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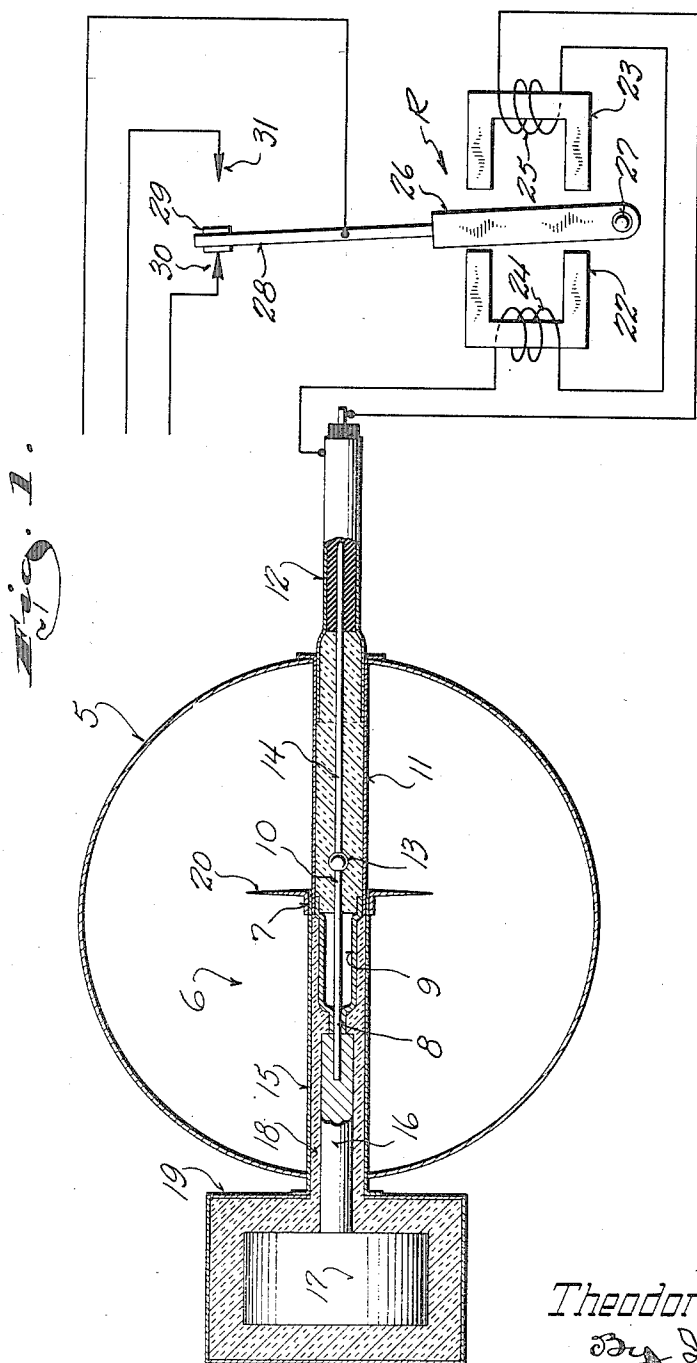
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2,304,489

CONTROL INSTRUMENTALITIES

Filed Aug. 14, 1939

4 Sheets-Sheet 1



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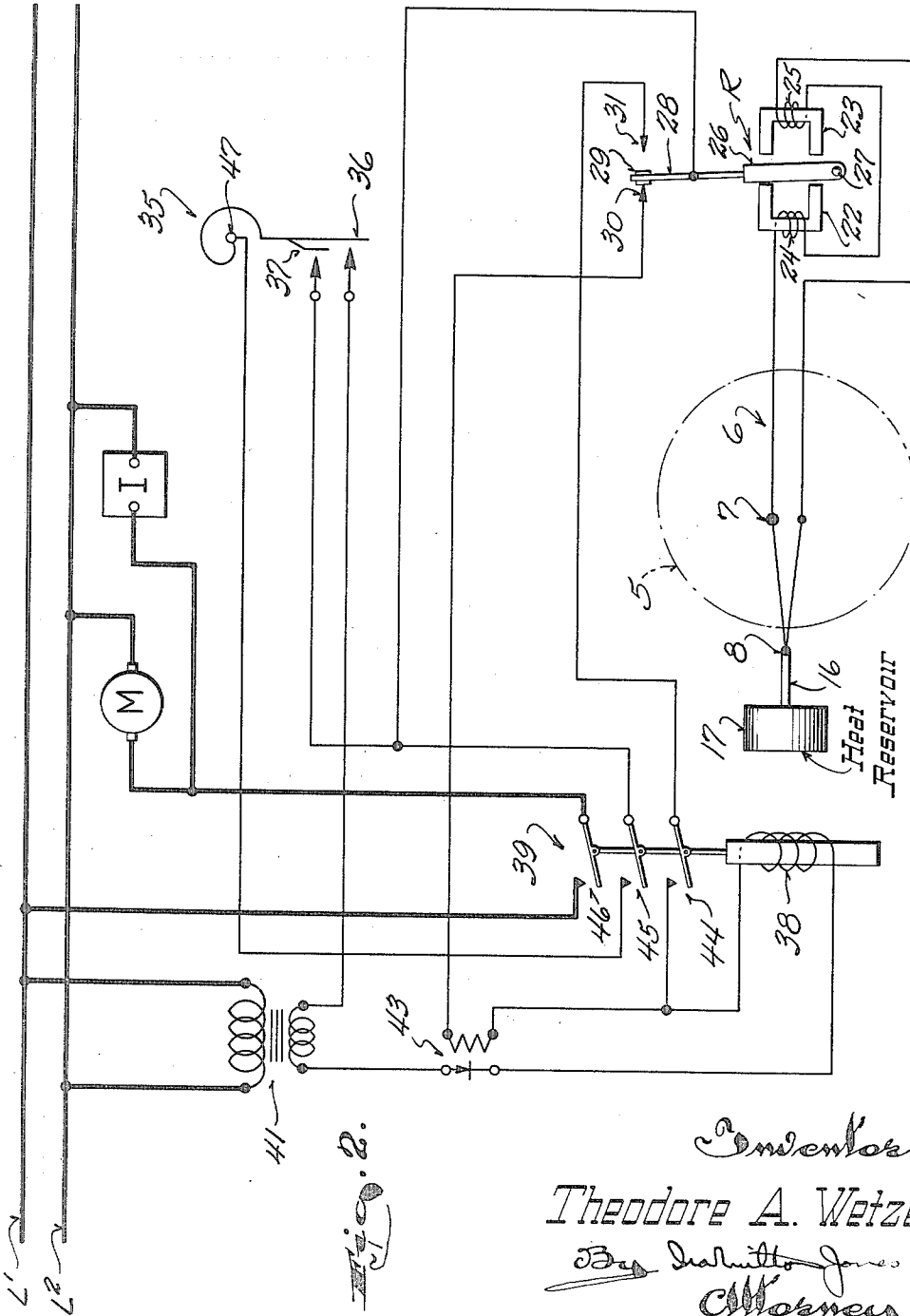
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Fig. 3.

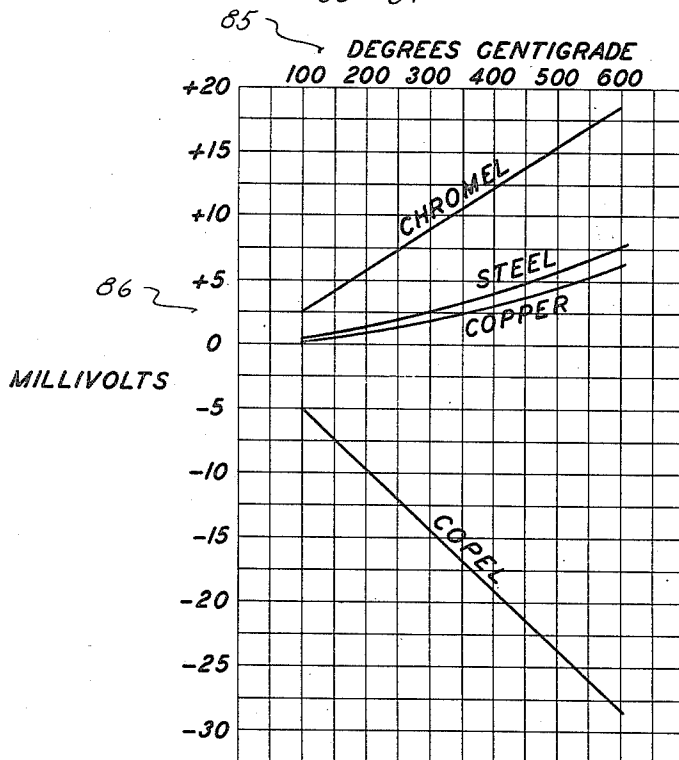
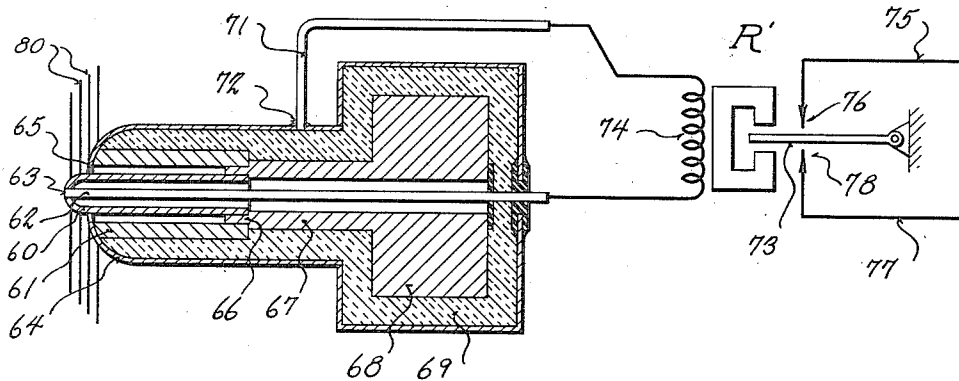


Fig. 4.

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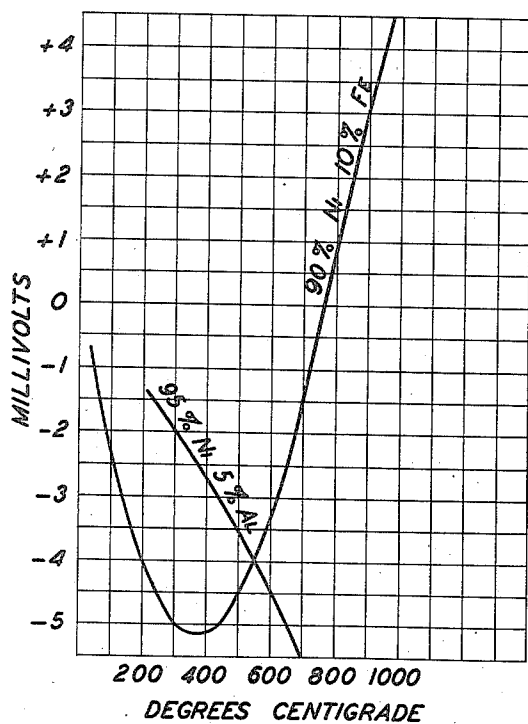
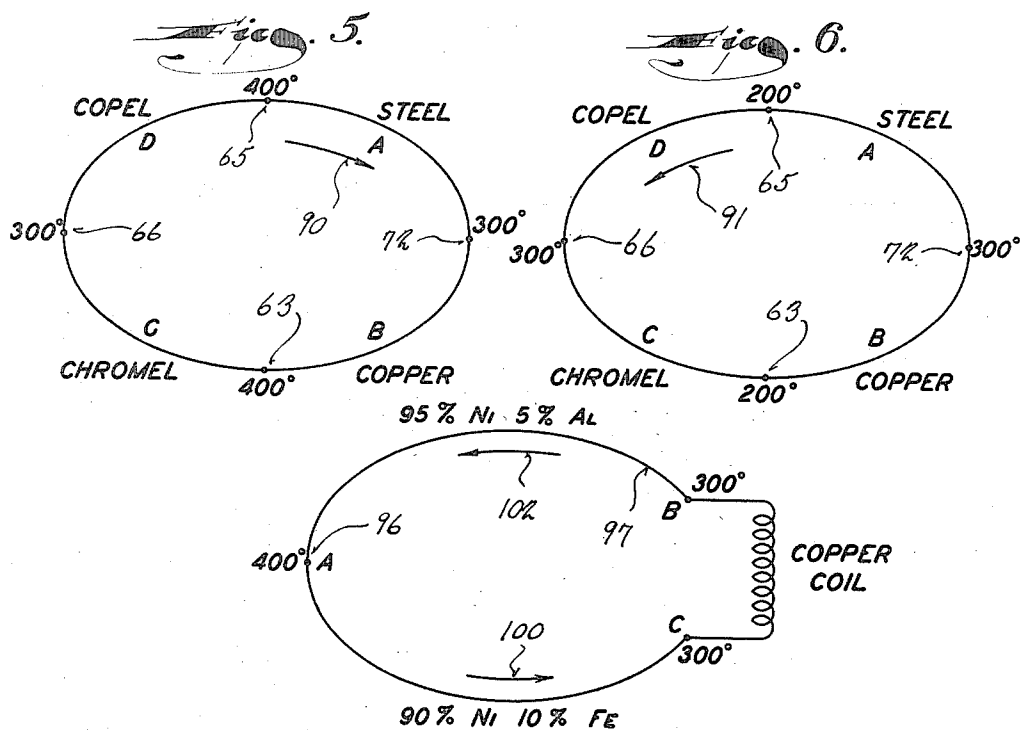
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CONTROL INSTRUMENTALITIES

Filed Aug. 14, 1939

4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,304,489

CONTROL INSTRUMENTALITY

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Application August 14, 1939, Serial No. 290,136

10 Claims. (Cl. 158—28)

This invention relates to control instrumentalities, and refers particularly to a thermoelectric control employing a thermocouple.

The properties of the thermocouple and of thermocouples connected in parallel or in series are well known, and their use in electrical control systems or apparatus is not broadly new; but this invention utilizes the known characteristics of thermocouples in a new and novel manner to effect an entirely new controlling function.

A broad object of the present invention thus resides in the provision of a new and improved manner of utilizing thermocouples in an electric control system.

More specifically, this invention contemplates as one of its objects the provision of means whereby a reversal in the relationship between the junctions of a thermocouple, i. e., the normally cold junction of the thermocouple becomes the hot junction, and vice versa, is definitely assured to bring about a positive and usable reversal in the flow of current in the thermocouple circuit.

While this broad concept is of course susceptible to wide application, and many different uses, it is admirably suited to use with the control systems of oil burners and other kindred appliances; and the invention, therefore, has, as another of its objects, the provision of an improved control system for oil burners wherein one of the controlling instrumentalities consists of a thermocouple and appropriate electroresponsive devices.

A further object of this invention is to provide a new and improved stack control for use on heating systems to effect "shut down" of the oil burner in the event of flame failure.

A still further object of this invention is to provide a control of the character described which will function directly upon any retrograde change in temperature at the exposed junction of a thermocouple, regardless of the point in the temperature gradient at which it occurs.

Another and more specific object of this invention is to provide in a safety device for apparatus of the class herein described, heating means, a thermocouple having a junction adapted to be subjected to the heat of said heating means which thermocouple has another junction adapted to cool more slowly than the first junction to effect a reversal of the thermoelectric current when the temperature of said second junction exceeds the temperature of said first junction, and means, and more specifically polarized relay means, connected in circuit with the thermocouple and operated in one manner by a flow of thermoelectric

current in one direction and, in another manner, by a flow of thermoelectric current in the opposite direction.

Another object of this invention is to provide, in connection with safety control apparatus of the class described, a thermocouple having more than two dissimilar metals and two or more junctions which are adapted to be heated, and to correlate the same with the control apparatus in a manner to provide a higher operating voltage and a greater voltage change on changing conditions of the apparatus.

Another object of this invention is to provide for utilizing the characteristic of certain thermocouple metals to reverse the generated E. M. F. when heated beyond the neutral point, for the purpose of actuating the control apparatus—for example, to shut off the supply of operative energy upon a rise in temperature beyond a safe operating temperature.

Another object of this invention is to combine the two effects, i. e., the reversal of generated E. M. F., which is secured by the reversal of temperature relationship of the thermojunctions, and the reversal which is secured when the thermocouple is heated beyond the neutral point to maintain the supply of operative energy to the apparatus so long as the desired but not excessive heat is applied to the thermocouple and to shut off the supply of operative energy upon falling off or cessation of the heat to which the thermocouple is subject and also upon a rise in temperature beyond a safe operating point.

With the above and other objects in view which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described, and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawings illustrate several complete examples of the physical embodiment of the invention constructed in accordance with the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a view illustrating one embodiment of this invention;

Figure 2 is a diagrammatic view illustrating the invention incorporated in a typical burner control system;

Figure 3 is a more or less diagrammatic view,

partially in section, showing another embodiment of the invention;

Figure 4 is a graph showing the thermal E. M. F. temperature characteristics of one particular combination of metals employed in the thermocouple shown in Figure 3 taken against platinum as a base;

Figures 5 and 6 are diagrams showing the manner in which the reversal of thermoelectric current is secured;

Figure 7 is a view showing diagrammatically another embodiment of the invention; and

Figure 8 is a graph showing the thermal E. M. F. temperature characteristics of one particular combination of thermocouple metals employed for purposes of illustration in Figure 7.

Referring now particularly to the accompanying drawings in which like numerals indicate like parts, the numeral 5 designates a heat conductor or flue which may be the stack of a furnace or other heating device. Mounted in this flue is a thermocouple, indicated generally by the numeral 6. The normally hot junction 7 of the thermocouple is positioned to be directly influenced by the temperature of the gases flowing through the duct, while the normally cold junction 8 of the thermocouple is insulated from the surrounding heat.

In the specific application of this invention illustrated in Figure 1, the thermocouple comprises a short sleeve or cylinder 9 of Copel, or other suitable metal, and which constitutes one element of the couple, and a wire 10 of Cromel "P," or other suitable metal, joined thereto at the normally cold junction 8 by shrinking or brazing the adjacent end of the sleeve 9 onto the wire, as shown. The opposite open end of the sleeve 9 is connected to a tube 11 at the normally hot junction 7. This tube, which is preferably of stainless steel to withstand the heat, extends out through the wall of the flue where it is connected to a flexible tubular conductor 12, preferably in the form of a length of copper tubing.

The center element 10 is joined, as at 13, to a wire 14 forming another thermoelectric junction, said wire 14 being within the tubing 12 but electrically insulated therefrom. This wire 14 and the tube 12 thus form two lines connectible with any electroresponsive instrumentality like, for instance, a polarized relay R.

The inner end of the steel tube 11 is telescoped into the adjacent end of a similar tube 15, which passes through an opening in the opposite side of the flue 5. The thermocouple structure is thus rigidly supported diametrically across the center of the flue by the tubes 11 and 15.

Inside the tube 15, the center element 10 and the element 9 of the thermocouple are joined at 8 to a stem 16, preferably formed of copper, aluminum or some other metal having a high specific heat or thermal storage capacity; and the outer end of this stem 16 is joined to a large mass or body 17 of similar metal. A packing 18 of asbestos spaces the stem 16 from the tube 15 and also provides heat insulation for the normally cold junction to insulate the same from the direct heat of the gases flowing through the flue.

The mass or body 17, which forms a heat reservoir, is also preferably encased within an insulating shell 19 so as not to be influenced by surrounding temperatures, nor to dissipate the heat conducted thereto from the thermocouple.

If desired, the normally hot junction 7 may

be provided with a fin 20 to insure more rapid heat transfer at this point.

In operation, when heated gases flow through the flue 5, which as stated, may be the stack of a heating plant or any other heat conductor, the temperature at the junction 7 rises above that of the junction 8; and as a consequence, current flows from the hot junction 7 along the element 9 to the cold junction 8, the junction 13, and out onto the wire 14. The wire 14 thus may be said to have a negative polarity during the rise of temperature in the flue 5, while the other side of the line formed by the tube 12, which joins with the hot junction 7, has a positive polarity during said time.

Hence, it will be seen that any electrical instrument connected across the lines provided by the wire 14 and the tube 12 may be energized; and if this instrumentality is polarity sensitive, its response will be one way or the other, depending upon the relationship which exists between the junctions of the thermocouple, and will reverse with a reversal of this relationship.

Concomitantly with initial functioning of the device, there is a continuous heat transfer by conduction from the junction 8 through the stem 16 and into the heat reservoir 17. Hence, it will be seen that as long as this condition obtains, the current flow in the control circuit will be unidirectional.

However, as soon as the temperature within the flue drops, and here it must be pointed out that it is immaterial at what degree in the temperature gradient such drop takes place, the normally hot junction 7 begins to cool and within a comparatively short period of time, a reversal of the temperature relationship at the spaced junctions takes place, i. e., the temperature at the normally hot junction drops below the temperature at the normally cold junction. This follows from the fact that the heat reservoir 17 stores a substantial reserve of heat energy, which it feeds back into the normally cold junction.

The instant this reversal in the temperature relationship between the spaced junctions takes place, there is a definite and positive reversal in the direction of current flow in the controlling circuit, and this invention utilizes this current reversal through the medium of the polarized relay R to effect a new and useful controlling function.

The relay R is of conventional design and comprises a pair of magnet cores 22 and 23 having coils 24 and 25, respectively, mounted thereon. An armature 26 pivotally mounted, as at 27, between the magnet cores is arranged to be attracted in one direction or the other depending upon the direction of current flow through the coils 24 and 25, which are connected in series, as shown.

Actuated by the armature 26 is a switch arm 28, the contact 29 of which is adapted to engage either of two stationary contacts 30 or 31 so that a circuit may be completed either from the switch arm 28 to the contact 30, or from the switch arm 28 to the contact 31.

In the embodiment illustrated in Figure 1, the magnet coils 24 and 25 are so connected with the tube 12 and the wire 14, which constitute the two leads from the thermocouple, that upon initial functioning of the device, as hereinbefore described, the armature 26 will be actuated toward the right because of the then direction of the current flow through the magnet coils. Instantly upon a reversal in the direction of cur-

rent flow, the armature is again swung back to the left position shown.

This invention is thus very well adapted for use as a stack control on heating systems; and in Figure 2, to which attention is now specifically directed, its application to a typical control system for oil fired heating plants is illustrated.

As here shown, the thermocouple 6 is mounted in the stack 5; and the contacts 30, 31 and 29 are electrically connected with the control system in such a manner that a drop in temperature in the flue as a consequence to flame failure will effect disruption of operation of the entire system. The manner in which this result is achieved is as follows:

When the room thermostat 35 calls for heat, it bridges its two contacts 36 and 37 with the result that the coil 38 of a control relay, indicated generally by the numeral 39, is energized. The circuit for this purpose beginning with contact 36 of the thermostat follows to one side of the secondary of a transformer 41, the primary of which is connected across lines L¹ and L². From the opposite side of the transformer secondary, the circuit extends through the contacts of a safety switch 43 to one side of the relay coil 38. From the other side of the relay coil, the circuit is continued to the heating element of the safety switch; and from there, to contact 30 on the polarized relay. The contact 29 being then in engagement with the contact 30, the circuit is continued to the contact 31 of the room thermostat.

Energization of the relay coil 38 thus effected closes the switches 44, 45 and 46, the last of which connects the burner motor M and the ignition I across the lines L¹ and L².

Closure of the switch 45 establishes a holding circuit for the relay. This holding circuit may be traced from contact 36 of the room thermostat to one side of the transformer secondary through the contacts of the safety switch 43, the relay coil, the heater coil of the safety switch 43, contacts 30 and 29 of the polarized relay, closed switch 45, contact 47 of the room thermostat, and back to its contact 36.

The safety switch 43 now begins to heat up; and as already stated, ignition and combustion have taken place.

With the initiation of combustion, the temperature in the stack 5 rises and as a result, the thermocouple 6 develops an electromotive force of such polarity as to cause the contact 29 of the polarized relay to be swung over into engagement with the contact 31. During this momentary interruption of the energizing circuit for the relay coil 38, which, however, is very slight, its switches 44, 45 and 46 remain closed by virtue of a slight time delay in the relay.

Immediately with this change in the polarized relay, the heater coil of the safety switch is shunted out, as the coil circuit of the relay is now, beginning with contact 36 of the room thermostat through the transformer secondary, the closed contacts of the safety switch 43, the relay coil, closed switch 44, contacts 31 and 29 of the polarized relay, and back to the room thermostat. Normal operation of the burner now obtains.

In the event of flame failure, regardless of when it may occur, the resultant reduction in stack temperature effects a reversal in the direction of current flow induced by the thermocouple in the manner hereinbefore described, and thus immediately causes the polarized relay to return

its contact 29 into engagement with the contact 30. The heater coil of the safety switch 43 is thus reinserted in the circuit, so that at the end of the period of time for which the safety switch is set, the entire system is rendered inoperative by the tripping of the switch.

The thermocouple shown more or less diagrammatically in Figure 3 comprises an inner tubular thermocouple element 60 of Chromel or other suitable metal, surrounded by a tubular thermocouple element 61 of Copel or other suitable metal; a copper lead 62 joined to the outer end of the element 60 at 63, and a shell 64, preferably of stainless steel or other suitable metal, joined at 65 to the element 61.

The inner ends of the elements 60 and 61 are joined at 66 to a stem 67 preferably formed of copper, aluminum, or some other metal having a high specific heat or thermal storage capacity; and the outer end of the stem 67 is joined to a relatively large mass or body 68 of similar metal. The stem 67 and body 68 have an axial opening for the passage of the lead 62 therethrough. A packing 69, of asbestos or other suitable material, spaces the stem 67 and body 68, and also the element 61 except at the thermojunction 65, from the shell 64, and also provides heat insulation for the normally cold junction at 66 to insulate the same from the heat to which the thermojunctions 63 and 65 are subjected.

A copper lead 71 is joined to the shell 64 at 72 and the polarized relay R' is connected in circuit between the leads 62 and 71. The armature 73 of the relay R' constitutes one suitable form of switch arm which, upon the flow of thermoelectric current through the coil 74 of the relay in one direction, closes a circuit 75 at the contact 76 to maintain a supply of operative energy to the apparatus being controlled; and upon the reversal of the thermoelectric current, closes a circuit 77 at the contact 78 to shut off the supply of operative energy to the apparatus.

If desired, the thermojunctions 63 and 65 and the adjacent portions of the element 60 and shell 64 may be provided with fins 80 to insure more rapid heat transfer at these points.

The thermocouple may be arranged with the thermojunctions 63 and 65 and the fins 80 in position to be directly subject to the temperature of the gases flowing through a duct or stack, as in the preceding embodiment of the invention; or it may be arranged with the thermojunctions 63 and 65 and the fins in position to be subjected directly to the heat of a flame or to any other desired source of heat to maintain the supply of operative energy to the apparatus so long as the heat on the thermojunctions 63 and 65 is maintained, and to shut off the supply of operative energy to the apparatus when the desired heating of these thermojunctions is discontinued.

The thermal E. M. F. characteristics for the Chromel, Copel, copper and steel elements employed in the thermocouple shown in Figure 3, as considered with respect to platinum as a base, are shown in the graph constituting Figure 4 of the drawings. It is to be understood that a wide variety of other metals may be employed within the scope of the present invention.

In Figure 4, the temperatures of the variable thermojunctions 63 and 65, which are subject to the heat, the presence or absence of which controls the apparatus, are plotted out horizontally at 85 and the millivolts are plotted out vertically at 86.

With reference now to Figure 3 and assuming

that the thermojunctions 63 and 65 are subject to the normal operating temperature—for example, to the temperature of the stack gases or to the temperature of a flame or other heating means—it will be understood that the thermojunctions 63 and 65 will be heated to a temperature above the temperature of the thermojunction 66; also as illustrated, to a temperature above that of the junction at 72. The temperature of the cold junction 66 will be below the temperature of the hot junctions 63 and 65 an amount dependent upon the heat conductivity of the Copel, Chromel, and other factors.

Using now the assumed figures shown in Figure 5; and referring to the plotted E. M. F., as shown in Figure 4, the following will be apparent:

$$\text{E. M. F. ABCD} = \text{E. M. F. steel} + \text{E. M. F. copper} + \text{E. M. F. Chromel} + \text{E. M. F. Copel}$$

Specifically:

$$\begin{aligned} & (\text{E. M. F. steel } 300 - \text{E. M. F. steel } 400) + \\ & (\text{E. M. F. copper } 400 - \text{E. M. F. copper } 300) + \\ & (\text{E. M. F. Chromel } 300 - \text{E. M. F. Chromel } 400) + \\ & (\text{E. M. F. Copel } 400 - \text{E. M. F. Copel } 300) \\ & = (+2.5 - +4.0) + (+3.0 - +2.0) + \\ & \quad (+9.0 - +12.0) + (-18.8 - -14.0) \\ & = -1.5 + 1 - 3 - 4.8 = -8.3 \text{ millivolts} \end{aligned}$$

From this, the electron flow is in a direction opposite to that in which the equation is set up or the thermoelectric current may be said to be in the ABCD direction as indicated by the arrow 90 in Figure 5.

Assuming now a drop in the stack temperature or a drop or cessation of the heat to which the thermojunctions 63 and 65 are subjected, these thermojunctions begin to cool; and, within a short time, a reversal of the temperature relationship at the junctions 63, 65 and 66 takes place, i. e., the temperature of the junctions 63 and 65 drops below the temperature of the normally cold junction 66. As in the preceding embodiment of the invention, this follows from the fact that the heat reservoir 68 stores heat which it feeds back to the normally cold junction 66.

Using now the assumed figures shown in Figure 6 and taking for this condition the E. M. F.'s shown in the graph in Figure 4, the following will be apparent:

$$\begin{aligned} \text{E. M. F. ABCD} = & (\text{E. M. F. steel } 300 - \text{E. M. F. steel } 200) + \\ & (\text{E. M. F. copper } 200 - \text{E. M. F. copper } 300) + \\ & (\text{E. M. F. Chromel } 300 - \text{E. M. F. Chromel } 200) + \\ & (\text{E. M. F. Copel } 200 - \text{E. M. F. Copel } 300) \\ & = (+2.5 - +1.5) + (1.0 - +2.0) + \\ & \quad (9.0 - +5.8) + (-9.5 - -14) \\ & = +1.0 - 1.0 + 3.2 + 4.5 = +7.7 \text{ millivolts} \end{aligned}$$

The flow of thermoelectric current is now in the reverse direction—namely, in the ABCD direction, as indicated by the arrow 91 in Figure 6.

The arrangement of thermocouple elements and thermojunctions as shown in Figure 3 is advantageous in that it provides a thermopile effect, consequently a higher operating voltage, and a far greater voltage change in consequence to a change in the condition of the apparatus.

Certain alloys, on continued heating, pass through a neutral point beyond which further heating causes a falling off of generated E. M. F., in some cases to a point of actual inversion where the E. M. F. generated changes sign.

This effect makes the present invention admirably suited for use in temperature safety de-

vices for shutting off, for example, the supply of operative energy to the apparatus when the temperature to which the heated junction of the thermocouple is subjected rises to an unsafe point.

A simple example and a graph of the curves of the metals involved are shown in Figures 7 and 8 of the drawings. The temperature at which the direction of the E. M. F. reverses is called the temperature of inversion with reference to the temperature of the reference junction. By reference to the graph constituting Figure 8, it will be seen that as the temperature of the variable junction shown at 96 in Figure 7 is raised beyond about 390° C., there is a falling off of the generated E. M. F. of the 95% Ni 5% Al element shown at 97, and at about 760° C. there is an actual inversion where the generated E. M. F. changes sign.

In Figure 7, let the junction

$$\begin{aligned} A &= 400^\circ \text{ C.} \\ B &= 300^\circ \text{ C.} \\ C &= 300^\circ \text{ C.} \end{aligned}$$

(the copper coil junctions may be neglected for purposes of this description).

$$\begin{aligned} \text{E. M. F. ABC} &= \text{E. M. F. 95\% Ni 5\% Al (at } 300^\circ - \\ & \quad 400^\circ) + \text{E. M. F. 90\% Ni 10\% Fe} \\ & \quad (\text{at } 400^\circ - 300^\circ) \\ & = (-2 - -2.6) + (-5.1 - -5.0) = +.5 \\ & \quad \text{millivolt} \end{aligned}$$

The flow of thermoelectric current is now in ACB direction, i. e., in the direction indicated by the arrow 100.

Now, if the junction A is heated to an unsafe temperature—say 700° C.—and B and C have followed up in temperature to, for example, as follows:

$$\begin{aligned} A &= 700^\circ \text{ C.} \\ B &= 500^\circ \text{ C.} \\ C &= 500^\circ \text{ C.} \end{aligned}$$

$$\begin{aligned} \text{then E. M. F. ABC} &= (-5.5 - -3.6) + \\ & \quad (-5.1 - -1.5) = -5.5 \end{aligned}$$

The flow of thermo-electric current is now in the reverse direction—namely, in the direction as indicated by the arrow 102 in Figure 7.

With the combination of the two effects, namely the reversal of the temperature relationship at the junctions as described in connection with Figures 1 and 2 and in connection with Figures 3 to 6, inclusive, and the actual inversion where the E. M. F. generated changes sign at unsafe temperatures, a thermo-electric safety control may be provided which will operate, for example, to shut off the supply of operative energy to the apparatus upon a drop or cessation of the heat to which the thermoelectric control is responsive and also to shut off the supply of operative energy upon a rise in temperature beyond (for example) a safe operating point.

For the purpose of providing one illustrated combination such as that above set forth, the thermoelectric control shown in Figure 3, or at least the means for adapting the normally cold junction to cool more slowly than the junction which is heated, may be combined with the thermoelectric control shown in Figure 7, each operatively connected with the polarized relay means for controlling the circuits indicated, for example, at 75 and 77 in Figure 3. These circuits 75 and 77 may correspond with the circuits shown in Figure 2, or they may be of any other suitable or preferred character to provide the desired control.

A combination of the arrangement shown diagrammatically in Figure 3 with the arrangement shown in Figure 7 in a single thermocouple, or in a pair of separate thermocouples, maintains, for example, the supply of operative energy to the apparatus so long as the heat to which the thermocouple means is subjected is maintained and shuts off the supply of operative energy upon cessation of the heat to which the thermocouple means is responsive, and also shuts off the supply of operative energy to the apparatus when the temperature to which the thermocouple means is subjected rises beyond a safe operating point.

From the foregoing description taken in connection with the accompanying drawings, it will be readily apparent to those skilled in the art that this invention provides a novel manner of utilizing the known properties of a thermocouple to produce a simple rapidly acting control instrumentality, and that the invention is particularly well suited for use as a stack control in oil or gas fired heating plants, or a direct fire control; and that by virtue of its extreme simplicity, reliable operation is assured.

It is also to be appreciated that while in the foregoing description, specific metals have been named for use as the elements of the thermocouple and its associated parts, it is obvious that the invention is not limited to the use of these particular metals, and that others may well be employed.

It is also to be appreciated that while the invention has been described as a control operating at the dictation of high temperatures in an exhaust flue or stack, or the direct heat of a flame, the antenna of the control, which is provided by the exposed junction of the thermocouple, may be subjected to the effect of a cold temperature modifying medium as present in a refrigerator evaporator.

What I claim as my invention is:

1. An electrical control instrumentality of the character described comprising: a tube adapted to extend crosswise of a flue through which a temperature modifying medium flows; a thermocouple inside the tube and having one of its elements joined thereto to provide its exposed junction, and whereby said junction is subjected to the influence of the temperature modifying medium in the flue; a conductor leading from said tube; a conductor leading from the other element of the thermocouple, said conductors providing for the connection of the thermocouple in a control circuit, the junction between the two elements of the thermocouple being spaced from the wall of the tube; and a metal heat reservoir exteriorly of the flue and joined in good heat conducting relation to said junction between the elements of the thermocouple to receive heat from the flue solely by conduction of heat from said junction between the two elements, whereby upon cessation of the temperature modifying influence on the exposed junction, the heat stored in the reservoir acts to cause a reversal in the temperature relationship between the junctions to effect a reversal in the flow of current in the control circuit.

2. A safety device for apparatus of the class described comprising, in combination: heating means; a thermocouple comprising at least two junctions adjacent to each other and positioned to be subjected to the heat of said heating means, said junctions being composed of more than two dissimilar metals, and the thermocouple having another junction adapted to cool more slowly

than said junctions to effect a reversal of the thermoelectric current when the temperature of said last junction exceeds the temperature of said junctions; and means operated by a flow of thermoelectric current in one direction to maintain a supply of operative energy to the apparatus and by a flow of thermoelectric current in the opposite direction to shut off the supply of operative energy to the apparatus.

3. A safety device for apparatus of the class described comprising, in combination: electrically operated heating means; thermocouple means comprising dissimilar elements and having thermojunction means adapted to be subjected to the heat of said heating means, said thermocouple means having another thermojunction adapted to cool more slowly than said thermojunction means to effect a reversal of the thermoelectric current when the temperature of said thermojunction exceeds the temperature of said thermojunction means, the dissimilar elements of said thermocouple being of a character to effect a reversal of the thermoelectric current upon a rise in temperature beyond a safe operating point; and means operated by a flow of thermoelectric current in one direction to maintain a supply of operative energy to the heating means and by a reversal of the thermoelectric current when the temperature of said thermojunction exceeds the temperature of said thermojunction means and, upon a rise in temperature beyond a safe operating point, to shut off the supply of operative energy to the heating means.

4. A safety device for apparatus of the class described comprising, in combination: electrically operated heating means; thermocouple means comprising dissimilar elements and having thermojunction means adapted to be subjected to the heat of said heating means, the dissimilar elements of said thermocouple being of a character to effect a reversal of the thermoelectric current upon a rise in temperature beyond a safe operating point; and means for controlling the supply of operative energy to said electrically operated heating means, said control means being operated in one manner by a flow of the thermoelectric current in one direction and in another manner by the flow of thermoelectric current in the opposite direction.

5. A safety device for apparatus of the class described comprising, in combination: electrically operated heating means; thermocouple means comprising dissimilar elements and having thermojunction means adapted to be subjected to the heat of said heating means, the dissimilar elements of said thermocouple means being of a character to effect a reversal of the thermoelectric current upon a rise in temperature beyond a safe operating point; and means operated by a flow of thermoelectric current in one direction to maintain a supply of operative energy to the heating means and by a flow of thermoelectric current in the opposite direction to shut off the supply of operative energy to the heating means.

6. In an electric control system: a thermocouple having a normally hot junction adapted to be subjected to heat, and a normally cold junction connected in heat conducting relation to the normally hot junction but insulated from direct influence of the heat to which the normally hot junction is subjected, said thermocouple being connectible in a circuit so that its junctions produce a flow of current in said cir-

cuit in one direction as a result of the temperature differential at said junctions during the application of heat to the thermocouple; and means forming a part of said thermocouple and spaced from but connected to the cold junction thereof in good heat conducting relation so as to receive and store heat energy solely as a result of the application of heat to the normally hot junction and conduction from the normally cold junction so that upon cessation of the application of heat on the normally hot junction said heat energy feeds the normally cold junction, whereby the normally cold junction becomes the hot junction and effects a reversal in the direction of current flow in the circuit.

7. A thermosensitive electric control instrumentality comprising: a thermocouple having a portion positionable inside a duct through which heated fluids flow and another portion adapted to lie exteriorly of said duct, said portion inside the duct including a normally hot junction exposed to be directly influenced by the temperature of the fluid flowing through the duct and a normally cold junction connected in heat conducting relation to the normally hot junction; said thermocouple being connectible in a circuit so that its junctions produce a flow of current in one direction in said circuit as a result of the temperature differential at said junctions during the application of heat to said first named portion of the thermocouple inside the duct in consequence to the flow of heated fluids there-through; and means on said other portion of the thermocouple exteriorly of the duct so as to be in a zone where substantially uniform ambient temperature obtains connected to the normally cold junction in good heat conducting relation for storing heat energy derived from the fluids flowing through the duct and conducted thereto from the normally cold junction so that heat energy from said means feeds the normally cold junction and effects a reversal of the relationship between the junctions upon a drop in the temperature of the fluids flowing through the duct thereby effecting a corresponding reversal of current flow in said circuit.

8. A control instrumentality of the character described comprising: a tubular element adapted to be mounted in a duct through which a temperature modifying medium flows; a thermocouple inside the tubular element having a first junction exposed to the influence of the temperature modifying medium flowing through the duct and a second junction inside the tubular element and insulated from direct influence of the temperature modifying medium but connected in good heat conducting relationship with the exposed first junction; and a heat reservoir joined in good heat conducting relation to said second junction, said heat reservoir being so located with respect to the tubular element as to be exteriorly of the duct and away from the direct influence of the temperature modifying medium flowing through the duct.

9. In a control system for fuel burning heating plants having a stack for exhaust gases and having an electrical control circuit for governing the feeding of fuel to the heating plant:

a switch in said circuit; a stack temperature responsive instrumentality for controlling said switch, said instrumentality comprising a thermocouple having a normally hot junction exposed to direct influence of the temperature within the stack and having a normally cold junction insulated against the influence of the temperature within the stack; a metallic mass exteriorly of the stack having a good thermoconductive connection with said normally cold junction so as to receive and store heat energy conducted thereto by the cold junction as a result of the application of heat to said normally hot junction; and electroresponsive means energized by the thermocouple for controlling said switch so that upon current flow in one direction induced by temperature differential at the two junctions of the thermocouple in consequence to the application of heat to the normally hot junction, said electroresponsive means holds the switch in its position at which the control circuit maintains the burner operative, and a reversal in direction of current flow caused by reversal in the temperature relation at the two junctions of the thermocouple effected by a drop in temperature in the stack and conduction of heat from the mass back to the normally cold junction causes the electroresponsive means to reverse the position of the switch and thereby cause the control circuit to shut off the supply of fuel to the burner directly after such drop in temperature in the stack.

10. A control instrumentality operated in response to temperature change in an enclosure or passage comprising: a thermocouple having a first junction inside the enclosure or passage to be subjected to the temperature obtaining therein and having a second junction insulated from direct influence of the temperature obtaining in the enclosure or passage but connected in good thermoconductive relationship with the first junction; a substantial mass of material having good thermoconductive qualities connected in good thermoconductive relation with the second junction and located exteriorly of the enclosure or passage so as to be unaffected by any temperature modification in the enclosure or passage except that resulting from conduction through the connection between the mass and said junctions, heat conduction in one direction between the mass and said insulated second junction and the external position of the mass insuring the maintenance of a temperature differential between said junctions during any sustained temperature condition in the enclosure or passage to maintain sustained generation of current flow in one direction by the thermocouple, said mass quickly reversing the temperature relationship between said junctions upon such temperature modification within the enclosure or passage as permits heat conduction in the opposite direction between the mass and said insulated second junction to cause the thermocouple to generate current flow in the other direction; and electrical conductors leading from said junctions for connecting the thermocouple in an electrical circuit.

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