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H. A. WADMAN ET AL

1,973,452

DRIFT CONTROL FOR LEERS AND DRIFT RESPONSIVE MEANS THEREFOR

Filed March 6, 1933

2 Sheets-Sheet 1

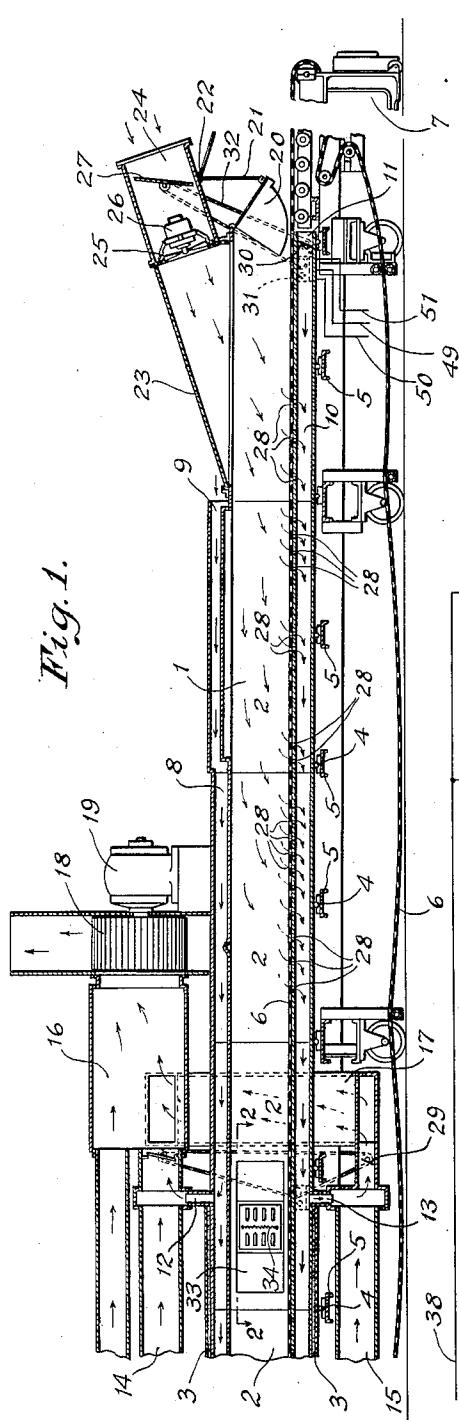


Fig. 1.

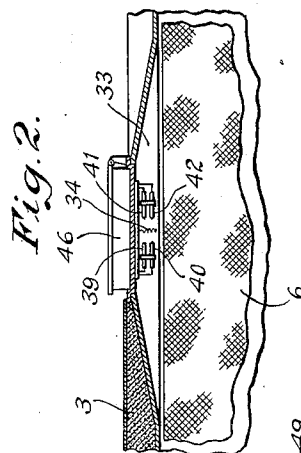


Fig. 2.

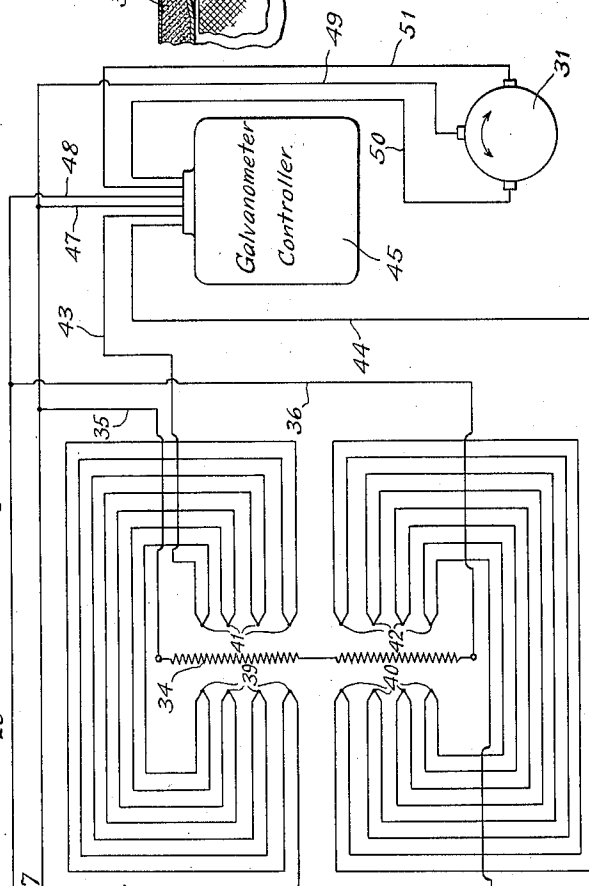


Fig. 3.

Witness:

A. A. Horn

Inventor:
Harold A. Wadman
and Harold W. McIntosh
by Brown + Parkham
Attorneys.

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2 Sheets-Sheet 2

Fig. 4.

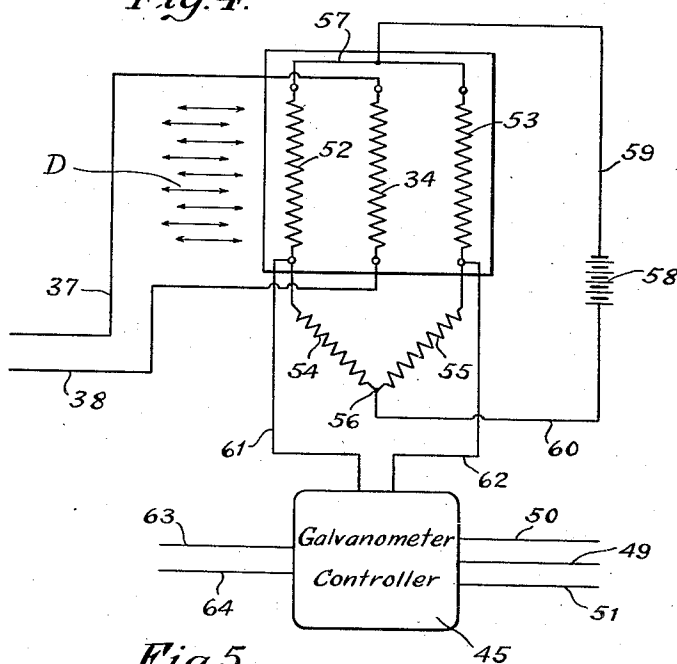
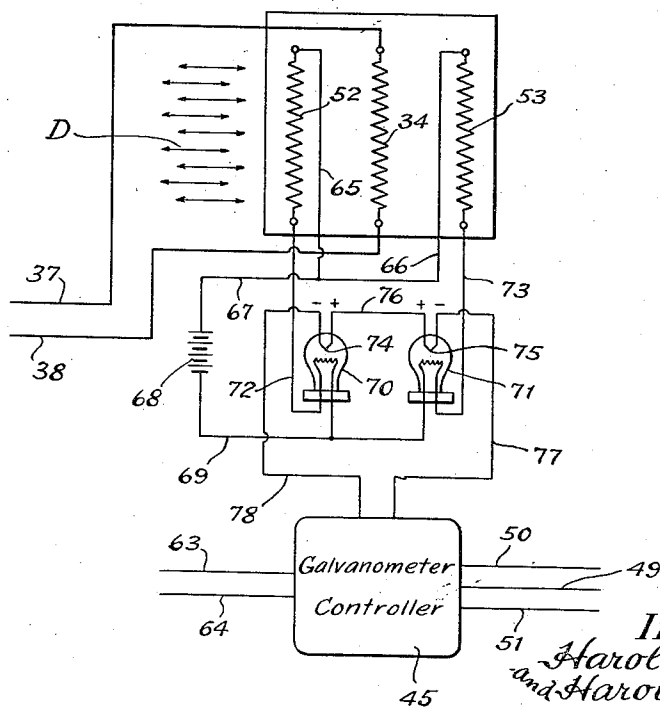


Fig. 5.



Witness:

A. A. Horn.

Inventors:
Harold A. Wadman
and Harold W. McIntosh
by Brown & Barlow
Attorneys.

UNITED STATES PATENT OFFICE

1,973,452

DRIFT CONTROL FOR LEERS AND DRIFT
RESPONSIVE MEANS THEREFOR

Harold A. Wadman, West Hartford, and Harold
W. McIntosh, Windsor, Conn., assignors to
Hartford-Empire Company, Hartford, Conn.,
a corporation of Delaware

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13 Claims. (Cl. 49-47)

This invention relates to apparatus for controlling drift, particularly through tunnel type glass annealing leers, and also relates to improvements in drift responsive devices for use in such apparatus.

In the annealing of glassware in tunnel type continuous leers, it is of course necessary that the ends of the tunnel be open. This requirement introduced certain difficulties into the leer operation particularly due to uncontrolled drafts of wind which may be moving through the plant in which the leer is operated and which cause a draft or "drift" of air of one direction or the other through the leer tunnel. It has been found in practice that this uncontrolled drift of air through the tunnel is detrimental to leer operation in that it tends to interfere with the otherwise accurate control of the temperature gradient existing along the tunnel, which gradient must be maintained substantially constant in order that the ware may be properly annealed.

Various attempts have been made to overcome these difficulties, the most outstanding of which are illustrated in the patents to Wadman, one of the present co-inventors, Nos. 1,808,192, granted June 2, 1931 and 1,896,874, granted February 7, 1933. The devices of these patents both include a means controlled by damper means for admitting air to the tunnel and abstracting air from other portions of the tunnel in such a manner that if the damper or dampers be properly regulated, the drift will be controlled and, if desired, eliminated altogether. Wadman also disclosed in his patents automatic means responsive to drift for controlling the necessary dampers to effect the desired control. The drift responsive device disclosed by Wadman in his two prior patents included a relatively short gas flame having little force which was blown to one side or the other and which influenced a differential mechanical thermostatic device which in turn controlled electric currents either directly or through a relay system to control a reversible motor which was mechanically connected to the necessary dampers. The disclosure of Wadman's prior patents is of a stream of gaseous medium directed in a plane transverse of the tunnel and adapted to be blown in one direction or the other longitudinally of tunnel by the drift, this gaseous medium being at a temperature materially different than that of the surrounding tunnel atmosphere.

Several difficulties have, however, arisen in practice with the particular devices illustrated

in the aforesaid Wadman patent. In the first place, the use of a gas flame in the relation disclosed in the Wadman patents was uncertain in its nature, due to the fact that there was a tendency for the drift to blow this flame out, which resulted in a stream of unburned gas being discharged toward the differential thermostatic device. A stream of cold gas such as that of the unburnt fuel gas could function as it is a stream of gas of materially lower temperature than that in the tunnel, but if this method of operation were to be employed the electric connections to the drift responsive device must be reversed. A second difficulty was that if the flame were adjusted to be of such little force as to be extremely sensitive to drift in one direction or the other, there was such incomplete combustion that the thermostatic device became sooted and consequently lost its sensitivity to some extent at least. If, on the other hand, the flame were sharpened, so as to insure complete combustion and positively prevent sooting of the thermostatic device, the flame would be so strong as not to be blown materially one way or the other by a slight drift, which reduced the sensitivity of the device.

Another difficulty which was encountered was that it is possible for a very slight drift in one direction or the other to have a greater effect in operating the differential thermostat used than a drift of larger proportions, due to the fact that the thermostatic members used by Wadman, as disclosed in his patent, were positioned relatively close to the transverse plane in which the flame was located so that a slight drift would cause a material temperature differential between the two sides of the thermostatic device, while a higher velocity drift in one direction or the other would blow the flame farther away from the thermostatic elements, and even though these elements were provided with heat conducting wings, the differential heating thereof due to an extreme drift was actually less than that occasioned by a slight drift, so that the control was rendered less certain than desired.

A primary object of the present invention is to provide drift responsive means adaptable for use in connection with a leer, such as shown in either of the Wadman patents above referred to, and which is not subject to any of the several difficulties of the patented devices above referred to.

A further and more specific object of the present invention is to provide a drift responsive

device which will be free of the difficulties occasioned by the use of a flame, and particularly one in which the source of heat is a heated element, such for example as an electric resistance element to which current is supplied for heating.

A further object of the present invention is to provide a drift responsive device in which the heat sensitive means are similar on each side of the source of heat and are located at substantially equally spaced intervals therefrom, so as to receive radiated heat in substantial equal amounts, while being influenced differentially by a drift which will cause one of the similar heat sensitive means to be cooled by the direct action of the cooler drift and the other to be heated to a greater extent, due to an increase in the convection heat transfer thereto from the heated element.

A further object of the present invention is to provide electrical heat responsive means, preferably such as will cause a current to flow in one direction or the other through a galvanometer in response to the deflections of which a damper controlling motor or other control means may be actuated.

Further and more specific objects of the present invention will become apparent from a reading of the following specification and appended claims when taken in connection with the accompanying drawings, in which:

Figure 1 is a fragmentary view with a part broken out seen substantially in vertical longitudinal section of a portion of a glass annealing leer with which our drift controlling means may be associated;

Fig. 2 is a fragmentary view in horizontal section taken substantially on the line 2—2 of Fig. 1;

Fig. 3 is a diagrammatic view of one form of drift responsive means and associated controlling means shown as a wiring diagram, this means being illustrated as a mechanical structure in Figs. 1 and 2;

Fig. 4 is a view similar to Fig. 3, but showing a modified form of drift responsive means; and

Fig. 5 is a view similar to Figs. 3 and 4, showing a still further modification of means by which a control may be effected in response to drift.

The portion of the leer shown in Fig. 1 is substantially the same as that illustrated in Fig. 2 of the Wadman Patent 1,896,874 and comprises a tunnel 1 formed in a plurality of independent sections 2 and built up in any suitable manner, preferably with a metallic lining supported in any suitable and desired manner and surrounded as to the hotter portions thereof by a layer of insulating material, part of which is shown at 3, this material tapering in thickness toward the exit end of the leer and being omitted altogether from certain of the cooler sections thereof, as illustrated. The several sections of the leer may be provided with means to provide for their longitudinal expansion under influence of the heat, there being as illustrated rollers 4 intermediate certain of the tunnel portions and supporting channel members 5. Glass articles are conveyed through the leer upon a suitable conveyor belt 6 which is slidably supported on the floor or bottom of the leer tunnel and which returns beneath the tunnel to the entrance end of the leer. This belt 6 may be of woven wire mesh fabric and may be driven by any suitable driving means, one end of which is generally in-

dicated at 7, such means preferably being of the type shown in the patent to Ingle, No. 1,764,791, issued June 17, 1930. The specific details of these means constitute no part of the present invention and no further description thereof will be given. The heat supplying means for the leer are not located in that portion thereof shown in Fig. 1 of the drawings, but may be assumed to be of any suitable character, such for example as those shown and described in detail in the copending application of Wadman, one of the present co-inventors, Serial No. 441,793, filed April 5, 1930, or of any other suitable type.

Certain of the cooling means for the ware are illustrated in the accompanying drawings and include one or more longitudinally extending flues 8 associated with the roof of the tunnel and communicating with the atmosphere at 9 adjacent to the exit end thereof and one or more longitudinally extending flues 10 associated with the floor of the tunnel and communicating with the atmosphere at 11 adjacent to the exit end of the leer, as seen at the right in Fig. 1. Means are provided for controlling the temperature gradient in these flues including a plurality of spaced tap-off passages, one of which is indicated at 12 for the upper flue or flues 8 and one of which is indicated at 13 for the lower flue or flues 10. These passages communicate respectively with take-off ducts 14 and 15 both of which communicate with a wind box 16, the duct 14 communicating directly therewith and the duct 15 communicating therewith through saddle pipes surrounding the leer, one of which is illustrated at 17. Means are provided for exhausting air from the wind box 16, such means, as shown, comprising an exhaust fan 18 driven by any suitable means, such as the electric motor 19. Suitable damper means may be provided for controlling the amounts of air drawn through the flues 8 and 10 respectively and for controlling the amounts of air withdrawn from these flues through the several tap-off passages 12 and 13. Such means form no part of the present invention and hence will not be further described in detail.

At the exit end of the leer is arranged a door member 20 which may be adjusted in position with regard to the height of the ware being annealed, the desired adjustment being one which just clears the top of the ware. This adjustment may be effected by a cable 21 passing over a suitable sheave at 22 and being connected to suitable means for securing it in various adjusted positions, these means being not shown, but being of any suitable design.

Arranged adjacent to the exit end of the leer tunnel is a passageway or hood 23 open at its rearward end 24 to the atmosphere, as shown. In this hood is arranged a fan 25 adapted to be driven by any suitable source of power, as an electric motor 26, for forcing atmospheric air into the tunnel 1 in a direction somewhat downwardly but generally countercurrent to the movement of the ware therethrough, which movement is from left to right, as shown in the present drawings. The air thus forced into the tunnel will be caused to pass onto and between the articles of ware on the conveyor 6 and will have a cooling effect on such articles. The amount of atmospheric air introduced is controlled by a damper 27 positioned in a passage like portion of the hood 23 and adapted to be controlled, as hereinafter to be specifically described, to control the

amount of air being forced into the tunnel 1 of the leer.

This construction will cause a flow of air from the rear or exit end toward the entrance end of the leer. It has been found, however, that while such a construction may be, and in fact is, very efficient from the point of view of cooling glass articles on the conveyor belt, it may result in an undesirable flow of air or gaseous media through the hotter portions of the leer and interfere with the temperature gradient in such hotter portions. Inasmuch as this gradient control is important to the proper annealing of the glass articles, it is necessary that some means be provided to control the flow through the hotter portions of the tunnel and in some instances reduce it substantially to zero.

In the present case, this result is obtained by withdrawing from the tunnel along a zone extending toward the entrance end thereof from the point or zone of introduction of the atmospheric air an amount of tunnel atmosphere proportioned relative to the amount of atmospheric air forced into the tunnel, so that the resultant drift or flow through the hotter portions of the tunnel is controlled as desired, and in some cases may be zero.

For this purpose the bottom or floor of the tunnel is provided with a plurality of apertures 28, best indicated by the curved arrows passing through the bottom or floor of the tunnel in Fig. 1, the apertures communicating with the lower flue or flues 10. The total flow of air through flue or flues 10 is controlled by the damper 29 intermediate the duct 15 and the saddle pipes 17. If then, the amount of air which is permitted to be drawn into the end 11 of the flues 10 be controlled, the amount of tunnel atmosphere drawn into this flue through the apertures 28 will be determined by the difference of the first two amounts. For this purpose a damper 30 is provided in the flue or flues 10 adjacent to the end 11 thereof to control the amount of air entering such flue or flues.

Thus by a suitable setting of the dampers 27 and 30, the relative amounts of air blown through the tunnel and tunnel atmosphere drawn therefrom may be controlled for any given setting of the damper 29 and by a proper control of these relative amounts, the drift through the hotter portions of the tunnel may be regulated at will.

There is provided automatic means for controlling the dampers 27 and 30 in the manner shown and described in the Wadman Patent 1,896,874. This means comprises a reversible electric motor 31 connected to the dampers 27 and 30 through a suitable reducing gear located in a gear box with the motor and operating through a suitable sprocket chain 32 passing around a sprocket driven by the motor 31, and also around sprockets on the shafts which carry the dampers 27 and 30. The motor 31 is operated by automatic drift responsive means, as in the Wadman patents above referred to, so that the drift through the hotter portions of the tunnel may be determined by the flow of the gaseous media past an index point preferably in a relatively cool portion of the tunnel, here indicated as a shallow bay 33 (Figs. 1 and 2). The drift responsive means forming particularly the subject matter of the present invention is located in the bay 33. The subject matter thus far described, and with the exception of the particular drift responsive means presently to be described, forms no part of the present in-

vention, but is substantially the same as that illustrated and described in the Wadman Patent 1,896,874 above referred to.

Fundamentally our present drift responsive means, three embodiments of which will be presently described, comprises a heated element which may take the form of an electric resistance element, such as a wire grid, through which a current is passed and which is located in the tunnel to be swept by drift therethrough in one direction or the other. On either side of this heated element there is located a heat responsive device, these devices being similar each to the other and being located at substantially the same distance from the heated element in the respective directions in which drift may flow through the tunnel. The heat responsive devices are arranged to be substantially equally heated by radiation from the heated element, so that even though the temperature surrounding the drift responsive device as a whole be raised or lowered, there will be no force effective to vary the drift responsive device and no adjustments need be made to compensate therefor. The heat responsive devices, however, are of such character and so located that if a drift exists in one direction or the other, one of these devices will be cooled by the direct action of the drift and the other will be heated to a greater extent, due to increased convection heating thereof by heat transmitted from the heated element. Thus, a drift will cause a differential heating of the heat responsive elements, which will be transmitted by suitable means to operate the motor 31 or other control means in one direction or the other, as may be necessary to compensate for the existing drift.

The several forms in which our invention may be embodied, which have been illustrated in the accompanying drawings, are all of an electrical character, although our invention is not necessarily limited to devices of this character. When, however, electrical means such as those presently to be described are used, the heat responsive elements are preferably of such character that they will cause a current to flow in one direction or the other through a galvanometer, which may be so arranged that it will operate a control to cause suitable connections to be made so that the motor 31 or other control device will operate in one direction or the other in response to the deflection of the galvanometer from its mid position in one direction or the other respectively.

Turning now to the form of the device shown in Figs. 1 to 3, the heated element is indicated at 34 and comprises a suitable grid or coil of electric resistance wire arranged substantially in a plane transverse of the leer tunnel 1. This resistance heating element may be connected by conductors 35 and 36 to line wires 37 and 38 leading from a suitable source of electric energy. Arranged adjacent to the heated element 34 in directions longitudinally of the leer are banks of thermocouples 39 and 40 on one side and 41 and 42 on the other side, there being as shown four thermocouples in each bank, so that there will be eight thermocouples on one side (toward the entrance end of the leer as shown) and eight thermocouples on the other side (toward the exit end of the leer as shown). These thermocouples are connected in series as shown in the wiring diagram in Fig. 3, the couples of banks 39 and 40 being connected in opposition to the couples of the banks 41 and 42. The

terminal conductors of the series circuit connections, including the thermocouples are indicated at 43 and 44 respectively, and lead to a galvanometer controller 45, which may be of any suitable commercial type adapted for the purposes presently to be described, there being several such types now available for purchase in the open market. Inasmuch as the galvanometer is assumed to be a commercial instrument and no invention is predicated on the construction thereof, only the function of this instrument will be described herein. It will be understood that as many thermocouples as may be desired may be connected together substantially in the manner here illustrated, the purpose being to cause a flow of current through the galvanometer 45 in one direction or the other according to the direction of flow of drift through the tunnel, which will be occasioned due to the opposed manner of connections of the thermocouples of the several banks. The use of a plurality of thermocouples on each side of the heated element rather than a single couple is merely for the purpose of insuring that a sufficient current be generated due to drift in one direction or the other positively to operate the galvanometer and to cause such operation in response to relatively slight drift, thus making for increased sensitivity of the control system. In practice, the several connections between the thermocouples may be made within a suitable connection box, indicated generally in Fig. 2 at 46. Current is conducted to the galvanometer controller 45 from the line wires 37 and 38, through conductors 47 and 48. The motor 31, which is indicated in Fig. 3 by the double ended arrow within the circle, is preferably of the type provided with two field coils each having a common terminal which is connected by the conductor 49 with one side of the line here illustrated, as the wire 37, and the other terminals of the field coils being connected by conductors 50 and 51 with the galvanometer controller 45 which connects one or the other of these wires with the other side of the line, wire 38, through the wire 48 whenever actuation of the motor 31 is necessary in order to provide a suitable control of drift. The conductor 49 could, if desired, be connected into the galvanometer controller and there be connected directly through to the wire 47 in a suitable manner.

In operation, assuming a drift to exist in the tunnel from left to right thereof, as seen in Fig. 1, this drift will act directly upon the banks of thermocouples 39 and 40 and will serve to cool these couples. At the same time the drift will cause increased convection heating of the banks of couples 41 and 42 by heat from the heated element 34 which will cause the couples 41 and 42 to be at a higher temperature than the banks of couples 39 and 40. This will cause a current to flow in a definite direction through the galvanometer 45 through conductors 43 and 44, which will cause a deflection of the galvanometer to cause a current to flow from line wire 38, through the galvanometer controller 45 and thence through one of the wires 50 or 51 and the motor 31 and conductor 49 back to line wire 37, thus actuating the motor to open both dampers 27 and 30 tending to correct the drift.

It will be understood that the banks of couples 39, 40, 41 and 42 are substantially equidistantly spaced longitudinally of the leer from the heated element 34 so as to be heated substantially uniformly by radiated heat. Also, any general

change in temperature adjacent to the drift responsive device will have no effect upon the control as all the couples will be heated or cooled to the same amount and hence will not cause any current to flow in either direction through the galvanometer 45. Thus, in our present device there is no liability of a flame blowing out, or of any adjustments which must be made due to sooting of the heat responsive devices as there will be nothing to cause such soot to collect. Furthermore, the greater the drift velocity, the greater is the differential temperature of the temperature responsive devices. This device thus overcomes all the difficulties above set forth which exist with previous types of devices as illustrated by the Wadman patents above referred to.

Turning now to Fig. 4, the heated element thereof may be of the same form as that shown in Fig. 3, and is indicated by the reference character 34 the same as in Fig. 3. Current is similarly supplied to this element from the line wires 37 and 38. The double ended arrows generally indicated at D indicate the possible directions of drift past the drift responsive device. On either side of the heated element 34 in the directions in which drift is to be expected there is indicated at 52 and 53 respectively resistance thermometers, each of which preferably comprises a coil or grid of material of such character that its resistance will vary widely with temperature changes. The resistance thermometers 52 and 53 are similar as to their electrical constants and are disposed at similar distances from the heating element 34 in the directions in which drift may flow so as to receive radiated heat from the element 34 in substantially equal amounts. A pair of similar fixed resistances 54 and 55 are connected respectively in series with the resistance thermometers 52 and 53 at one end and are connected together as at 56 at their other end. The other terminals of the resistance thermometers are connected together by a conductor 57. An electrical potential is impressed across the circuit between the point 56 and the conductor 57 as illustrated from a source of direct current electric energy, generally indicated as the battery 58, which is connected by a conductor 59 to the conductor 57 and by a conductor 60 to the point 56. The galvanometer controller 45, which may be similar to that above described in connection with Fig. 3, is respectively connected by conductors 61 and 62 to the connections intermediate the resistance thermometers 52 and 53 and their respective fixed resistances 54 and 55. There is thus formed a Wheatstone bridge type of circuit having the galvanometer 45 connected across the middle of the bridge, so that if resistance 52 and 53 are balanced, as are the resistances 54 and 55, there will be no current flowing through the galvanometer 45. If, on the other hand, the resistances 52 and 53 are unbalanced due to a temperature difference thereof, as would be caused by a drift, in one direction or the other, a current will flow in one direction or the other through the galvanometer 45, which will be effective to actuate a control in substantially the same manner as discussed above in connection with Fig. 3. Current may be supplied to the galvanometer 45 from line wires 63 and 64, which may communicate with the line wires 37 and 38 respectively if desired, or with any source of electric energy. The galvanometer 45 may

be similarly connected to any suitable controlling means, as the motor 31, through conductors indicated by the reference numerals 49, 50 and 51. The operation of the device shown in Fig. 4 will be obvious from the above description.

In Fig. 5 we have shown a still further modification of drift responsive means by which the desired results may be effected. In this figure there is illustrated a heated element 34 similar to that shown in Fig. 4 and connected in the same way to line wires 37 and 38. The possible directions of drift are similarly illustrated by the double ended arrows D. This form of the invention also employs a pair of similar resistance thermometers 52 and 53 similar each to the other and similarly disposed as in the case of the similarly numbered resistance thermometers described above in connection with Fig. 4. The connections and manner of operating the galvanometer controller 45 in this instance are, however, somewhat different. As shown, one terminal of each of the resistance thermometers 52 and 53 are connected by conductors 65 and 66 with a common conductor 67 leading to one terminal of a battery 68 or other source of electric energy. The other terminal of the battery 68 or source of electric energy is connected by a conductor 69 with one terminal of each of the filaments of a pair of similar vacuum tubes 70 and 71. The other terminals of these filaments are respectively connected by conductors 72 and 73 to the remaining terminals of the resistance thermometers 52 and 53 respectively. Thus upon a drift in one direction or the other which will vary the temperatures and consequently the resistances of the resistance thermometers 52 or 53, the filaments of the vacuum tube 70 or 71 will be differentially heated. Within the vacuum tubes 70 and 71 there are located thermo-couples 74 and 75 respectively, these thermo-couples being connected in opposition to each other and in series in a circuit including conductors 76 connecting one terminal of each of the thermo-couples, a conductor 77 communicating between the other terminal of thermo-couple 75 and one terminal of the galvanometer 45, and a conductor 78 communicating between the other terminal of the galvanometer 45 and the other terminal of the thermo-couple 74. Thus when the filaments of the vacuum tubes 70 and 71 are differentially heated, the thermo-couples 74 and 75 will be differentially heated which will cause a current to flow in one direction or the other through the galvanometer 45. The galvanometer controller may communicate, as in Fig. 4, with line wires 63 and 64 on the one hand and with a suitable controlling mechanism by conductors 49, 50 and 51, on the other hand, so as to effect a control in response to deflections of galvanometer caused by drift in one direction or the other.

While we have shown and described several embodiments of our invention, it will be obvious that various further changes may be made therein, both as to the character of the devices used and as to the manner of effecting the control, as by the employment of different types of circuits. It is also contemplated that the invention could be applied to a mechanically operated device, for example using materials of different coefficients of expansion, or differentially heated mechanically acting means having the same coefficient of expansion. We do not wish to be limited, therefore, except by the

scope of the appended claims, which are to be construed as broadly as the state of the prior art permits.

What we claim is:

1. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising a stationary heated element, means for heating said element to a predetermined fixed temperature, two similar heat responsive means located one at either side of said element in the directions in which the gaseous medium may drift respectively, said heat responsive means being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on one of said heat responsive means and a convection transfer of heat from said element to the other of said heat responsive means, and means constructed and arranged to be inactive when said heat responsive means are substantially equally heated and responsive to a differential temperature of said heat responsive means for effecting a control.

2. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising a heated element, means for heating said element to a predetermined fixed temperature, two similar electric heat responsive means located one at either side of said element in the direction in which the gaseous medium may drift respectively, said heat responsive means being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on one of said heat responsive means and a convection transfer of heat from said element to the other of said heat responsive means, a galvanometer, an electric circuit system for causing a current to flow through said galvanometer in one direction or the other in response to a differential temperature of said heat responsive means, and so arranged that when said heat responsive means are equally heated, no current will flow through said galvanometer, and means controlled by said galvanometer for effecting a control.

3. Apparatus for controlling drift in a tunnel type glass annealing leer through which a gaseous medium may flow, comprising means for controlling the flow of gaseous medium through the tunnel, an electric resistance heating element located in the tunnel to be swept by a drift of gaseous medium therethrough, means for supplying a predetermined substantially constant electric current to said heating element, two similar electric heat responsive means located one at either side of said element in the directions in which the gaseous medium may drift through the tunnel respectively, said heat responsive means being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on one of said heat responsive means and a convection transfer of heat from said element to the other of said heat responsive means, a galvanometer, electric circuit means for operating said galvanometer in response to a differential temperature of said heat responsive means and so arranged that when said heat responsive means are equally heated, no current will flow through said galvanometer,

and means controlled by said galvanometer for controlling the first named means.

4. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising a heated element, means for heating said element to a predetermined fixed temperature, two similar heat responsive means each including at least one thermo-couple and each having at least a portion thereof located one at either side of said element in the directions in which the gaseous medium may drift respectively, said portions being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined action of a drift on one of said portions and a convection transfer of heat from said element to the other of said portions, a galvanometer, electric circuit means in which said thermo-couples are connected in a manner such as to oppose each other and including said galvanometer, said circuit means being so constructed and arranged that when said heat responsive means are equally heated, no current will flow through said galvanometer and a current will flow through said galvanometer in one direction or the other in response to differential temperature of said portions caused by a drift in one direction or the other, and means responsive to said galvanometer for effecting a control.

5. Apparatus for controlling the drift in tunnel type glass annealing leers, comprising means for controlling the flow of gaseous medium through the tunnel, an electric resistance heating element located in the tunnel to be swept by drift therethrough, means for supplying a predetermined substantially constant electric current to said heating element for heating it, two similar electric heat responsive means each including at least one thermocouple and each having at least a portion located at either side of said element in the directions in which the gaseous mediums may drift through the tunnel respectively, said portions being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined action of a drift on one of said portions and a convection transfer of heat from said element to the other of said portion, a galvanometer, electric circuit means including said thermo-couples connected in opposing relation and said galvanometer to cause a deflection of the latter in response to differential heating of said portions caused by drift in one direction or the other, said circuit means being so constructed and arranged that when said heat responsive means are equally heated, no current will flow through said galvanometer, and means controlled by said galvanometer for controlling the operation of the first named means.

6. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising a heated element, means for heating said element to a predetermined fixed temperature, two resistance thermometers having the same electrical constants located one at either side of said element in the directions in which the gaseous medium may drift respectively, said resistance thermometers being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on one of said resistance thermometers and a convection transfer of heat

from said element to the other of said resistance thermometers, a galvanometer, electric circuit means responsive to differential temperature of said resistance thermometers for causing a current of electricity to flow in one direction or the other through said galvanometer according to the direction of drift, said circuit means being so constructed and arranged that when said resistance thermometers are equally heated, no current will flow through said galvanometer and means controlled by said galvanometer for effecting a control.

7. Apparatus for controlling drift in a tunnel type glassware annealing leer, comprising means for controlling the flow of gaseous medium through the tunnel, an electric resistance heating element located in the tunnel to be swept by drift therethrough, means for supplying a predetermined substantially constant current to said element for heating it, two similar resistance thermometers located one at either side of said element in the directions in which gaseous medium may drift through the said tunnel respectively, said resistance thermometers being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on one of said resistance thermometers and a convection transfer of heat from said element to the other of said resistance thermometers, a galvanometer, electric circuit means including said resistance thermometers for causing a current to flow through said galvanometer in one direction or the other in response to a differential temperature of said resistance thermometers, said circuit means being so constructed and arranged that when said resistance thermometers are equally heated, no current will flow through said galvanometer, and means controlled by said galvanometer for controlling the operation of the first named means.

8. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising a heated element, means for heating said element to a predetermined fixed temperature, two similar heat responsive means each comprising at least one thermocouple located at the opposite sides of said element in the directions in which the gaseous medium may drift respectively, the thermocouples of each heat responsive means being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on the thermocouples of one of said heat responsive means and a convection transfer of heat from said element to the thermocouples of the other of said heat responsive means, a galvanometer, a series electric circuit including said galvanometer and all said thermocouples, the thermocouples on opposite sides of said element being connected in opposed relation so as to cause an electric current to flow through said galvanometer in one direction or the other in response to a drift in one direction or the other respectively, said circuit being so constructed and arranged that when said thermocouples are equally heated, no current will flow through said galvanometer, and means controlled by said galvanometer for effecting a control.

9. Apparatus for controlling drift through a tunnel type glass annealing leer, comprising

means for controlling the drift of gaseous medium through the tunnel, an electric resistance heating element located in the tunnel to be swept by the drift of gaseous medium there-
 5 through, means for supplying a predetermined substantially constant current to said element for heating it, two similar heat responsive means each comprising a plurality of thermocouples and located one at either side of said element in the
 10 directions in which the gaseous medium may drift through the tunnel respectively, the thermocouples of each of said heat responsive means being spaced from said element so as to receive radiated heat therefrom in substantially equal
 15 amounts but being adapted to vary in temperature due to the combined cooling action of a drift on the thermocouples of one heat responsive means and a convection transfer of heat from said element to the thermocouples of the
 20 other of said heat responsive means, a galvanometer, an electric circuit including said galvanometer and all of said thermocouples in which the thermocouples are connected in series and in such manner that the thermocouples of
 25 one of said heat responsive means are in opposition to those of the other so as to cause a current to flow through said galvanometer in response to differential heating of the thermocouples of the two heat responsive means in re-
 30 sponse to a drift in one direction or the other, and constructed and arranged in such manner that when the opposing thermocouples are equally heated, no current will flow through said galvanometer, and means controlled by said
 35 galvanometer for controlling the operation of the first named means.

10. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising a heated element, means for heating said
 40 element to a predetermined fixed temperature, two resistance thermometers having the same electrical constants located one at either side of said element in a direction in which the gaseous medium may drift respectively, said resistance
 45 thermometers being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift on one of said resistance
 50 thermometers and a convection transfer of heat from said element to the other of said resistance thermometers, an electric circuit of the Wheatstone bridge type including in the two parallel
 55 connected legs of the bridge said resistance thermometers and also having a pair of equal resistances in series with said resistance thermometers and connected in the two parallel legs of the bridge, a galvanometer connected across
 60 between parallel legs of the bridge intermediate the resistance thermometers and the fixed equal resistances, a source of electric current connected to cause a current flow in parallel through the legs of the bridge through said resistance
 65 thermometers and the fixed resistances in series therewith, and means controlled by said galvanometer for effecting the control.

11. Apparatus for controlling drift of a gaseous medium in one direction or the other
 70 through a tunnel type glass annealing leer, comprising means for controlling the flow of gaseous medium through the tunnel, an electric resistance heating element located in the tunnel to be swept by drift of gaseous medium there-
 75 through, means for supplying a predetermined

substantially constant electric current to said element for heating it, two resistance thermometers having the same electrical constants located one at either side of said element in directions in which the gaseous medium may
 80 drift respectively, said resistance thermometers being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action
 85 of a drift on one of said drift thermometers and a convection transfer of heat from said element to the other of said resistance thermometers, a galvanometer, an electric circuit means of the Wheatstone bridge type including a source of
 90 direct current electric potential, parallel current paths each including one of said resistance thermometers and a fixed resistance, the two fixed resistances having the same electrical constants, conductors connecting the galvanometer
 95 across said bridge so as to cause a current to flow through said galvanometer in one direction or the other only in response to differential temperatures existing in said resistance thermometers caused by drift in one direction
 100 or the other, and means controlled by said galvanometer for controlling the operation of the first-named means.

12. Apparatus responsive to drift of a gaseous medium in one direction or the other, comprising
 105 a heated element, means for heating said element to a predetermined fixed temperature, two resistance thermometers having the same electrical constants located one at either side of said element in the directions in which the gas-
 110 eous medium may drift respectively, said resistance thermometers being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined
 115 cooling action of the drift on one of said resistance thermometers and a convection transfer of heat from said element to the other of said resistance thermometers, two vacuum tubes, a circuit for the filament of each of said vacuum
 120 tubes including one of said resistance thermometers respectively and a source of electric energy, a thermocouple located in each of said vacuum tubes to be heated by the filament thereof, a galvanometer, a circuit including said
 125 galvanometer and said thermocouples and arranged in such manner that the thermocouples are connected in opposition to each other and both thermocouples are arranged in series with the galvanometer so as to cause a current to
 130 flow through the galvanometer in one direction or the other only in response to differences in the temperature of the filaments of the vacuum tubes which are responsive in turn to differential temperatures existing in said resistance
 135 thermometers caused by drift in one direction or the other, said circuit being so constructed and arranged that when said resistance thermometers are equally heated, no current will flow through said galvanometer, and means
 140 controlled by said galvanometer for effecting a control.

13. Apparatus for controlling the drift in one direction or the other through tunnel type glass annealing leers, comprising means for controlling
 145 the flow of gaseous medium through the tunnel, an electric resistance heating element located in the tunnel to be swept by drift of gaseous medium therethrough, means for supplying a predetermined substantially constant
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electric energy to said element for heating it, two resistance thermometers having the same electrical constants located one at either side of said element in the directions in which the gaseous medium may drift through said tunnel respectively, said resistance thermometers being spaced from said element so as to receive radiated heat therefrom in substantially equal amounts but being adapted to vary in temperature due to the combined cooling action of a drift in one direction or the other on one of said resistance thermometers and a convection transfer of heat from said element to the other of said resistance thermometers, two vacuum tubes having filaments therein connected in series with said resistance thermometers respectively and with a source of electric energy, a thermocouple in each of said vacuum tubes, said thermocouples having the same electrical constants and being similarly positioned in said tubes to be responsive to the temperatures of the filaments thereof respectively, a galvanometer, a circuit including said galvanometer and said thermocouples in series and having the thermocouples connected therein in such a manner as to oppose each other, and means controlled by said galvanometer for controlling the operation of the first-named means.

HAROLD A. WADMAN.
HAROLD W. McINTOSH.

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