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APPARATUS FOR SIGNALING THE ESCAPE OF ILLUMINATING GAS AND OTHER SIMILAR COMBUSTIBLE GASES

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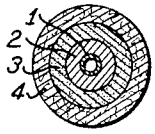


FIG. 1
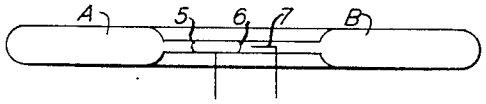


FIG. 2

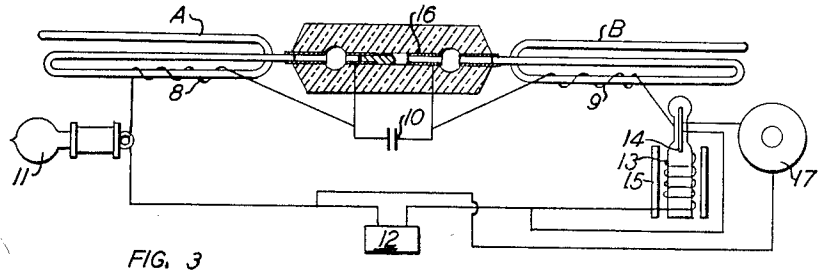


FIG. 3

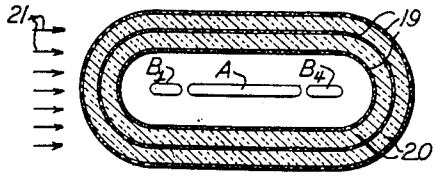


FIG. 6



FIG. 4

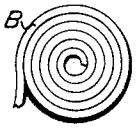


FIG. 5

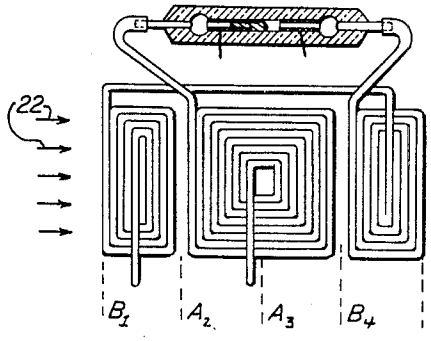


FIG. 7

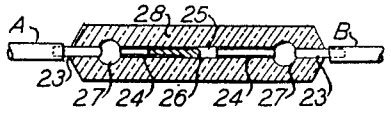


FIG. 8

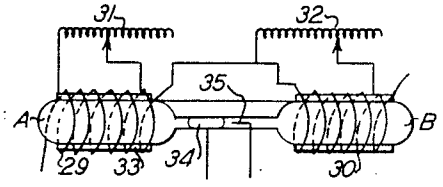


FIG. 9

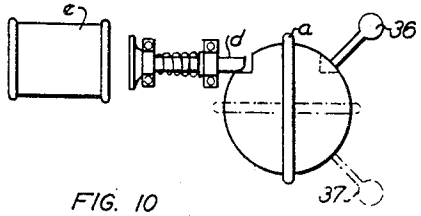


FIG. 10

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APPARATUS FOR SIGNALING THE ESCAPE OF ILLUMINATING GAS AND OTHER SIMILAR COMBUSTIBLE GASES

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Claims priority, application Italy August 10, 1948

13 Claims. (Cl. 200—61.03)

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The present invention relates generally to apparatus for signalling or indicating the escape of illuminating gas, and is particularly directed to improvements in apparatus of the kind disclosed in United States Letters Patents Nos. 2,178,486 and 2,178,487, both issued to Giuseppe Menozzi on October 31, 1939.

Use of apparatus embodying the inventions disclosed in the above Letters Patents has shown such apparatus to be insufficiently sensitive for signalling the escape of small quantities of gas, with such sensitivity diminishing rapidly so that the apparatus becomes completely inoperative after being in use for as little as four months. Further, the existing apparatus has a tendency to give false alarms when there is no escaping gas in the vicinity thereof, and the mercury containing capillary tubes included in the apparatus are often broken during transportation.

Accordingly, it is a general object of the present invention to provide apparatus of the described character which is free of the above mentioned disadvantages of the existing apparatus.

More specifically, it is an object of the present invention to provide apparatus of the described character for signalling or indicating the escape of illuminating gas, wherein the apparatus is sensitive to the escape of only small quantities of the gas and yet avoids the giving of false alarms.

Another object is to provide apparatus of the described character wherein the sensitivity thereof is maintained for a long period without substantial deterioration.

A further object is to provide a device of the described character which is sturdy so that it may be transported without damage to the parts thereof.

It has been found that the decrease in sensitivity of the apparatus is caused by poisoning or adulteration of the catalyst by gases contained in the atmosphere, such as, for example, sulphuretted hydrogen (H_2S) and the like, and accordingly one aspect of the present invention provides a filter having ferric oxide (Fe_2O_3), manganese oxide (MnO_2) and the like, therein around the catalyst to prevent contamination or adulteration of the latter.. Further, the filter preferably also includes an adsorbent substance, such as carbon, which apparently raises the concentration of hydrogen or of other combustible gases in the vicinity of the catalyst above that of the surrounding atmosphere and thereby increases the speed of the reaction of the catalyst to the escape of such gases. Further, in accordance with another aspect of the present invention, the apparatus is made sensitive to gas escapes which result in a differential temperature between the temperatures of the two bulbs amounting to

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only a few tenths of a degree by maintaining the gas in the two tubes at a value greater than twice the superficial tension of the mercury, in the capillary tube between the gas-filled tubes, divided by the produce of the radius of the capillary tube and the quotient of the predetermined differential temperature resulting in an alarm or indication and the absolute temperature of the gas in the gas-filled tubes. In order that the apparatus will respond sensitively to the escape of illuminating gas only and not to other factors which might independently vary the temperatures of the gas-filled tubes, the latter are, in accordance with the present invention, elongated and interlaced, so as to be subjected to exactly the same atmospheric conditions.

The foregoing, and other objects, features and advantages of the present invention will be apparent in the following detailed description of illustrative embodiments thereof when the same is read in connection with the accompanying drawings forming a part hereof, and wherein:

Fig. 1 is a transverse sectional view of a gas-filled bulb included in apparatus embodying the present invention and having a filter extending therearound;

Fig. 2 is a diagrammatic view of a differential thermometer of the kind included in apparatus to which the present invention relates;

Fig. 3 is a diagrammatic view of apparatus embodying the present invention for indicating or signalling the escape of illuminating gases;

Fig. 4 is an elevational view of a coiled gas-filled tube which may be substituted for the coiled corresponding tubes of Fig. 3 in accordance with another embodiment of the invention;

Fig. 5 is a view similar to Fig. 4, but showing still another form of gas-filled tube which may be used in the apparatus of Fig. 3;

Fig. 6 is a sectional view showing an enclosure surrounding the differential thermometer of Fig. 3 in accordance with still another embodiment of the invention;

Fig. 7 is a diagrammatic view showing an arrangement of the gas-filled tubes of the apparatus of Fig. 3 constructed in accordance with still another modification of the invention;

Fig. 8 is a detail view showing an improved arrangement for connecting the mercury containing capillary tube to the gas-filled tubes in a differential thermometer included in apparatus embodying the present invention;

Fig. 9 is a diagrammatic view showing further electrical devices for association with the gas-filled tubes of apparatus embodying the present invention; and

Fig. 10 is a schematic view of an electrically controlled valve for association with the appa-

ratus of Fig. 3 embodying the present invention.

Referring to the drawing in detail, and initially to Fig. 1 thereof, an arrangement is there shown for improving or extending the useful operating life of apparatus of the described character. Such apparatus generally includes two gas-filled bulbs which are connected by a capillary tube containing mercury and having electrical contacts disposed therein to complete an electrical circuit through the mercury when the latter is displaced in the capillary tube by a suitable difference in the gas pressures in the two gas-filled bulbs. In order to create a pressure differential in response to the presence of illuminating gas in the surrounding atmosphere, a platinum sponge 2 is disposed around one of the gas-filled bulbs 1 and reacts with the illuminating gas to raise the temperature, and hence the pressure of the gas, in the related bulb above that in the other of the bulbs.

However, it has been found that the ability of the platinum catalyst to react with the illuminating gas deteriorates rapidly and may become non-existent only four months after its preparation as a result of contaminating or neutralizing gases contained in the atmosphere and in the illuminating gas itself, such as, for example, sulphuretted hydrogen (H_2S). In accordance with the present invention, a protective filter is disposed around the platinum catalyst 2 and includes a layer of active carbon 3, and an outer layer of cotton wool and the like impregnated with ferric oxide (Fe_2O_3), manganese dioxide (MnO_2), and the like. The impregnated outer layer serves to render the sulphuretted hydrogen harmless, while the active carbon, by reason of its high adsorptive power serves to concentrate the hydrogen, or other combustible gases contained in the atmosphere, in the area immediately around the catalyst so that the reaction with the latter is accelerated.

The increase of temperature effected by the platinum sponge when placed in a room into which gas is escaping depends upon the rate at which the gas escapes and the volume of the room. With a platinum sponge prepared six years before and protected by the above described filter and placed in a room having a volume of 36 cubic meters with an open inner door communicating with another room of similar volume and with the windows or shutters to the outside being closed, illuminating gas escaping at the rate of 5 litres per minute caused a temperature rise of a few tenths of a degree centigrade after only a very few minutes of exposure.

Accordingly, an apparatus of the described character can be considered safely efficient for a period of at least six years only if it is sufficiently sensitive to indicate the presence of illuminating gas in response to a differential temperature between the two gas-filled bulbs of only a few tenths of a degree centigrade, and yet avoids the giving of false alarms in response to conditions other than the escape of gas.

The conditions necessary to provide an apparatus having the required sensitivity can be determined as follows:

If V is the volume of each of the two gas-filled bulbs of the differential thermometer, P is the gas pressure in the two bulbs and the gases in the two bulbs have the same absolute temperature T, it is known that an increase ΔT of the temperature in only one of the two bulbs, for

example, the bulb A of Fig. 2, results in an increase in pressure in the bulb A, with

$$\Delta P=\frac{P\Delta T}{T}, \text{ or } \Delta P'=\frac{1}{2}\frac{P\Delta T}{T}$$

according to whether the mercury column in the capillary tube is stationary or allowed to move. In the calculation, the equations for perfect gases are used as a basis since permanent gases, at ordinary temperatures and pressures below one hundred atmospheres, deviate only insignificantly from Boyle's law.

If movement of the mercury column is prevented, the pressure differential ΔP acting upon the end surface 5 (Fig. 2) of the mercury establishes a force F which urges the mercury in the direction toward the bulb B and is equal to $S\Delta P$ or

$$\frac{SP\Delta T}{T}$$

where S equals the cross-sectional area of the mercury column.

If the mercury column is allowed to shift, the volume of bulb A increases, while the volume of bulb B is correspondingly decreased until the pressure in bulb B is increased to a value equal to that in bulb A, to wit, $P+\Delta P'$.

The variation of the volume of the two bulbs A and B is ΔV and equals

$$\frac{1}{2}\frac{V\Delta T}{T}=sl$$

where l is the distance through which the mercury column has been moved or shifted. Thus, it can be said that:

$$l=\frac{1}{2}\frac{V\Delta T}{sT}$$

If no force, other than that resulting from the gas pressures, acts upon the mercury column, it is apparent that force $F=s\Delta P$ would cause movement of the mercury through a distance l sufficient to reestablish the equality of the pressures in the two bulbs A and B and to reduce the force F to zero.

If, on the contrary, the movement of the mercury column is opposed by a resistance R, the mercury will be displaced only when the force F exceeds the resistance R, and such displacement will cease when F becomes equal to R. In this case, the distance l_1 through which the mercury is shifted or displaced will be smaller than the distance l, as calculated above. The new distance l_1 can be calculated as follows:

$$\frac{F-R}{F}=\frac{l_1}{l}$$

$$l_1=\frac{F-R}{F}l=l-\frac{R}{F}l$$

By substituting the values for F and l derived above:

$$l_1=l-\frac{\frac{RlV\Delta T}{2sT}}{\frac{sP\Delta T}{T}}$$

or,

$$l_2=l-\frac{1}{2}\frac{RV}{s^2P}$$

From the last equation it can be seen that, if the volume V of the bulbs is such that the temperature increase ΔT in the bulb A causes a shifting movement l greater than the distance

l_1 between the end 6 of the mercury and the contact wire 7 (Fig. 2), the temperature increase ΔT will always be adequate for effecting closure of the electric circuit by overcoming the resistance R to such movement provided that the gas pressure P in the two bulbs has a predetermined value. That is, the sensitivity of a given differential thermometer is a function of the gas pressure in the two bulbs.

In order to calculate the pressure P required to obtain a desired sensitivity, after the values of V and

$$\frac{\Delta T}{T}$$

have been established, it is necessary to determine the value of the resistance R to the movement of the mercury column. This resistance cannot be calculated exactly for it depends to some extent upon the purity of the mercury and the time that it has been motionless within the capillary tube. While the mercury tends to stick to the interior surface of the capillary tube if it has remained motionless for a considerable period of time, it can be stated generally that the resistance R to movement of the mercury is substantially equal to the force required to overcome the superficial tension of the mercury along the circumference of the meniscus at the end of the column.

If r is the radius of the capillary tube containing the mercury and n is the superficial tension of the mercury, the maximum value of $R=2\pi rn$. However, it is apparent that the resistance R never reaches the above value, and is reduced well below it, as soon as the mercury begins to shift within the capillary tube.

The value of P can be derived from the formula given above for l_1 as follows:

$$P=\frac{1}{2}\frac{RV}{s^2(l-l_1)}$$

Substituting $2\pi rn$ for R in the above formula, we obtain:

$$P=\frac{nV}{\pi r^3(l-l_1)}$$

and this represents the maximum value of the gas pressure in the bulbs A and B for effecting a movement of the mercury l_1, if it is assumed that the resistance R to movement of the mercury is constant and expressed as $2\pi rn$.

If, on the other hand, it is properly assumed that the resistance to movement of the mercury column will be reduced to zero, or at least to a negligible value, as soon as the mercury has begun to move, the following calculations can be made:

$$F=\frac{sP\Delta T}{T}$$

as shown hereinabove.

$$P=\frac{F}{s\frac{\Delta T}{T}}$$

If $R=2\pi rn$ is substituted for F:

$$P=\frac{2\pi rn}{s\frac{\Delta T}{T}}=\frac{2\pi rn}{\pi r^2\frac{\Delta T}{T}}=\frac{2n}{r\frac{\Delta T}{T}}$$

A sample numerical calculation, employing the above equations, is given below merely by way of example:

Assuming that $r=0.03$ cm.; $T=300°$ C.;

$\Delta T=0.3°$ C.; $l=0.1$ cm.; and $l_1=0.05$ cm.; and inserting these values in

$$l=\frac{1}{2}\frac{V}{s}\frac{\Delta T}{T}$$

we find that $V=0.564$ cm^3.

Since the superficial tension n of mercury=

$$436\ \frac{\text{dyne}}{\text{cm.}}$$

$$P=\frac{nV}{\pi r^3(l-l_1)}=58 \text{ atmospheres}$$

while

$$P=\frac{2n}{r\frac{\Delta T}{T}}=30 \text{ atmospheres}$$

Thus, in an apparatus having the assumed dimensions and characteristics, the making of contact in response to a temperature rise in one gas-filled bulb of 0.3° C. requires a gas pressure in the bulbs of approximately 60 atmospheres.

Generally, it may be stated that the gas pressures in the bulbs must be greater than twice the superficial tension of the mercury divided by the product of the radius of the capillary tube and the quotient of the predetermined temperature increment and the absolute temperature of the gas in the bulbs, and that the sensitivity of the apparatus is increased by increasing the gas pressures within the bulbs. Further, it has been found that the increased gas pressures also tend to reduce sparking at the contacts when the mercury moves away from the latter for opening the alarm or indicator circuit.

From the above, it is apparent that the gas-filled bulbs of an apparatus of the described character should have adequate resistance to high pressures, good thermal conductivity and small heat capacity. These characteristics can be obtained by employing metal bulbs of elongated cylindrical shape and having a very small inner diameter and a length sufficient to supply the volume required by:

$$l=\frac{1}{2}\frac{V}{s}\frac{\Delta T}{T}$$

Such an extended length provides a great area of contact with the platinum catalyst, and together with the good heat conductivity of the metal bulb ensures that the gas enclosed within the catalyst enveloped bulb will closely follow any temperature changes in the catalyst. The desired small heat capacity of the bulbs is achieved by providing the latter with a small cross-sectional wall thickness which is possible because of the small inner diameter. That is, with a bulb of given volume and gas pressure therein, the wall thickness can be reduced along with reductions in the diameter thereof and without sacrificing the desired safety factor.

However, bulbs formed of metal tubing having a small diameter and a predetermined volume each would be of a length, using the values given in the above specific example, equal to approximately two meters. Thus, if the bulbs were straight, the apparatus would have the undesirable length of approximately four meters. Further, such bulbs would be so widely spaced apart as to be subjected to different ambient or atmospheric temperatures which would cause closing of the alarm circuit and false alarms even when no illuminating gas was escaping.

In accordance with the present invention, the overall dimensions of the apparatus are reduced by giving each of the bulbs A and B a coiled configuration of the form shown in any one of Figs. 3, 4 and 5. Such a coiled configuration has the further advantage of reducing the quantity of platinum catalyst required for covering one of the gas-filled bulbs. However, the coiled configuration of the bulbs does not completely avoid the possibility that the two bulbs will be subjected to different ambient temperatures as a result of heating stoves, cooking stoves, radiators and the like either disposed adjacent to one of the bulbs or acting to set up currents of warm air which pass over one of the bulbs and not the other.

In order to avoid this last mentioned difficulty, the two coiled bulbs A and B are preferably interlaced, as shown in Fig. 7. For example, the bulb B is arranged into two coiled parts disposed at the opposite sides of the centrally located coiled bulb A. With such an arrangement, false alarms are avoided even when relatively hot air is passed over the coils in the direction of the arrows 22, this being the most critical condition. Assuming that the parts B_1 and B_4 constituting the bulb B are equal in area and volume to each other and to each of the half parts A_2 and A_3 making up the gas-filled bulb A, it is apparent that warm air, moving in the direction of the arrows 22 (Fig. 7) will heat the coil part B_1 most intensely and the coil part B_4 with the least intensity, while the coil parts A_2 and A_3 will be heated to an intermediate extent so that the heating of the coiled bulbs A and B will be substantially equal.

Further, the passage of air currents over the bulbs A and B, preferably arranged in an interlaced manner, as in Fig. 7, may be prevented by a protective envelope of the kind shown in Fig. 6. This protective envelope is formed of alternating layers of appropriate metal net or screen material 19 and of porous heat retaining material 20, such as, for example, glass wool, ordinary wool, asbestos fibers and the like. Such a protective envelope breaks up any currents of heated or cold air, for example, currents as represented by the arrows 21 (Fig. 6), and by providing a suitable number of alternate layers, the temperature differences between the two coiled bulbs resulting from changes in the ambient temperatures can be held to a value lower than that required to close the alarm or indicating circuit.

Referring now to Fig. 3, an apparatus embodying the present invention is there illustrated and includes still further devices for preventing false alarms in response to conditions other than the escape of illuminating or other combustible gases. The apparatus of Fig. 3 is generally similar to that described hereinabove and includes two electrical heating resistances 8 and 9 wound around the catalyst covered bulb A and the other gas-filled bulb B, respectively, of the differential thermometer, and having the values R_a and R_b with the latter being greater than the former. The resistances 8 and 9 are connected in series with a condenser 10 and with an indicating lamp 11, a current source 12, for example, a transformer, and a resistance coil 13. The contacts, which are either closed or opened by the mercury column in the capillary tube connecting the bulbs A and B, are generally indicated by the reference numeral 16 and are shunted across the condenser 10 between the resistances 8 and 9. Further, an alarm circuit is provided and includes an electrically energised bell 17 and a thermo-responsive switch 14 disposed adjacent the heating resistance 13 and connected in series between the bell 17 and the electrical source 12. Insulation 15 is provided around the heating resistance 13 and the thermo-responsive switch 14 to ensure that the latter, which is normally open, is closed only in response to heating by the coil 13, and to prevent the heat emanating from the resistance or coil 13 from affecting the temperatures around the bulbs A and B.

The arrangement shown in Fig. 3 operates as follows:

If for any reason the temperature of bulb A is raised above that of bulb B by an amount sufficient to close the contacts 16, an electric current flows through the resistances 8, 9 and 13 and heats the bulbs A and B and the thermo-responsive switch 14. Since the value R_b of resistance 9 is greater than the value R_a of resistance 8, the bulb B will be more intensely heated than the bulb A and in a predetermined time interval t after closing of the circuit the bulb B will reach the temperature of the bulb A to again open the circuit through the contacts 16. The resistance 13 has a heat output which is sufficiently small so that the switch 14 will not be closed to effect sounding of the warning bell during heating for the time interval t. Thus, when after the time interval t the circuit is again opened, the heating resistance 13 and the thermo-responsive switch 14 will be allowed to cool.

If the closing of the circuit through the contacts 16 was caused by means other than escaping illuminating gas, the opening of the circuit through contacts 16 which deenergizes the resistances 8 and 9 will permit cooling of the bulbs A and B back to the same ambient temperature. Since the catalyst-coated bulb A has a protective filter (Fig. 1) therearound to prevent contamination of the platinum catalyst, it may be necessary to provide a suitable insulating layer around the bulb B to delay cooling of the latter so that the bulbs A and B cool at the same rate.

Since the bulbs A and B are preferably protected against changes in the ambient temperature, as in Fig. 6, and interlaced, as in Fig. 7, so as to be similarly subjected to such changes, even extremely adverse conditions acting on the bulbs A and B will only cause intermittent and widely spaced apart closing of the circuit through the contacts 16, so that adequate cooling periods will be provided between the successive closures of the circuit to prevent heating of the thermo-responsive switch 14 to a point at which it closes the circuit to the warning bell 17. Thus, if the temperature differences between the bulbs A and B are caused by means other than the escape of gas and are sufficiently large to close the circuit through the contacts 16, such intermittent closures of the circuit will only be indicated by intermittent illumination of the lamp 11.

However, if illuminating gas is escaping at a substantial rate, the heating of the catalyst 2 around the bulb A is greater than the difference between the heating effects of the resistances 8 and 9 so that the temperature of the bulb A exceeds that of the bulb B to continuously close the circuit through the contacts 16 and thereby to continuously energize the resistance 13 so that the thermo-responsive switch 14 is soon closed to energize the alarm bell 17. If the rate at which the gas is escaping is relatively small, the temperature increase produced by the catalyst on bulb A may not be sufficient to completely overcome the contrary effect of the resistances 8 and

9 when the circuit has been closed through the contacts 16. In that event, the more intense heating by the resistance 9 will tend to return the bulbs A and B to the same temperature to effect intermittent opening of the circuit through contacts 16. However, as soon as the temperatures between the bulbs A and B are equalized to open the circuit, the equalizing effect of the resistance 9 will be interrupted but the heating effect of the catalyst on bulb A will continue in response to the continuing escape of gas. Thus, after a period of time t_1 following the opening of the circuit, the temperature differential will again become sufficient to close the circuit. The heating resistance 13 and the thermo-responsive switch 14 are arranged so that the latter will be closed to energize the alarm bell 17 in response to repeated energization of the resistance 13 where the intervals between the repeated energizations, for example, two or three, of the resistance are relatively short, for example, the period t_1, and do not permit full cooling of the switch 14.

Thus, the apparatus embodying the present invention functions to indicate, or warn of, the escape of illuminating gas even at a small rate, while avoiding the giving of false alarms.

Fig. 8 illustrates a preferred construction for connecting the metal bulbs A and B to the glass capillary tube containing the mercury column. In the preferred construction, the metal bulbs A and B are soldered, at their open ends, to small metal tubes 23 which, in turn, extend into and are connected to the opposite ends of the glass capillary tube 28 by soldering or the like. Preferably, the contacts within the glass capillary tube 28 are in the form of metal tube sections 24 disposed at spaced apart locations in the bore of the capillary tube, with one of the metal tubes 24 being disposed for continuous contact with the mercury column 26, while the other tube 24 is normally spaced from the mercury by an insulating space 25 and contacts the mercury only after the latter has been shifted to the right, as viewed in Fig. 8, by an increased pressure in bulb A over the pressure in bulb B. Further, spherical enlargements 27 are provided in the bore of the capillary tube 28 adjacent the opposite ends of the latter to prevent the flow of mercury into the metal bulbs A and B where it might become amalgamated.

Further, one of the causes of the progressive weakening of the catalytic action is the absorption by the latter of atmospheric humidity. It is known that in the preparation of the platinum catalyst care must be exercised to obtain the removal of all hygroscopic substances therefrom, and that, when a catalyst has become inactive by reason of its absorption of moisture, it can be restored to a useful condition by annealing. Therefore, in accordance with the present invention, provision is made for simultaneously heating the bulbs A and B of the apparatus to deter absorption of moisture by the catalyst on the bulb A.

Such heating is preferably achieved, as shown in Fig. 9, by a heating coil or resistance 29 wound around the bulb A and passing through the platinum catalyst 33 on the latter. Another heating coil or resistance 30 is wound around the bulb B and an energizing circuit is provided for passing current through the resistances 29 and 30 so that both bulbs A and B are uniformly heated to a temperature well above the atmospheric or ambient temperature.

Preferably the energizing circuit for the resistances 29 and 30 includes variable resistances 31 and 32 connected in parallel with the resistances 29 and 30, respectively, so that the variable resistances provide means for adjusting the relative temperatures of the bulbs A and B and the initial position of the mercury 34 relative to the contact 35.

Since apparatus embodying this invention employs a capillary tube having a bore of small cross-section and maintains the gas in the bulbs A and B under a relatively high pressure which deters movement of the mercury column in the capillary tube, the capillary tube is characteristically resistant to rupture as a result of shocks or impacts sustained during transportation of the apparatus.

Further, while the description of the apparatus referring to Fig. 3 of the drawing spoke of the action of the apparatus in providing a warning of the escape of illuminating gas, it is to be understood that an electro-magnetically actuated valve, for example of the kind shown in Fig. 10, may be connected in series with the alarm bell 17 of Fig. 3 to interrupt the supply of gas when the switch 14 is closed for sounding of the alarm bell. While any suitable electro-magnetically actuated valve may be used for the above purpose, the valve of Fig. 10 is shown to include a valve cock a having an arm 36 extending radially therefrom at an angle of 45° relative to the horizontal and having a weight on its free end which tends to turn the arm through an angle of 90° to the broken line position 37 and with it the cock a. When the arm is raised, as at 35, the cock a is open, and when the arm is lowered by gravity to the position 37, the cock is closed to shut off the supply of gas to the leaking or defective appliance. The cock a is normally maintained in its open position by a spring urged plunger d which enters into a suitable notch formed in the periphery of the cock and prevents rotation of the latter. An electro-magnetic coil or solenoid e is in axial alignment with the plunger d and is connected in series with the alarm bell 17 of Fig. 3 to be energized with the latter for disengaging the plunger d from the cock a and permitting rotation of the latter to its closed position.

It is to be understood that the alarm circuit for energizing the bell 17 of Fig. 3 can also be employed for actuating other safety devices in the event of the escape of illuminating gas, such as, for example, ventilating systems, means for opening windows or for substituting illumination by safety lights for the conventional lighting system.

While a particular embodiment of the present invention has been illustrated and described in detail, merely by way of example, it is to be understood that the present invention is not limited to that particular embodiment, and that various changes and modifications may be effected therein to adapt the device for use in detecting and indicating the presence of any combustible gas which reacts with a catalyst without departing from the spirit or scope of the invention as defined in the appended claims.

What is claimed is:

1. A device for signaling the presence of illuminating gas comprising a differential thermometer including a pair of coil-shaped interlaced tubes, a capillary tube connecting said pair of tubes and containing mercury, gas under pressure in each of said pair of tubes positioning the mercury in said capillary tube, a catalyst around one of said pair of gas filled tubes responding to

the presence of illuminating gas to raise the temperature of said one tube relative to the other of said tubes, and electrical contacts in said capillary tube contacted by said mercury for closing an electrical circuit when a predetermined temperature increment is obtained between the respective temperatures of said pair of gas filled tubes, the pressure of the gas in said pair of tubes being greater than twice the superficial tension of said mercury divided by the product of the radius of said capillary tube and the quotient of the predetermined temperature increment and the absolute temperature of the gas in said pair of tubes.

2. A device for signaling the presence of illuminating gas comprising a differential thermometer including a capillary tube having a drop of mercury therein, a pair of sealed elongated small diameter coiled tubes extending from the opposite ends of said capillary tube, said coiled tubes being interlaced to thereby equalize the atmospheric conditions acting thereon, gas under pressure in each of said coiled tubes positioning said mercury drop in said capillary tube, a catalytic covering extending about one of said coiled tubes to effect a temperature rise in the latter in response to the presence of illuminating gas, and a pair of contacts projecting into said capillary tube and coacting with said mercury drop to close an electric circuit when the temperature of said one of said coiled tubes rises a predetermined amount above that of the surrounding atmosphere.

3. A device for signaling the presence of illuminating gas comprising a differential thermometer including a capillary tube having mercury therein, a pair of sealed bulbs connected to the opposite ends of said capillary tube and having gas therein to position the mercury, a catalytic covering extending around one of said bulbs to effect a temperature rise in the latter in response to the presence of illuminating gas, a pair of contacts projecting into said capillary tube to establish an electric circuit through the mercury for energizing a thermal relay when the temperature of said one bulb rises a predetermined amount above that of the other of said bulbs, and electrical heating means for each of said bulbs connected in series with said contacts, the electrical heating means associated with the other of said bulbs being operative to heat the latter more quickly than the rate at which the heating means associated with said one bulb heats said one bulb so that the thermal relay is closed only when illuminating gas is continuously present.

4. A device for signaling the presence of illuminating gas comprising a differential thermometer including a capillary tube having mercury therein, a pair of sealed bulbs extending from the opposite ends of said capillary tube and containing gas for positioning the mercury in the latter, a catalytic covering extending about one of said gas containing bulbs to effect a temperature rise in the latter in response to the presence of illuminating gas, a pair of contacts extending into said capillary tube and coacting with the mercury in the latter to close an electric circuit when the temperature of said one bulb rises a predetermined amount above the temperature of the other of said bulbs, electrical heating means for each of said bulbs, and means for energizing said heating means so that said catalytic covering is maintained at a temperature above that of the surrounding atmosphere to increase the sensitivity of the catalytic covering and to discourage deterioration thereof by reason of the presence of moisture in the atmosphere.

5. A device for signaling the presence of illuminating gas as set forth in claim 4, wherein said means for energizing said electrical heating means includes a source of electrical energy, conductors connecting each of said heating means to said source, and variable resistances interposed in said conductors so that the heating of said bulbs may be varied to adjust the initial position of the mercury in said capillary tube.

6. A device for signaling the presence of illuminating gas as set forth in claim 5, wherein said bulbs are coiled and interlaced to thereby equalize the atmospheric conditions acting thereon.

7. A device for signaling the presence of illuminating gas as set forth in claim 4, wherein said bulbs are coiled and interlaced to thereby equalize the atmospheric conditions acting thereon.

8. A device for signaling the presence of illuminating gas as set forth in claim 4, further including a housing surrounding said differential thermometer and formed of alternating layers of metal net and of porous heat retaining material.

9. A device for signaling the presence of illuminating gas according to claim 4; wherein the gas in said pair of sealed bulbs is under high pressure and said bulbs are formed of a metal of sufficient strength to resist the pressure of the gas therein and of good thermal conductivity.

10. A device for signaling the presence of illuminating gas according to claim 9; including short metallic tubes connecting said bulbs to the ends of said capillary tube, said short metallic tubes extending at their opposite ends into the related bulb and the adjacent end of said capillary tube and being soldered thereto.

11. A device for signaling the presence of illuminating gas according to claim 9, wherein the ends of said metal bulbs connected to said capillary tube are formed with reduced diameters to extend into the latter and are soldered thereto.

12. A device for signaling the presence of illuminating gas according to claim 9, wherein the opposite end portions of said capillary tube are formed with spherical enlargements therein to receive the mercury and prevent the flow of the mercury into said metal bulbs and amalgamation therewith.

13. A device for signaling the presence of illuminating gas according to claim 4, wherein said bulbs are coil shaped to reduce the space required to accommodate the bulbs and to reduce the quantity of catalytic covering required to extend about said one of the bulbs.

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