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Levinn

[11] **3,731,247**

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[54] **HIGH TEMPERATURE SENSING APPARATUS EFFECTIVE OVER EXTENSIVE LENGTHS**

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[52] **U.S. Cl.** ....**337/140,** 200/153 T, 337/126, 337/382, 337/393

[51] **Int. Cl.** **H01h 61/06**

[58] **Field of Search** ....200/82 C, 153 T; 337/126, 131, 133, 140, 382, 393

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[57] **ABSTRACT**

In order to sense the presence of excessively high temperatures at points along an extended length, an elongated element is extended along that length in heat-transfer relationship to the area where temperature is to be sensed, that element being formed of a material having a "memory" which is actuated when the material is subjected to the predetermined excessive temperature, that "memory" causing the material then to change its shape and therefore alter the effective length of the element. Work means is operatively connected to that element, the work means performing a function appropriate to the sensing of the excessive temperature. That function may, for example, be the opening of a circuit to a heater, the sounding of an alarm, or the actuation of fire extinguishing apparatus. Because of the characteristics of the material of which the elongated element is formed, it is essentially inactive over a range of temperatures below the predetermined excessive temperature, and becomes operatively active only when that predetermined excessive temperature is reached. The arrangement in question is particularly well adapted for use in conjunction with elongated baseboard heaters the heating action of which is normally controlled by a room thermostat located remotely from the heater. The apparatus of the present invention will determine whether sections of the heater become heated to excessive temperatures even though the room being heated may not be at an excessive temperature.

9 Claims, 10 Drawing Figures

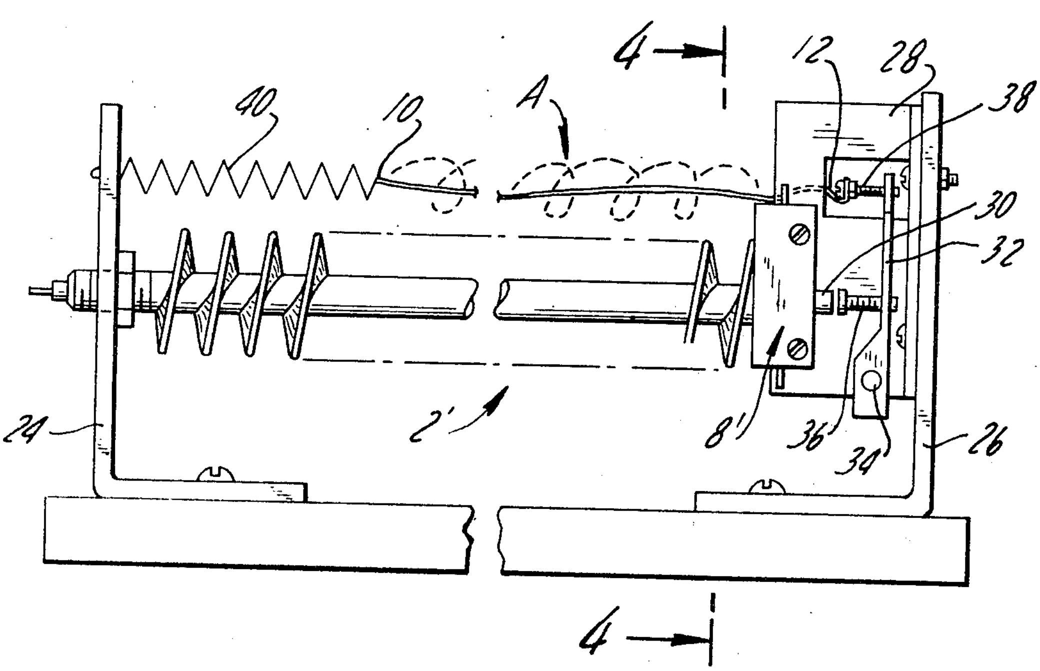
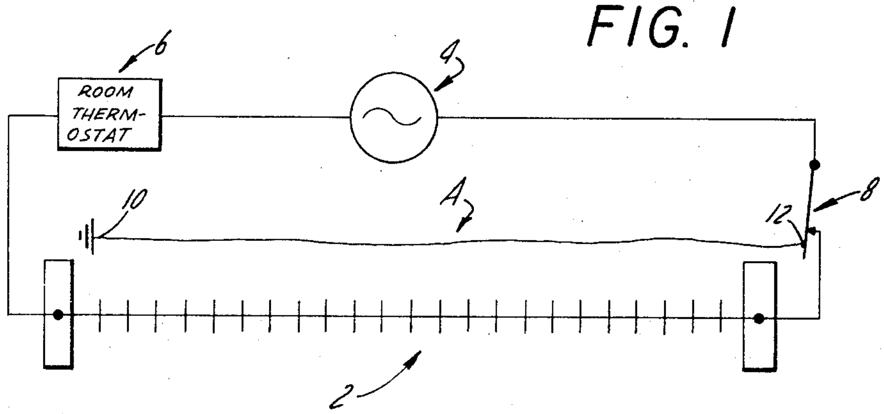


FIG. 1



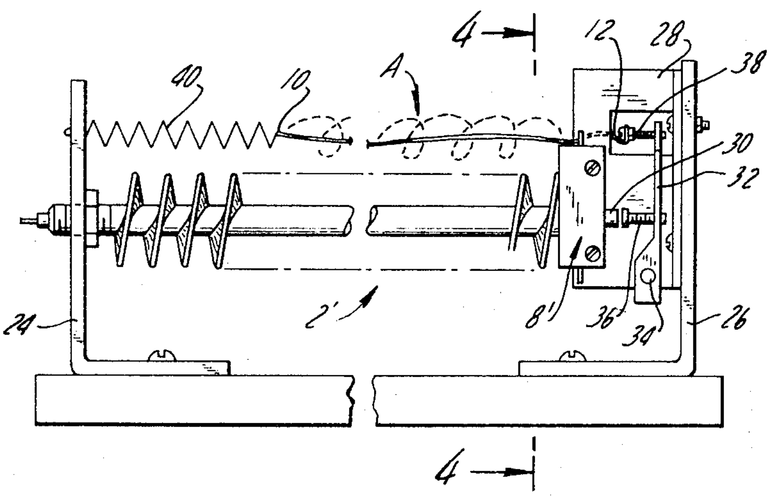


FIG. 3

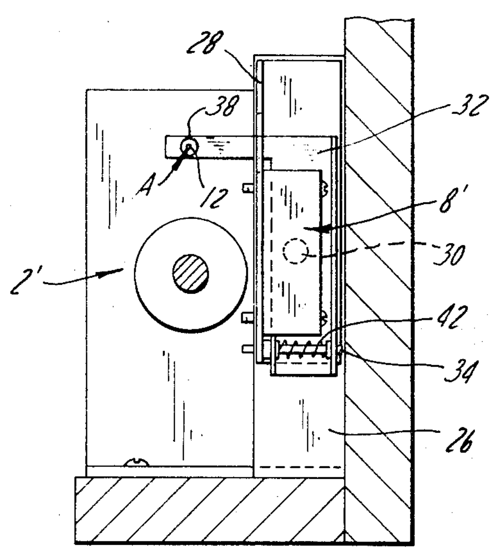


FIG. 4

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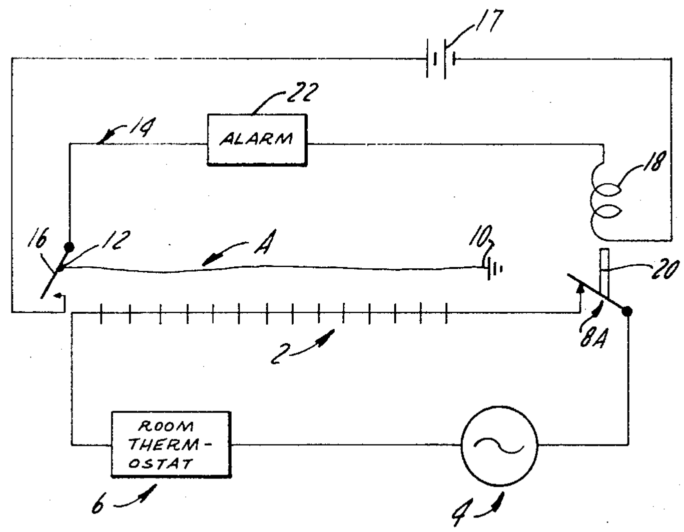

FIG. 2

FIG. 5

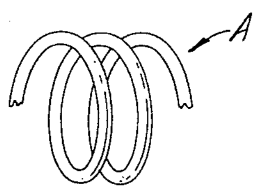

FIG. 5A

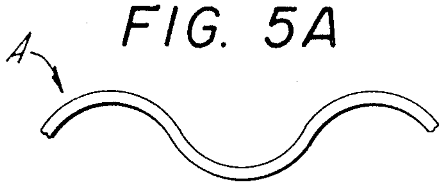

FIG. 6

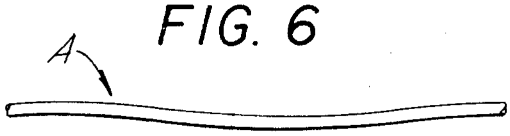

FIG. 7

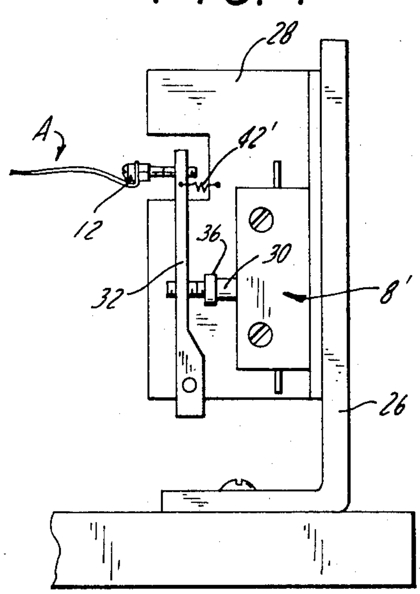

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FIG. 8

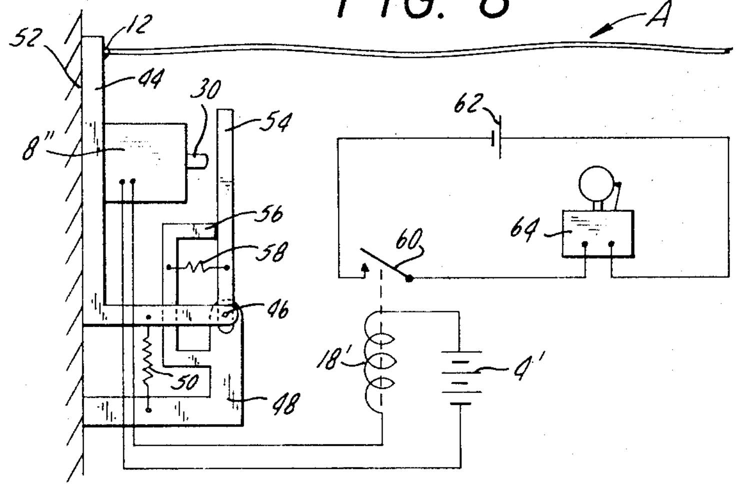
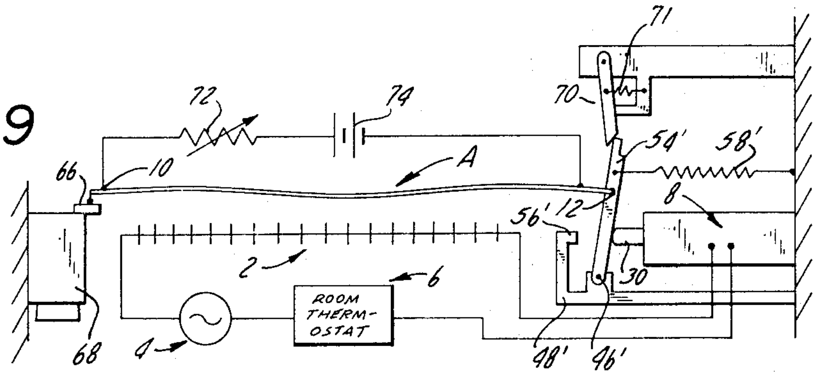


FIG. 9



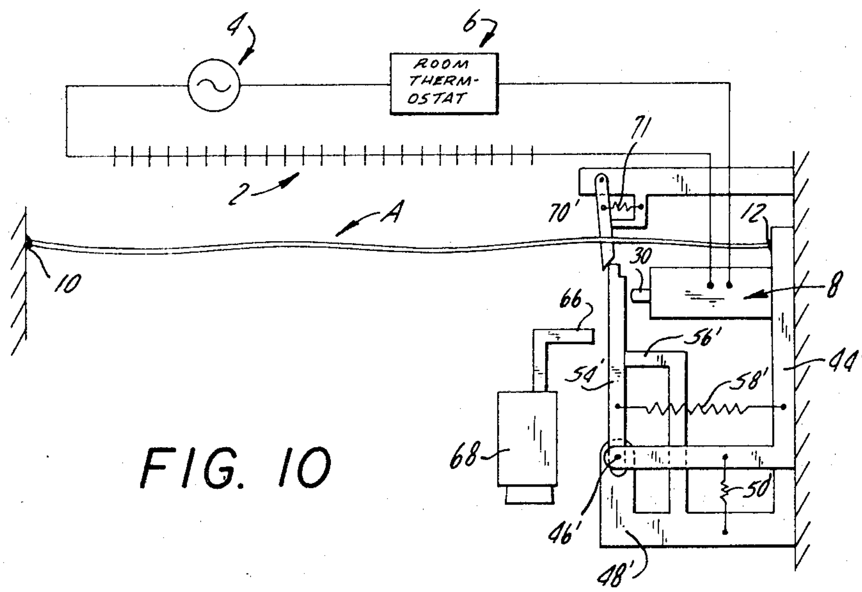


FIG. 10

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HIGH TEMPERATURE SENSING APPARATUS EFFECTIVE OVER EXTENSIVE LENGTHS

The present invention relates to an excessive temperature sensing apparatus utilizing a material which normally retains a given shape over a given range of temperatures but which, when subjected to a predetermined elevated temperature, then tends to change its shape and to exert substantial force in thus changing its shape.

There are many instances where action has to be taken if excessive temperatures occur at any place over an extended length. A prime instance is in connection with baseboard heaters for rooms. These heaters, usually electrically energized, produce heat which is transmitted to the room, and the operation and energization of the heaters is controlled in accordance with the temperature of the room, in order to maintain that temperature at desired level. Air circulates over the heaters, is warmed thereby, and then moves into the room. Sometimes air circulation is blocked over a section of the heater, as if a drape or coat were to fall thereover, and when that occurs the particular heater section where air circulation is thus blocked will rise in temperature sometimes to an unsafe degree. The room thermostat which controls the operation of the heater will be entirely insensitive to any such occurrence. Consequently it is necessary, as a safety factor, to sense localized temperature changes along the length of the heater. If this is not done the heater temperature may rise sufficiently so that the fabric which is blocking the air circulation will be raised above its ignition temperature and smolder or burn, thus starting a fire.

One approach to this problem has been to provide, along the length of the heater, a plurality of individual thermostats. This is exceedingly expensive, presents difficulties in maintenance and adjustment, and is in essence only a compromise, since temperature is really sensed only at the specific locations where those individual thermostats are positioned. If the thermostats are placed too widely apart they will not provide proper protection, and if they are placed closely together a large number of thermostats will be required, thereby making the cost of the installation relatively prohibitive. Another approach has been to utilize an elongated element which has the characteristics of changing its effective length in accordance with temperature, and to mount that element along and in proximity to the heater. A capillary tube filled with a fluid which expands to a considerable degree as the temperature to which it is subjected rises has been used for this purpose. This approach does provide sensing of excessive temperatures over the entire length of the heater, but it is extremely sensitive in operation, since the materials used will expand as the temperature rises over substantially the entire range of temperature variation, including not only the excessive temperatures but also the normal operating temperatures. Hence adjustment and calibration of these devices are often quite critical, and subject to dislocation with time and use.

The problems presented in sensing excessive temperatures over an extended length are not limited to the baseboard heater application. They are present in many installations. Thus it may be desired to protect against excessive temperatures any place within a large cabinet where various substances are stored or heat-producing devices are located. One may wish to detect fire in a large space even when the fire is highly localized, and before that fire has heated up the room sufficiently to cause a conventional temperature sensing device to be actuated. When the room is that hot the fire may be already so large as to be unmanageable, whereas if the existence of fire could have been ascertained at an earlier stage, while the fire was still small, adequate fire prevention might have been effective. This is particularly important in connection with the actuation of built-in fire extinguishing apparatus, such as sprinkler systems or carbon dioxide cylinders. Other installations and applications will suggest themselves.

The temperature sensing element of the present invention is an elongated element formed of a material having a very special characteristic — it is not appreciably affected by temperature in a given range up to a given temperature value, but above that value it changes its effective length quite rapidly and with the exercise of appreciable force. One substance having that characteristic is a nickel-titanium intermetallic compound known as "Nitinol." It is disclosed in U.S. Pat. No. 3,174,851 of Mar. 23, 1965 entitled "Nickel-Base Alloys," U.S. Pat. No. 3,351,463 of Nov. 7, 1967 entitled "High Strength Nickel-Base Alloys" and U.S. Pat. No. 3,403,238 of Sept. 24, 1968 entitled "Conversion of Heat Energy to Mechanical Energy," all patents being assigned to the United States of America as represented by the Secretary of the Navy. This material has a "memory." If it is given a first shape or configuration and subjected to an appropriate treatment, and thereafter its shape or configuration is changed, it will retain that changed shape of configuration until such time as it is subjected to a predetermined elevated temperature, for example, around 280°F. When it is subjected to that temperature it tends quite strongly to return to its original shape or configuration. This material is available in elongated wire-shaped lengths. The wire can be given a sinuous configuration and heat-treated, and can thereafter be stretched out to substantially linear configuration. It will retain that linear configuration until subjected to the predetermined activated temperature, at which time it will revert to its sinuous configuration. Within a range of temperatures, the predetermined temperature at which the wire will tend to revert to its "memory" configuration can be varied by altering the proportions of the constituents of the intermetallic compound, as is known to the art.

The advantage of using an elongated element of this character for sensing excessive temperature is quite great. Each segmental part of the elongated wire element will have the "memory" which is built into it, and consequently if any part of the wire is subjected to excessive temperature it will tend to become sinuous rather than straight even though the rest of the wire may be at normal temperature and remain straight. The tendency of any part of the wire to change its configuration from straight to sinuous (or vice versa) will alter the effective length of the wire by an appreciable amount, and the tendency of the wire, and even of a short section thereof, to thus change its configuration will exert a quite appreciable force. By this means, therefore, one is able to obtain a sizable and effective force or degree of movement at one elevated temperature while substantially no force or degree of movement is obtained at another temperature only slightly therebelow. Hence elements of the type under discussion are quite temperature-sensitive and they produce operative action of appreciable magnitude over only a very slight temperature differential when the predetermined temperature is closely approached. Hence problems of calibration and adjustment are minimized, the necessity of utilizing a plurality of individual thermostats or other temperature-sensing devices is eliminated, and yet the entire length over which the elongated element extends is effectively monitored. accomodate

The action exerted by an elongated element of (e.g. character under discussion, once its predetermined activating temperature has been exceeded, will increase in accordance with the severity of the sensed temperature disturbance or the length of the space where it occurs. If the elongated element is subjected to excessive temperature over a substantial portion of its length, that entire portion will tend to change its shape, and thus the effective overall length of the element will tend to be varied appreciably. Even if the excessive temperature is highly localized, if it lasts for a long time or is quite excessive portions of the wire to either side of the portion directly affected will themselves become heated to above the predetermined temperature, they too will tend to change their configuration, and in all of these situations the force or movement of the elongated element will be accentuated and increased. Hence the temperature sensing elements of the type here under discussion are well adapted to actuate a series of work elements in sequence, the nature of the work elements being appropriate to the extent of the excessive temperature sensed. For example, a slight increase in temperature above the predetermined value may be effective to turn off a baseboard heater, but a greater excessive heat effect sensed by the elongated element may then be effective to sound an alarm or even to actuate a fire extinguishing device such as a cylinder of carbon dioxide.

This progressive action of the elongated temperature sensing devices of the type under discussion, while producing useful results as set forth above, generally requires special mounting for those elements, with means being provided, once the elongated element has done the work that it is supposed to do, to take up and compensate for any further changes in effective length thereof. This is usually accomplished by providing a resilient means as part of the mounting apparatus. This resilient means performs another function - when the elongated element has changed its shape after being subjected to the predetermined activating temperature, it will not tend inherently to resume its original shape after that excessive temperature has been withdrawn. If the device is to be active over a number of detection cycles, means must be provided for restoring it to its original sensing condition once the excessive temperature is no longer present, and the resilient mounting means performs that function.

The particular temperature to which a given material of the type under discussion is sensitive will be determined by its composition, and once the material has been made its composition cannot be varied. Different washer, may call for temperature sensing at different temperatures within a range. The elongated temperature sensing devices of the present invention can be adapted to function operatively at different predetermined (e.g. within that range in various ways. The material in question is somewhat electrically conductive, and hence a controlled amount of current can be passed therethrough, thereby normally to raise its temperature somewhat and therefore to lower the external temperature required in order to actuate the elongated element. Variation in the degree of tension exerted by the spring mounting for the elongated element, or variation in the spring resistance to movement exerted by the part to which the elongated element is secured, which part is designed to actuate the work means, will also provide for temperature adjustment within a range.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to a system for sensing excessive inner over an extended length and for actuating work means in accordance therewith, as defined in the appended claims and as described in this specification, taken together with the accompanying drawings, in which:

FIG. 1 is a circuit diagram of a typical circuit for a baseboard heater, showing the present invention actuating a normally closed switch within the baseboard heater circuit;

FIG. 2 is a view similar to FIG. 1 but showing the present invention actuating a normally open switch angles in conjunction with a baseboard heater circuit and also actuating an alarm;

FIG. 3 is a side elevational view of an exemplary baseboard heater construction with which the temperature sensing system of the present invention has been combined;

FIG. 4 is a cross sectional view taken along the line 4—4 of FIG. 3; coverage

FIG. 5 is a view of a typical section of the elongated element temperature sensing means of the present invention in its "memory" configuration;

FIG. 5A is a view similar to FIG. 5 but showing a specifically different "memory" configuration for the elongated element;

FIG. 6 represents the elongated element section of FIG. 5 or 5A stretched out from its "memory" configuration;

FIG. 7 is a side elevational view showing one manner of mounting of a switch and actuating means therefore, specifically adapted to be actuated in accordance with the teachings of the present invention;

FIG. 8 is a semi-schematic diagram showing the mounting and manner of operation of yet another normally open switch embodiment, that switch being shown actuating an alarm circuit;

FIG. 9 is a semi-schematic view showing a mounting arrangement for a system of the present invention in which elongated temperature sensing element is adapted to control two different work means, a switch in a heater circuit and a fire extinguishing cylinder, in sequence, that view also showing the use of an external circuit passing current through the elongated element in order to control the predetermined temperature at which it will tend to change its configuration, and also showing a latching arrangement for the system; and

FIG. 10 represents yet another embodiment in which the temperature sensing system actuates two different work means in sequence and in which a latching arrangement is provided.

As has been indicated, the elongated temperature sensing element is formed of a material which has a "-memory" effective when the material is subjected to a predetermined elevated temperature to cause the material to resume a shape which had previously been imparted to it. For purposes of illustration the elongated element is provided, as embodied in the various installations here disclosed, with a "memory" which makes it resume a coiled shape, such as is shown in FIG. 5, or a sinuous or undulating shape such as is shown in FIG. 5A. This "memory" is imparted to the material by causing it to assume the configuration shown in FIG. 5 or 5A, by way of example, and then subjecting it to an appropriate heat treatment while it is in that configuration. Thereafter the elongated strip or wire is stretched out into a substantially straight line configuration such as is shown in FIG. 6. As a practical matter there may well be some undulation of low amplitude in the wire, and such undulations are shown in FIG. 6, but they are far less in amplitude than the undulations in the "memory" configuration of FIG. 5A or the coiled configuration of FIG. 5. It will be appreciated, therefore, that when the elongated wire has been changed from its configuration of FIGS. 5 or 5A to its configuration of FIG. 6 the effective length of the wire will be greatly increased, and conversely, when the material, after being subjected to the predetermined critical temperature, tends to resume its "memory" configuration the effective length of the elongated element, from one end thereof to the other, will be greatly shortened.

FIGS. 1 and 2 illustrate schematically two different arrangements where an elongated wire of the type here disclosed, generally designated A, is used as temperature sensing instrumentality in conjunction with an elongated baseboard heater. In FIG. 1 the wire A acts upon a normally closed switch whereas in FIG. 2 the wire A acts upon a normally open switch. These representations are, of course, but exemplary of a large number of arrangements which could be employed for various purposes.

In FIGS. 1 and 2 the baseboard heater is generally designated 2, a power source therefor is generally designated 4, and a room thermostat designed to control the energization of the heater 2 is generally designated 6. These elements are connected together in series in an electrical circuit so that the heater 2 is appropriately energized and de-energized depending upon the temperature sensed by the room thermostat 6.

In the embodiment of FIG. 1 a normally closed switch generally designated 8 is interposed in the circuit for the heater 2. A wire A having the characteristics set forth above is mounted in any appropriate fashion so as to extend along the heater 2 adjacent to but spaced from the latter, thereby to be able to sense the temperature of the portion along the length of the heater 2. One end 10 of the wire A is fixed, while the other end 12 is operatively connected to the switch 8. The wire A is in its substantially linear form such as is shown in FIG. 6, and that wire has a "memory" configuration which may be that of FIGS. 5 or 5A. Consequently, if any section of the wire A is subjected to a temperature above that critical temperature which causes the material to revert to its "memory" configuration, the thus-affected section will indeed tend to revert to the condition, the overall length of the wire A will tend to reduce, and consequently a normally closed switch 8 will be opened and the circuit to the heater 2 will be interrupted.

In the exemplary embodiment illustrated in FIG. 2, there is a normally closed switch 8a in the heater circuit, but it is not directly acted upon by the wire A which extends along the length of the heater 2. Instead, a circuit generally designated 14 is provided comprising a normally open switch 16, and, in series therewith a power source 17 and a solenoid coil 18 which acts upon an armature 20 connected to the normally closed switch 8a. If desired, an alarm 22 may also be interposed in the circuit 14. In this type of circuit when the wire A, or any section thereof, is subjected to a temperature above the critical temperature, that wire or wire section will tend to resume its "memory" configuration, its effective length will tend to change, and since its free end 12 is secured to the normally open switch 16, it will at such time pull the switch 16 closed. This will energize the solenoid winding 18, which will in turn attract the armature 20 and open the switch 8a, thus interrupting the heater circuit, and at the same time an alarm 22, which may take any desired form, will be sounded.

FIGS. 3 and 4 illustrate a typical structural embodiment which, in accordance with the type of switch employed and the nature of the electrical connections thereto, could be either of the normally closed switch type shown in FIG. 1 of the normally open switch type shown in FIG. 2. The heater element 2' is mounted on brackets 24 and 26 and appropriate electrical connections are made thereto, all as is well known in the art. Baseboard heaters of the type here illustrated are usually of appreciable length, 3 feet or considerably more in length. As has been indicated, it is desirable to sense the temperature of the heater along its entire length so that if any portion thereof exceeds a safe value, an appropriate control or warning action is automatically taken. To that end the switch 8', which may either be of the normally open or normally closed type, is mounted on a framework 28 secured to the bracket 26. That switch has an actuating element or button 30 extending therefrom. When the button is in its normal extended condition the switch 8' is in its normal condition, either open or closed depending upon its character. When the button 30 is depressed the condition of the switch is changed — a normally open switch is closed and a normally closed switch is opened. In order to actuate the button 30, an arm 32 is pivotally mounted on the framework 28 at 34, and that arm is provided with an adjustable screw stop 36 located opposite the button 30. The upper end of the arm 32 is connected, by means of adjustable screw 38, to the free end 12 of the wire A, the other end 10 of that wire being connected to the bracket 24 either rigidly or by means of the spring 40. The wire A has a "memory" configuration such as illustrated in FIG. 5 and is shown in the broken lines in FIG. 3. It is, however, in its standby condition stretched out to its substantially straightline configuration such as is shown in FIG. 6. It is located relatively close to the heater 2', usually only a few inches, perhaps 2–5 inches, from the heater 2'. With baseboard heaters temperatures of 180°–190°F are satisfactory, but temperatures of 200°–250°F are unsatisfactory, and consequently the material of which the wire A is made is so compounded that its critical temperature, the predetermined temperature at which it will tend to resume its "memory" shape, is in the 200°–250°F range. As may be seen from FIG. 4, a spring 42 of the torsion type is wound about the pivot shaft 34 and is active on the arm 32 so as to tend to cause it to rotate in a clockwise direction as viewed in FIG. 3, thereby putting tension on the wire A and tending to retain it in its substantially straight line configuration.

If now any section of the wire A should be subjected to a temperature such as to cause that section to tend to return to its "memory" configuration, the wire A will tend to exert a pull on the arm 32 against the action of the spring 42, and when that pull has become strong enough to overcome the action of the spring 42 and the force active on the button 30 tending to keep it projected out, the arm 32 will be pulled by the wire A in a counter-clockwise direction, bringing its screw stop 36 into engagement with the switch actuating button 30 and depressing that button, thereby causing the switch 8' to change its condition from open to closed or closed to open depending upon the particular nature of the switch. If, as is shown in FIGS. 1 and 2, the switch 8' is operatively connected to the heater 2 so as to break the energizing circuit therefor, the detection of the excess temperature by the wire A will have the effect of deenergizing the heater 2, thereby causing it to cool and eliminating the dangerous condition.

When the arm 32 has been pulled by the wire A and caused to rotate in a counter-clockwise direction as viewed in FIG. 3 until the switch-actuating button 30 is fully depressed, the arm 32 can move no further. The wire A, however, may, because of the temperature to which it is subjected and the extend of the length of the wire which is subjected to that temperature, still tend to resume its "memory" configuration, so that the effective length of the wire A will tend to reduce still further. When the end 10 of the wire A is connected to its support by means of the spring 40, the force of the wire in thus tending to resume its "memory" configuration will stretch the spring 40, and hence no damage will be done to the system. When the wire A itself cools to below the predetermined temperature, the spring 40 (if present) and the spring 42 active on the arm 32 will exert a stretching force on the wire A which will cause it to return it to its stand-by substantially straight line condition. The wire A will then be ready for another temperature sensing sequence.

FIG. 7 discloses another type of mounting for the switch 8'. In this embodiment its actuating button 30 is normally engaged and depressed by the screw stop 36 on the arm 32, that arm in this instance normally being urged into button-depressing condition by means of spring 42'. The wire A, when it tends to shorten because it tries to resume its "memory" configuration, will pull the arm 32 against the action of the spring 42', causing it to rotate in a counter-clockwise direction, thus releasing the button 30 and permitting the button 8' to resume its normal condition, either open or closed, depending upon the nature of the switch. In this embodiment continued contraction of the overall length of the wire A after the switch 8' has been actuated will have no appreciable deleterious effect, merely stretching the spring 42'. If there is any danger that the spring 42' may thus be stretched beyond its elastic limit, an appropriate positive stop can be provided for the arm 32, limiting the degree to which it can pivot in a counter-clockwise direction. When such a positive stop is provided, it may be desired to mount the end 10 of the wire A by means of the spring 40, as in FIG. 3.

FIG. 8 discloses another type of mounting which is effective in connection with the present invention. Here the switch 8'' is mounted on a bracket 44 which is itself pivotally mounted at 46 on a fixed supporting structure 48. The switch 8'' has an actuating button 30 projecting therefrom. A spring 50 is connected between the supporting bracket 48 and the bracket 44 and tends to cause the bracket 44 to pivot in a counter-clockwise direction as viewed in the drawing until it comes up against a vertical support 52. Also pivotally mounted about the axis 46 is an arm 54, which arm is urged against a positive stop 56 by means of spring 58. The positive stop 56 is so located that when the arm 54 is against it and when the bracket 44 carrying the switch 8'' is against the stationary support 52, the switch actuating button 30 is in its projecting condition. The wire A has its end 12 connected to the bracket 44, so that as the wire A tends to resume its "memory" configuration, thereby shortening its effective length, the bracket 44 is caused to pivot in a clockwise direction against the action of the spring 50. This brings the switch actuating button against the arm 54, and the force of the spring 58 acting on the arm 54 is greater than the resilient force which tends to urge the switch actuating button 30 outwardly. Consequently the switch actuating button 30 will be pushed in by the arm 54 as the bracket 44 and switch 8'' are moved toward that arm 44, thereby changing the status of the switch 8'' from open to closed or closed to open as the case may be. Any further shortening of the effective length of the wire A by reason of its tendency to resume its "-memory" configuration will cause the bracket 44 to pivot in a clockwise direction to a further degree, this causing the arm 54 to pivot in the same direction, stretching the spring 58, while still keeping the switch actuating button 30 depressed. In this particular figure, by way of illustration, the switch 8'' is shown as a normally open switch connected in circuit between a battery 4' and a relay winding 18', the relay winding 18' in turn being active on the armature of a normally open switch 60 in series with a battery 62 and an alarm 64. Hence it will be seen that when the normally open switch 8'' is closed the relay winding 18' will be energized, and this in turn will close the circuit to the alarm bell 64.

In the embodiments thus far illustrated, the wire A has been effective to actuate work elements such as alarms or circuit switches, all of those elements being actuated substantially simultaneously. The embodiment of FIG. 9 illustrates an arrangement by which the wire A may actuate a pair of work means sequentially. It also illustrates a different type of structural mounting for the switch-type work means, and it also illustrates one means which may be employed for adjusting, within limits, the predetermined temperature sensed by the wire A. In addition, it shows an arrangement involving a latching action, so that when the wire A actuates one or both of the work means, as desired, it will be latched in actuated position, requiring a manual operation for resetting. While these various instrumentalities are all included in the embodiment of FIG. 9, it will be understood that this is by way of exemplification only, and that each of these features could be employed in one or another of the illustrated embodiments, or in specific embodiments not here explicitly illustrated.

The end **10** of the wire A is connected to the trigger **66** of a work means such as a cylinder **68** of carbon dioxide or other fire extinguishing fluid. The other end **12** of the wire A is connected to arm **54'** pivotally mounted at **46'** on bracket **48'**. The switch **8** is illustrated as being of the normally open type, and has a projecting actuating button **30** adapted to be engaged and depressed by the arm **54'** under the action of the spring **58'**. The bracket **48'** is provided with a positive stop **56'** which is active on the arm **54'** to limit the degree to which it can pivot in a counter-clockwise direction. The normally open switch **8** is shown in circuit with a baseboard heater **2**, a power source **4**, and a room thermostat **6**, as in the circuit of FIG. **1**, the normally open switch **8** being normally held closed by the spring **58'** acting on the arm **54'**. When the wire A is subjected to an appropriate temperature and tends to assume its "memory" configuration it will pull the arm **54'** to the left up against the positive stop **56'**, thus releasing the switch actuating button **30** and causing the switch **8** to open, thereby interrupting energization of the heating unit **2**. If this is sufficient to permit the wire A to cool down and thus no longer tend to assume its "memory" configuration, the spring **58'** will be effective to reelongate the wire A and once again bring the arm **54'** into engagement with the switch button **30**, thus closing the switch **8**. However, if the wire A becomes further subjected to excessive temperature, it will continue to tend to shorten its effective length. The arm **54'** can no longer move to the left, as viewed in the figure, because it is up against the positive stop **56'**. The force exerted by the wire A will then be transmitted to the trigger **66** for the carbon dioxide cylinder **68**, and will actuate that trigger so as to cause the cylinder **68** to emit carbon dioxide, thereby to extinguish any fire which might be present. In place of the carbon dioxide cylinder **68** any other suitable fire extinguishing apparatus could be employed, such as a water sprinkling system. Alarms could also be actuated in this instance. Because the trigger **66** for the work means **68** has a greater resistance to movement than the arm **54'**, the wire A will therefore actuate the work means defined by the switch **8** before the work means defined by the cylinder **68**.

Located above the arm **54'** is a pawl **70** adapted to cooperate with the tip of the arm **54'**. When that arm has been moved against the stop **56'**, the pawl **70** will, either by its own weight or assisted by a spring (not shown), fall down in front of the arm **54'**, latch it in its counter-clockwise position, and thus prevent it from resuming its position as shown in FIG. **9**. As a result manual release of the latching pawl **70** will be required before the circuit to the heater **2** can be closed. This is a particularly desirable feature when a serious overheating has been detected. Accordingly, it may be desirable to so locate the pawl **70**, the positive stop **56'**, and the switch button **30** that the arm **54'** can be moved to release the button **30**, thereby opening the switch **8**, before it engages the positive stop **56'** and is latched by the pawl **70**, the latching pawl **70** becoming effective only when the arm is pulled all the way to the positive stop **56'**. In this way there will be automatic reset for small sensed departures from proper temperature, but manual reset will be required when extensive overheating is sensed.

In addition, in FIG. **9**, an electrical circuit is completed through the wire A, that circuit including a variable resistor or potentiometer **72** and a battery **74**. Through appropriate adjustment of the resistor or potentiometer **72**, the amount of current passing through the wire A and be controlled. That current, in passing through the wire A, will produce heat and will raise the temperature of the wire A, thus reducing the external temperature which is required in order to cause the wire A to tend to assume its "memory" configuration. For example, if a current is selected which will raise the temperature of the wire A by 30°F, and if the material of which the wire is formed becomes effective at 280°F to assume its "memory" configuration, then the thus-energized wire A will tend to change its configuration when the ambient temperature is at 250°F.

FIG. **10** illustrates another embodiment where the wire A is adapted to sequentially actuate two different work means. It further illustrates another way of mounting the various parts of the control assembly. As in FIG. **8**, bracket **44'** carries switch **8**, which in this instance is a normally closed switch. That bracket is pivotally mounted on support **48'** at **46'** and is pivotally urged in clockwise direction by spring **50'**. Support **48'** carries positive stop **56'**, against which pivotally mounted arm **54'** is adapted to be pulled by spring **58'**. In this instance the second work means, here shown by way of exemplification as a carbon dioxide cylinder **68**, is mounted so that its trigger **66** is located close to the arm **54'** and on the opposite side thereof from the stop **56'**. The end **12** of the wire A is connected to the bracket **44'**, while the end **10** thereof is fixed in position. As the wire A tends to shorten, because at least a portion of the wire is tending to resume its "memory" configuration, the bracket **44'** is caused to pivot in a counter-clockwise direction, bringing the switch button **30** into engagement with the arm **54'**, the spring **58'** being strong enough so that this causes the button **30** to be depressed, thereby changing the status of the switch **8** — as here disclosed the switch **8** is of the normally closed type, is in series with the heater **2**, and therefore when the button **30** is depressed the heating circuit is opened. If the wire A continues to contract its effective length, the arm **54'** will be pivoted in a counter-clockwise direction against the action of the spring **58'**, will be brought into engagement with the trigger **66** for the carbon dioxide cylinder **68**, and eventually will be caused to actuate that trigger **66**, thus setting off the fire extinguishing element. In this embodiment, as in the embodiment of FIG. **9**, a latching pawl **70'** is provided, which pawl snaps behind the arm **54'** only after that arm has been moved away from the positive stop **56'**. Consequently there will be automatic reset for small excessive temperature detection, and a manual reset will be required if a serious excessive temperature situation is detected.

Control of the temperature at which the work means will be actuated by a wire A can also be accomplished by varying the spring force which resists shortening of the wire A. Thus any of the springs 42, 42', 50, 58' may be adjustable in order to provide for such control, which will be effective over a range of approximately 20°–40F.

While the system in question has been here illustrated primarily in connection with baseboard heaters, because it is in conjunction with such devices that temperature sensing at various places along the length of the heater, and optimally at every point along its length, is very important, the temperature sensing effect of the system here disclosed may also be used wherever safety factors are important and the sensing of excessive temperatures over an appreciable space or distance is involved. For example, the insides of computer or television set cabinets can be monitored by stringing the wire A along the inner surface thereof.

The structural apparatus involved in order to carry out the excessive temperature sensing in accordance with the present invention is exceedingly simple and need not be made to any high degree of precision either mechanically or electrically. The wire or strip may be provided in elongated form, cut to length, and secured in place in simple fashion. The work means actuated by the strip may be simple, commercially available devices. The precision and effectiveness of the excessive temperature sensing is dependent upon the material of which the wire is formed, and not on any particularly precise method of mounting thereof. Various types of control and actuation can be achieved without excessive complexity of structure or operation. Where adjustment is required or desired, it can be accomplished in no more complex a manner than by changing the value of a variable resistor or adjusting the tension of a spring.

While reference has been made in this specification specifically to the use of Nitinol as the material from which the elongated temperature sensing element A is formed, it will be understood that any material having the described characteristics will be effective for the purposes described.

While various structural and operational arrangements have been here specifically disclosed in order to bring out the flexibility of use of the system of the present invention, it will be understood that these are by way of exemplification only, and that many other structural and functional arrangements could be employed, that the work means actuated by the system can be of virtually any type desired, depending upon the particular application, that the various means of mounting and adjustment shown in a particular specific embodiment could if desired be employed in some other specific embodiment, and that many variations may be made in that which is here specifically disclosed, all without departing from the spirit of the invention as defined in the following claims.

I claim:

1. The combination of an elongated heater, means operatively connected thereto to cause it to heat, a work means operatively associated therewith and effective when actuated to perform a work operation appropriate to overheating on the part of said heater, and means for actuating said work means, in which said actuating means comprises an elongated element of material, means operatively connected to said element for mounting it to extend along said heating element and in operative heat transfer relation thereto with the ends of said element normally separated by a first distance, said element being formed of material having the characteristic that sections along its length when subjected to temperatures below a predetermined temperature will tend to retain their configuration but when subjected to said predetermined temperature will tend to change their configuration, thereby to tend to alter the separation between the ends of said element, said element being operatively connected to said work means and effective to actuate said work means when said ends of said element tend to be separated by a second distance different from said first distance, said work means comprising a part movable between first and second positions means biasing said part to one of said positions, said element moving said part to the other of said positions when a section of said element changes its shape in response to said predetermined temperature, a member mounted opposite said part, said member and said part being mounted for relative movement respectively into and out of engagement with one another, biasing means active on one of said member and said part and effective to cause said relative movement in one sense, said element being operatively connected to only one of said member and said part and effective to cause relative movement between them in the opposite sense, in which one of said member and said part is mounted independently of the other in a first position where it is engaged by the other when the other moves in one direction, said one of said member and said part being mounted so as to then be movable in said one direction out of said first position as the other of said member and said part moves further in said one direction.

2. The combination of an elongated heater, means operatively connected thereto to cause it to heat, a work means operatively associated therewith and effective when actuated to perform a work operation appropriate to overheating on the part of said heater, and means for actuating said work means, in which said actuating means comprises an elongated element of material, means operatively connected to said element for mounting it to extend along said heating element and in operative heat transfer relation thereto with the ends of said element normally separated by a first distance, said element being formed of material having the characteristic that sections along its length when subjected to temperatures below a predetermined temperature will tend to retain their configuration but when subjected to said predetermined temperature will tend to change their configuration, thereby to tend to alter the separation between the ends of said element, said element being operatively connected to said work means and effective to actuate said work means when said ends of said element tend to be separated by a second distance different from said first distance, said work means comprising a part movable between first and second positions a member mounted opposite said part, said member and said part being mounted for

relative movement into and out of engagement with one another, biasing means active on one of said member and said part and effective to cause said relative movement in one sense, said element being operatively connected to only one of said member and said part and effective to cause relative movement between them in the opposite sense, in which one of said member and said part is mounted independently of the other in a first position where it is engaged by the other when the other moves in one direction, said one of said member and said part being mounted so as to then be movable in said one direction out of said first position as the other of said member and said part moves further in said one direction.

3. The combination of an elongated heater, means operatively connected thereto cause it to heat, a work means operatively associated therewith and effective when actuated to perform a work operation appropriate to overheating on the part of said heater, and means for actuating said work means, in which said actuating means comprises an elongated element of material, means operatively connected to said element for mounting it to extend along said heating element and in operative heat transfer relation thereto with the ends of said element normally separated by a first distance, said element being formed of material having the characteristic that sections along its length when subjected to temperatures below a predetermined temperature will tend to retain their configuration but when subjected to said predetermined temperature will tend to change their configuration, thereby to tend to alter the separation between the ends of said element, said element being operatively connected to said work means and effective to actuate said work means when said ends of said element tend to be separated by a second distance different from said first distance, said heater being electrically energized, said work means comprises a switch movable between open circuit and closed circuit positions and operatively connected to said heater, and said actuating means is operatively connected to said switch to move the same from one of said positions to the other in response to the presence or absence of said tendency on the part of said element when subjected to said predetermined temperature, said actuating means comprising a part movable between first and second positions a member mounted opposite said part, said member and said part being mounted for relative movement into and out of engagement with one another, biasing means active on one of said member and said part and effective to cause said relative movement in one sense, said element being operatively connected to only one of said member and said part and effective to cause relative movement between them in the opposite sense, in which one of said member and said part is mounted independently of the other in a first position where it is engaged by the other when the other moves in one direction, said one of said member and said part being mounted so as to then be movable in said one direction out of said first position as the other of said member and said part moves further in said one direction.

4. The combination of an elongated heater, means operatively connected thereto to cause it to heat, a work means operatively associated therewith and effective when actuated to perform a work operation appropriate to overheating on the part of said heater, and means for actuating said work means, in which said actuating means comprises an elongated element, means operatively connected to said element for mounting it to extend along said heating element and in operative heat transfer relation thereto with the ends of said element normally separated by a first distance, said element being formed of material having the characteristic that sections along its length when subjected to temperatures below a predetermined temperature will tend to retain their configuration but when subjected to said predetermined temperature will tend to change their configuration in a given sense, thereby to tend to alter the separation between the ends of said element, said element being operatively connected to said work means and effective to actuate said work means when said ends of said element tend to be separated by a second distance different from said first distance, a second work means having an actuating means operatively connected thereto, and means operatively connecting said element to said actuating means for said second work means and effective to actuate the latter if said element continues to tend to change its configuration in a given sense after said first work means has been actuated by a change in configuration of said element in said given sense.

5. The combination of claim 4, in which said first and second work means are respectively connected to said element at points spaced along the length of said element, said actuating means for said first work means being more easily actuatable than is said actuating means for said second work means.

6. The combination of claim 4, in which said element is connected to said first work means and is effective when change in configuration occurs to move said first work means, said actuating means of said second work means being located in the operative path of movement of said first work means to be operatively engaged and actuated thereby when said first work means is moved a predetermined amount.

7. Apparatus for sensing excessive temperature at points along an extended length comprising an elongated element the length of which corresponds to said extended length, said element having the characteristic that individual sections along its length will tend to assume a substantially straight line condition when subjected to temperatures below a predetermined temperature but when subjected to said predetermined temperature will tend to assume a non-linear condition, thereby acting to reduce the end-to-end length of said element, means operatively connected to said element for mounting it to extend with its sections in substantially straight line condition along said extended length, a work means effective when actuated to perform a work operation appropriate to the sensing of overheating at points along said extended length, and means operatively connecting said elongated element and said work means to actuate said work means when said elongated element is subjected to said predetermined temperature at least over a section thereof, whereby said section tends to assume said non-linear condition, a second work means effective when actuated to perform a work operation appropriate to the sensing of overheating at a point along said extended length, and means operatively connecting said elongated element

and said second work means and effective to actuate said second means after said first work means has been actuated if sections of said elongated element continue, after actuating said first work means, to tend to assume said non-linear condition.

8. The combination of an elongated heater, means operatively connected thereto to cause it to heat, a work means operatively associated therewith and effective when actuated to perform a work operation appropriate to overheating on the part of said heater, and means for actuating said work means, in which said actuating means comprises an elongated element of material, means operatively connected to said element for mounting it to extend along said heating element and in operative heat transfer relation Thereto with the ends of said element normally separated by a first distance, said element being formed of material having the characteristic that sections along its length when subjected to temperatures below a predetermined temperature will tend to retain their configuration but when subjected to said predetermined temperature will tend to change their configuration, thereby to tend to alter the separation between the ends of said element, said element being operatively connected to said work means and effective to actuate said work means when said ends of said element tend to be separated by a second distance different from said first distance, in which said work means includes a part movable between first and second positions, a support, said work means being operatively mounted on said support, and a mechanical connection between said part and said element comprising a member mounted on said support operatively opposite said part, at least one of said work means and said member being articulately mounted on said support for relative movement in first and second directions respectively into and out of engagement with the other, means for biasing said at least one of said work means and said member for movement in one of said directions, said element being connected to said one of said work means and said member for moving it in the other direction when a section of said element changes its configuration in response to said predetermined temperature, in which said member is fixed to said support against movement in at least one direction, said work means is articulately mounted on said support, and said biasing means biases said work means so as to move said part out of engagement with said member.

9. In the combination of claim **8**, a positive stop for said member, biasing means urging said member against said stop toward but short of said work means, thereby to fix said member to said support against movement toward said work means but permit said member to move with said work means when said work means continues to move after its part engages said member.

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