards to the edge of the system, you would find that the temperature drops progressively as you move farther away from the heat source. This gradual drop existing in a system is called a thermal gradient.

Every operating thermal system has a gradient at all times. Temperature changes are occurring continuously because of heater cycling and heat losses, but these changes are not transmitted immediately through the remainder of the system. As a result there is always a temperature differential or gradient between points, with the highest temperature obtained at the heat source and lowest at the outer edges of the system. Some gradient is essential for heat flow, since heat cannot flow unless there are areas of lower temperature to move into.

Assume you have a metal bar containing a heater, sensing element, and a pellet of material representing the work load. If you place a sensitive temperature indicator at various points in the bar and record the temperatures existing at the beginning, middle and end of the operating cycle, you would obtain three different temperature curves. These represent the temperature gradient in the system at three instants during its continuous cyclic change from minimum to maximum steepness.

A. *Allow for Gradient When Measuring and Controlling Temperature. Because temperature varies along the gradient, it is important to measure temperature as close as possible to the area you want controlled.* If you place the thermometer between the work and the heater, the reading will usually be higher than the temperature in the work area. If you measure the temperature at a low point in the gradient, for example, near the outer surface of the system, it may well be lower than the temperature at the work area.

By the same reasoning, the set point of the controller must be adjusted according to its relative location. The closer to the heater you get, the larger the offset necessary to keep from shutting off the heater too soon. For example, to control the work at 300 degrees when the sensing element is between the work and the heater, you may have to set the controller at 305 or 310 degrees to enable the heater to reach a suf-



ficiently high temperature to produce a useful temperature rise at the work area.

B. *How to Reduce Gradients.* Although thermal gradients are inevitable and necessary, excessive gradients can be troublesome. They can be reduced in these ways (covered in detail in following section):

1. Balancing heater capacity against heat demand. Gradients are influenced by the amount of heat input and heat losses. Too large an input will increase the gradient and the temperature bandwidth.
2. Proper setting and location of the sensing element to control the duration of the heat cycle.
3. Insulating the system to reduce heat loss.

2. Thermal Lag

The delay in the distribution of heat through a system is called *thermal lag.* It is present to some extent in every system. It is influenced by the distance between the heat source and the work, and the resistance to heat flow and heat capacity of the heat transfer medium.

Thermal lag is the enemy of accurate control because it handicaps the controller. It withholds from the controller for a certain interval—which may be as much as several minutes in some cases—information about temperature changes in the system. This lag can prevent the sensing element from sensing heat demand soon enough to deliver the heat when needed. It can also delay the arrival of heat at the element so long that the heater has delivered more heat than the system needs to recover from a temperature drop. The result in the first case is temperature undershoot; in the second case, temperature overshoot. Both can produce an undesirably large system bandwidth.

Since thermal lag can never be entirely eliminated, one of the major prerequisites for close control is to reduce lag to the largest extent practical, and to compensate for the remainder. Thermal lag can be reduced by using materials and techniques to speed up heat distribution. The remaining lag can be compensated for by selecting a controller of sufficiently fast response and carefully placing its sensing element at a point where it can sense important temperature changes quickly.

Thermal lag can produce misleading information for evaluating controller performance in a rapidly changing system. In certain systems the lag can be large enough so that, when the sensing element is placed between the heat source and the work area, the controller may call for heat because of reduced temperature in its area, while the temperature at the work is just starting to rise as a result of the previous heating cycle. This effect can seem even more pronounced if the controller has a fast response while the temperature indicator at the work has a large inherent lag, such as is found in many mercury-in-glass thermometers.

3. Selecting the Heat Transfer Medium

The selection of the heat transfer medium has much to do with the amount of thermal lag.

Solids, liquids and gases are all used as heat transfer media, with metals probably the most commonly used. In most cases the choice is already fixed by the cost, size, and application for the thermal system. However, where close control is the first consideration, the following evaluation of transfer media will be helpful. They are listed in order of decreasing preference for close control, and, in some cases, there may be overlap between individual materials in different classes.

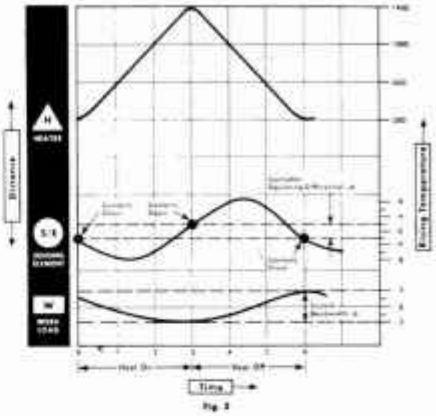
1. Well-agitated liquids
2. Rapidly moving air
3. High-diffusivity metals
4. Low diffusivity solids
5. Stagnant air
6. Stagnant liquids

4. Proper Location of Components

By now it should be clear that a controller performs no better than the system permits. Thermal lag is one of the major factors in handicapping the controller. Lag can be reduced by proper choice of the heat transfer material. It can be further reduced by a wise matching of the controller with the application and by placing the components correctly in the system. Correct placement is essential, because starting with the same heat source, controller and thermal load, you will obtain widely different control accuracies depending on the relative locations of these components.

If the heat source, sensing element and work could be always grouped into a compact area, there would be little problem with control. The short heat path from the heater would enable the sensing element to respond quickly to temperature increases at the heater, cycle frequently and minimize overshoot.

In the majority of cases this intimate grouping of system elements is not feasible due to the relatively large size of the system and the fact that the heat source is at some distance from the work area. The problem then arises as to where to place the sensing element, because



moving it away from either the heater or load affects control in some manner. There is no single answer to the problem. The designer's problem is to arrive at the best compromise for his thermal system.

When the work and the heat source are separated, placement of the sensing element involves compromising the advantages of smallest bandwidth and constant mean temperature at the work area. Both cannot be attained at the same time. You must decide which of the two types of accuracy is more important for your system.

A. *Importance of Cycling Frequency.* Precision performance of ON-OFF controls requires frequent cycling of the heat source. (In systems using other than an ON-OFF control mode, frequent cycling is unnecessary.) Rapid cycling produces a series of short bursts of heat which approximates a steady heat input at the load. Infrequent cycling, on the other hand, causes prolonged heating intervals in which large quantities of heat enter the system. This results in wide variation in thermal gradient during the operating cycle and undesirably increases the system bandwidth.

Although rapid cycling is desirable because it reduces bandwidth, there are practical limits to be considered. Excessive cycling decreases the service life of contacts and mechanical components of the controllers, relays, heaters, and other cycled components. The optimum cycling frequency is one that produces the desired system bandwidth without excessive wear on the cycling components.

Cycling frequency can be reduced by moving the sensing element away from the heat source. If this is not practical, you can reduce it by increasing the thermal lag to the element by some artificial means, such as insulating the element with a strip of asbestos, a heat shield or a reflecting strip.

Rapid advances in the state of the art of solid state electronic devices such as silicon controlled rectifiers and thyristors allows their direct replacement for mechanical relays and controllers in electrical heating. These solid state devices can be switched rapidly without the mechanical problems of wear and servicing. However, initial installation costs are somewhat higher.

B. *Preferred Component Location for Various Thermal Systems.* Although in practice thermal systems are not purely steady or variable, they usually are predominantly one or the other. For such systems, the following rule of thumb will be helpful: where the heat demand is relatively steady, the sensing element should be placed closer to the heat source; where the demand is largely variable, it should be nearer to the work area.

C. *Liquid and Gas Systems.* In liquid baths and ovens where the heat demand is primarily steady, locating the sensing element fairly close to—and above—the heat source should minimize bandwidth. In the arrangement illustrated in Figure X, the element is in an undesirable position because the slowly moving convection currents take too long to reach it. By the time the controller can turn off the heater, too much heat has already been generated and overshoot becomes inevitable. Agitation and/or distribution of the heat sources over the bottom of the tank will help shorten the lag in heat transmission, increase temperature uniformity and improve control. However, the narrowest bandwidth will be obtained with the arrangement illustrated in Figure Y. Bringing the sensing element closer to the heaters further reduces thermal lag, while the agitator promotes uniform mixing and reduces heat gradients.

Figure Z shows an analogous situation for ovens. Generally, the best location for the sensing element is fairly close to the heating elements to reduce the transfer lag of the convection currents. It may have to be moved closer to the center of a large oven, where the heat source is also large, to lower temperature offset to a point where the temperature will be more representative of the entire oven. Wherever feasible, blowers should be installed to prevent temperature stratification and eliminate stagnant air pockets around the sensing element which can insulate it and slow its response. Multiple heaters or coils distribute the heat faster and more uniformly than a single concentrated source, and are preferable for that reason.

5. Insulation is Important

Proper insulation has the double-barreled advantage of reducing heating costs while improving control accuracy.

Besides saving heat, another important function of insulation is to minimize temperature gradients within the system. Although gradients cannot be eliminated entirely, they should be as small as possible to keep the temperature nearly uniform throughout the system. Reduction of gradients also lowers the offset required for the controller setpoint, and produces a narrower system bandwidth as the heaters cycle.

Best temperature control with minimum heat input is obtained when the thermal conductivity within a system is high but the conduction of heat away from the system is low. For this reason the system should be thermally insulated from any supporting structures which will carry away heat and increase the gradient. This is particularly important where the heated mass is relatively small compared with the supporting structure; for example, a heated platen in a large press.

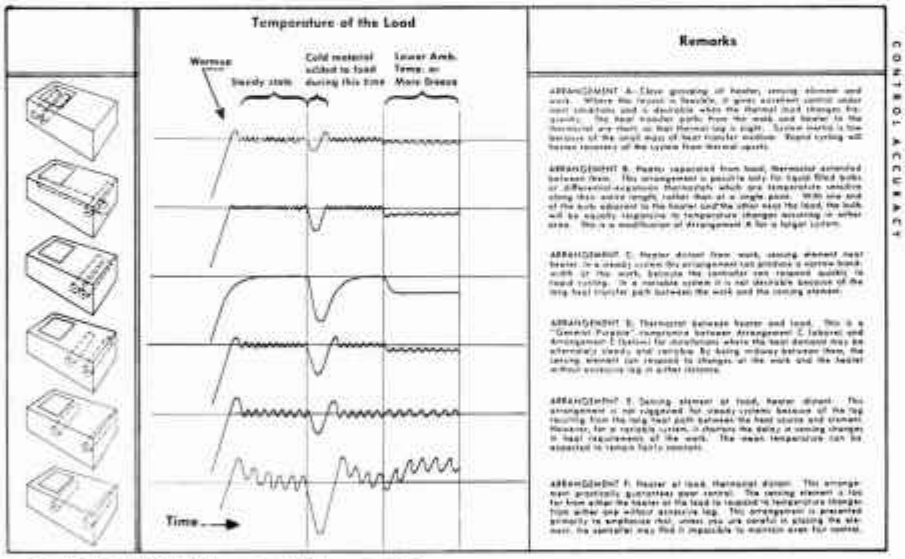
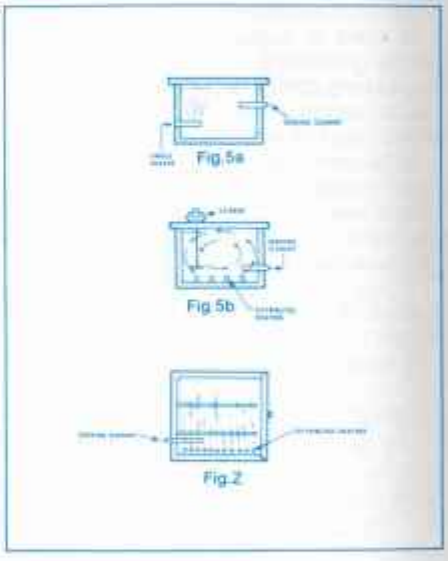


Fig. X



How to Heat the System

1. Sizing the Heat Source

No ON OFF system can be controlled accurately without proper heat balance. Heat balance refers to the relationship between the capacity of the heat source and the heat requirements in a given system. For best control, the heat should be on 50 percent of the time when the system is at the desired operating temperature. The three curves in Figure 4 illustrate the effect of heat balance on temperature control. Curve (A) shows what happens when the heat source is too large. The temperature of the system rises sharply each time the heat is turned on, causing repeated thermal overshoot with each cycle. Curve (B) illustrates the control in a balanced system (heat-on 50% of the time). Note that the rates of heating and cooling are approximately equal and the deviations from the control point are small and equal. Such a system will be flexible enough to maintain good control even if the heat demand should increase or decrease by a fairly substantial amount. Curve (C) shows what happens when the steady heat demand exceeds the heater capacity. Even though the heater is on continuously, the system never reaches control temperature. Even if the heat is ON 50% of the time under normal circumstances, more than double this amount of heat may be required if low voltage combines with cool breezes or fans. Allowances must be made for this factor when selecting heaters to obtain an actual 50% ON time.

It is seldom possible to obtain perfect heat balance in normal industrial operations. However, whenever the heat source is on more than 60% of the time, the heater rating should be increased. If the heater is on less than 40% of the time, the rating is too large and should be decreased.

Procedure for Proper Sizing of the Heat Source. Two factors enter into determining the required heater rating: (1) the amount of heat needed to bring the system up to operating temperature from a cold start within a specified time, and (2) the amount of heat required to satisfy the demand of the system (including losses) during normal operation. Usually the larger of the two will determine the minimum rating. However, where the warm-up requirements are relatively large, special techniques to handle warm-up conditions can be used.

2. Heater Selection

There are many heating methods available, such as steam or hot-water jackets or coils, Dowtherm and similar heat exchangers, as well

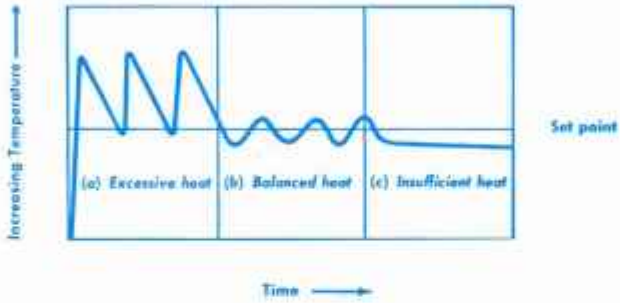


Fig. 4 Effects of heat balance on temperature fluctuations in a thermal system, resulting from use of: *a*, too large a heater; *b*, the right capacity heater; and *c*, too small a heater

as radiant and direct contact heaters.

A. *Installation Method.* The manner in which the heaters are installed can affect uniformity of heat distribution, rate of heat build-up and heating costs in the system, as well as determine the configuration and rating of heaters to be used. The more intimate the contact between the heaters and the material or part being heated, the better is the heat conductivity. Good conductivity improves temperature control and lengthens heater life. The usual methods of installing heaters, listed in decreasing order of heat conductivity are:

1. Cast integral with metal or immersed in liquids or gases
2. Inserted in hole drilled in metal
3. Placed in groove in surface of metal
4. Wrapped around or clamped to the surface
5. Spaced away from surface being heated (except for radiant heaters)

Heaters are manufactured in a variety of shapes and forms to fit the type of installation. Cartridge, strip, ring, tubular and immersion are common configurations.

B. *Selecting the Proper Sheath Material.* The resistance element and outer sheath ofa heater are designed for service within certain temperature limits. If the heater is operated consistently at excessive temperatures, the heating element will fail prematurely and the sheath metal will deteriorate rapidly.

Corrosion problems must also be considered when selecting the proper sheath material. When working with corrosive or oxidizing materials, it is vital to select a sheath material that has good corrosion-resistance at the temperatures in question. For unusual service requirements, consult the heater manufacturer.

C. *Selecting Proper Watt Density.* Because of differences in heat absorption and heat transfer, there is a limit to the *rate* at which various types of materials can be heated safely. If the heating rate is excessive, the area around the heater will become overheated. This localized overheating may deteriorate the material being heated and damage the sheath and heating element.

Heaters are rated on the basis of *watt density*, which is the number of watts produced per square inch of heated sheath surface. The higher the absorption rate of the material, the higher the permissible watt density for the heater. To aid in selecting a heater which will produce a safe heating rate, most heater manufacturers publish recommendations on allowable watt densities for various situations.

Selecting the Temperature Controller

Good temperature control depends on many more factors than the performance of the controller alone. Nevertheless, the type of controller must fit the application if the system or equipment is to operate within the required accuracy limits. The process for choosing a controller should be based on the following considerations.

1. What to Look For

A. *Temperature range:* the operating range of most controllers is limited by one or more of the following factors: type of sensing element, type of liquid fill, mechanical design or construction materials. The system operating temperatures should fall well within the controller's operating range, leaving leeway for possible over and undershoots.

B. *Resolution sensitivity:* this factor—one measure of controller quality—states the amount of temperature change that must occur before the controller will actuate. It may be expressed either as a specified number of degrees or as some percentage of the controller's operating range or scale.

In the majority of controllers, the sensitivity is some fixed value, but in many higher-quality controllers the sensitvity can be adjusted over a range of values to provide greater flexibility. The better the sensitivity, the narrower the system bandwidth produced, all other conditions being equal. However, to translate good controller sensitivity into correspondingly accurate control calls for careful designing, heating and insulating of the system as well as relatively high cycling rates. For these reasons, unless it is actually needed, high sensitivity should not be the only consideration. In most applications a controller having a sensitivity of from 2-5°F will be adequate, if it is properly installed and used.

C. *Speed of response:* this factor is a measure of the time it takes for a temperature change occurring at the sensing element to be translated into a controller action. This is a distinctly different concept from resolution sensitivity because, even though two controllers may be equally sensitive, they may not necessarily respond within the same time.

Response time depends to a large extent on the operating principle of the controller. For example, a THERMOSWITCH® control will respond considerably faster than an ordinary thermostat with an enclosed bi-metallic element, because its shell is the temperature-sensing element. The housing of the enclosed-element type, on the other hand, acts as a barrier which slows up heat transfer and increases response time. Liquid-filled systems are more rapid than gas-filled systems, because liquids have higher thermal conductivities and thus respond more quickly to temperature changes. Thermo-electric sensing elements are the most rapid of all. In general, response time will be low for sensing elements having low mass (e.g., the thermistor), and a short heat transfer path between the temperature to be sensed and the actual sensing member (e.g., the THERMOSWITCH design). In addition, the probe should be as thin as possible and fabricated from a good thermal conductor.

Fast response is important in two types of applications: (1) where the system temperature changes rapidly and frequently; (2) where the heat transfer medium is a relatively poor conductor, such as gases or slowly-circulating liquids. Speed of response is less important where temperatures remain relatively constant for long periods, where highly accurate control is not essential, or where proportional control is used.

D. *Sensing element dimensions:* these vary depending on the operating principle of the controller. Of the commonly used industrial controllers, liquid-filled controllers are available in a variety of sensing element configurations ranging from long, thin, to short, squat types, and can be adapted to many installation requirements. Where space is a critical consideration, a midget or miniature THERMOSWITCH unit, or a thermistor element no bigger than a common pin, will solve the problem.

E. *Method of adjusting setpoint:* where the sensing element must be placed in a location that is difficult or hazardous to reach, there is little alternative to using a remote-setting controller to adjust the setpoint. Bulb-and-capillary controlls can be furnished with capillary lengths of 10 ft or more; thermistor control leads can be 200 ft long. However, wherever adjustments will be accessible while the system is operating, a local-bulb type controller is a good choice, and will be more economical.

F. *Control mode:* this refers to the method in which the controller attempts to restore system temperature to the desired level. The two most common methods are two-position (on off) and proportioning (throttling) control. Two-position control results in a certain amount of over and undershoot, which may be excessive under certain conditions. Proportioning control provides one method for preventing overshoot by tailoring the size of the correction to the amount of temperature error. Some Fenwal controllers are designed to operate as on off controls; oth-

ers operate in both the on-off and proportioning modes. The advantages and limitations of each control mode will be discussed in detail in a later section.

2. How Temperature Controllers Work

The operating principle of a controller can tell a great deal about the performance to expect. Most of the commonly-used industrial temperature controllers today are based on one of three operating principles. These are: differential expansion of metals; fluid expansion; and electronic. Fenwal manufactures controllers of each type.

A. *Differential expansion controllers:* This familiar principle of sensing temperature makes use of the fact that dissimilar metals undergo unequal changes in length with a given change in temperature. The sensing element in a common class of thermostats consists of two pieces of dissimilar metals fabricated into a strip, coil or disc. As the temperature changes, the element tends to warp or distort and the resulting motion can be used to operate a circuit by moving an electrical contact toward or away from a mating contact. This motion can also be used to overcome the force of a spring-loaded detent, which will actuate a snap switch.

A refinement of the differential-expansion principle is the strut-and-tube thermostat, such as the cartridge THERMOSWITCH unit, and its midget and miniature counterparts. In this design, the bimetals are not bonded together into a single element, but comprise two basic parts of the thermostat. The outer shell is made of the high-expanding material, usually brass or stainless steel and the strut assembly is made from a low-expanding metal, usually a high nickel alloy. The strut assembly, on which a pair of electrical contacts are mounted, is installed in the shell under tension or compression depending on whether the maximum overshoot capability or maximum setting range is desired. Because each end of the strut assembly is mechanically connected to the ends of the shell, a net change in force is produced on the low-expansion strut assembly as the high-expanding shell expands or contracts with changing temperature. The amount of shell movement necessary to cause the contacts to open or close is set by an adjusting screw and since this movement is a direct function of temperature, the screw settings determines the control temperature. This adaptation of the differential-expansion principle gives several important control advantages:

1. Because the outer shell is the active temperature sensing member, and not merely a housing, response to temperature change is almost instantaneous.

2. This shell and strut arrangement has "anticipation" characteristics, which substantially reduce the amount of over and undershoot under conditions or rapid temperature change. Anticipation is produced by an inherent time lag between the shell and internal struts, which causes the shell to "lead" the stuts by an interval that varies directly with the rate of temperature change. With rapid temperature rise, the shell exerts a larger net force on the struts and tends to pull them apart sooner than would be the case when the temperature is rising slowly. The result is several degrees or more of anticipation which help produce closer control.

3. The strut-and-contact assembly operates by slow make and break, which means that every temperature change, no matter how small, causes a corresponding change in the spacing between the electrical contacts. This means that contact action can be produced by a very small temperature change, which accounts for the excellent resolution sensitivity (0.1°F) of THERMOSWITCH controls. On the other hand, thermostatic units whose contacts are actuated by a snap switch or similar detent action, have sensitivities of several degrees since a finite amount of energy must be absorbed to overcome the restraining forces on the contact assembly and thus produce contact actuation.

4. Since the strut assembly is assembled under tension or compression, a properly installed unit has excellent vibration resistance and will operate reliably and accurately under difficult physical conditions.

All current-carrying devices tend to heat up as the current load increases. This is also true of THERMOSWITCH units. As current load across its contacts increases, the heat generated is largely absorbed by the strut assembly on which they are mounted. Heating the strut assembly has the same net effect of raising the setting of the controller. For this reason, although the control will handle loads up to 10 amps, it produces best control at more conservative loads. Where the loads are greater than 3 to 4 amps, much better results will be obtained by using a relay as the load-carrying element with the control handling the pilot load. Another alternative, where electrical load exceeds 3-4 amps and the operating temperature is applicable, is to use the Series 20000 liquid-filled thermostat. In this unit, the current is handled by a snap switch so that the size of the current load has little effect on the controller action.

B. *Liquid-filled controllers:* if a small container is completely filled with an incompressible liquid, the volume of the liquid will change with the temperature. If the container is somewhat elastic, such as a bellows, it will move in response to the changing volume of the liquid. The motion of the bellows can then be transmitted through a push rod or mechanical linkage to actuate the contacts of an electrical switch. By setting the height of the switch with an adjusting screw, the amount of push rod travel required to operate the switch—hence the operating temperature of the unit—can be controlled.

There are two basic types of liquid-filled temperature controllers. The first is the local-bulb thermostat. An example of this type is the Series 20000 unit, in which the sensing liquid, bellows and push rod are all enclosed in a cylindrical shell which is inserted directly in the process. At the top of the shell is the head of the unit containing the control switch and lead wires. This type is non-indicating.

The second type is the bulb-and-capillary controller. In this type the expansible liquid is contained in a metal bulb which is the sensing element. The pressure from the expanding fluid in the bulb is transmitted hydraulically to the bellows through a thin capillary tube, 6-10 ft long, also filled with the expansible fluid. A separate housing, located remotely from the bulb, contains the bellows, actuating mechanical linkages, indicating mechanism and control switches, etc. A typical bulb-and-capillary controller is the 400 Line (indicating).

The liquid-filled local bulb thermostat is intended to supplement, not replace, the differential-expansion THERMOSWITCH design. While the liquid-filled thermostat is inherently less sensitive, the use of snap switches to carry the electrical load simplifies the circuitry. The load carrying characteristics of both the local-bulb and bulb-and-capillary controllers are quite versatile, since their snap switches can be interchanged for various types of service, including 20 amps at 120 or 240 volts AC, as well as narrow differential, high inrush and manual reset. In addition, switches can be paired to produce control action at two selected temperatures. In the 400 Line controller, the two-switch arrangement can be furnished to permit individual setting or constant differential between the two settings, with indication of one or both settings as well as the process temperature. The Fenwal 400 Line also includes a proportioning potentiometric output controller which provides "straight line" control when used with proportional positioning motors or valves.

C. *Thermistor-Actuated controllers:* these controllers, exemplified by the Fenwal Series 194, represent a relatively new development in temperature control techniques. These are temperature controllers actuated by a thermistor sensing element, connected by lead wires to an electronic amplifier, indicating circuit (if present) and control circuit all contained in a separate housing or chassis. These controllers offer unusual advantages. They are highly accurate and mechanically rugged, have excellent stability with age, utilize a small sensing element, require infrequent calibration and can be located up to 200 ft or more from the sensing element using standard electrical conductors. This performance results from the remarkable properties of the thermistor.

The thermistor is a semi-conducting material made into tiny beads or other shapes by sintering a mixture of metallic oxides. One of the outstanding attributes of the thermistors is that their electrical resistance decreases rapidly per degree of temperature rise. Compared with the sensing elements used in other types of temperature controllers, i.e., resistance bulbs and thermocouples, thermistors produce a very large working "signal." Some thermistors undergo a thousandfold change in resistance between 100 and 600°F, while a resistance bulb may change in resistance by a factor of only 2 over the same temperature range. The output of the commonly used iron-constantan thermocouple varies over an even smaller range of values at these temperatures.

Since a relatively small change in temperature at the thermistor produces a large change in resistance, the controller has unusually good

sensitivity capable of producing stable control well within 1°F in a properly designed system. The sensing and control circuits are relatively more compact, less subject to mechanical shock and generally require less maintenance than those used with a thermocouple or resistance bulb.

D. *Thermocouple Actuated Controllers:* exemplified by Fenwal Series 543 and 550 represent the latest developments in solid-state electronics employing integrated circuits and relay or solid-state thyristor outputs. The thermocouple sensor consists of two wires of dissimilar metals joined at one end called the "hot" or measuring junction, while the other ends become the reference junction. The reference or "cold" junction is held constant at either 32°F (melting ice) or calibrated to an equivalent EMF value. The temperature or difference between the hot and reference junctions develops a DC millivoltage that is linear with temperature within a few degrees. This signal is fed into a bridge balance potentiometer which measures the EMF output and, with amplification to a useful level, controls process temperature through the operation of a relay or solid-state device.

The overall thermocouple range is −300°F to approximately 4000°F and is derived from several base metal combinations such as iron/constantan, copper/constantan, chromel/alumel and noble metal combinations of platinum or platinum/rhodium with rhodium in varying percentages.

Thermocouple wires are available in commercial and premium grades with wire error limits within 2°F. Thermocouple sensors generally have a response time about ten times better than a resistance temperature detector and are tip sensitive.

E. *The Platinum Resistance Temperature Detector (RTD):* differs from a thermocouple in that a finely wound platinum wire changes its resistance directly with temperature. This eliminates the need for dissimilar metals and cold junction compensation.

Mounting may be similar to that of thermocouples; protection from stress or corrosive environments is achieved by encapsulation and/or installation in thermowells. Two, three or four leads may be provided with connection to a Wheatstone bridge circuit being common. Care must be exercised to avoid resistance change from excess current or heat conducted to the resistance bobbin along its leads.

3. Types of Control Action

A. On/Off (two position)
B. Proportioning (throttling)
C. Proportioning plus Integral (automatic reset)
D. Proportioning plus Integral plus Derivative (rate)

A. *On-off control:* in on-off control the controller permits the controlled element (heater, valve, etc.) to be completely ON or OFF, open or closed. No intermediate position is possible. As a result, the size of the corrective action has no relation to the amount of temperature deviation. Full heat (or other action) is supplied regardless of whether the temperature is 2° or 20° below the setpoint. The heat stays until the controller senses that the system temperature corresponds to the setpoint (or more accurately, the higher limit of the controller's operating bandwidth).

The end result of two-position control is that the system temperature oscillates continuously above and below an "average" system temperature. The size or amplitude of these oscillations determine the system's bandwidth and they are governed by many design factors which have already been discussed.

1. Adjustable differential: most on-off controllers have a fixed operating differential, but in some more elaborate controllers the operating differential can be varied to suit the application. Operating differential is the "dead zone" or the difference between the temperatures at which the controller opens and closes its contacts.

The chief advantage of increasing the operating differential is to decrease the cycling rate and thus the wear on switches, heaters and other cycled components. However, reduced cycling affects control.

Since the system bandwidth is strongly influenced by cycling frequency, the operating differential of a controller, if adjustable, should be increased judiciously. The best choice is the one which will reduce the cycling frequency of the equipment as much as possible, without producing an excessive temperature bandwidth in the system.

B. *Proportioning control:* in proportioning control the controller "recognizes" the deviation from the setpoint and proportions the corrective action to the size of the deviation. The proportioning action occurs when the system temperature falls within a range of temperatures known as the proportioning band. At the approximate center of this band is the desired system temperature.

In true proportioning control, the controlled element, for example a valve, can be moved to any position from 0 to 100% open, as required by the size of the deviation from the control point.

The virtue of proportioning control is that the system temperature does not oscillate continuously around the desired value, as it does in the case of on-off control. Since the corrective action is tailored to the size of the deviation to be corrected, the system has less opportunity to overshoot or undershoot. This action is particularly helpful in systems which go through frequent work cycles where the system is cooled down by the addition of cold material and then must be brought up to temperature quickly. Under these conditions, the temperature tends to overshoot in each recovery cycle and the throttling action of proportioning control is most helpful in combating this tendency.

1. Selecting the proper proportioning band: ideally the proportioning band for any particular system should be just wide enough to accommodate the time lags in the system.

The proportioning band for a given system can be established by operating the system at the desired temperature with the controller functioning on the on-off control mode at minimum differential and noting the limits of overshoot and undershoot encountered. The proportioning band should then be set to just exceed these temperature excursions.

2. Droop: there is, however, an inherent limitation in proportioning control. The size of the corrective action depends only on the size of the difference between the system temperature and the setpoint. But this corrective action can fit only one set of equilibrium conditions. A proportioning controller cannot correct the valve position without a change in sensing element temperature. This will result in the system being controlled at progressively lower temperatures having, in effect, a "droop."

However, by the nature of proportioning control, the droop cannot go below the lower limit of the proportioning band under normal operating conditions. Thus, a narrowing of the band will reduce droop. Droop can be corrected by resetting the setpoint above or below the original setting or by rotating a manual reset adjustment (if provided) so that the system stabilizes at the desired temperature. Droop also can be corrected by adding INTEGRAL ACTION or automatic reset to the controller.

In this variation (PI), the integrator adds a signal to the controller action so that the output of the controller is proportional to the time integral of the input. In other words, reset recognizes the deviation between actual process temperature and setpoint and supplies a signal to correct for this deviation. This signal moves the proportioning band up or down to cause agreement over a period of time. By design, reset action occurs only *within* the proportioning band. This type of operation is termed to have *anti-reset windup* which prevents a large reset charge causing overshoots on startup.

4. HELPFUL HINTS FOR ADJUSTING PROPORTIONING CONTROLLERS

A. Rapid cycle time provides better control and prolongs heater life; if relay output is used, relay life is shortened.

B. Bandwidth should be adjusted so that oscillations just cease. Wide bandwidth provides stable control, but droop is larger.

C. Automatic reset adjusted properly eliminates droop. Too fast a reset rate causes unstable operation (system oscillates). With too little reset rate, system response is slow.

D. If rate time constant is too short, overshoot occurs (virtually no rate). If rate time constant is too long, oscillations can be caused by on-off action.

E. *System Startup:* Adjust reset for lowest repeats per minute (largest reset time) and rate for shortest time. This is essentially proportioning only control. Adjust reset in incremental steps so that droop is eliminated with minimum amount of oscillations. Adjust rate so that slight power line changes are nullified in shortest period of time without oscillations.

General Operating Techniques

1. Preventing Overshoot During Warm-Up

In many thermal systems the temperature must never exceed a certain maximum. In such systems the possibility of overshoot, particularly on initial heat-up, can be a serious problem.

A. *Anticipation:* two types of controllers can produce the anticipation needed to prevent overshoot during warm-up cycles: proportioning and differential expansion. Proportioning control is, of course, highly effective since it continuously reduces the heat input as the temperature rises toward the setpoint. The advantages and limitations of proportioning control have already been described.

When the expense of a proportioning control is not justified, the differential expansion THERMOSWITCH unit will produce a considerable degree of anticipation. The amount of anticipation produced increases with increasing rate of temperature change in the system. Where overshoot is a particular problem, various THERMOSWITCH units can be supplied to produce the desired degree of anticipation for any particular application.

Location of the thermostat with respect to the heater also will affect the amount of anticipation. The shorter the distance between the heater and thermostat, the greater the anticipation effects.

B. *Extra warm-up heaters—single thermostat control:* another approach to obtaining rapid warm-up without overshoot is to use two sets of heaters. The circuit is connected so that the heaters will operate during the warm-up cycle, but when the control temperature is closely approached or reached, one of the heaters is switched out of the circuit leaving sufficient capacity to deliver the basic control heat. Both heaters can be operated by a single thermostat, provided some switching mechanism is inserted to reduce heat input after the first cycle. For example, during warm-up one of the heaters can be connected to a holding relay in series with the temperature controller. After the first controller cycle, the relay and its associated heater drop out of the circuit.

Another way to reduce warm-up heat using just one thermostat is to reduce the voltage supply after the warm-up interval. This can be accomplished by using a voltage selector relay which switches the power supply from 220 volts to 110 volts after the first cycle. If desired, a variable transformer can be inserted in the low voltage power supply line to provide exactly the proper voltage for the heat output required by the application. Relay action can also be applied in other ways, such as changing the connection of two heaters from parallel to series.

This general technique of using high heating capacity for warm-up has one significant limitation. The higher heating rate during the first cycle tends to exaggerate overshoot to some extent. This can be reduced by installing one of the warm-up heaters close to the thermostat, so as to produce an extra amount of anticipation. Since this heater will be inoperative after the warm-up interval it will not produce excessive anticipation which might interfere with control under normal operating condition.

C. *Extra warm-up heaters—two thermostat control:* the use of two thermostats, instead of one, can permit rapid warm-up without either producing overshoot or requiring any compromises in control during the normal operating cycle. The added thermostat is set to actuate at a temperature lower than the desired system temperature and switches off the warm-up heaters at some selected temperature. In the interest of reducing warm-up time, the setpoint of this thermostat should be as close as possible to the control temperature without producing overshoot. The warm-up thermostat and its heaters should be electrically independent of the control heaters and their thermostat. Another alternative is to use a step-down voltage supply arrangement to supply the heaters, using the warm-up thermostat to switch from the high- to the low-voltage source through a relay.

2. Installation and Service Tips

One of the truisms of control is that the controller can respond only to what its sensing element "sees." Here are some important points which will insure that the sensing bulb does its job accurately.

A. *Proper location of sensing element:* in an earlier section we discussed at length the effect of locating the bulb at various points between the heat source and the load.

In large chambers and long ovens, where there is a continuous flow of work in and out, it is sometimes impossible to place the sensing element at a point where the temperature is reasonably representative of temperatures elsewhere in the system. This creates a problem when the temperature of the work must be closely controlled during the entire process. In such cases control can be improved by using several controllers, each controlling a group of heaters, spotted at intervals along the direction of travel. In this way each controller can be responsive to the temperature existing at its particular location, and no undue reliance is placed on the ability of any one sensing element to respond to temperature changes at remote points. Remember that temperature gradients exist in every system and unless it is placed right at the point where the temperature must be controlled, the setpoint of the controller will have to be offset to compensate for the temperature difference existing at the sensing element's location.

B. *Good installation practice:*

1. Immerse the bulb completely. The sensing element must be completely immersed in the controlled medium, whether gas, liquid or solid, in order to give accurate response. If it is only partly immersed, the temperature reported to the controller may not be the actual temperature in the system, but an average of system temperature and the temperature around the exposed surface of the element. It should be insulated from brackets, bushings, etc., which are not at the same temperature as the bulb or which can conduct heat away to cooler parts of the structure. Otherwise it will be cooled and sense a lower temperature than the one actually existing.

2. Help the sensing element to "see." Any condition which tends to insulate the sensing element will slow down its response and introduce control inaccuracies, regardless of how good the controller is. When installed in an oven, the element must be installed where it is exposed to moving air and should not be buried in brick work, oven walls or shielded by some structure which will prevent its full length from being exposed. It should be placed so that it cannot be covered by accumulations of dirt, scale, sludges or any other materials that will insulate it from the process. Where such as accumulation does occur, clean the sensing element as often as necessary.

When the sensing element is imbedded in a solid, such as a platen, bearing, etc., there should be minimum clearance between it and the solid. Any air space will act as an insulator. The element should contact as much of the surface as possible. Thus, it should be cylindrical over its entire length, rather than tapered, to permit complete contact with the sides of the socket. A special heat transfer compound can also be used to fill in voids and irregularities in the hole.

In liquids and gases, good heat transfer between the sensing element and the medium can be obtained only if the fluid is moving fast. For that reason, the element should be placed in an active moving stream which is part of the general circulation of the system. In addition, without good circulation, there will be hot and cold spots in the system as well as a large sensing lag.

Do not locate the sensing element close to or parallel with walls and ducts that may be considerably hotter or cooler than the gases or liquids flowing past it. Watch out for radiation from hot surfaces or from the heat source impinging directly on it. This type of radiation can make the element considerably hotter than the actual temperature around it and cause what appears to be an offset in calibration. If it is not possible to avoid radiation by relocation, install a shield to intercept the radiation before it can heat the element.

3. Physical protection: install the sensing element where it cannot be knocked or jolted by moving parts of the system, doors, trays, etc. To protect it against corrosion and chemical attack, use stainless steel sensing elements and capillaries or install it in a thermal well of a corrosion-resistant metal.

Besides protecting the sensing element, thermal wells are a great convenience wherever it must be inserted through a tank wall, since it can be removed for replacement or adjustment without draining the tank. To insure good heat transfer, make certain it fits snugly in the well. Where the clearance is excessive, fill the air gap with a conducting material, such as graphite metallic filings or powder. Occasionally, open wells, which are simply open-end pipes, are used to protect capillaries from vapors and other undesirable materials which lie on the surface of a bath. The top of the well should be high enough above the liquid to keep the capillary out of range of the vapors.

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

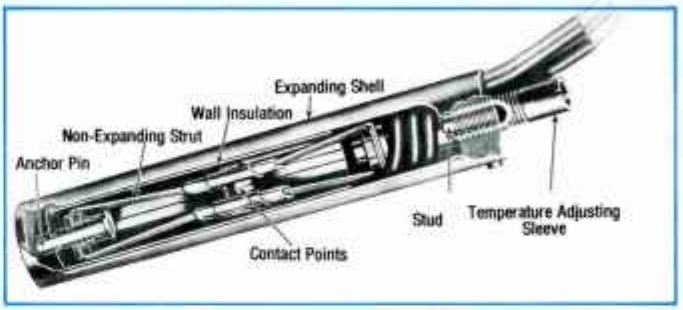
THERMOSWITCH® TEMPERATURE CONTROLLERS

These Fenwal THERMOSWITCH Units are strut-and-tube type thermostats comprised of two basic parts (1) the outer shell—made of high expanding metal and (2) the strut assembly—made of low expanding metal.

A pair of electrical contacts is mounted on the strut assembly and installed in the shell under tension or compression. Because each end of the strut assembly is mechanically connected to the ends of the shell, a net change in force is produced on the low-expansion strut assembly as the high-expanding shell expands or contracts with changing temperature. The temperature at which the contacts make or break can be regulated by a temperature adjusting sleeve.

Typical Applications

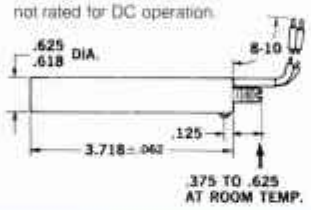
Hydraulic Laminating Presses
Label Adhesive Applicators
Deep Fat Cookers
Respirators
Vending Machines
Milk Pasteurizers
Typesetting Machines
Livestock Watering Fountains
Textile Platens
Paint Drying Equipment
Hot Stamp Printers
Tropical Fish Tanks



Series 17000 Cartridge

This unit may be inserted in a ⅜" reamed hole. If reamed hole is used, a short spline should be added to receive locating pin on thermostat—this prevents thermostat from turning when the temperature adjusting sleeve is turned.

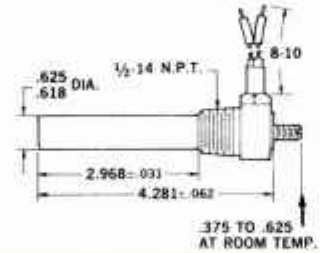
*UL Component recognized units not rated for DC operation.



CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS (MAX. RESISTIVE)
17000-0	−100° to 400°F	OPENS	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC* 2 amps@ 28 volts 2 amps@ 120 volts
17021-0	−100° to 400°F	CLOSES	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC* 2 amps@ 28 volts 2 amps@ 120 volts
17002-0	−100° to 600°F	OPENS	321 S.S. SHELL	AC 10 amps@ 120 volts 5 amps@ 240 volts DC* 2 amps@ 28 volts 2 amps@ 120 volts
17023-0	−100° to 600°F	CLOSES	321 S.S. SHELL	AC 10 amps@ 120 volts 5 amps@ 240 volts DC* 2 amps@ 28 volts 2 amps@ 120 volts

Series 17100 Hex Head

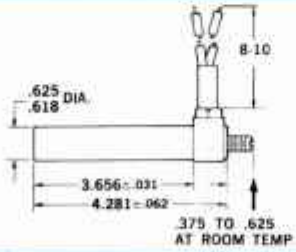
Has all the internal features of the Cartridge Type above with the addition of a standard pipe thread for mounting purposes. A dial, knob and armored cable over lead wires can be supplied with this model.



CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS (MAX. RESISTIVE)
17100-0	−100° to 400°F	OPENS	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17121-0	−100° to 400°F	CLOSES	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17102-0	−100° to 600°F	OPENS	321 S.S. SHELL BRASS HEAD	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17123-0	−100° to 600°F	CLOSES	321 S.S. SHELL BRASS HEAD	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts

Series 17200 Block Head

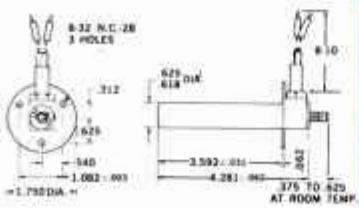
It has the same mounting characteristics as the Cartridge Type unit but is designed so additional components such as a dial, knob, armored cable over lead wires, packing glands over lead wires, and tamper-proof cap over temperature adjusting sleeve may be included.



CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS (MAX. RESISTIVE)
17200-0	−100° to 400°F	OPENS	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17221-0	−100° to 400°F	CLOSES	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17202-0	−100° to 600°F	OPENS	321 S.S. SHELL BRASS HEAD	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17223-0	−100° to 600°F	CLOSES	321 S.S. SHELL BRASS HEAD	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts

Series 17300 Flange Head

Has all the features of the Block Head Type except a mounting flange has been provided for easy mounting.



CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS (MAX. RESISTIVE)
17300-0	−100° to 400°F	OPENS	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17321-0	−100° to 400°F	CLOSES	ALL BRASS	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17302-0	−100° to 600°F	OPENS	321 S.S. SHELL BRASS HEAD	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts
17323-0	−100° to 600°F	CLOSES	321 S.S. SHELL BRASS HEAD	AC 10 amps@ 120 volts 5 amps@ 240 volts DC 2 amps@ 28 volts 2 amps@ 120 volts

**Factory Temperature Setting Tolerance (Mod.#3):* REGULAR TENSION *(Indicated by 4th and 5th digits of Catalog Number, i.e. 00 or 02)*—±5° from -100° to 100°F; ±3° or 2% of *Setting Value (which ever is greater)* from 100° to 600°. INVERSE COMPRESSION *(Indicated by 4th and 5th digits of Catalog Number, i.e. 21 or 23)*—±5° or 3% of Setting *Value (whichever is greater).*

Tolerances: Decimal Dimensions ±.015 Unless otherwise specified

Recognized under the Component Program of Underwriters Laboratories, Inc.
Underwriters Laboratories Listed
Certified by Canadian Standards Association

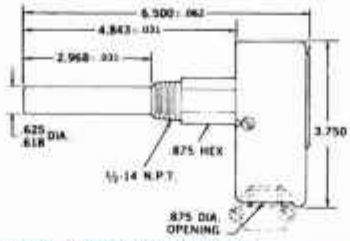
FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

THERMOSWITCH® TEMPERATURE CONTROLS

Series 17800 Junction Box Immersion

Has electric conduit junction box containing terminal block, temperature adjusting dial and knob. Extended hexagonal section with standard pipe thread permits easy mounting into properly tapped hole or boss, immersing shell into fluid medium to be controlled. Dial and knob can be provided outside of box.

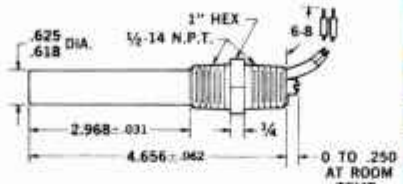


*UL listed units not rated for DC operation.

CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS (MAX. RESISTIVE)
17800-0	−100° to 400°F	Opens	All Brass	AC 10 Amps@ 120 Volts 5 Amps@ 240 Volts DC* 2 Amps@ 28 Volts 2 Amps@ 120 Volts
17821-0		Closes		
17802-0	−100° to 600°F	Opens	321 S.S. Shell Brass Head	
17823-0		Closes		

Series 18000 Coupling Head

The Coupling Head unit has a hexagonal mounting section with standard male pipe threads at each end, either of which may be used for mounting. This unit may be directly attached to electrical conduits or explosion-proof fittings.

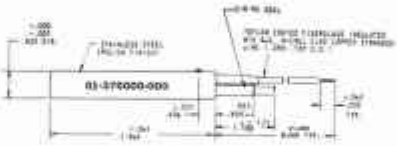


*UL Component recognized units not rated for DC operation.

CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS (MAX. RESISTIVE)
18000-0	−100° to 400°F	Opens	All Brass	AC 10 Amps@ 120 Volts 5 Amps@ 240 Volts DC* 2 Amps@ 28 Volts 2 Amps@ 120 Volts
18021-0		Closes		
18002-0	−100° to 600°F	Opens	321 S.S. Shell Brass Head	
18023-0		Closes		

Series 370000

Cartridge style moisture resistant Thermoswitch® controller in ranges up to 400°F. For applications where fumes and acids are present or where equipment must be washed down.

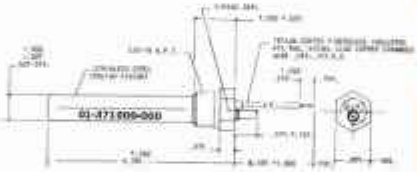


MOISTURE RESISTANT UNITS

CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS
370000-000	−40° to 400°F	Opens	321 S. S. Shell	10A @ 120 VAC. 5A @ 240 VAC

Series 371000

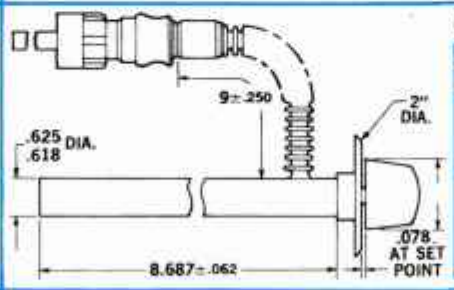
Hex head style of above.



CATALOG NUMBER	TEMP. RANGE**	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS
371000-000	−40° to 400°F	Opens	321 S.S. Shell	10A @ 120 VAC 5A @ 240 VAC

Series 17500 All Purpose

Complete with extended shell, dial and knob and plug connector. Provided with moisture-proof armored cable and "O" ring seal around temperature adjusting sleeve.

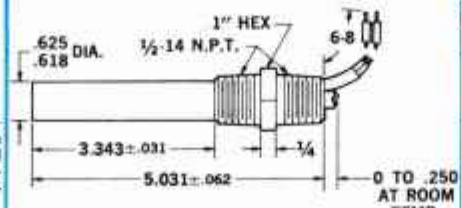


CORROSION RESISTANT UNITS

CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS
17502-0	−100° to 600°F.	Opens	321 S.S. Shell Blockhead and Cable Assembly	AC 10A @ 120 VAC 5A @ 240 VAC DC 2A @ 28 VDC 2A @ 120 VDC
17503-0		Closes		

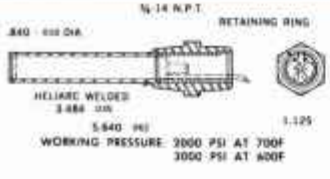
Series 18000 Coupling Head

Unit has a hexagonal melting section with standard male pipe threads at each end, either of which may be used for mounting. Type 316 stainless steel is used throughout for resistance against corrosion. May be directly attached to electrical conduits or other fittings.



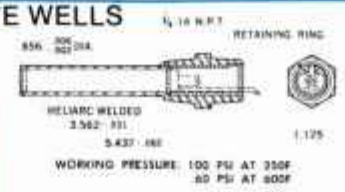
CATALOG NUMBER	TEMP. RANGE*	CONTACT OPERATION ON TEMP. RISE	SHELL AND HEAD MATERIAL	CURRENT RATINGS
18002-21	−100° to 600°F	Opens	All 316 S.S.	AC 10A @ 120 VAC 5A @ 240 VAC DC 2A @ 28 VDC 2A @ 120 VDC
18023-7		Closes		

PROTECTIVE WELLS



Catalog No. 11204-7
High Pressure Coupling Head Well
(316 Stainless Steel Well and Head)

Applicable Modifications
1 Special Marking



Catalog No. 11204-0
Coupling Head Well
(321 Stainless Steel Well and Head)

Applicable Modifications
1 Special Marking

**Factory temperature setting tolerance: Regular Tension—±5°F from −100° to 100°F. ±3°F or 2% of setting value (whichever is greater) from 100 to 400°F

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MODIFICATIONS FOR THERMOSWITCH® TEMPERATURE CONTROLS

These modifications are applicable to the THERMOSWITCH Units shown on pages 10 and 11.

Note the chart on the right for modifications which cannot be combined.

■ **MODIFICATIONS WHICH CANNOT BE COMBINED**

MOD	4	5	6	8	10	14
4			■	■	■	
5			■		■	■
6	■	■			■	
8	■					
10	■	■	■			■
14		■			■	

Temperature offsets due to pressure (approx. only)	
Pressure psi	Setpoint Offset
100	+3°F
200	+6°F
300	+9°F
400	+12°F
500	+15°F
Collapsing pressure (brass shell) 1400 psi Collapsing pressure (S.S. shell) 3500 osi	

1 SPECIAL MARKING

Special marking may be made by rubber or metal stamping at points A, B and C. Metal stamping at point A requires the switch or switches to be made in separate lots. Amount of marking limited by space at point B. 1/16" sharp face Gothic letter used for marking.

2 EXTENDED LEAD WIRES

Lead wires may be extended to any length. Wire lengths are specified as portion of lead wire outside of THERMOSWITCH Unit such as indicated at dimension "L." Special lead wire stripping may be had by specifying length shown at dimension "X."

3 FACTORY TEMPERATURE SETTING

Any unit may be factory preset at any temperature within its listed range as indicated on page 11 and page 12. Unless this Modification is specified on order, unit will be shipped set at approx. 74°F. Modification 4 or 27 is recommended when ordering a factory set unit to preclude possible shift in set point due to mis-handling.

4 TEMPERATURE LOCKING DEVICE

After a THERMOSWITCH Unit has been calibrated, it is advisable to lock the temperature adjustment sleeve to prevent unauthorized tampering with the setting. The locking device is also desirable if the unit is to be subjected to extreme vibration in service.

5 TAMPER-PROOF CAP

A tamper-proof cap can be furnished to prevent tampering with a THERMOSWITCH Unit equipped with Modification 4 above.

6 DIAL AND KNOB

6A A large dial and knob (as diagrammed) may be added to applicable THERMOSWITCH Units. Graduations on dial are marked from "1" to "7" for adjustment to higher or lower temperature. Units may be ordered unset or factory preset. Pointer or knob will be set on No. 4 dial position unless otherwise specified.

6B Same as 6A above except small dial and knob (as diagrammed).

Mods 6A and 6B applicable to UL and units also.

8 MOISTURE RESISTANT SEAL

8A Under certain operating conditions where there is excessive moisture or vapor, a Moisture Resistant Seal may be added to protect the interior of the THERMOSWITCH Control from seepage. (Modification 13 should be ordered in conjunction with this modification.)

8B Same as 8A above except seal is four hole type so dial and knob may be used. (Modification 13 should be ordered in conjunction with this modification.)

Extreme temperature exposure

Units employing regular tension contacts that open on temperature rise:
−100°F indefinitely and 100°F above Set Point for intervals not exceeding one hour.

Units employing inverse compression contacts that close on temperature rise:
−100°F indefinitely and 100° above high end of temperature range for intervals not exceeding one hour.

10 MOISTURE RESISTANT TAMPER-PROOF CAP

To seal the THERMOSWITCH Unit against moisture and tampering, a Moisture Resistant Tamper-Proof Cap may be mounted over temperature adjusting sleeve. It may be used with unset or factory pre-set units.

11 ARMORED CABLE OVER LEAD WIRES

When additional protection over lead wires is required, an Armored Cable can be added. (Cable is not moisture resistant.) Lead wires will be 6" longer than cable if cable is extended over 12", unless otherwise specified. (Dimension "L" in photo indicates cable length.)

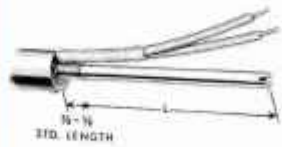
12 CONNECTOR

A Terminal Plug Connector may be added to the end of the wires. Connector may be ordered with or without armored cable (Modification 11) as shown in photo.

13 PACKING GLAND ON LEAD WIRES

In installations where moisture may enter THERMOSWITCH Unit around lead wires, a Packing Gland is recommended around lead wires. (Modification 8 should be used in conjunction with this modification.)

PACKING GLAND



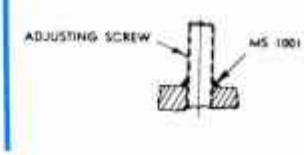
14 EXTENDED TEMPERATURE ADJUSTING SLEEVE

Under certain conditions, it is desirable to extend the adjustment sleeve. Extensions should be ordered in multiples of one inch. When ordering, the length specified is the "extended by" length. For example: If the standard adjusting sleeve length for the unit ordered is ⅝" to ¾" (as diagrammed) and a 4" extension is ordered, the overall length will be 4⅝" to 4¾".

16 DIAL AND KNOB OUTSIDE COVER

16A A dial and knob may be added to outside of junction box on Series 17700 and 17800 units. Refer to Modification 6A for further nomenclature.

16B A dial and knob may be added to outside of junction box on U.L. Listed Series 47700 and 47800 units.



27 TAMPER RESISTANT UNIT

Glyptal (Fenwal part #MS1001) is applied to adjusting screw to provide a tamper resistant unit. Units using this modification are limited to 300°F max. temperature setting.

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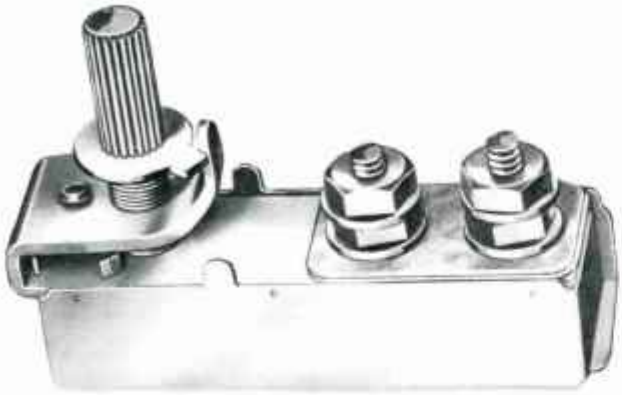
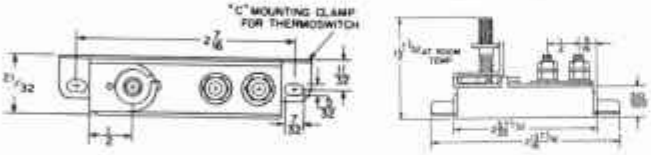
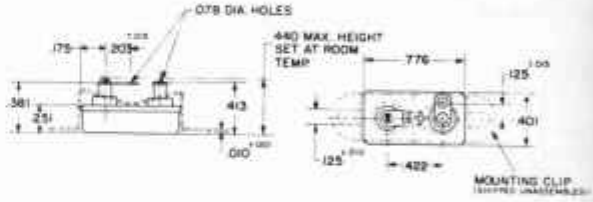
Surface Mounting and Miniature THERMOSWITCH® Controllers







The Fenwal Series 30000 surface mounting THERMOSWITCH controllers operate on the principle of the differential expansion of metals. In this series, the outer shell or case is the activating element. A temperature change is sensed immediately by the case, expanding or contracting in response. This linear change activates an internal bridge, opening the electrical contacts with increase in temperature.

Fenwal Miniature THERMOSWITCH units operate on a unique differential expansion principle. They need not be heated through before responding to temperature change. Rather, the outer case itself is the activating element. This results in (1) short heat transfer path (2) built-in temperature anticipation (3) inherent thermostat sensitivity of less than 1°F.

TYPICAL APPLICATIONS

Appliances, vending machines, platens, plastic laminating presses, dental equipment, popcorn machines, milk pasteurizers, swimming pool heaters, copy machines, overheat limit protection.

TYPICAL APPLICATIONS

Respirators
Label Adhesive Applicators
Vending Machines
Typesetting Machines
Hot Stamp Printers
Textile Platens

Type	CATALOG NUMBER	DESCRIPTION	TEMP RANGE*	CONTACT OPERATION ON TEMP. RISE	MATERIAL	Current Rating (Max. Resistive)
Series 30000 SURFACE MOUNTING	30000-0	Adjustable, low temp. type	50°-300°F	OPENS	S.S. Case and cover Aluminum bronze adjusting screw. Aluminum mounting clamps.	10A, 120VAC 5A, 240VAC
	30000-48		85°-250°F			
	30002-0	Adjustable, high temp. type	50°-600°F			
Series 32400 MINIATURE	32410-2	Rectangular, hermetically sealed with regular contact action	−20° to 200°F	OPENS	S.S. case, copper flashed	2.5A, 120VAC 2.0A, 28 VDC
	32411-2	Same as above with inverse contact action.	−20° to 200°F**	CLOSES		

*Factory Temperature Setting Tolerance: ± 5° or 3% of Setting Value (whichever is greater).
**Up to 275°F when used as limit.

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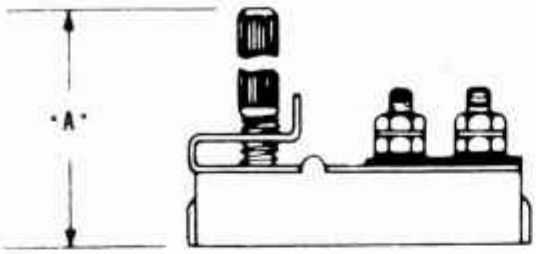
MODIFICATIONS FOR SURFACE MOUNTING and MINIATURE CONTROLLERS

For Series 30000

51



ADJUSTING SCREW LENGTHS

The Temperature Adjusting Screw may be ordered in different lengths so that dimension "A" is as follows:

1-3/64 1-1/4 1-3/4 1-7/8 2-3/8 2-11/16

Unless this modification is specified units will be shipped with dimension "A" 1-1/2" long. Minimum length of "A" is 1-3/64".

When ordering: Specify Cat. No. and Modification 51 with desired length. Typical order would read "Cat. No. 30000-0 with Mod. 51, dimension "A" 1-7/8" long.

52

TEMPERATURE SETTING

Any unit may be factory preset at any temperature within its listed range with a setting tolerance of ±5°F or 3% of setting value, whichever is greater.

Special locking screw is furnished with this modification. (See Mod. 55.)

When Ordering: Specify Modification 52 temperature set at —°F.

55

LOCKING SCREW

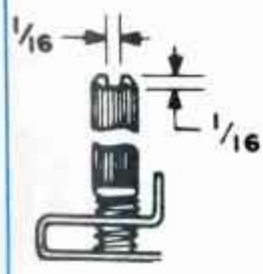
If units are to be temperature set by customer, a special locking screw is provided with unit. Torque spring is not shipped with this unit.

55A

LOCKING SCREW AND TORQUE SPRING

If units are to be temperature set by customer, but still remain adjustable, a locking screw and torque spring are provided with unit.

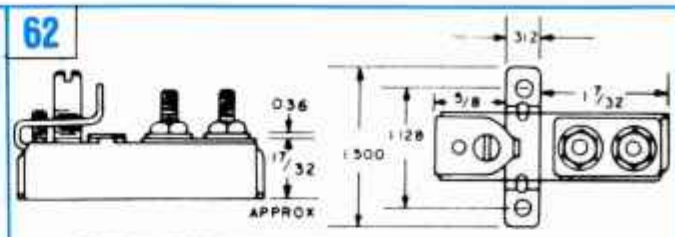
57



SLOTTED TEMPERATURE ADJUSTING SCREW SCREW

For ease of adjustment, using screwdriver, a slot is furnished on top of adjusting screw.

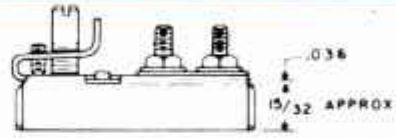
62



SPECIAL CROSS MOUNTING BRACKET

A cross mounting bracket may be added to any Series 3000 Surface Mounting unit as shown on diagram.

62A



Same as No. 62 above except bracket is inverted. See mounting dimensions on diagram.

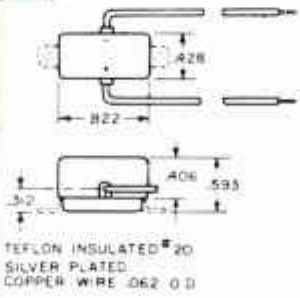
For Series 32400

3

FACTORY TEMPERATURE SETTING

Series 32400 units may be factory preset at any temperature within its listed range. Unless this Modification is specified on order, unit will be shipped set at room temperature (approx. 75°F.)

89



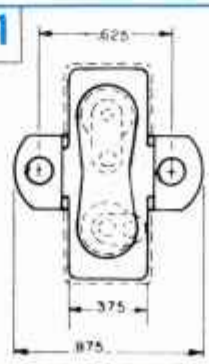
PROTECTIVE CAP & LEAD WIRES

A silicone rubber overmold protective cap for terminal protection may be added to Series 324XX-0 rectangular Miniature units. One foot of attached lead wires is also supplied with this Modification. For longer lengths, specify desired length on sales order.

If mounting attachment is required, order by Catalog No. 32410-0 or 32411-0. Mounting tabs are indicated by dotted line on drawing.

For factory set and sealed units only.

91



MOUNTING BRACKET

A cross mounting bracket as shown may be added to Series 324XX rectangular Miniature units (Mod. 89 above cannot be used in conjunction with this Modification.)

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DETECT-A-FIRE® Detection & Release Devices

DETECT-A-FIRE units are the "heart of many Fire Protection Systems. These highly reliable devices have been a standard of the industry for over 25 years. Many thousands of these units are now in use controlling the release of extinguishing agents such as Halon 1301, CO_2, water, or dry chemicals. In some systems the device is used as an ALARM device, to sense overheat or fire, and alert personnel. In other systems, it is used as a RELEASE device, to sense fire and actuate fire attack systems.

The secret of the unit's sensitivity is in the design (Figure 1). The outer shell is made of a rapidly expanding alloy which closely follows changes in surrounding air temperature. The inner struts are made of a lower expanding alloy. Designed to resist thermal energy absorption and sealed inside the shell, the struts follow temperature changes more slowly.

A slow rate fire (Figure 2) will heat the shell and struts together. At the "set point" the unit will trigger, actuating the alarm or releasing the extinguishant.

But, let a fast rate fire (Figure 3) start and the shell will expand rapidly. The struts will close, actuating the alarm or releasing the agent. The faster the fire rate of growth, the sooner the alarm.

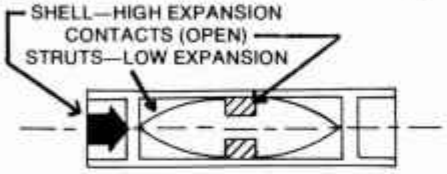


FIG. 1 READY

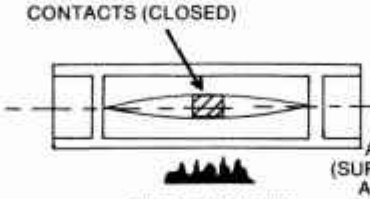


FIG. 2 SLOW FIRE

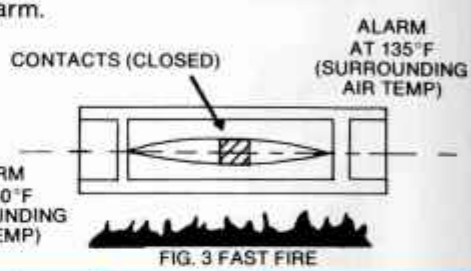
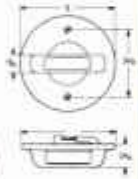
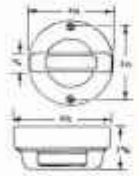
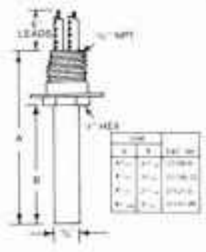


FIG. 3 FAST FIRE

TYPE	Catalog Number	Temperature Ratings (Suggested setting a minimum of 100°F. above ambient) Color Coding and Agency Spacing				Contact Arrangement	Contact Operation On Temp. Rise	Material	Current Rating (Max. Resistive)
		°F Setting	Color Coding	Spacings (in ft.) UL	FM	CSA				
Horizontal Flush Mounting Units for Concealed Wiring  	27020-0	140	No Color	50	25	50	Normally Closed	Opens	S.S. shell sensing element. Cold rolled steel mounting facility. Gray metal primer finish over dull nickel plate	5A, 125 VAC 0.5A 125 VDC
		160	No Color	25	25	25				
	27021-0	190	White	50	25	50	Normally Open	Closes		5A @ 125 VAC 0.5A @ 125 VDC 2.0A @ 24 VDC 1.0A @ 48 VDC
		225	White	50	25	50				
		275	Blue	50	25	50				
		325	Red	50	25	50				
Horizontal Surface Mounting Units For Exposed Wiring  	27020-1	140	No Color	50	25	50	Normally Closed	Opens	Same As Above	5A @ 125 VAC 0.5A @ 125 VDC
		160	No Color	25	25	25				
		190	White	50	25	50				
	27021-1	225	White	50	25	50	Normally Open	Closes		5A @ 125 VAC, 0.5A @ 125 VDC, 2.0A @ 125 VDC, 1.0A @ 48 VDC
		275	Blue	50	25	50				
		325	Red	50	25	50				
Vertical Units For Concealed Wiring  	27120-0	140	Yellow	50	25	50	Normally Closed	Opens (500°F max.)	S.S. shell sensing element. Brass hex head mounting facility. −22 and −20 units are Type 300 S.S., heliarc welded	5A, @ 125 VAC 0.5A @ 125 VDC
	27120-22	160	Yellow	50	25	50				
		190	White	50	25	50				
		210	White	50	25	50				
		225	White	50	25	50				
		275	Blue	50	25	50				
	27121-0	325	Red	50	25	50	Normally Open	Closes		5A @ 125 VAC 0.5A @ 125 VDC 2.0A @ 24 VDC 2.0A @ 24 VDC 1.0A @ 48 VDC
		360	Red	50	25	50				
		450	Green	50	25	50				
		500	Orange	50	25	50				
		600	Orange	50	25	50				
	27121-20	725	Orange	50	25	50				

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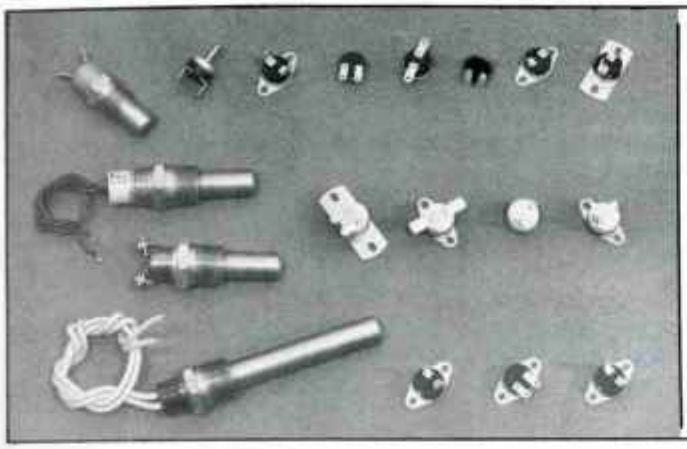
PRECISION SNAP DISC THERMOSTATS



FEATURES

- SNAP ACTION SWITCHING
- TAMPER-PROOF PRESET TEMPERATURE
- CALIBRATED SETTINGS FROM −20 to 550°F
- AUTOMATIC RESET
- SURFACE MOUNTING OR PROBE TYPE
- ALKYD OR CERAMIC BASES
- VARIABLES MOUNTING & TERMINALS

SURFACE MOUNTING TYPES

A positive-acting bimetal snap disc serves as the actuating element in these rugged, precision thermostats. As temperature reaches the tamper-proof predetermined set point, the disc snaps to provide rapid, positive contact action without radio frequency interference.
Designed to meet UL and CSA exacting requirements, these thermostats are individually calibrated and tested to meet both thermal and electrical characteristics. The single contact switch arm assembly minimizes failures due to contact contamination, while the fine silver contacts assure long life and excellent current carrying capacities. Insensitivity to vibration and harsh environments are additional features.

Many terminations and mounting assemblies are available on all models to permit great flexibility in installation. For additional configurations, consult Fenwal.

PROBE TYPES

These probe type thermostats are designed specifically for applications where hermeticity and vibration resistance are required. A snap-acting bimetal disc, mounted in the tip of the probe provides fast thermal response and rapid, positive contact action when the preset temperature is reached.

Two basic types are available: The Series 08-80 is for high temperature applications to 550°F, while the Series 08-81, which features the same rugged construction is ideal for lower temperature ranges up to 350°F.

TEST SAMPLES

Operating samples generally can be supplied for application tests. A completed Fenwal Snap Disc Application Data Form is required to select and produce an operating sample.
Application Data Forms are available from Fenwal or your local Fenwal sales representative.

SPECIFICATIONS

	Model No.	Temp. Range	Tolerance	Differential	Elect. Rating	Ambient Range
SURFACE MOUNTING TYPES	08-01	−10 to 200°F 200 to 275°F 275 to 350°F	Close ±5°F, Open ±7°F Close ±7°F, Open ±8°F Close ±8°F, Open ±10°F	20°F nominal 20°F nominal 30°F nominal	7A @ 120VAC or 30VDC 7A @ 240VAC 240VA, pilot duty	−65 to 350°F
	08-02	−10 to 200°F 200 to 275°F 275 to 350°F	Open ±5°F, Close ±7°F Open ±6°F, Close ±8°F Open ±7°F, Close ±10°F	20°F nominal 25°F nominal 30°F nominal	12A @ 120VAC or 30VDC 10A @ 240VAC 240VA, pilot duty	−65 to 350°F
	08-03	−10 to 200°F 200 to 275°F 275 to 350°F 350 to 400°F 400 to 450°F 450 to 500°F 500 to 550°F	Open ±5°F, Close ±7°F Open ±6°F, Close ±8°F Open ±7°F, Close ±10°F Open ±10°F, Close ±15°F Open ±15°F, Close ±20°F Open ±20°F, Close ±25°F Open ±25°F, Close ±30°F	20°F nominal 25°F nominal 30°F nominal 40°F nominal 60°F nominal 80°F nominal 100°F nominal	5A @ 120VAC or 30VDC 5A @ 240VAC 240VA, pilot duty	−65 to 600°F
	08-04	−10 to 200°F 200 to 275°F 275 to 350°F	Open ±5°F, Close ±7°F Open ±6°F, Close ±8°F Open ±7°F, Close ±10°F	20°F nominal 25°F nominal 30°F nominal	12A @ 120VAC or 30VDC 10A @ 240VAC 240VA, pilot duty	−65 to 350°F
PROBE TYPE	08-80	−10 to 275°F 275 to 300°F 300 to 350°F 350 to 400°F 400 to 450°F 450 to 500°F 500 to 550°F	Close ±5°F, Open ±7°F Close ±7°F, Open ±10°F Close ±10°F, Open ±12°F Close ±12°F, Open ±15°F Close ±15°F, Open ±20°F Close ±20°F, Open ±25°F Close ±25°F, Open ±30°F	20°F nominal 30°F nominal 35°F nominal 35°F nominal 40°F nominal 60°F nominal 100°F nominal	3A @ 120VAC or 30VDC 3A @ 240VAC 240VA, pilot duty	−65 to 600°F
	08-81	−10 to 275°F 275 to 300°F 300 to 350°F	Close ±5°F, Open ±7°F Close ±7°F, Open ±10°F Close ±10°F, Open ±12°F	20°F nominal 30°F nominal 35°F nominal	5A @ 120VAC or 30VDC 5A @ 240VAC 240VA, pilot duty	−65 to 350°F

NOTE: Fenwal Snap Disc thermostats are designed specifically for use by high volume original equipment manufacturers. Minimum quantity order is 50 pieces per model.

FENWAL

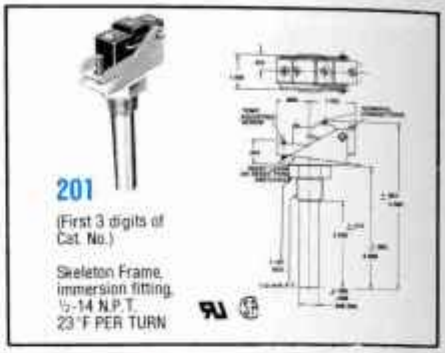
FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

SERIES 20000 SNAP ACTION THERMOSWITCH CONTROLS

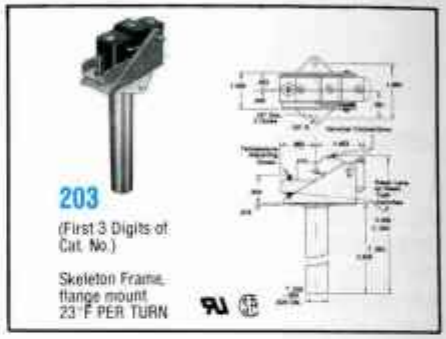
Fenwal presents a complete line of snap-action units with either single or dual switch control. Control action is provided by an expandable liquid action on a bellows assembly. Bellows motion, created by volume changes of the liquid, actuates the switch contacts through a push rod.

- HIGH LOAD CAPACITY—a variation of application rated switches with current ratings up to 15 amps 115-250 VAC, 10 amps 125 VDC.
- FAST RESPONSE—expandable liquid which surrounds bellows is in direct contact with temperature sensing outer shell.
- CUSTOMER ADJUSTED—a temperature adjusting screw provides simple adjustment of temperature range. Switch can easily be set at any temperature within controller's range.
- "INDEPENDENTLY ADJUSTABLE"—on dual switch units each switch may be set individually at any temperature setting within its range thus allowing completely independent action.

VARIETY OF TEMPERATURE RANGES—single switch and dual switch models are available with 3 temperature ranges from —75 to 300°F.



201
(First 3 digits of Cat. No.)
Skeleton Frame, immersion fitting, ½-14 N.P.T. 23°F PER TURN



203
(First 3 Digits of Cat. No.)
Skeleton Frame, flange mount 23°F PER TURN

★ *Minimum Diameter of any point is .812*

CATALOG NO.	CATALOG SUFFIX NO.	TEMPERATURE RANGE	CURRENT RATING	AC CONTACTOR SIZE	JUNCTION BOX FINISH	APPLICABLE MODIFICATIONS (See Page 20)
STANDARD DOUBLE THROW SWITCH ±2°F DIFFERENTIAL						
201, 203	00 10 20	100 to 300°F 25 to 225°F −75 to 125°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC	2	Baked Gray Enamel	3 and 36
210, 211	00 10 20	50 to 300°F 0 to 250°F −75 to 175°F			Cadmium Plated	3, 30, 32, 34, and 36
NARROW DIFFERENTIAL DOUBLE THROW SWITCH ±1°F						
201, 203	03 13 23	100 to 300°F 25 to 225°F −75 to 125°F	15.0A 125-250 VAC	1	Baked Gray Enamel	3 and 36
210, 211	03 13 23	50 to 300°F 0 to 250°F −75 to 175°F			Cadmium Plated	3, 30,32, 34, and 36
HIGH INRUSH DOUBLE THROW SWITCH ±2.5°F						
201, 203	50 60 70	100 to 300°F 25 to 225°F −75 to 125°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC ¾ HP 125 VAC 1½ HP 250 VAC	3	Baked Gray Enamel	3 and 36
210, 211	50 60 70	50 to 300°F 0 to 250°F −75 to 175°F			Cadmium Plated	3, 30, 32 34, and 36
DIRECT CURRENT DOUBLE THROW SWITCH ±6°F						
201,**203**	09 19 29	100 to 300°F 25 to 225°F −75 to 125°F	10.0A 125 VAC ⅛ HP 125 VAC 10.0A 125 VDC ⅛ HP 125 VDC	1	Baked Gray Enamel	3 and 36
210, 211	09 19 29	50 to 300°F 0 to 250°F −75 to 175°F			Cadmium Plated	3, 30, 32 34, and 36
MOISTURE RESISTANT DOUBLE THROW SWITCH ±2°F						
201, 203	53 63	100 to 300°F 25 to 225°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC	2	Baked Gray Enamel	3 and 36
210, 211	53 63	50 to 300°F 0 to 250°F			Cadmium Plated	3, 30, 32, 34, and 36
MANUAL RESET DOUBLE THROW SWITCH—OVERHEAT PROTECTION						
201, 203	06 16 26	100 to 300°F 25 to 225°F −75 to 125°F	15.0A 125-250VAC 0.4A 125 VDC 0.2A 250 VDC	1	Baked Grey Enamel	3 and 36

NOTES: Differential is mechanical. It is not possible to specify control differential because of undetermined parameters such as rate of temperature change, medium, and location of tubular sensing element.

(UL) (SA) symbols denote units listed by Underwriters' Laboratories or Canadian Standards Association for current ratings up to and including 15A 125-250 VAC. High ratings consult factory.

Recognized under the Component Program of Underwriters Laboratories, Inc.

† Types 201 and 203 are not mounted in junction boxes.

†† Screw terminals on Models 201 and 203, are inch pigtails provided on other models in this group.

FENWAL

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Ashland, Mass. 01721 617/881-2000

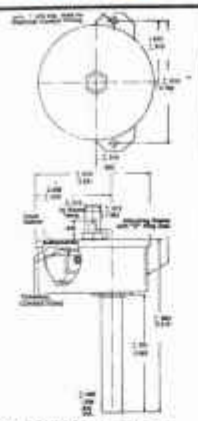
SERIES 20000 SNAP ACTION CONTROLS

(Shown with Mod. 30)

210

(First 3 Digits of Cat. No.)

Junction box. Flange Mounted. Moisture-proof cover, external (sealed) adjustment shaft. Drip proof if installed with electric outlet at bottom. Airtight if electrical outlet is sealed. 280°F PER TURN



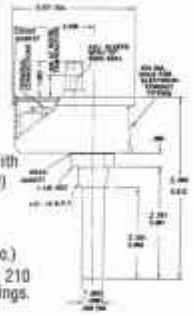
Meets NEMA 1,2,3,4,12

(Shown with Mod. 30)

211

(First 3 Digits of Cat. No.)

Junction Box. Same as 210 but with immersion fittings. ½-14 N.P.T.

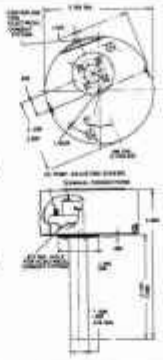


Meets NEMA 1,2,3,4,12

INDEPENDENTLY ADJUSTABLE

227

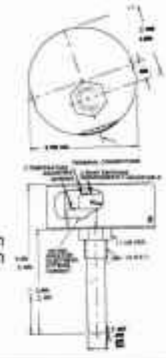
(First 3 Digits of Cat. No.)
Cover not drip proof Junction Box For Air or metal block 23°F Per Turn



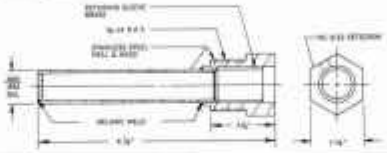
INDEPENDENTLY ADJUSTABLE

228

(First 3 Digits of Cat. No.)
Cover not drip proof Junction Box ½-14 N.P.T. immersion fitting 23°F Per Turn

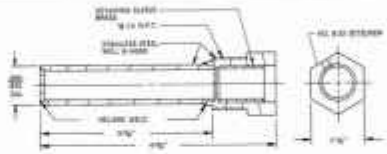


PROTECTIVE WELLS for use with 203, 210, 227 units



Cat. No. 11208-0

Low Pressure Hex Head Well (321 Stainless Steel Well and Head)



Cat. No. 11208-1

High Pressure Hex Head Well (316 Stainless Steel Well and Head)

CATALOG NO.	CATALOG SUFFIX NO.	TEMPERATURE RANGE	SNAP SWITCH TYPE AND DIFFERENTIAL Switch No. 1	Switch No. 2	CURRENT RATINGS Switch No. 1	Switch No. 2	AC CONTACTOR SIZE Switch No. 1	Switch No. 2
227, or 228	00 10 20	100 to 300°F 25 to 225°F −75 to 125°F	Standard Double Throw ±2°F		15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC		2	2
	03 13 23	100 to 300°F 25 to 225°F −75 to 125°F	Narrow Differential Double Throw ±1°F		15.0A 125-250 VAC		1	1
	06 16 26	100 to 300°F 25 to 225°F −75 to 125°F	High Inrush Double Throw ±2.5°F		15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC ⅓HP 125 VAC		3	3
	50 60	100 to 300°F 25 to 225°F	Moisture Resistant Double Throw ±2°F		1½HP 250 VAC 15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC		2	2
	01 11 21	100 to 300°F 25 to 225°F −75 to 125°F	Standard D.T. ±2°F	Narrow Differential D.T. ±1°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC	15.0A 125-250 VAC	2	1
	02 12 22	100 to 300°F 25 to 225°F −75 to 125°F	Standard D.T. ±2°F	High Inrush D.T. ±2.5°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC	15.0A 125-250 VAC ⅓HP 125 VAC 1½HP 250 VAC	2	3
	04 14 24	100 to 300°F 25 to 225°F −75 to 125°F	Narrow Differential D.T. ±1°F	Standard D.T. ±2°F	15.0A 125-250 VAC	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC	1	2
	05 15 25	100 to 300°F 25 to 225°F 75 to 125°F	Narrow Differential D.T. ±1°F	High Inrush D.T. ±2.5°F	15.0A 125-250 VAC	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC ⅓HP 125 VAC 1½HP 250 VAC	1	3
	07 17 27	100 to 300°F 25 to 225°F −75 to 125°F	High Inrush D.T. ±2.5°F	Standard D.T. ±2°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC ⅓HP 125 VAC 1½HP 250 VAC	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC	3	2
	08 18 28	100 to 300°F 25 to 225°F −75 to 125°F	High Inrush D.T. ±2.5°F	Narrow Differential D.T. ±1°F	15.0A 125-250 VAC 0.50A 125 VDC 0.25A 250 VDC ⅓HP 125 VAC 1½HP 250 VAC	15.0A 125-250 VAC	3	1

* Switch No. 1 is nearest electrical outlet hole.

NOTES: Direct current models available on special request. Consult factory.
Differential is mechanical. It is not possible to specify control differential because of undetermined parameters such as rate of temperature change, medium, and location of tubular sensing element.

All switches on this page listed by Underwriters' Laboratories for current ratings up to and including 15A 125-250 VAC. For higher ratings consult factory.
Junction box finish, all models, baked gray enamel.
Applicable modifications all models, 3 and 36.

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

MODIFICATIONS FOR SERIES 20000 SNAP ACTION CONTROLS

3 FACTORY TEMPERATURE SETTING

When factory preset, greater set point accuracy can be attained by specifying the temperature setting desired and which contact (NO or NC) is to open or close on temperature rise or fall. See example under "HOW TO ORDER" section. Unless otherwise specified, unit will be set at midpoint between make and break of contacts.
Factory setting tolerance on all 20000 and 22000 Series THERMOSWITCH controls is ±3°F. On all 21000 Series units it is ±5°F.
Unless this Modification is ordered, unit will be set at approximately 75°F.

30 CALIBRATED DIAL AND KNOB IN °F

A calibrated dial and knob may be added to any Series 210 or 211 units.

30 With temperature range of 50 to 300°F.
30B With temperature range of 0 to 250°F.

32 MOISTURE RESISTANT FITTINGS

A moisture resistant electrical connector may be added to any Series 210 or 211 units.

Mod. No.	Cable, Cord or Conduit Dia.
32A	1/8" to 1/4"
32B	1/2" to 3/8"
32C	3/8" to 1/2"
32D	1/2" to 5/8"
32E	11/16"

34 NON-CALIBRATED DIAL AND KNOB

A non-calibrated dial and knob with arbitrary numerals may be added to any Series 210 or 211 control.

36 HEAT EXCHANGER FINS

In air sensing applications where faster response is needed, heat exchanger fins may be added to any unit.

Note: Addition of modifications may affect agency approvals—consult factory.

SPECIAL FEATURES

34A PLATING

To overcome certain corrosive conditions, the brass shell may be plated with Tin, Cadmium, Nickel or Chromium. (Standard Chromium plating thickness .00002"-.00003" over .001"-.002" Nickel Plate).

NOTE: Special Feature 34A is applicable to all units.

GENERAL NOTES

Unless otherwise specified, all ratings apply to non-inductive loads, such as heaters or resistors. Tungsten filament lamps have an inrush of ten to fifteen times the steady state current. Do not exceed switch ratings at any time.

Any of the snap switches listed is capable of controlling motor contactors up to and including size #1. For specific contactor ratings see the snap switch chart.

Unless otherwise specified, all snap switches will be furnished with screw terminals. DC snap-switches on the 210, and 211 series are furnished with pigtail lead wires.

Sensing bulbs may be exposed indefinitely at −100°F and at the upper limit of the setting range. Snap switch temperature may not be allowed to exceed 180°F.

The variations of single pole, double throw snap switches are easily interchangeable with one another. All units may be safely adjusted at any time throughout the full range.

For pressure applications, set point decreases approximately 1°F per 100 psi applied pressure.

All units not recommended for pressure over 500 psi.

Certain gases or liquids including water at elevated temperatures could be corrosive and may also cause electrolytic action which could severely shorten the life of the controller. Where corrosion or electrolysis is suspect, the use of stainless steel heliarc welded thermowells, various platings or coatings (see above) may increase controller life. The rate of corrosion or electrolysis is influenced by a great many system parameters such as chemical makeup and temperature of the solution, stray electric currents, etc. Consult the supplier of your chemicals or the factory for suggestions.

HOW TO ORDER

1. Select basic switch type from appropriate columns.
2. Select desired temperature range and add suffix number to catalog number.
3. When ordering Modifications, add Modification number after switch catalog number.
4. To order a thermowell, specify the well catalog number.

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

400 LINE LIQUID EXPANSION TEMPERATURE CONTROLLERS

FM Approved High Temperature Limit Switch

INDICATING

NON-INDICATING

UL and CSA Listed

INDICATING

Fenwal offers a large selection of indicating controllers in the "400 Line", including electrical dual or single circuit models, proportioning potentiometric output models; and pneumatic on/off and proportioning models.

Standard snapswitch models can be equipped with additional 5 amp miniature snapswitches, permitting programming of an entire process if required.

Dual switch models can be provided with separate external knobs for easier adjustments of differential.

On-off control of one or more set points is provided through switches actuated by the volumetric expansion of the fill fluid.

As temperature variations cause expansion or contraction of the liquid in the bulb and capillary, changes of pressure are transmitted to a bellows assembly in the actuator housing. This, in turn, moves a push rod which actuates the output (snapswitch, proportioning potentiometric or pneumatic). Both set point and process temperatures are indicated on a large, easy-to-read cali brated dial.

All standard models have dual meter scales indicating both Fahrenheit and Centigrade degrees.

Designed to comply with NEMA requirements for Types 1, 2, 4 and 12.

For outdoor applications, a separate cover or shield is recommended to protect the controller from exposure to the elements.

Neoprene gaskets seal all access ports and covers.

Exposure limits for housing and capillary are −65 to 175°F in units with a top range limit up to and including 200°F; and −100 to 175°F in units with a top range limit from 300°F through 500°F. The 50 to 700°F model has exposure limits of 25 to 175°F.

The 400 features a field replaceable actuator with 1% factory calibration and 1% indication and control accuracy.

NON-INDICATING

UL listed and CSA certified

Fenwal's "400 Line" non-indicating mechanical temperature controllers are lightweight, compact and designed to provide many years of dependable service.
Fenwal's precision internal mechanism* and liquid filled thermal system assures lasting accuracy.

- Ease of installation—just two (2) screws required for mounting housing.
- Simple temperature adjustment—single, easy-to-grip knob for temperature settings.
- Quick snap switch change-mounting arrangement simplifies snap switch replacement.

These are just a few of the many outstanding features of this controller—designed for User Convenience!

Applications for this versatile instrument are limited only by the physical requirements of the thermal system to be controlled.

*U.S. Patent No. 3,038,979

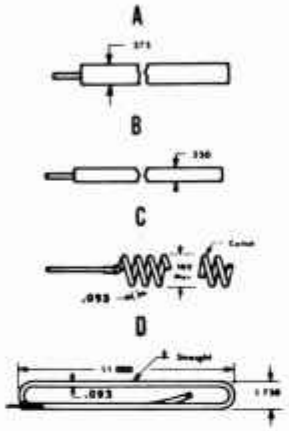
FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

NON-INDICATING CONTROLLERS

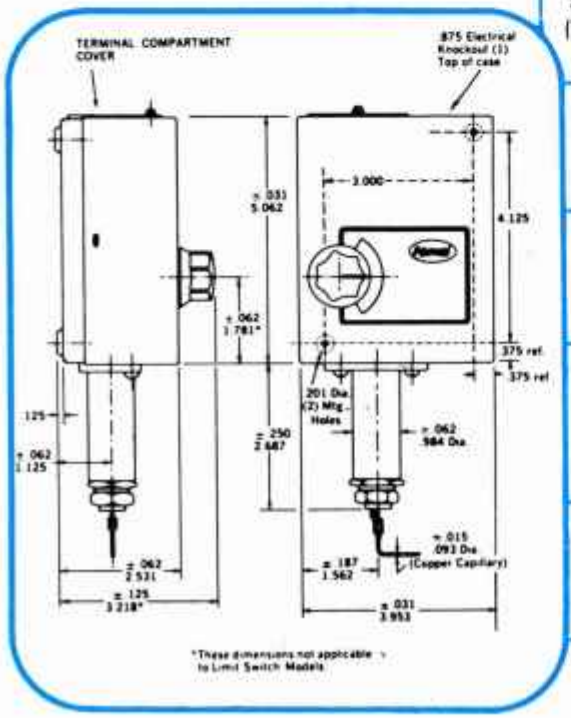
TYPE 316
Stainless Steel to 700°F

For optimum sensitivity select the smallest diameter bulb consistent with the length the installation can accommodate.
Refer to specifications for bulb dimensions.



Style "D" shipping configuration may be straightened at installation; uncoiling may result in calibration offset of ±2% of scale.

Outline Dimensions



SPECIFICATIONS—NON-INDICATING

SERIES 40-302 & 40-303 NON-INDICATING CONTROLLERS			SERIES 40-304 LIMIT SWITCH	
A	B	C	A1	B1
Temperature Scale Range	Single Circuit Models One SPDT Switch One Knob & Dial Catalog Number	Dual Circuit Models Two SPDT Switches *Front Switch High Control Point Rear Switch Low Control Point* One Knob & Dial Traveling Differential Catalog Number	Temperature Scale Range★	FM Approved Catalog Number
-150°F to 200°F (-100°C to 200°C)	40-302092-101 40-302091-101 40-302090-101 40-302089-101	40-303092-101 40-303091-101 40-303090-101 40-303089-101	-50°F to 200°F (-40°C to 100°C) [-90 ± 5°F]	40-304092-101 40-304091-101 40-304090-101 40-304089-101
-20°F to 120°F (-30°C to 50°C)	40-302092-102 40-302091-102 40-302090-102 40-302089-102	40-303092-102 40-303091-102 40-303090-102 40-303089-102	20°F to 120°F [-10 ± 5°F]	40-304092-102 40-304091-102 40-304090-102 40-304089-102
50°F to 200°F (10°C to 95°C)	40-302092-103 40-302091-103 40-302090-103 40-302089-103	40-303092-103 40-303091-103 40-303090-103 40-303089-103	100°F to 200°F (40°C to 95°C) [45 ± 5°F]	40-304092-103 40-304091-103 40-304090-103 40-304089-103
50°F to 300°F (10°C to 150°C)	40-302092-124 40-302091-124 40-302090-124 40-302089-124	40-303092-124 40-303091-124 40-303090-124 40-303089-124	125°F to 300°F (50°C to 150°C) [50 ± 5°F]	40-304092-124 40-304091-124 40-304090-124 40-304089-124
50°F to 400°F (10°C to 200°C)	40-302092-125 40-302091-125 40-302090-125 40-302089-125	40-303092-125 40-303091-125 40-303090-125 40-303089-125	150°F to 400°F (60°C to 200°C) [50 ± 5°F]	40-304092-125 40-304091-125 40-304090-125 40-302089-125
50°F to 500°F (10°C to 260°C)	40-302092-129 40-302091-129 40-302090-129 40-302089-129	40-303092-129 40-303091-129 40-303090-129 40-303089-129	200°F to 500°F (90°C to 260°C) [50 ± 5°F]	40-304092-129 40-304091-129 40-304090-129 40-304089-129
50°F to 700°F (10°C to 370°C)	40-302092-116 40-302091-116 40-302090-116 40-302089-116	40-303092-116 40-303091-116 40-303090-116 40-303089-116	250°F to 700°F (120°C to 370°C) [55 ± 5°F]	40-304092-116 40-304091-116 40-304090-116 40-304089-116
-30°F to 170°F	40-302092-108 40-302091-108 40-302090-108 40-302089-108	40-303092-108 40-303091-108 40-303090-108 40-303089-108	30°F to 170°F [-20 ± 5°F]	40-304092-108 40-304091-108 40-304090-108 40-304089-108

*Figure in brackets indicates factory preset low limit point.

All Specifications are subject to change without notice.

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

NON-INDICATING CONTROLLERS

SPECIFICATIONS

ADDITIONAL SPECIFICATION — ALL MODELS

Actuator Assemblies Only (6' copper capillary with St. St. Bulb) Catalog Number	★ Bulb Style	D BULB† Diameter & Length (In inches)	Current Ratings	AC Contactor Size (NEMA)
40-100092-001	A	3/8 x 2.807	Series 40-302 and 40-303	
40-100091-001	B	1/4 x 5.846		
40-100090-001	C	3/32 x 7.3 (ref)		
40-100089-001	D	3/32 x 55.0 (ref)		
40-100092-002	A	3/8 x 6.984	Standard Differential (2% of Scale Range) SPDT 15A, 125-250VAC 0.50A, 125 VDC 0.25A, 250 VDC	Standard Differential Models
40-100091-002	B	1/4 x 14.875		
40-00091-002	C	3/32 x 18.500(ref)		
40-100089-002	D	3/32 x 143.000(ref)		
40-100092-003	A	3/8 x 5.865	Narrow Differential (1% of Scale Range) SPDT 15A, 125-250 VAC	2
40-100091-003	B	1/4 x 12.500		
40-100090-003	C	3/32 x 15.650(ref)		
40-100089-003	D	3/32 x 119.437 (ref)		
40-100092-024	A	3/8 x 4.400		Narrow Differential Models
40-100091-024	B	1/4 x 9.276		
40-100090-024	C	3/32 x 12.533(ref)		
40-100089-024	D	3/32 x 88.902 (ref)		
40-100092-025	A	3/8 x 3.201		1
40-100091-025	B	1/4 x 6.680		
40-100090-025	C	3/32 x 9.338(ref)		
40-100089-025	D	3/32 x 72.168 (ref)		
40-100092-029	A	3/8 x 2.551	Series 40-304 FM 15A, 125-250 VAI 0.40A, 125 VDC 0.20A, 250VDC	(Contactors NOT furnished with controller)
40-100091-029	B	1/4 x 5.259		
40-100090-029	C	3/32 x 6.843(ref)		
40-100089-028	D	3/32 x 50.328 (ref)		
40-100092-016	A	3/8 x 1.872		
40-100091-016	B	1/4 x 3.866		
40-100090-016	C	3/32 x 5.223(ref)		
40-100089-016	D	3/32 x 25.661(ref)		
40-100092-008	A	3/8 x 4.920		
40-100091-008	B	1/4 x 10.440		
40-100090-008	C	3/32 x 13.300(ref)		
40-100089-008	D	3/32 x 100.100 (ref)		

• MODIFICATIONS See Page

For other special requirements, consult factory

HOW TO ORDER

NON-INDICATING CONTROLLERS SERIES 40-302 & 40-303

1. Select temperature scale range desired from Column A. (If Centigrade Range is required, change 9th digit of Cat. No. as shown below.)
2. Next, decide on mode of operation using Column B or Column C.

   On DUAL SWITCH Models only:

   A. Control knob is normally correlated with Rear Switch. When specified on order, factory will change controller so that control knob and Front Switch are correlated.

   B. Differential is factory set with Rear Switch 10% of scale range Lower than Front Switch. When specified, this differential can be changed to customer requirements between limits of 2 to 50%, ±2% of scale range'
3. Then select the Bulb Style for your application from Column D. (Four choices in each temperature range.) 6' copper capillary normally provided.

SERIES 40-304 LIMIT SWITCH

1. Select temperature range from Column A-1. (If Centigrade Range is required, change 9th digit of catalog number as shown below.)
2. Snap Switches supplied on Limit Switch Controllers CANNOT be substituted.
3. Then select the Bulb Style for your application from Column D. (Four choices in each temperature range.) 6' copper capillary normally provided.

   CAUTION: In corrosive atmospheres, and particularly at temperatures above 500°F. Nickel Plating of Copper Capillaries is recommended.

The chart at left contains the basic specifications and catalog numbering system. To obtain other combinations, change 6th or 9th digit of catalog number as indicated on code below. Other data and catalog digit numbers are selected from chart at left.

40—XXXXXX—XXX

- 1—Fahrenheit Scale
- 2—Centigrade Equivalent Scale
- 0—Standard differential snap switch(es)

NOW—Order your controller by catalog number from Columns B or C based on choice of items 1, 2 and 3 . . . and add appropriate Modifications.

FENWAL
INDICATING CONTROLLERS

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

SPECIFICATIONS

A Temp. Scale Range	40-702 B Single Circuit Models One SPDT Switch One Control Pointer and Knob		40-703 C Dual Circuit Models Two SPDT Switches with Constant Differential One Control Pointer and Knob		40-704 D Dual Circuit Models Two SPDT Switches Two Control Pointers and Knobs		40-723 E (135 ohms) Proportioning Potentiometric Output Models	
	6' Capillary	10' Capillary	6' Capillary	10' Capillary	6' Capillary	10' Capillary	6' Capillary	10' Capillary
−150° to 200°F (−100° to 100°C)	40-702010-401 40-702011-401 40-702012-401 40-702013-401	40-702014-401 40-702015-401 40-702016-401 40-702017-401	40-703010-401 40-703011-401 40-703012-401 40-703013-401	40-703014-401 40-703015-401 40-703016-401 40-703017-401	40-704010-401 40-704011-401 40-704012-401 40-704013-401	40-704014-401 40-704015-401 40-704016-401 40-704017-401	40-723010-401 40-723011-401 40-723012-401 40-723013-401	40-723014-401 40-723015-401 40-723016-401 40-723017-401
−30° to 170°F (−35 to 75°C)	40-702010-406 40-702011-406 40-702012-406 40-702013-406	40-702014-406 40-702015-406 40-702016-406 40-702017-406	40-703010-406 40-703011-406 40-703012-406 40-703013-406	40-703014-406 40-703015-406 40-703016-406 40-703017-406	40-704010-406 40-704011-406 40-704012-406 40-704013-406	40-704014-406 40-704015-406 40-704016-406 40-704017-406	40-723010-406 40-723011-406 40-723012-406 40-723013-406	40-723014-406 40-723015-406 40-723016-406 40-723017-406
−20° to 120°F (−30° to 50°C)	40-702010-402 40-702011-402 40-702-12-402 40-702013-402	40-702014-402 40-702015-402 40-702016-402 40-702017-402	40-703010-402 40-703011-402 40-703012-402 40-703013-402	40-703014-402 40-703015-402 40-703016-402 40-703017-402	40-704010-402 40-704011-402 40-704012-402 40-704013-402	40-704014-402 40-704015-402 40-704016-402 40-704017-402	40-723010-402 40-723011-402 40-723012-402 40-723013-402	40-723014-402 40-723015-402 40-723016-402 40-723017-402
50° to 200°F (10° to 95°C)	40-702010-403 40-702011-403 40-702012-403 40-702013-403	40-702014-403 40-702015-403 40-702016-403 40-702017-403	40-703010-403 40-703011-403 40-703012-403 40-703013-403	40-703014-403 40-703015-403 40-703016-403 40-703017-403	40-704010-403 40-704011-403 40-704012-403 40-704013-403	40-704014-403 40-704015-403 40-704016-403 40-704017-403	40-723010-403 40-723011-403 40-723012-403 40-723013-403	40-723014-403 40-723015-403 40-723016-403 40-723017-403
50° to 300°F (10° to 150°C)	40-702010-424 40-702011-424 40-702012-424 40-702013-424	40-702014-424 40-702015-424 40-702016-424 40-702017-424	40-703010-424 40-703011-424 40-703012-424 40-703013-424	40-703014-424 40-703015-424 40-703016-424 40-703017-424	40-704010-424 40-704011-424 40-704012-424 40-704013-424	40-704014-424 40-704015-424 40-704016-424 40-704017-424	40-723010-424 40-723011-424 40-723012-424 40-723013-424	40-723014-424 40-723015-424 40-723016-424 40-723017-424
50° to 400°F (10° to 200°C)	40-702010-425 40-702011-425 40-702012-425 40-702013-425	40-702014-425 40-702015-425 40-702016-425 40-702017-425	40-703010-425 40-703011-425 40-703012-425 40-703013-425	40-703014-425 40-703015-425 40-703016-425 40-703017-425	40-704010-425 40-704011-425 40-704012-425 40-704013-425	40-704014-425 40-704015-425 40-704016-425 40-704017-425	40-723010-425 40-723011-425 40-723012-425 40-723013-425	40-723014-425 40-723015-425 40-723016-425 40-723017-425
50° to 500°F (10° to 260°C)	40-702010-429 40-702011-429 40-702012-429 40-702013-429	40-702014-429 40-702015-429 40-702016-429 40-702017-429	40-703010-429 40-703011-429 40-703012-429 40-703013-429	40-703014-429 40-703015-429 40-703016-429 40-703017-429	40-704010-429 40-704011-429 40-704012-429 40-704013-429	40-704014-429 40-704015-429 40-704016-429 40-704017-429	40-723010-429 40-723011-429 40-723012-429 40-723013-429	40-723014-429 40-723015-429 40-723016-429 40-723017-429
50° to 700°F (10° to 370°C)	40-702010-416 40-702011-416 40-702012-416 40-702013-416	40-702014-416 40-702015-416 40-702016-416 40-702017-416	40-703010-416 40-703011-416 40-703012-416 40-703013-416	40-703014-416 40-803015-416 40-703016-416 40-703017-416	40-704010-416 40-704011-416 40-704012-416 40-704013-416	40-704014-416 40-704015-416 40-704016-416 40-704017-416	40-723010-416 40-723011-416 40-723012-416 40-723013-416	40-723014-416 40-723015-416 40-723016-416 40-723017-416

HOW TO ORDER

ELECTRIC INDICATING CONTROLLERS SERIES 40-702, 40-703, 40-704 & 40-723

1. Select temperature scale range desired from Column A.
2. Next, decide on the mode of operation using Column B, C, D or E. If other than standard differential snapswitches are required such as Moisture Proof Switches, Modification 157, refer to page and add appropriate number(s) to catalog number.
   appropriate number(s) to catalog number.

On DUAL SWITCH models only: (Column C)

A. Control knob is normally correlated with Rear Switch. When specified on order, factory will change controller so that control knob and Front Switch are correlated.
B. Differential is factory set with Rear Switch 25° of scale range Lower than Front Switch. When specified, this differential can be changed to customer requirements between limits of 2 to 50%, ±2% of scale range. State alternate differential on sales order when required.
C. Independently Adjustable Dual Circuit controllers (Column D) have two external adjustment knobs and two pointers to facilitate set point changes.

3. Then select the Bulb Style for your application from Column F (Four choices in each temperature range). *A 6' or 10' stainless steel capillary is normally provided. Copper capillaries are available upon request.*

The chart above contains the basic specifications and catalog numbers. To obtain other combinations such as: (1) Two external control knobs, (2) alternate snapswitches; change 5th or 6th digit of catalog number as indicated on code below:

Product Code—Series 40-702, 40-703 & 40-704
40-70XXXX-XXX

- Temperature Scale Range
- Bulb Style & Capillary Length
- 1 thru 8, Alternate Snapswitches Consult Factory
- 2—Single Circuit, One Knob, 1 Pointer
- 3—Dual Circuit, One Knob, 1 Pointer Constant Differential
- 4—Dual Circuit, Two Knobs, 2 Pointers Independently Adjustable

Product Code—Series 40-723
40-7230XX-XXX

- Temperature Scale Range
- Bulb Style & Capillary Length

NOW—Order your controller by catalog number from Columns B, C, D or E . . . and add appropriate Modification.

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

INDICATING CONTROLLERS

Actuator Assemblies Only Stainless Steel Bulb 6' Capillary	10' Capillary	F Bulb Style	Bulb Diameter x Length (in inches)	40-830 G Proportional Output Pressure Rating 0 to 100 PSIG (Max.) Top Valve Exit 6' Capillary	40831 H Proportional Output Pressure Rating 0 to 100 PSIG (Max.) Bottom Valve Exit 6' Capillary	40-835 I On-Off Snap Action Pressure Rating 0 to 30 PSIG (Max.) Bottom Exit 6' Capillary	Additional Specifications
40-100010-001	40-100014-001	A	3/8 x 2.807	40-830010-401	40-831010-401	40-835010-401	Bulb & Capillary Material Type 316 Stainless Steel
40-100011-001	40-100015-001	B	1/4 x 5.846	40-830011-401	40-831011-401	40-835011-401	
40-100012-001	40-100016-001	C	3/32 x 7.3 (ref.)	40-830012-401	40-831012-401	40-835012-401	
40-100013-001	40-100017-001	D	3/32 x 55.0 (ref.)	40-830013-401	40-831013-401	40-835013-401	
40-100010-008	40-100014-008	A	3/8 x 4.920	40-830010-408	40-831020-408	40-835010-408	AC Contactor Size (NEMA)
40-100011-008	40-100015-008	B	1/4 x 10.440	40-830011-408	40-831011-408	40-835011-408	
40-100012-008	40-100016-008	C	3/32 x 13.3 (ref.)	40-830012-408	40-831011-408	40-835012-408	
40-100013-008	40-100017-008	D	3/32 x 100.1 (ref)	40-830013-408	40-831012-408	40-835013-408	
40-100010-002	40-100014-002	A	3/8 x 6.984	40-830010-402	40-831010-402	40-835010-402	Standard Differential Models 2
40-100011-002	40-100015-002	B	1/4 x 14.875	40-830011-402	40-831011-402	40-835011-402	
40-100012-002	40-100016-002	C	3/32 x 18.5 (ref.)	40-830012-402	40-831012-402	40-835012-402	
40-100013-002	40-100017-002	D	3/32 x 143.0 (ref.)	40-830013-402	40-831013-402	40-835013-402	
40-100010-003	40-100014-003	A	3/8 x 5.865	40-830010-403	40-831010-403	40-835010-403	Narrow Differential Models 1
40-100011-003	40-100015-003	B	1/4 x 12.500	40-830011-403	40-831011-403	40-835011-403	
40-100012-003	40-100016-003	C	3/32 x 15.6 (ref.)	40-830012-403	40-831012-403	40-835012-403	
40-100013-003	40-100017-003	D	3/32 x 119.4 (ref.)	40-830013-403	40-831013-403	40-835013-403	
40-100010-024	40-100014-024	A	3/8 x 4.400	40-830010-424	40-831010-424	40-835010-424	(Contactors Not Furnished with Controller
40-100011-024	40-100015-024	B	1/4 x 9.276	40-830011-424	40-831011-424	40-835011-424	
40-100012-024	40-100016-024	C	3/32 x 12.533 (ref.)	40-830012-425	40-831012-424	40-835012-424	
40-100013-024	40-100017-024	D	3/32 x 88.902 (ref.)	40-830013-425	40-831013-424	40-835013-424	
40-100010-025	40-100014-025	A	3/8 x 3.201	40-830010-425	40-831010-425	40-835010-425	Current Ratings Series 40-702, 40-703 40-704
40-100011-025	40-100015-025	B	1/4 x 6.680	40-830011-425	40-831011-425	40-835011-425	
40-100012-025	40-100016-025	C	3/32 x 9.338 (ref.)	40-830012-424	40-831012-425	40-835012-425	
40-100013-025	40-100017-025	D	3/32 x 72.168 (ref.)	40-830013-425	40-831013-425	40-835013-425	
40-100010-029	40-100014-029	A	3/8 x 2.551	40-830010-429	40-831010-429	40-835010-429	Standard Differential SPDT 15A, 125-250 VAC 0.5A, 125 VDC 0.25A, 250 VDC
40-100011-029	40-100015-029	B	1/4 x 5.259	40-830011-429	40-831011-429	40-835011-429	
40-100012-029	40-100016-029	C	3/32 x 6.843 (ref.)	40-830012-429	40-831012-429	40-835012-429	
40-100013-029	40-100017-029	D	3/32 x 50.328 (ref.)	40-830013-429	40-831013-429	40-835013-429	
40-100010-016	40-100014-016	A	3/8 x 1.872	40-830010-416	40-831010-416	40-835010-416	Narrow Differential SPDT 15A, 125-250 VAC Series 40-723 135 Ohms Potentiometric Output 24 VAC max.
40-100012-016	40-100015-016	B	1/4 x 3.866	40-830011-416	40-831011-416	40-835011-416	
40-100012-016	40-100016-016	C	3/32 x 5.223 (ref.)	40-830012-416	40-831012-416	40-835012-416	
40-100013-016	40-100017-016	D	3/32 x 35.661 (ref.)	40-830013-416	40-831013-416	40-835013-416	

All specifications are subject to change without notice

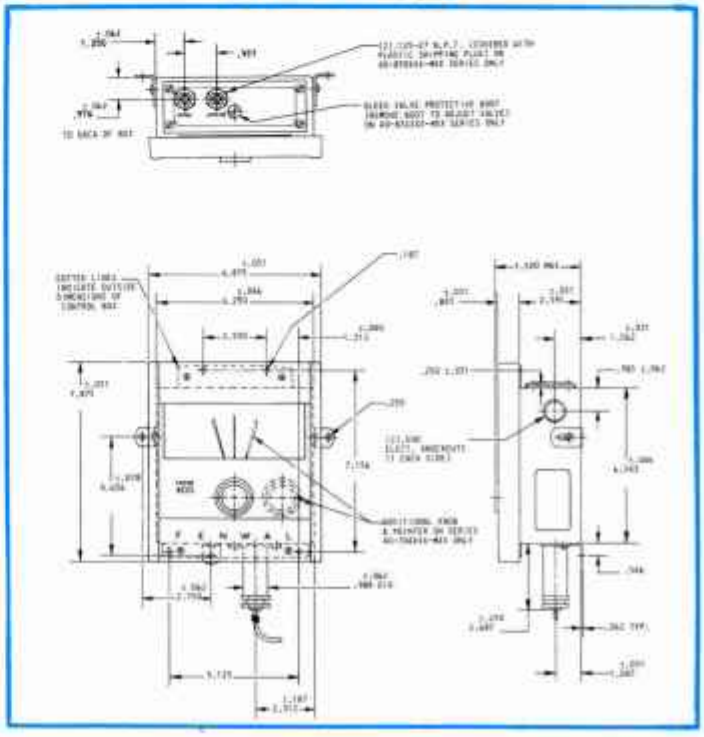
HOW TO ORDER

PNEUMATIC INDICATING CONTROLLERS
SERIES 40-83X

1. Select temperature scale range desired from Column A.
2. Next decide on mode of operation using Columns G, H, or I. If other than standard units are required, consult factory.
3. Then select the Bulb Style for your application from Column F (Four choices each temperature range) ***A 6' or 10' stainless steel capillary is normally provided. Copper capillaries are available upon request.***

NOW—Order your controller by catalog number from Column G, H or I based on choice of items 1, 2 and 3 . . . and add appropriate Modification and Special Feature numbers to order.

OUTLINE DIMENSIONS



FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

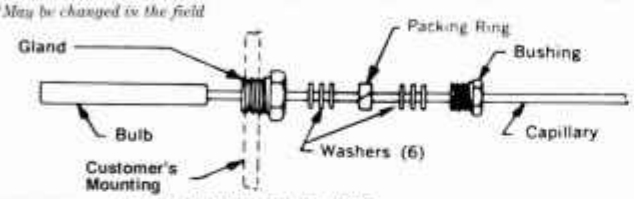
MODIFICATIONS FOR INDICATING and NON-INDICATING CONTROLLERS

MOD. 25—PACKING GLAND

Addition of a capillary tube packing gland to any remote bulb type temperature controller.
For bulb diameter .375 nominal or smaller; Bulb Styles "A" "B" and "D". Pressure 400 P.S.I. at 700°F.

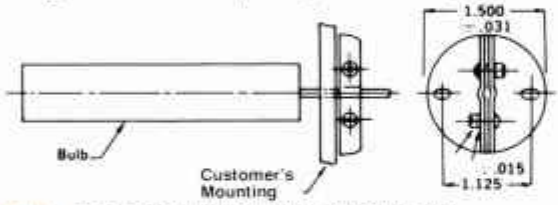
Brass Nickel Plated		300 Series Stainless Steel	
Mod. No.	Gland Size	Mod. No.	Gland Size
25A*	⅜-18 NPT	25D*	⅜-18 NPT
25B*	½-14 NPT	25E*	½-14 NPT
25C*	¾-14 NPT	25F*	¾-14 NPT

May be changed in the field



MOD. 25J—SPLIT MOUNTING FLANGE

For use with coiled bulb "C". Not for use as seal against harmful gases or where liquid tight seal is required.



MOD. 65—ARMORED CABLE AND PACKING GLAND

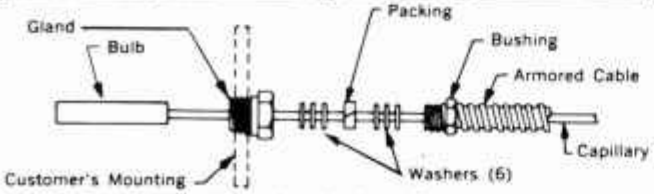
The addition of armored cable and capillary tube packing gland to a remote bulb type temperature controller (bulb styles "A", "B" and "D"). Pressure 400 psi at 700°F.

ARMORED CABLE Length Stainless Steel	Mod. No.	ARMORED CABLE Length Stainless Steel	Mod. No.
2½ to 3'	65A	over 13 to 14'	65L
over 3 to 4'	65B	over 14 to 15'	65M
over 4 to 5'	65C	over 15 to 16'	65N
over 5 to 6'	65D	over 16 to 17'	65(O)
over 6 to 7'	65E	over 17 to 18'	65P
over 7 to 8'	65F	over 18 to 19'	65Q
over 8 to 9'	65G	over 19 to 20'	65R
over 9 to 10'	65H	over 20 to 25'	65S
over 10 to 11'	65(I)	over 25 to 30'	65T
over 11 to 12'	65J	over 30 to 35'	65U
over 12 to 13'	65K	over 35 to 40'*	65V

For longer lengths—consult factory

Packing Gland

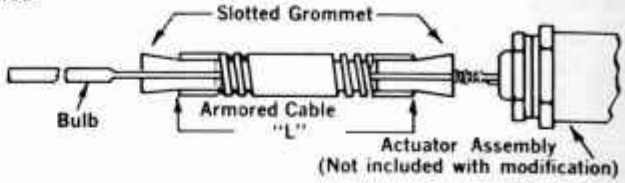
Brass Nickel Plated		300 Series Stainless Steel	
Style	Gland Size	Style	Gland Size
A	⅜-18 NPT	D	⅜-18 NPT
B	½-14 NPT	E	½-14 NPT
C	¾-14 NPT	F	¾-14 NPT



NOTE: This mod. shipped unattached unless otherwise specified on order.
When ordering this modification provide model number and letter plus letter for gland style; i.e., Mod. 65J, Style E.

MOD. 107—ARMORED CABLE AND GROMMET

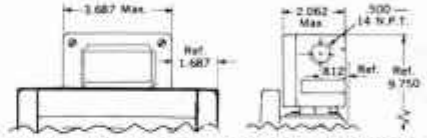
For addition to capillary tubing having bulb styles "B" and "D" only. Stainless Steel armored cable and rubber grommet.



When ordering this modification, specify dimension "L", Armored Cable Length. Available in from 1' to 20' lengths.

MOD. 110—EXPLOSION PROOF HOUSING

For addition only to Single Switch Models 40-7020XX-XXX with standard Double Throw Switch. Instrument can be surface mounted only.



U.L. approved switch compartment. Suitable for use in Class I, Groups C and D; or Class II, Groups E, F and G locations.

MOD. 111—DIAL STOP—INDICATING ONLY

The addition of a stop collar to limit either high or low setting of pointer. Modification is factory installed and **not** field adjustable. Specify temperature setting desired on order.

MOD. 157—MOISTURE PROOF SNAPSWITCH

The substitution of a moisture proof switch for any **standard differential** snapswitch.

INDICATING	NON INDICATING
MOD. 157A—Single Switch Controllers	MOD. 157C
MOD. 157B—Dual Switch Controllers	MOD. 157D

MOD. 158—HIGH INRUSH SWITCHES

The substitution of a high inrush snapswitch for a standard differential snapswitch. Applicable to Series 40-702 single switch controllers only.

MOD. 40-992032-XXX

Application of protective sleeving over bulb and capillary of any "B" style bulb (max. temp. 180°F). Specify desired length in feet in suffix number. EX: 40-992032-006 = 6 feet length. (See note, below)

MOD. 40-992046-001—INDICATING ONLY

A feature that will deactivate the controller in heating applications in event of capillary damage. (Can be field installed, however, only U.L. recognized if factory installed.)

MOD. 40-992065-1XX

Application of protective tubing (Teflon®) over the bulb and capillary of any Style "B" bulb. (max. temp. 400°F.) Specify desired length in feet in suffix number.

NOTE: The use of this Teflon tubing to obtain corrosion resistance is believed to be thoroughly reliable. However, the many and varied chemical solutions and operating temperatures do not permit a guarantee. Each application should be carefully evaluated.

Note—Contact factory for UL or CSA listing

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

SERIES 550 and 551 DIN SIZED TEMPERATURE CONTROLLERS

FEATURES

- Thermistor and Thermocouple Sensing Models
- On/Off Time Proportioning and PID Control Modes
- Full Scale or Nonindicating Models
- Lead Break Protection
- Dual Set Point Control in DIN Size Package
- Easy to mount from in front of panel
- 10 amp relay outputs or output for solid state relay
- UL Componet recognized

The **Series 550** operates with standard Types T, K, and R thermocouples and is available in six models and temperature ranges from -200 to 2500°F. and equivalent Centigrade ranges. (See Table II.)

The Series 550 is supplied as a single or dual set point control. The first point is adjustable 100% of span while the second is adjustable up to 20% above or below the first set point With on/off control on the second point either high limit or low limit action is field selectable.

The **Series 551** operates with Fenwal Thermistor Probes, which are available in a wide selection of configurations. Thermistor lead extensions are standard copper wire. Available as single set point, on/off and time proportioning full scale indicating controller.

Adjustments for bandwidth and reset are made from front panel controls and permit 'tuning' the controller to system to meet your particular heating and cooling needs. To simplify mounting, Series 551 design allows one man, in-front of panel mounting.

SPECIFICATIONS

INPUT POWER:
120,208,240VAC, +10%, −15%, 50-60Hz, field selectable. NOTE: the controller will function within rated specifications under "brownout" conditions down to 15% below nominal line voltage.

OUTPUT

Single set point and first set point on Dual point models:

RELAY (SPDT and DPDT)
Resistive—10A @ 120VAC 50/60 Hz or SA @ 208/240VAC 50/60 Hz. Pilot duty, 250VA, 240VAC maximum.

SOLID-STATE RELAY DRIVER
Capable of driving SSR with isolated 3-32VDC control signal input. Instrument not damaged by shorted output terminals. De-energized output less than 1VDC. Energized output less than 32VDC with no load on output and instrument voltage @ +10% from nominal; greater than 5VDC with 200Ω load on output with instrument voltage @ −15% from nominal.

4-20mA DRIVER
Capable of driving with 4-20 mA control signal input. Max. load resistance is 750Ω. Instrument is not damaged by shorted output terminals.

20A @ 240VAC with integral heat sink. For availability and detailed specifications, consult factory.

Second set point on Dual point models:

Resistive—10A @ 120VAC, 50/60 Hz or 5A @ 208/240VAC, 50/60 Hz. Pilot duty, 250VA, 240VAC maximum.

ADD OUTPUTS:
4-20 mA models; 10A SSR output;
20A SSR output

AMBIENT TEMPERATURE LIMITS:
Operating——32 to 135°F.
Storage ——20 to 165°F.

ACCURACY (Set Point and Indication):
±1% of dial span under nominal conditions.

CYCLE TIME (internally adjustable):
Relay output controller—10 to 20 seconds.
Solid state relay driver—0.35 to 1 second.

BANDWIDTH (Proportioning Units):
Single set point: 1 to 10% of dial span; front panel adjustment; Second set point 5-20%.

OFFSET ADJUSTMENT (Proportioning Units):
Manual reset—Manually adjustable within the bandwidth; front panel adjustment.

CONTROL STABILITY:
Control point will remain within below stated limits with line voltage changes of +10%, −15% from nominal;
On/Off units—±0.25% of dial span.
Proportioning Units—±0.25% of dial span at minimum bandwidth, ±1% of dial span at maximum bandwidth.
Control point will remain within ±1% of dial span with ambient changes from 32 to 135°F.

LEAD BREAK PROTECTION:
550—Relay will de-energize upon an open thermocouple (500K ohms or greater) with the case grounded, terminals TC+ or TC− grounded or floating with either polarity of line voltage applied to instrument power terminals.
551—Relay will de-energize upon an open thermistor probe.

DIFFERENTIAL (On/Off Units):
0.1% of range, typical.

TERMINALIZATION:
No. 6 screw barrier strip on rear panel; will accept bare wire or No. 6 spade/ring terminals (supplied).

ADDITIONAL SPECIFICATIONS

PID Models only (first set point)
Reset Rate: 0.1 to 5 repeats/min.
Rate: 30 seconds nom.

550 FM Approved Hi-limit
(Single set point): Output energized above set point; resets automatically on power failure. Provisions SPDT models for remote reset. Standard set point adjustment requires a screwdriver.

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INSTRUMENT TYPES AND MODEL NUMBERS — TABLE 1 — SERIES 550 and 551

Controller Description	Input	Control Mode	Output				
			SPDT Relay	DPDT Relay	To Drive SSR	4-20mA Driver	20A SSR
Non Indicating Single Setpoint	Thermcouple	On/Off	55-001110-xxx	55-001410-xxx	55-001210-xxx	—	—
Deviation Indicating Single Setpoint	Thermocouple	On/Off Proportioning PID	55-001120-xxx 55003120-xxx 55-004120-xxx	55-001420-xxx 55-003420-xxx 55-004420-xxx	55-001220-xxx 55-003220-xxx 55-004220-xxx	— — —	— 55-003620-xxx —
Full Scale Indicating Single Setpoint	Thermocouple	On/Off Proportioning PID FM Approved High Limit	55-001140-xxx 55-003140-xxx 55-004140-xxx 55-002140-xxx	55-001440-xxx 55-003440-xxx 55-004440-xxx 55-002440-xxx	55-001240-xxx 55-003240-xxx 55-004240-xxx —	— 55-003540-xxx 55-004540-xxx —	— 55-003640-xxx 55-004640-xxx —
Full Scale Indicating Dual Point	Thermocouple	On/Off-On/Off Prop.-On/Off Prop.-Prop. PID-On/Off PID-Prop.	55-011140-xxx 55-013140-xxx 55-023140-xxx 55-014140-xxx 55-024140-xxx	55-011440-xxx 55-013440-xxx 55-023440-xxx 55-014440-xxx 55-024440-xxx	55-011240-xxx 55-013240-xxx 55-023240-xxx 55-014240-xxx 55-024240-xxx	— 55-013540-xxx — — —	— — — — —
Non Indicating Single Setpoint 72mm Square	Thermocouple	Proportioning	55-003010-400	—	—	—	—
Deviation Indicating Single Digital Setpoint 72mm Square	Thermocouple	Proportioning	55-003020-400	—	—	—	—
Digital Indicating	RTD* Thermocouple	On/Off Proportioning	55-001160-xxx 55-003160-xxx	— —	— —	— —	— —
Full Scale Indicating Single Setpoint	Thermistor	On/Off Proportioning PID	55-101140-xxx 55-103140-xxx 55-104140-xxx	55-101440-xxx 55-103440-xxx 55-104440-xxx	55-101240-xxx 55-103240-xxx 55-104240-xxx	— — —	— — —

*For use with 55-001160-406, 100 Plt RTD (JIS C1604);
S.S. Coupling type with ¼-18NPT Threads: ⅛" dia. probes with 2.5" under threads.

TEMPERATURE RANGES — TABLE 2

550 Non-Indicating & Deviation Model

Temp. Range	Suffix Number	ISA Type Thermocouple	Full Scale Increments	Deviation Meter Range	Deviation Meter Increments
-200° to 400°F	-101	T	10°	±50°	5°
0° to 800°F	-103	J	10°	±50°	5°
0° to 1200°F	-108	J	20°	±100°	10°
0° to 2000°F	-106	K	20°	±100°	10°
1000° to 2500°F	-120	R	20°	±100°	10°
-130° to 200°C	-201	T	5°	±50°	5°
-20° to 430°C	-203	J	5°	±30°	5°
-20° to 650°C	-208	J	10°	±50°	5°
-20° to 1100°C	-206	K	20°	±50°	5°
540° to 1370°C	-220	R	10°	±50°	5°

550 Full Scale Indicating Models

Temp. Range	Suffix Number	Isa Type Thermocouple	Full Scale Increments °F	Full Scale Increments °C
-200° to 400°F/-130° to 200°C	-301	T	10°	5°
0° to 400°F/-20° to 200°C	-302	J	5°	5°
0° to 800°F/-20° to 430°C	-303	J	10°	5°
0° to 1200°F/-20° to 650°C	-308	J	20°	10°
0° to 2000°F/-20° to 1100°C	-306	K	20°	20°
1000° to 2500°F/540° to 1370°C	-320	R	20°	10°

551 Full Scale Indicating Models

Temp. Range	Suffix Number	Thermistor Probes	Full Scale Increments °F	Full Scale Increments °C
50° to 150°F/10° to 65°C	-345	Note 1	1°	0.5°
-50° to 150°F/-45° to 65°C	-340		2°	1°
25° to 250°F/0° to 120°C	-341		2°	1°
100° to 400°F/35° to 205°C	-342	Note 2	5°	2°
200° to 600°F/95° to 315°C	-343		5°	2°
300° to 750°F/150° to 400°C	-344		5°	2°

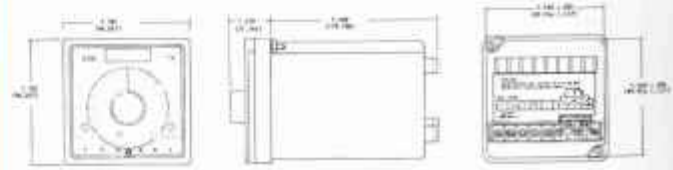
Digital Indicating Model 55-00X160-XXX

Temp. Range	Suffix Number	ISA Type Thermocouple
0° to 1000°F	-400	J
0° to 2500°F	-401	K
0° to 1200°F	-404	K
0° to 400°F	-405	J
Temp. Range	**Suffix Number**	**ISA Type RTD**
0° to 50°C	-406	100 Ω Plt

Note 1 — Matched probes must be used for best systems accuracy. P.N. 28-232xxx-xxx
Note 2 — Low Temperature Precision Assemblies must be used for -50 to 150°F or -50 to 50°C range. P.N. 28-432xxx-x04, -50 to 150°F/-45 to 65°C P.N. 28-432xxx-x08.

OUTLINE DIMENSIONS

FULL SCALE INDICATION MODELS



NON-INDICATING AND DEVIATION MODELS

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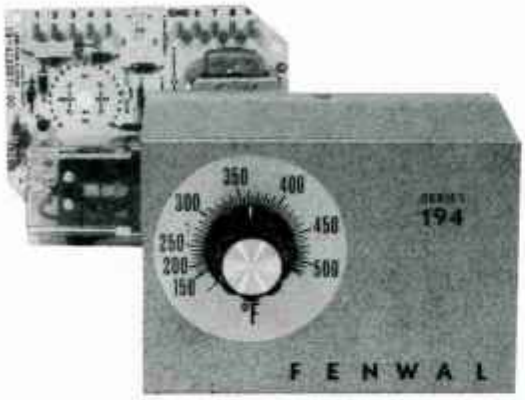
SERIES 194

THERMISTOR SENSING TEMPERATURE CONTROLLER WITH REMOTE INDICATING METER OPTIONS



Relay Output Controller

Triac Output Controller

FEATURES

Relay or Triac outputs . . . lead break protection . . . 120, 208, 240 VAC inputs . . . full transformer isolation . . . remote single or multi-point indication option . . . local or remote set point . . . line voltage compensation . . . on/off or adjustable proportioning control . . . −90 to 700°F in five ranges.

TYPICAL APPLICATIONS

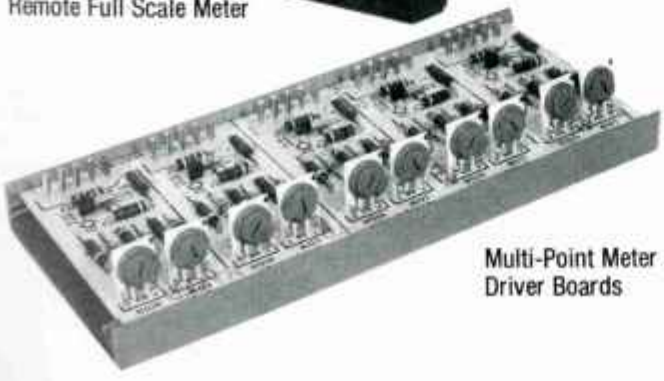
- Thermoplastic Packaging
- Injection Molding
- Photographic Processing
- Hot Stamp Printing
- Compression Molding
- Hot Melt Glue Applications
- Environmental Test Chambers
- Sterilization Systems
- Plastic Molding
- Food Processing

The Fenwal Series 194 is a versatile, economical solution to virtually any temperature control problem in the −90 to 700°F range. These thermistor sensing controllers provide lead break protection against both open and shorted leads, a choice of five relay or triac outputs, plus an optional meter for full scale indication of from one to ten stations.

Field selectable input voltages, local or remote set point adjustment and flexible mounting options, including a unique "Reverse Shaft" feature, provide additional versatility.

Combined with long-lasting, highly sensitive thermistor sensors, the Series 194 offers low cost, accurate temperature control designed to satisfy your most demanding applications.

Remote Full Scale Meter



Multi-Point Meter Driver Boards

Sensors and Accessories

FENWAL

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SPECIFICATIONS FOR SERIES 194 CONTROLLERS

CONTROLLERS

CONTROL MODES:
On/Off or Adjustable Time Proportioning.

TEMPERATURE RANGES:
−90 to 700°F in five overlapping ranges (and equivalent Centigrade scales). See Tables III and IV for ranges. Other ranges available, consult factory.

INPUT POWER:
120, 208 or 240VAC, ±10%, 50-60Hz, field selectable.

OUTPUT RATED LOAD:
Relay Models — SPDT heavy duty relay rated 10 amps @ 120 VAC, 5 amps @ 208/240VAC, resistive; 250VA up to 240VAC, inductive.

— DPDT heavy duty relay rated 10 amps @ 120 VAC, 5 amps @ 208/240VAC each contact set, resistive; 250VA up to 240VAC, inductive.

— SPDM heavy duty relay rated 25 amps @ 120 VAC, 12.5 amps @ 208/240VAC, resistive; 760VA up to 240 VAC, inductive.

TRIAC MODELS — 10 amp model rated per Figure 1 at 120, 208, 240 VAC. Inrush: 150 amps.
NOTE: Controller must be mounted to minimum of 2 square foot 20 ga. metal panel with both sides radiating. 1 amp pilot duty model, rated per Figure 1 at 120, 208, 240 VAC. Inrush: 50 amps.

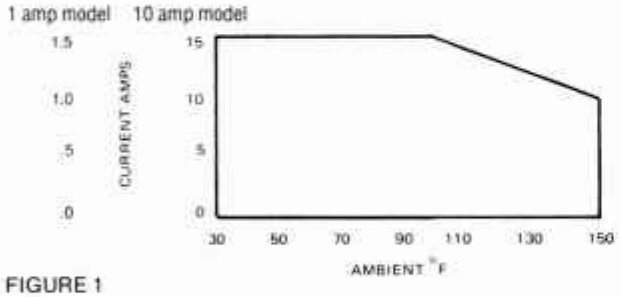

FIGURE 1

VIBRATION:
Exceeds MIL STD 202D, Method 201A.

AMBIENT TEMPERATURE LIMITS:
Relay Model — 30 to 130°F, operating; −50 to 165°F, storage.
Triac Model — 30 to 155°F, operating; −50 to 165°F, storage.

SET POINT ADJUST:
Local or remote; "Reverse Shaft" option for thru-panel mounting. See HOW TO ORDER Section.

SET POINT ACCURACY:
Local set point typically 5% of range.
Remote set point typically 3% of range.
NOTE: Accuracies are based on nominal Fenwal thermistor resistance curves. Accuracies can be improved through calibration to user's thermal system.

SET POINT STABILITY:
Will not exceed 2% of span, from nominal, with ambient changes from 30 to 135°F and line voltage changes of ±10%.

DIFFERENTIAL (On/Off Models):
Typically 0.2°F at mid-range.

BANDWIDTH (Proportioning Models):
Adjustable from 1.0 to 5% of range, typical.

CYCLE TIME (Proportioning Models):
Relay Model — 15 seconds typical; 10 seconds minimum; fixed.
10 amp Triac Model — 1 second, typical; fixed.
1 amp Triac Model — 10 seconds typical; fixed.

LEAD BREAK PROTECTION:
Controller will de-energize heating load on lead break. Power cut-off is guaranteed over 1.5M ohms. Controller will de-energize heating load on lead short. NOTE: Lead break protection can be eliminated if required, any range, for cooling applications. Consult factory for details.

TERMINALIZATION:
Relay Model — 3/16" Quick connect terminals. 25 amp model, 6" lead wires, load connections only.
Triac Model — 9 pin Molex plug.
Meter — Pin connectors.
See MODIFICATIONS Section for ordering details.

10A, SPDT Relay and Triac output and 25A models are UL Component Recognized. ℛ

REMOTE INDICATING METERING UNIT

TEMPERATURE RANGES:
See Table III.

ACCURACY:
3% of range when meter is calibrated to controller.
NOTE: Accuracies are based on nominal Fenwal thermistor resistance curves. Accuracies can be improved through calibration to user's thermal system.

SUPPLY VOLTAGE:
12VDC, supplied by 194 controller.

STABILITY:
Will not exceed 2% of range with ambient change from 32 to 130°F. Will not exceed 1% of range with line voltage variations of ±10% from nominal.

TERMINALIZATION:
Molex connector with 2' lead wires standard. On multi-point models, 12" lead wires with ring terminals for connection to channel selector switch. For different lead lengths, see MODIFICATIONS.

READABILITY:
2.5°. Minor scale divisions, 5° on all ranges.

19-45 Indicating Meter is UL Component Recognized ℛ

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ORDERING INFORMATION—SERIES 194 CONTROLLERS

TABLE I

19-404105-100

TYPE	CODE
PROPORTIONING	0
ON/OFF	2

OUTPUT	CODE
RELAY—SPDT, 10A	00
RELAY—DPDT, 10A	01
RELAY—SPDM, 25A	04
TRIAC—1A	10
TRIAC—10A with integral heat sink	17

SET POINT ADJUSTMENT		CODE
WITHOUT LEAD BREAK PROTECTION		
	LOCAL	0
	REMOTE	2
	LOCAL, REVERSE SHAFT	4
WITH LEAD BREAK PROTECTION		
	LOCAL	5
	REMOTE	7
	LOCAL, REVERSE SHAFT	9

ENCLOSURE	CODE
WITHOUT	100
WITH*	200

*Enclosed, 1A Triac units are not available as standard.

1. To order a Series 19-4 controller, specify the appropriate code numbers for (1) type of controller, (2) output, (3) set point adjustment and (4) enclosure. An example of a correctly specified unit is given below.

19-404105-100 is a proportioning control with IA, triac output, local setpoint adjustment, with lead break protection and without enclosure.

2. NEXT indicate terminalization and specify modification code number, where required. When ordering, the modification code should appear separately from the controller designation. Example 19-404104-100 (controller) with 19-992061-002 (modification). Note that lead wires and connectors *are not* supplied as standard on triac models or relay models with remote set point.

TABLE II

TERMINALIZATION		MODIFICATION CODE
RELAY MODELS	SPDT & DPDT, 10A output units supplied with 3/16" quick connect terminals as standard. User must supply 1/4" quick connect mating terminals for power, thermistor and remote potentiometer.	NONE
	SPDM, 25A output units supplied with 6" lead wires, load connections only. User must supply 1/4" quick connect mating terminals for power, thermistor and remote potentiometer.	NONE
	One foot long 3-wire conductor cable including 1/4" female connect terminals; for remote set point potentiometers.**	19-992016-001
TRIAC MODELS	9-Pin Molex connector with six pins; for thermistor and instrument power connections of local set point models. Unassembled	19-992058-000
	9-Pin Molex connector with wire pins; for thermistor, instrument power and remote set point connections. Unassembled	19-992059-000
	9-Pin Molex connector with six 2' lead wires attached; for thermistor and instrument power connections on local set point models.**	19-992060-002
	9-Pin Molex connector with nine 2' lead wires attached; for thermistor and instrument power connections on remote set point connections.**	19-992061-002

**2' lead length is standard. For different lengths, specify desired length in last three digits of code number. Ex: 4' = 004; 12' = 012, etc.

3. Indicate the temperature range required by selecting a dial from Table III. *Note:* Controllers with triac output and local set point adjustment as well as unenclosed relay models with local set point, have arbitrary 0 to 10 dial printed on the control board. For special temperature ranges not listed in Table III, consult the factory. When ordering, the dial part No. should appear separately from the controller designation and the terminalization modification code number. Ex: 19-404105-100 (controller) with 19-992061-002 (terminalization) and 06-231013-004 (dial).

TABLE III

Temperature Range	DIAL PART NO'S For Matched or Noncalibrated Probes	DIAL PART NO'S For Precision, Low Temperature Assemblies
-90 to 125°F	06-231013-001	06-231013-056
0 to 200°F	06-231013-002	06-231013-057
100 to 375°F	06-231013-003	
150 to 525°F	06-231013-004	
275 to 700°F*	06-231013-005	
-70 to 50°C	06-231013-011	06-231013-058
-10 to 100°C	06-231013-012	06-231013-059
40 to 190°C	06-231013-013	
70 to 270°C	06-231013-014	
130 to 370°C*	06-231013-015	

*In this range, order controller **less** break protection, (set point adjustment code 0, 2 or 4).

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ORDERING INFORMATION — REMOTE INDICATING METER FOR SERIES 194 CONTROLLER

19-450534-100

NUMBER OF POSITIONS ON SELECTOR SWITCH		CODE
Single—	None	00
Two	Points	02
Three	Points	03
Four	Points	04
Five	Points	05
Six	Points	06
Seven	Points	07
Eight	Points	08
Nine	Points	09
Ten	Points	10

TEMPERATURE RANGE (°F & °C)	CODE
-90° to 125°F (-65° to 50°C)	1
0° to 212°F (-15° + 100°C)	2
100° to 375°F (40° to 190°C)	3
150° to 525°F (70° to 170°C)	4
275° to 700°F (135° to 370°C)*	5

*In this range, order controller less lead break protection (Set Point Adjustment Code 0, 2 or 4).

CABLE ASSEMBLY	CODE
Other than standard	000
Standard, 2' long lead wires	100

To order a Remote Indicating Meter for a Series 19-4 Controller, specify the appropriate code numbers for: (1.) Number of positions, (2.) temperature range, and (3.) cable assembly.
Note: Multi-point indicating units include one meter driver board per channel, a selector switch, appropriate wiring harnesses and connectors, together with one meter. Factory calibrated systems are marked to indicate proper channel identification. For example, controller #1 is marked to mate with meter driver board #1 and switch position #1. *User must specify whether he wishes the metering unit to be calibrated or uncalibrated.* An example of two correctly specified units is given below:

19-450032-100 = Single point meter with attached driver board and 2' cable assembly. 0 to 212°F and -10° to 100°C scales.

19-450534-100 = 5 position selector switch, five meter driver board in mounting track, five wiring harnesses, one meter with 150 to 525°F and 70 to 270°C scales.

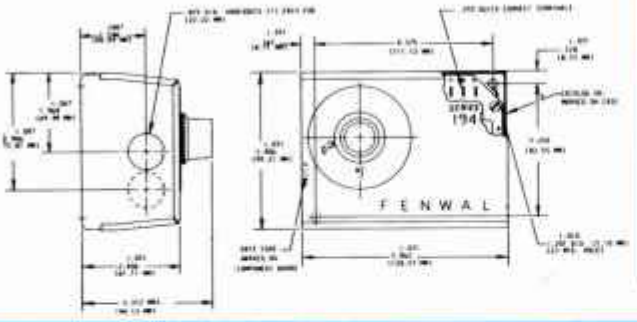
If the user wishes a cable assembly with lead wires longer than the standard 2' lengths (code 000), he must specify, per the following:

NON-STANDARD CABLE ASSEMBLIES	MODIFICATION CODE
Single Set Point Units—For connection to 19-4 controller—3-Pin Molex connector with three wires attached with quick connect pins. Lead wire length to be designated in last three digits. Ex: 4' = 004, 12' = 012, etc.	19-992068-XXX
Multi-point indicators—For extended cable lengths other than standard 2', designate length in last three digits of modification code. Ex: 4' = 004, 12' = 012, etc.	19-992074-XXX

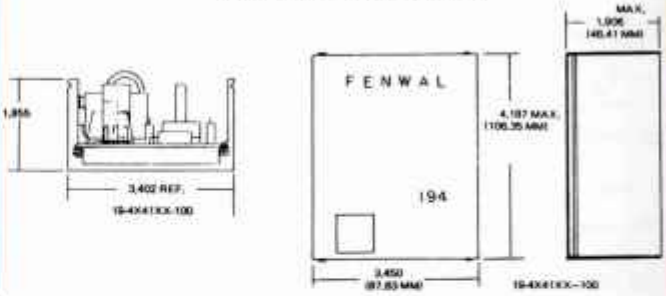
Like the other components in the 19-4 System, the Remote Indicating Meter should appear separately from the controller designation, the terminalization modification code number, the dial part number, and the probe part number(s). Ex: 19-404105-100 (controller) with 19-992061-002 (terminalization), 06-231013-004 (dial), six 28-232103-305 (probes) and 19-450534-000 (remote indicating meter) with 19-992074-012 (cable assembly modification).

OUTLINE DIMENSIONS

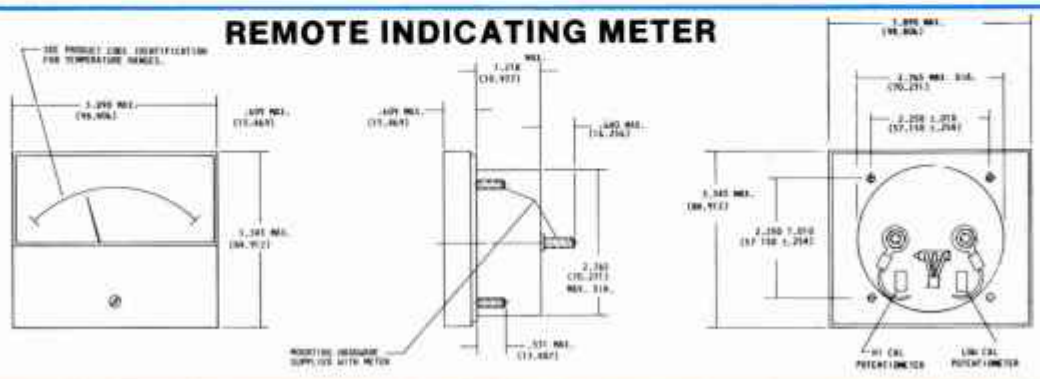
RELAY MODELS



TRIAC MODELS



REMOTE INDICATING METER



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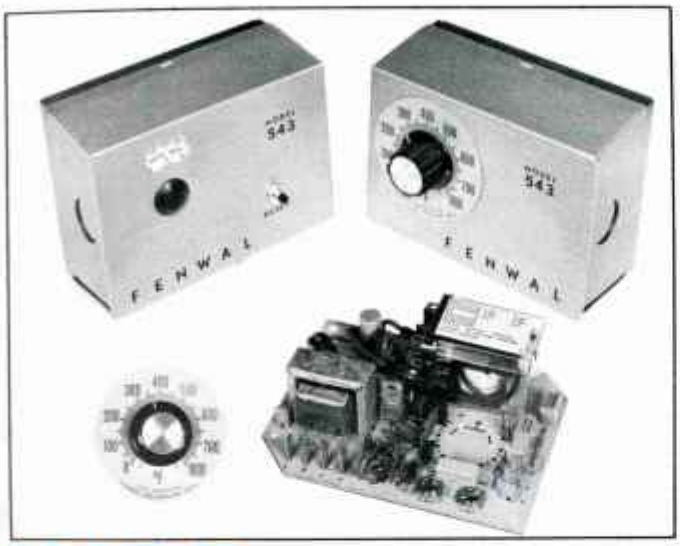
SERIES 543 CONTROLLER and HIGH LIMIT PROTECTOR



FEATURES

- Low Cost
- Four Models Available
- Field Selectable Power Inputs
- Single Pole or Double Pole Heavy Duty Relay Outputs
- Solid State Circuitry
- Line and Load Voltage Compensation
- UL Component Recognized
- FM Approved High Limit.

TYPICAL APPLICATIONS

Dip tanks
Degreasers
Plating equipment
Cooking equipment
OSHA-related high limit protection
Food processing
Plastics processing
Temperature control
Packaging machinery
Laboratory equipment

INPUT POWER

120,208 or 240VAC ±10%, 50-60Hz, field selectable.
UL Limit is 120/208 or 120/240VAC only.

OUTPUT

Heavy duty SPDT or DPDT relay rated 10A @ 120VAC, 5A @ 208 or 240VAC, resistive, each contact.
Pilot Duty: 250 VA, 240VAC maximum.

2A relay rated 2A @ 120VAC, 1A @ 240VAC, resistive.
Inductive: 20VA @ 120VAC.

Output to drive solid state relay: non-isolated output, 20VDC max into 1500 ohms, 5VDC minimum into 200 ohms.

SPDM 25A relay rated 25A @ 120VAC, resistive.

AMBIENT TEMPERATURE LIMITS

Operating: 32 to 135°F.
Storage: −25 to 165°F.

SET POINT ACCURACY

(at 77°F ambient and nominal voltage)
Proportioning and ON/OFF models—±1% typical, ±1½% maximum, of dial span for remote set point models; ±3% of dial span for local set point models.
Adjustable set limit models (FM)—±3% of dial span.
Fixed set limit models (UL)—±1% of dial span (±1.5% of dial span in 0-700°F range).
Accuracy based on millivoltage for National Bureau of Standards Thermocouple Characteristics.

AMBIENT TEMPERATURE EFFECTS (CONTROL ACCURACY)

Control point will remain within ±1% of dial span with ambient changes from 32 to 135°F.

CYCLE TIME (Proportioning Models)

15 seconds nominal at 50% power, Relay Models 2 seconds nominal at 50% power, ALL models with output to operate opto-coupled solid state relays.

LINE & LOAD VOLTAGE EFFECTS (CONTROL ACCURACY)

Proportioning and ON/OFF models—Control point will remain within ±0.5% of dial span with line and load voltage changes of ±10% from nominal at any bandwidth setting. High limit models—Control point will remain within ±0.25% of dial span with voltage change of ±10% from nominal.

BANDWIDTH (Proportioning Models)

Adjustable 1 to 5% of dial span, 0-800°F range; 0.5 to 3% of dial span, 0-2000°F range.

LEAD/BREAK PROTECTION Proportioning and ON/OFF Models

Relay will de-energize upon an open thermocouple (500K ohms or greater) with the case grounded, terminal TC+ or TC− grounded or floating and with either polarity of line voltage applied to the instrument power terminals.

Reverse action upon open thermocouple (cooling load de-energized) can be supplied. Consult factory.

High Limit Models

Relay energized upon an open thermocouple.

DIFFERENTIAL (ON/OFF Models)

0.2% of span, typical.

TERMINALIZATION

Instrument power and remote pot: .250" quick connect.
Load connections: .187" quick connect (supplied).
Thermocouple: #8 screws.
Solid state switch output: .093 quick-connects (supplied) 25 amp output: #14 AWG lead wires.

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HOW TO ORDER SERIES 543 CONTROLLERS

1. Select desired instrument from Table I.
2. Select temperature range (or thermocouple type) from Table II and add appropriate three-digit suffix to catalog number.
   NOTE: For UL Component Recognized (factory-fixed) High Limit units, specify thermocouple type from Table II and add desired fixed temperature setting to order.
3. Order appropriate thermocouples from pages 36 & 37. See Table II for compatible ISA type thermocouples.

TABLE II TEMPERATURE RANGES

MODEL	TEMP. RANGE	THERMOCOUPLE	SUFFIX NO.
ON/OFF & Prop.	0-800°F	J	-103
	0-1000°F	J	-104
	0-2000°F	K	-106
	-20 to 430°C	J	-203
	-20 to 1100°C	K	-206
FM Approved Limit	0-800°F	J	-103
	0-2000°F	K	-106
	-20 to 430°C	J	-203
	-20 to 1100°C	K	-206
High Limit (including UL models)	0-700°F	T	-113
	0-1200°F	J	-108
	0-2000°F	K	-106

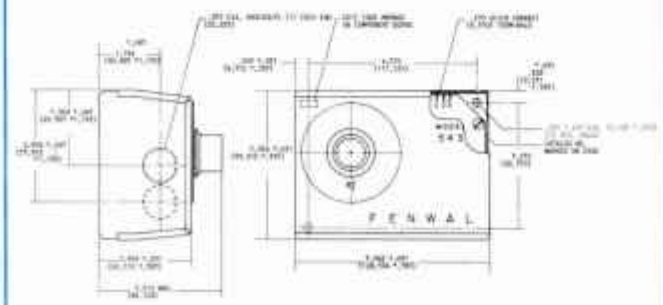
TABLE I INSTRUMENT TYPES AND MODEL NUMBERS

CONTROLLER	SPDT RELAY 10/5A	OUTPUT TO DRIVE SOLID STATE SWITCH	SPDM RELAY 25A	DPDT RELAY 10/5A	SPDT RELAY 2A	DESCRIPTION
ON/OFF	*54-301111-XXX	54-301211-XXX	*54-301311-XXX	54-301411-XXX	54-301511-XXX	w/o case & cover, local set point
	*54-301113-XXX	54-301213-XXX	*54-301313-XXX	54-301413-XXX	54-301513-XXX	w/o case & cover, remote set point
	*54-301121-XXX	54-301221-XXX	54-301321-XXX	54-301421-XXX	54-301521-XXX	w/case & cover, local set point
	*54-301123-XXX	54-301223-XXX	54-301323-XXX	54-301423-XXX	54-301523-XXX	w/case & cover, remote set point
FM Approved Limit (Adjustable set point)	54-302121-XXX			54-302421-XXX		w/case & cover, local set point
High Limit (Factory-fixed set point)	*54-302114-XXX			54-302414-XXX		w/o case & cover, remote reset, 120/240VAC input
	54-302115-XXX			54-302415-XXX		w/o case & cover, remote reset, 120/208VAC input
	*54-302124-XXX			54-302424-XXX		w/case & cover, local reset, 120/240VAC input
	54-302125-XXX			54-302425-XXX		w/case & cover, local reset, 120/208VAC input
	*54-302134-XXX			54-302434-XXX		w/case & cover, remote reset, 120/240VAC input
	54-302135-XXX			54-303435-XXX		w/case & cover, remote reset, 120/208VAC input
Proportioning	*54-303111-XXX	54-303211-XXX	*54-303311-XXX	54-303411-XXX	54-303511-XXX	w/o case & cover, local set point
	*54-303113-XXX	54-303213-XXX	*54-303313-XXX	54-303413-XXX	54-303513-XXX	w/o case & cover, remote set point
	*54-303121-XXX	54-303221-XXX	54-303321-XXX	54-303421-XXX	54-303521-XXX	w/case & cover, local set point
	*54-303123-XXX	54-303223-XXX	54-303323-XXX	54-303423-XXX	54-303523-XXX	w/case & cover, remote set point

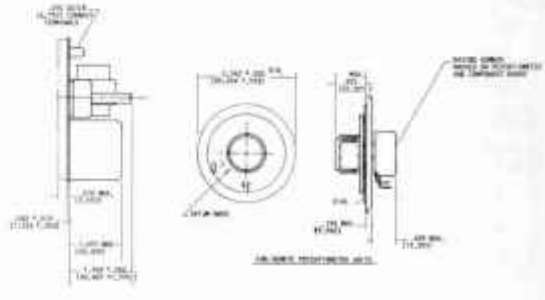
*UL COMPONENT RECOGNIZED

OUTLINE DIMENSIONS

WITH CASE AND COVER



CIRCUIT BOARD MODEL



FENWAL

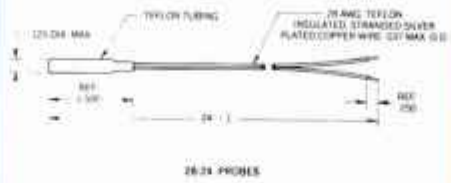
FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

THERMISTOR and THERMOCOUPLE PROBES

THERMISTORS

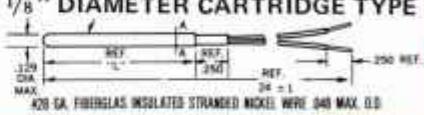
BARE GLASS PROBE TYPE

BARE DISC PROBE TYPE

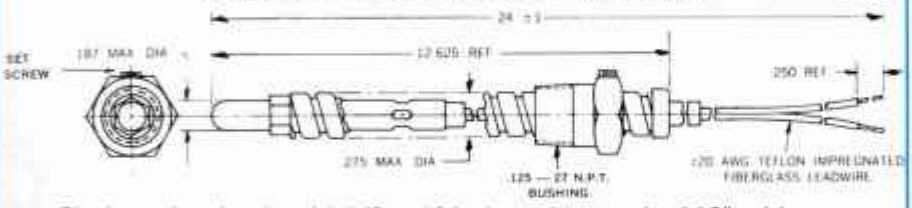


28-2301
3/16" DIA. CARTRIDGE TYPE*
STANDARD PROBE

28-2101
1/8" DIAMETER CARTRIDGE TYPE

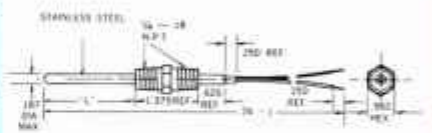


28-50 & 54
ADJUSTABLE INSERTION DEPTH PROBE



Fits insertion depths of 1-1/2 to 10 inches with standard 12" cable.
Install bushing, insert thermistor probe to desired depth and tighten set screw in bushing.
Special Feature 28-982005-XXX extends cables and leads (see page 37)

28-2308
COUPLING HEAD TYPE*
STANDARD PROBE

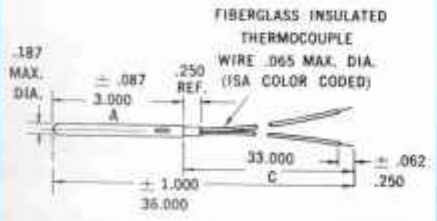


*Lead wire all probes except ⅛" dia. cartridge type and low temperature precision #20 GA fiberglas insulated stranded nickel wire .065 max. OD. Lead wire on precision low temperature is #22 GA teflon insulated stranded copper wire .065" max. O.D.

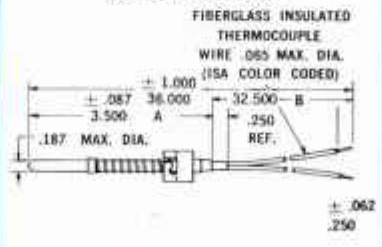
All dimensions in inches.

THERMOCOUPLES

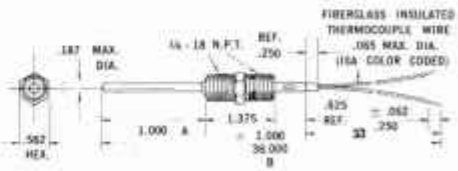
CARTRIDGE TYPE
53-111206-0XX



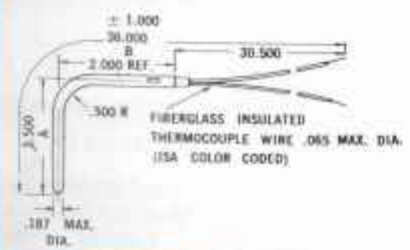
BAYONET TYPE
53-131207-00X



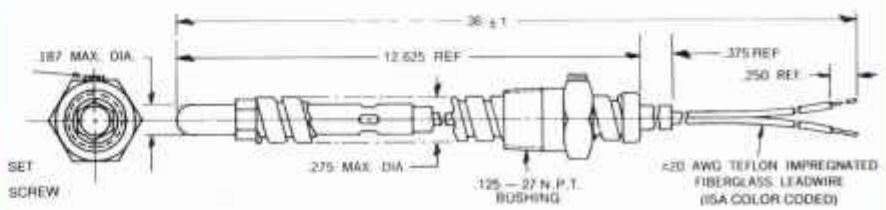
COUPLING TYPE
53-121202-00X



53-111207-20X



ADJUSTABLE INSERTION DEPTH PROBE
53-531204-00X



FENWAL

THERMISTOR PROBES

PROBE TYPE	−50 to 750°F NONCALIBRATED	−50 to 750°F MATCHED	−50 to 250°F PRECISION LOW TEMPERATURE	
		Not available in −X02 or −X08 ranges	Interchangeability ½%	1%
	Not directly interchangeable May require calibration	Directly interchangeable For indication or dial accuracy		
Bare Probe (⅝")	28-200001-00X	28-202001-00X	28-242003-004, -008	28-240003-004
⅜₁₆" dia. Cartridge (1½")	28-230103-30X	28-232103-30X	——	——
⅛" dia. Cartridge (3")	28-230106-30X	28-232106-30X	28-432106-304, -308	28-430106-304
⅛" dia. Cartridge (1½")	28-210103-30X	——	——	——
⅛" dia. Cartridge (3")	28-210106-30X	——	——	——
Std. Coupling Head (1½")	28-230803-30X	28-232803-30X	——	——
Std. Coupling Head (3")	28-230806-30X	28-232806-30X	28-432806-304, -308	28-430806-304
Adjustable Insertion Type	28-500403-30X	28-502403-30X	28-542403-304, -308	28-540403-304

THERMOCOUPLE PROBES

Cartridge	53-111206-00X
90° Cartridge	53-111207-20X
Coupling Type	53-121202-00X
Bayonet	53-131207-00X
Adj. Insertion	53-531204-00X

Thermocouple Range	Suffix No
−200 to 400°F (Type T)	−X00
0 to 1200°F (Type J)	−X01
0 to 2500°F (Type K)	−X02

TEMPERATURE RANGES	
Thermistor Range*	Suffix No
−50 to 150°F (−90 to 125°F)	−X08#
25 to 250°F (0 to 200°F)	−X04
100 to 400°F (100 to 375°F)	−X06
150 to 450°F (100 to 375°F)	−X02#
200 to 600°F (150 to 525°F)	−X05
300 to 750°F (275 to 700°F)	−X07

*Ranges in parenthesis for Series 194 controllers
For Celsius ranges, see corresponding ranges under specific controllers.
#Not available in matched probe configuration

NOTES

PROBE SELECTION

Noncalibrated Probes are designed for nonindicating controllers. They require calibration on initial installation as well as when replaced.

Matched Probes are ideally suited for indicating instruments but can be used for nonindicating controllers as well. They do not require calibration on initial installation and have an interchangeability of ±0.5% of scale range. In addition, they provide dial and indication accuracies of better than 1% of scale range.

Precision Low Temperature Assemblies may be substituted for Matched Probes in applications up to 250°F. Instruments require calibration on initial conversion from Matched Probes; however calibration information is included with each probe. When ordering controller and sensor together, specify Factory calibration per Mod. 2033 for best results. Indication accuracies are typically 1% of scale range. Interchangeability of these assemblies is shown below:

SERIES	RANGE	SERIES	RANGE
28-242XXX-X04		28-24XXXX-X08	
28-4X2XXX-X04	½%	28-4XXXXX-X08	¼%
28-542XXX-X04		28-54XXXX-X08	

SERIES	RANGE
28-240XXX-X04	
28-4X0XXX-X04	1%
28-540XXX-X04	

INSTALLATION OF PROBES

Both types of probes are tip sensitive. The following will help insure accurate temperature sensing.

1. Liquid applications—In liquids, a minimum of ½ inch immersion is essential for good thermal contact.
2. Solids applications—The probe tip should be in direct contact with the medium to be sensed.
3. It is good practice to run leads separate from power leads to minimize electrical pickup.

SHELL MATERIAL

Type 316 stainless steel.

STANDARD LEAD WIRE LENGTH

Standard lead wire length, measured from the tip of the probe assembly, is 24" for thermistors and 36" for thermocouples.

PROBES IN SHELL ASSEMBLIES

Lead wires—maximum longitudinal pull, 8 lbs.

BAYONET MOUNTED PROBES

When ordering Fixed Bayonet mounted probes indicate the total immersion depth. The total immersion depth is the depth of the hole plus one inch for Fenwal's standard mounting adaptors. (Cat. No. 06-126111-000 or 06-126113-000.)

COUPLING HEAD PROBES

Maximum torque 25 ft. lbs.

ADJUSTABLE INSERTION DEPTH PROBES

Standard Adjustable probes with 12.00 inches of armored cable provides insertion depths of 1.5 to 10.0 inches.

BARE PROBE ASSEMBLIES

Lead wires—maximum longitudinal pull, 5 lbs.
Dielectric strength 1500 VAC for one minute, both leads to shell except bare assemblies and 300 to 750°F range.

FITS AND CLEARANCE

The 0.125 and 0.187 diameter probes are designed for insertion into 0.1285 (#30) and 0.191 (#11) inch diameter drilled holes respectively. Bayonet style probes require 0.261 diameter drilled hole. Adjustable Insertion Depth probes require 0.290 diameter drilled hole.

MODIFICATIONS FOR THERMISTOR and THERMOCOUPLE PROBES

EXTENDED LEAD WIRE LENGTHS

MOD. 2A—Lead wire extension is available to any reasonable length. Normal lead wire length of 24 inches (from the tip of the probe to the ends of the leads) is supplied unless this modification, and the desired length, is specified. Special lead wire stripping also is available on request.

MOD. 131—EXTENDED LEAD WIRE LENGTHS (ALL #20 AWG)—THERMOCOUPLE MODELS ONLY

Modification Number	Lead Wire Material	Length (ft.) Min.	Max.
131A	Copper/Constantan	0	170
131B	Iron/Constantan	0	150
131C	Chromel/Alumel	0	85

IMPORTANT—All Fenwal lead wire lengths **are measured** from the end of the thermocouple probe. Standard thermocouple probes are provided with 36" lead wires and the amount of wire extending from the end of the probe is determined by the length of the probe. Example: Refer to Cartridge Type Straight Probe—Lead Wire Length **C** beyond end of probe is 33", Length of probe **A** is 3", therefore, TOTAL LEAD WIRE LENGTH **B** which should be ordered is 36".
Determine temperature range, lead wire length and specify appropriate Mod No. on order. Example: Mod 131C, 87 inches.

CABLES AND BRAIDS

MOD. 135—The addition of stainless steel armored cable to any 0.187 diameter probe except adjustable depth types—See Special Features.

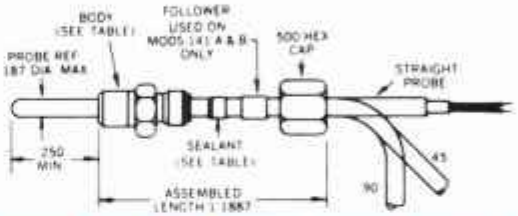
MOD. 140—The addition of stainless steel braid to 0.187 probes.

MOD. 142—The addition of stainless steel armored cable to any 0.125 diameter cartridge probe assembly.

MOD. 150—The addition of stainless steel braid to any 0.125 diameter probe assembly.

COMPRESSION FITTINGS

MOD. 141—(For Cartridge Type Probes Only) When required, compression fittings can be provided for liquid or gastight applications. This modification is shipped unassembled for installation in the field.



Mod. No.	Body Size (NPT)	Sealant Material	Fitting Material	Maximum Operating Temperature	Maximum Working Pressure	Assembly Torque	Assembly Length
141A	⅛-27	Teflon	S.S.	to 500°F	3000 psi	45 ft. lb.	1.187
141B†	⅛-27	Lava	S.S.	to 1850°F	5000 psi	55 ft. lbs.	1.187
141C†	⅛-27	Brass	Brass Nickel Pl.	to 800°F	2000 psi	55 ft. lbs.	1.234
141D	¼-18	Teflon	S.S.	to 500°F	3000 psi	45 ft. lbs.	2.000
141E†	¼-18	Lava	S.S.	to 1850°F	5000 psi	55 ft. lbs.	2.000

†This fitting cannot be reused.

SPECIAL FEATURES

S.F. 53-982005-XXX—Extended Armored Cable and Lead Wire. (Applicable to Adjustable Insertion Depth Probes only.)
Extension of both armored cable and lead wire in 1 inch increments. Indicate length required in last three digits. Ex: S.F.53-982005-024 = 24 inch length.

S.F. 54—Extended Lead Wires for Bare Probe Series—This feature extends lead wires of bare probes in one foot increments. Due to the possibility of damaging the probe, we recommend that this feature be accomplished at the factory.

S.F. 84—Extended Probe Lengths—This feature provides for extended probe length, (REF: Dimension "L" on diagrams), any probe except the bare probe type, may be extended in increments of ½ inch. For example, extension would be as follows:

Basic Probe Length "L"	Extension	Overall Probe Length "L"
1½"	10"	11½"
2½"	9"	11½"
3"	9"	12"

HOW TO ORDER

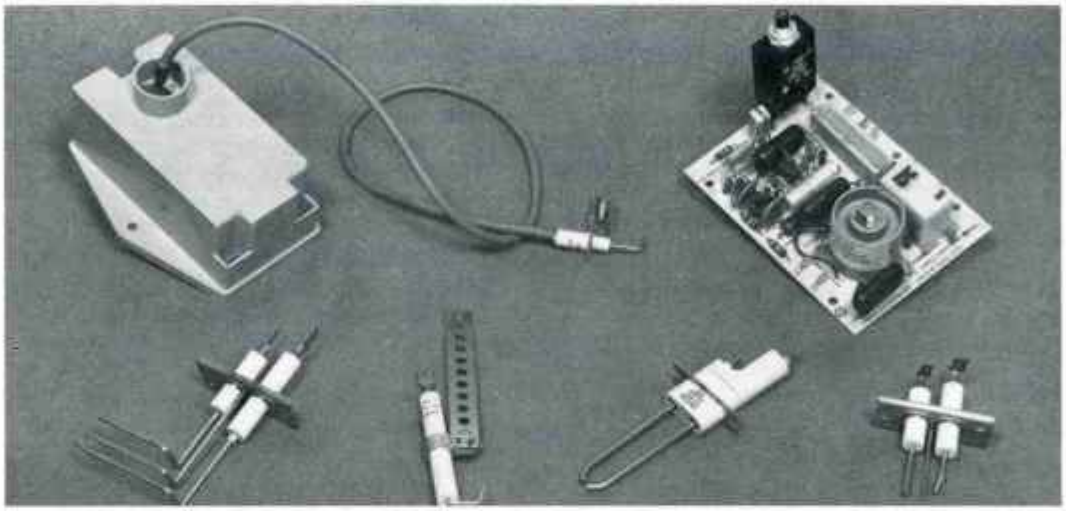
1. Decide on the type of probe required—cartridge, bayonet, coupling, etc.
2. Next, select the probe configuration, straight, 90° or adjustable insertion depth probe.
3. Choose the probe temperature range that covers the temperature range of your Fenwal Controller and add appropriate catalog number to your order.
4. When a Modification and/or Special Feature is desired, include the number(s) on your purchase order.

FENWAL

FENWAL INCORPORATED
Ashland, Mass. 01721 617/881-2000

DIRECT SPARK IGNITION SYSTEMS & PILOT RELIGHTERS

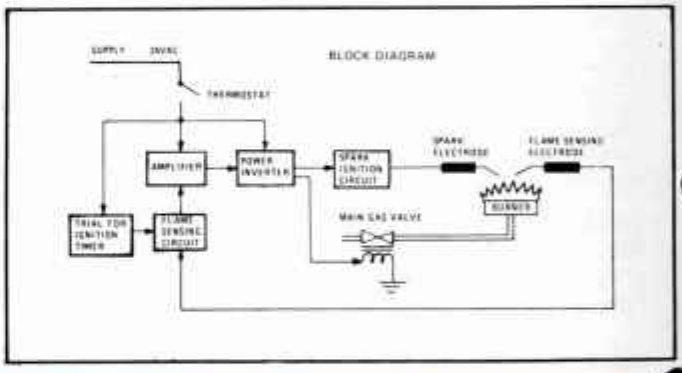
for use on heating equipment with power vent or open flame type burners



Fenwal Direct Spark Ignition Systems eliminate the need for constant pilot flame which can waste costly fuel. At the same time, they utilize standard piloted methods of ignition which are required for roof-top heaters, residential furnaces and crop dryers, as well as industrial applications such as heating glue and solder pots, in bookbinding, on printing presses and incinerators.

HOW IT WORKS:

1. Input voltage causes solid state capacitive discharge system to create spark.
2. Principals of flame conduction and rectification are used to monitor the flame.
3. Gas supply valve is deenergized if flame is not present.



Model No	Type	Input Voltage (50/60 Hz Nom.)	Current Drain		Ambient (°F)	Gas Valve Relay Current Ratings	Flame Establishing Period (seconds)	Flame Failure Re-ignition Time Sec	Approved By	Ignitions Means	Notes
			Continuous Duty (mA)	Momentary, during Ignition (mA)							
05-12	Pilot Relighter	24 120 240 VAC	25	50	−40 to +165	No Relay	Continuous if flame is not proven	0.25	UL, CSA, AGA (Cased Models Only)	Continuous Interrupted	
05-14	Proof of Flame	120 VAC	50	175-250	−40 to +140	120 VAC 1.0 a Max. 24 VAC 2.0 a Max. 240 VAC 0.5 a Max.	3.3 4.7 10	less than 0.8	UL, CSA, AGA	Interrupted	
05-15	Electronic Spark Ignition Systems	12 VDC	50[1]	500	−40 to +150	12 VDC 2.0 a Max.	3.3 6.8 10				[1]Including Valve Power
05-16	Direct Spark Ignition System	24 VAC	50	300		24 VAC 2.0 a Max.					
05-17	Purge Timer	120 VAC	5	Not Applicable	−40 to +140	120 VAC 1 a Max.	Not Applicable	Not Applicable	UL	Not Applicable	30 Sec. Minimum Purging period
05-18	Flame Relay		50	175-250	−40 to +150	120 VAC 1 a Max. 24 VAC 2.0 a Max. 240 VAC 0.5 a Max.	3.3 4.7 10	less than 0.8	UL, CSA, AGA		
05-143	Two-Stage Start-Up				−40 to +140					Interrupted	

NOTE: Ask your local authorized stocking wholesaler or distributor for additional information on Fenwal Direct Spark Ignition Systems and accessories.

CONTROLS DIVISION Fenwal REPRESENTATIVE LISTING

ALABAMA

Birmingham, 35223
Applebee-Church, Inc.
13 Office Park Circle - Suite 22
(205) 879-4417

ALASKA

Refer to Seattle, WA

ARIZONA

Refer to Van Nuys, CA

ARKANSAS

Central and West
Refer to Tulsa, OK

East
Refer to Memphis, TN

CALIFORNIA

Oakland, 94608
Belilove Company, Engineers
960 Arlington Avenue
P.O. Box 8612
(415) 658-9011

Van Nuys, 91406
Pacific Thermal Sales, Inc.
6740 Balboa Blvd.
(213) 997-1772
(213) 873-6262

CANADA

Pointe Claire, Quebec, H9R 1G3
Canadian Chromalox Company
243 Hymus Blvd.
(514) 697-1131

Rexdale, Toronto, Ontario, M9W 1R4
Canadian Chromalox Company
210 Rexdale Blvd.
(416) 743-8000

COLORADO

Englewood, 80110
E & M Sales, Inc.
3990 S. Lipan Street
(303) 761-6202

CONNECTICUT

Middletown, 06457
Dittman and Greer, Inc.
Coe Ave. at Randolph Road
P. O. Box 781
(203) 347-4655

DELAWARE

Refer to Narberth, PA

DISTRICT OF COLUMBIA

Refer to Ellicott City, MD

FLORIDA

Miami, 33152
Ludlum Associates Co.
6925 N. W. 42nd Street
P. O. Box 52-3337
(305) 592-6523

Orlando, 32803
Ludlum Associates Co.
999 Woodcock Road, Suite 110
P. O. Box 6274
(305) 894-7761

GEORGIA

Atlanta (Chamblee), 30341
Applebee-Church, Inc.
2375 John Glenn Drive, Suite 102
P. O. Box 80186
(404) 451-2747

HAWAII

Refer to Oakland, CA

IDAHO

North
Refer to Seattle, WA

Central and South
Refer to Salt Lake City, UT

ILLINOIS

Northwest
Refer to Davenport, IA

Northeast and Central
River Forest, 60305
Tourtelot Co.
7716 Madison Street
P. O. Box 313
(312) 771-6300

South
Refer to St. Louis, MO

INDIANA

Northwest
Refer to River Forest, IL

Northeast, Central and South
Indianapolis, 46240
Couchman-Conant, Inc.
10085 Allisonville Road
Box 40222
(317) 849-9890

IOWA

Davenport, 52801
Volco Company
911 Kahl Building 326 W. Third St.
(319) 326-5233

KANSAS

Overland Park, 66214
Richard Greene Co.
11882 West 91st Street
(913) 492-6886

KENTUCKY

West
Refer to St. Louis, MO

Central and East
Refer to Cincinnati, OH

LOUISIANA

Baton Rouge, 70815
Ross & Pethtel, Inc.
12551 S. Harrell's Ferry Road
P. O. Box 15223
(504) 293-0520

MAINE

Refer to Ashland, MA

MARYLAND

West
Refer to Pittsburgh, PA

Central and East
Ellicott City, 21043
McCourt Company, Inc.
9070 Chevrolet Drive
P. O. Box 627
(301) 465-4515

MASSACHUSETTS

West
Refer to Albany, NY

West Central
Refer to Middletown, CT

Central and East
Ashland, 01721
Fenwal Incorporated
New England District Office
Main Street
(617) 881-4800

MICHIGAN

Grand Rapids, 49508
Smith Instrument Grand Rapids Corp.
3685 Hagen Drive, S. E.
(616) 245-2259

Midland, 48640
Smith Instrument & Equipment Co.
1814 Austin
(517) 496-9250

Warren, 48089
Smith Instrument & Equipment Co.
24487 Gibson Drive
P. O. Box 1066
(313) 755-3110

MINNESOTA

Minneapolis, 55426
Volco Company
7505 Highway No. 7
P. O. Box 26363
(612) 933-6631

MISSISSIPPI

North
Refer to Memphis, TN

South
Jackson, 39209
Ross & Pethtel, Inc.
P. O. Box 20245
(601) 355-7882

MISSOURI

St. Louis, 63132
Richard Greene Co.
1235 Research Blvd.
(314) 994-0222

MONTANA

Refer to Salt Lake City, UT

NEBRASKA

West
Refer to Salt Lake City, UT

Central and East
Omaha, 68106
Volco Company
700 West Central Road
(402) 393-5141

NEVADA

South
Refer to Van Nuys, CA

North
Refer to Oakland, CA

NEW HAMPSHIRE

Refer to Ashland, MA

NEW JERSEY

North
Clifton, 07013
Faber Associates
P. O. Box 2000
460 Colfax Avenue
(201) 773-8900

South
Refer to York, PA

NEW MEXICO

Albuquerque, 87107
E & M Sales, Inc.
2840 Vasser Blvd., N.E.
(505) 883-8955

NEW YORK

Albany, 12205
The Robert F. Lamb Co., Inc.
P. O. Box 5083
(518) 869-3355

Buffalo, 14217
The Robert F. Lamb Co., Inc.
1865 Kenmore Avenue
(716) 874-4900

New York City & Long Island
Faber Associates, Inc.
See New Jersey Listing for Address
(212) 947-4100

NEW YORK (continued)

Rochester, 14622
The Robert F. Lamb Co., Inc.
4515 Culver Road
(716) 544-5580

Syracuse, 13211
The Robert F. Lamb Co., Inc.
160 Pickard Bldg.
P. O. Box 28
E. Malloy Road
(315) 454-2469

NORTH CAROLINA

Matthews, 28105
W. K. Hile Company, Inc.
833 W. John Street
P. O. Box 1015
(704) 847-9125

NORTH DAKOTA

Refer to Minneapolis, MN

OHIO

Cincinnati, 45240
Arnold & Associates, Inc.
11070 Southland Road
(513) 851-7200

Cleveland, 44120
Anderson-Bolds, Inc.
11701 Shaker Blvd.
(216) 229-4700

Worthington, 43085
Anderson-Bolds, Inc.
P. O. Box 123
(614) 885-3933

OKLAHOMA

Tulsa, 74135
Driscoll Automatic Control Co.
3545 E. 51st Street
P. O. Box 74152
(918) 747-6625

OREGON

Refer to Seattle, WA

PENNSYLVANIA

Narberth, 19072
Clifford B. Ives & Company, Inc.
114 Forrest Avenue
(215) 839-6850

Pittsburgh, 15237
Gilson Engineering Sales, Inc.
978 Perry Highway
(412) 931-6114

York, 17405
Clifford B. Ives & Company, Inc.
2568 N. George Street
P. O. Box 2006
(717) 764-8571

PUERTO RICO

Hato Rey, 00919
Badrena & Perez, Inc.
225 Carpenter Road
P. O. Box 1839
(809) 767-2467

RHODE ISLAND

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SOUTH CAROLINA

Refer to Charlotte, NC

SOUTH DAKOTA

Refer to Minneapolis, MN

TENNESSEE

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Hile Controls of Tennessee, Inc.
P. O. Box 11003
6712 Kingston Pike
(615) 573-0700

Memphis, 38112
Jordan/Marlar/Hale, Inc.
426 Scott Street
(901) 452-7441

Nashville, 37217
Jordan/Marlar/Hale, Inc.
1276 Murfreesboro Road, Suite G
(615) 361-3006

TEXAS

Dallas, 75251
Don Shuhart Company, Inc.
12011 Coit Road, Suite 106
(214) 239-0185

Houston, 77040
Gaumer Company, Inc.
13240 Hempstead
(713) 460-5200

UTAH

Salt Lake City, 84101
E & M Sales, Inc.
328 W. 2nd South
(801) 521-2111

VERMONT

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VIRGINIA

Northeast
Refer to Ellicott City, MD

East, South and West
Chester, 23831
Hile Controls of VA., Inc.
P. O. Box 894
(804) 275-0799

WASHINGTON

Seattle, 98108
Seatronics, Inc.
515 South Michigan Street
(206) 767-6272

WEST VIRGINIA

Refer to Pittsburgh, PA

WISCONSIN

Milwaukee, 53215
Gordon Hatch Company, Inc.
635 South 28th Street
(414) 671-6550

WYOMING

Refer to Salt Lake City, UT

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Fenwal Incorporated represents that this product is free from defects in material and workmanship, and it will repair or replace any product or part thereof which proves to be defective in workmanship or material for a period of twelve (12) months after installation by the buyer but not to exceed eighteen (18) months after shipment by the seller. For a full description of Fenwal's LIMITED WARRANTY, which among other things, limits the duration of warranties of MERCHANTABILITY and FITNESS FOR A PARTICULAR PURPOSE and EXCLUDES liability for CONSEQUENTIAL DAMAGES, please read the entire LIMITED WARRANTY on the Fenwal Quotation, Acceptance of Order and/or Original Invoice which will become a part of your sales agreement. Defective units should be returned to the factory, Ashland, Massachusetts, shipment prepaid. Fenwal Incorporated will repair or replace and ship prepaid.

M.P.3.3 7/5/75

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