April 1, 1969 A. W. LINKE ET AL 3,435,682

DISPERSION EBULLATOR

Filed April 26, 1966

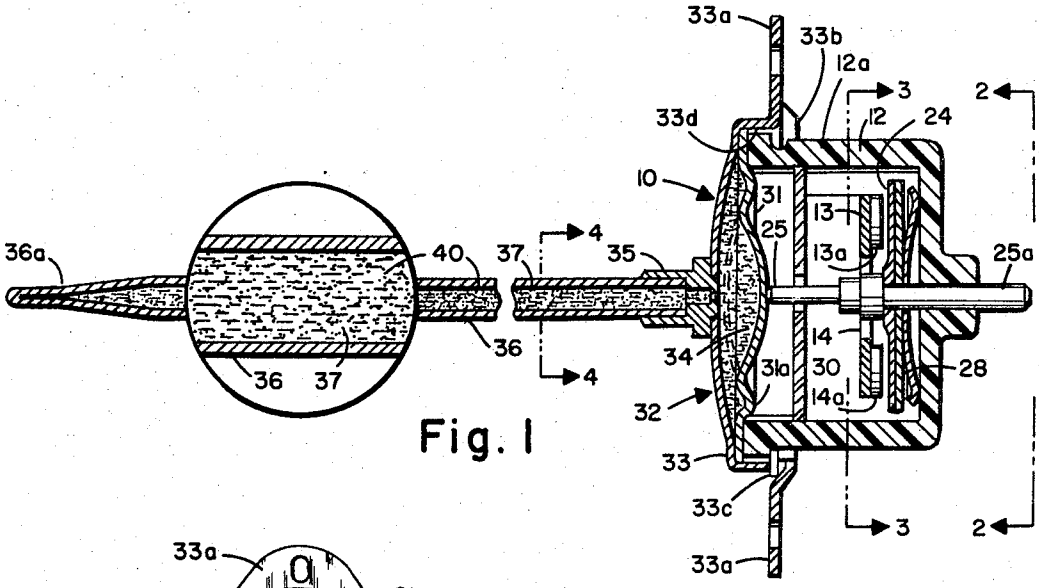


Fig. 1

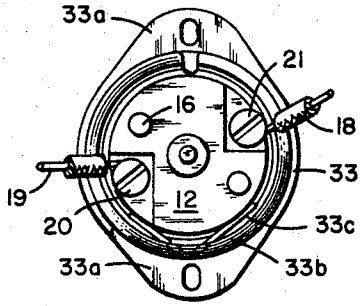


Fig. 2

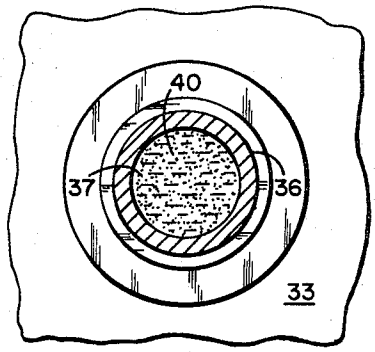


Fig. 4

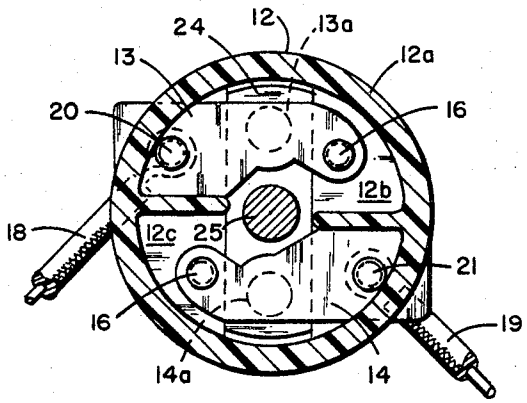


Fig. 3

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DISPERSION EBULLATOR

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ABSTRACT OF THE DISCLOSURE

A thermally responsive power element comprises an expansible member having a tube connected at one end thereto and in communication with the interior thereof. The tube is otherwise closed and contains a volatile liquid which is adapted to boil and expand the expansible member when any portion of the tube is subjected to a given temperature. The liquid contains particles of non-wettable material, such as polytetrafluoroethylene. The particles are of such a size that they are held in suspension and dispersed throughout the liquid and are effective in promoting ebullation of the liquid at a given temperature.

This invention relates to improvements in thermally responsive power means of the type comprising a liquid-containing expansible chamber having a movable wall which is distended when any of the liquid is vaporized by an increase in temperature thereof. The movable wall may be utilized to actuate a control device such as an electric switch or valve. More specifically the present invention is directed to the aforesaid thermally responsive power means which comprises a non-wettable material of small particle size dispersed in the liquid contained in said expansible chamber, which combination effects thermally, reliable, efficient, and economical means for actuating the control device such as an electric switch or valve.

Thermally responsive power means of the general type described are known, but prior to our invention the liquid therein would not vaporize consistently at predetermined temperatures throughout a considerable passage of time. Experience has shown that minute quantities of gas in the liquid will cause the liquid to vaporize at predetermined temperatures; however, this gas eventually separates from the liquid and the remaining pure liquid will not vaporize unless it is heated to an unpredictable temperature appreciably above that at which the impure liquid vaporizes.

The present invention is an improvement over the device disclosed in U.S. Patent No. 3,163,045, issued on Dec. 29, 1964, an important feature of said patent being directed to an abraided "Teflon" (polytetrafluoroethylene) coated wire extending through a capillary tube comprising an elongated temperature sensing member and containing a volatile liquid for operating a control device, for example, the abraided coating assuring boiling of the liquid at a predetermined temperature. The present invention provides more economical, simple, efficient and reliable means for assuring boiling of the liquid at any point throughout the entire length of the capillary tube than that disclosed in the aforementioned patent.

An object of the present invention is the provision of a thermally responsive power means of the type described in which fine particles of a non-wettable material, such as polytetrafluoroethylene, is dispersed throughout the body of the volatile liquid so that the liquid or any portion thereof subjected to its volatilizing temperature vaporizes consistently at a definite temperature. In a preferred form of the invention, the liquid includes water, and the non-wettable material is polytetrafluoroethylene, known commercially as "Teflon," a long-chain synthetic polymer. Other non-wettable materials may be long-chain synthetic polymeric amids, some members of which are known commercially under such trade names as "nylon," "Dynel," "Orlon," etc., manufactured by the Du Pont Company of Wilmington, Del.

Another object of this invention is the provision of an improved power means of the foregoing character wherein the expansible chamber includes a substantial length of a relatively small diameter tubular sensing member containing at least a portion of the liquid fill and having the non-wettable material in the interior thereof and distributed throughout the length of the tubular member in the form of a dispersion of minute particles thereof. For example, the liquid may include water, glycols, alcohols, etc., or mixtures of the same. The non-wettable material may be of the character set forth above such as a dispersion of polytetrafluoroethylene plastic ("Teflon") having an average particle diameter size in the range of about .05 micron and 0.5 micron in the tube and extending throughout its length, whereby the liquid in all sections of the tube is in contact with the non-wettable material so that when any relatively short zone or segment of the tubular member is heated to raise the temperature of the liquid in the segment a predetermined degree, the portion of the liquid in this segment will vaporize and cause a substantial increase in pressure and distend the movable wall of the chamber even when the major portion of the liquid remains unvaporized.

Yet another object of this invention is the provision of an improved control device comprising a switch, valve, or the like, operable by the movable wall of an expansible chamber connected to a tubular temperature sensing member containing a liquid comprising water, organic liquids, such as ethylene glycol, methyl alcohol, etc., or a mixture of water and another volatile liquid and having a dispersion material of relatively fine average particle diameter size of a non-wettable material disposed in the tubular member and extending substantially throughout the length thereof.

Another object of this invention is the provision of a dispersed activating non-wettable material dispersed in said liquid for improved contact of said liquid with said non-wettable material for enhanced control of the power sensing device.

Another object of the present invention is directed to the product of a resin dispersed in a liquid fill which functions for the purpose disclosed herein.

Other objects and advantages of this invention will become apparent from the following detailed description of a presently preferred embodiment thereof, taken in conjunction with the accompanying sheet of drawing forming a part of this specification and in which:

FIG. 1 is a longitudinal sectional view of a control device, embodying the present invention, with a portion of the tubular member thereof shown in a magnified scale;

FIG. 2 is an end view of the device of FIG. 1 taken along line 2—2 on a slightly reduced scale;

FIG. 3 is a sectional view taken along line 3—3 of FIG. 1; and

FIG. 4 is a sectional view of an enlarged scale taken along line 4—4 of FIG. 1.

In the form of the invention shown in the drawings and described hereinafter, the invention is embodied in a thermally responsive control switch device **10**, although it will be understood that the invention may be embodied in devices having other control functions such as a thermally responsive control valve, or the like.

Referring to FIGS. 1, 2 and 3, control device **10** is seen to comprise a cylindrical or cup-shaped housing **12** formed of a suitable insulating material such as "Bakelite." A pair of stationary contact members **13** and **14** extend through the side wall **12***a* of housing **12** and having their inner ends riveted to bosses **12***b* and **12***c* as by

rivets **16**. The outer ends of contact member **13** and **14** serve as switch terminals for the connection of wires such as **18** and **19** secured thereto by binding screws **20** and **21**. A movable bridging contact **24** is mounted for movement with an axially movable operating rod **25** which is slidably received in a guide bore **26** formed in housing **12**. Bridging contact **24** is normally biased in bridging engagement with contacts **13***a* and **14***a*, on contact members **13** and **14** respectively, by a bowed leaf spring **28**. Operating rod **25** extends through an opening in a guide disc **30** and is adapted to be moved by the action of a flexible diaphragm **31** forming part of a thermally responsive power means generally indicated at **32**.

Power means **32** comprises a cup-shaped member **33** having mounting ears **33***a*, and in which the open end of housing **12** is received and retained by an inwardly directed tab **33***b* and a spring clip **33***c* which projects through one wall of cup **33**. Diaphragm **31** is welded about its peripheral edge to the bottom of cup-shaped member **33** adjacent wall **33***d* thereof, thereby forming a narrow chamber **34**. A nipple **35** is spot welded or brazed in a central opening of member **33** and receives one end of a capillary tube **36**. The opposite end **36***a* of the tube is sealed and the tube and chamber **34** contain a liquid fill **37** comprising a mixture of water and volatile liquid such as methyl alcohol, which liquid fill will be discussed more fully hereinafter.

Diaphragm **31** is formed with convolutions **31***a* embossed therein which cause it to have an over-center snap action when flexed, and if unrestrained would tend to remain in the position of FIG. 1 in which rod **25** is moved to the right and the switch contacts are separated. Chamber **34** and tube **36** are, however, charged with liquid fill **37** at a pressure substantially less than the ambient atmospheric pressure acting on diaphragm **31**, so that at temperatures less than the boiling point of the liquid the diaphragm is held in the dotted line position of FIG. 1, with the switch contacts closed. It will be recognized that either upon boiling of the liquid fill **37** or upon a leak developing in the system, the pressure in chamber **34** will increase and permit diaphragm **31** to snap to its full line position and open the contacts so as to deenergize a circuit connected thereto. Thus, the control device **10** is not only adapted to actuate the switch contact upon predetermined increases in temperature along the tubular member **36**, but also incorporates a fail-safe feature effecting opening of the contacts in the event of loss of fluid-tight integrity in the thermally responsive power means **32**. In the present example, the diaphragm **31** snaps out upon a decrease of vacuum in the chamber **34** to within a range of about 3 to 8 inches of mercury, and will snap in or "reset" when the vacuum is increased to about 13 to 18 inches of mercury. It will be noted that rod **25** extends beyond the wall of housing **12** as shown at **25***a* and slideable therein so that the rod **25** can be operated manually when desired or found necessary for resetting the flexible diaphragm **31** to its dotted line position of the drawing.

Included also in tube **36** is a dispersion of said non-wettable resin material preferably, but not limited thereto, of polytetrafluoroethylene plastic particles **40** as shown in FIGS. 1 and 4. For convenience, in quantity production of devices embodying the invention, the dispersion may be introduced into the liquid prior to charging the liquid into the tube, and this is accomplished by preparing a convenient batch volume of the particular liquid to be employed and then adding a small quantity of a dispersion of the particles in tap or distilled water, for example, and the liquid and the dispersion are then thoroughly mixed, as by stirring. The liquid is then introduced into the capillary tubes **36** of the individual control devices in the usual manner. The capillary tube **36** is then fused as at **36***a*.

The liquid fill in another example may comprise a mixture of water and methyl alcohol, with water constituting about 65% of the mixture and methyl alcohol constituting about 35% of the mixture. This mixture, when confined at the previously mentioned pressure in the capillary tube **36** with dispersed "Teflon" as the activating agent, will vaporize or boil at 165° F. thereby flexing diaphragm **31** for operation of the switch device. It should be understood that while the non-wettable dispersed material preferably comprises "Teflon," other materials may be resins that belong to the family of long-chain synthetic polymeric amides such as "nylon," "Orlon," "dynel," etc., other materials which conform to the class of non-wettable materials would function for the purpose of the present invention.

While resin dispersions in liquid fills may be produced commercially, an example only of such a dispersion for the present purpose would comprise aqueous dispersed "Teflon" therein to the extent of about 59% to 61% solids and having about 5.5% to about 6.5% of a non-ionic wetting agent in water. Such a mixture would consist of about 7.5 pounds of powdered "Teflon" per gallon of water. It is also to be noted that such dispersions will settle somewhat on prolonged standing, but can be redispersed by mild agitation. In addition, the dispersion should be protected against freezing, which would cause an irreversible coagulation. Another effective liquid fill besides water, per se, could be prepared using dipropylene glycol with or without any additions, and "Teflon."

Mixtures of water and other substances such as methyl alcohol, ethylene glycol, etc., may be used in different proportions to provide actuation at other temperatures. For example, water mixtures containing the listed percentages of ethylene glycol or methyl alcohol will provide response at the following temperatures:

	°F.
Methyl alcohol, 6%	190
Ethylene glycol, 51%	210
Ethylene glycol, 82%	240
Ethylene glycol, 89%	260
Ethylene glycol, 94%	285

In addition, extensive experimentation has shown that certain pure liquids which have been subject to the problem of unpredictable superheating heretofore may be used as the fill and will provide reproducible results repeatedly when in the presence of the "Teflon," or other non-wettable materials. For example, pure distilled water may be used as the fill, and under the mentioned pressures will result in an operating temperature of 205° F., and triethylene glycol will result in an operating temperature of 550° F. However, such liquids with, for example, only the added powdered dispersion therein as noted above, in a concentration of about 0.1% by volume, will produce far better results, economically, efficiently, and reliably than the device of the previously referred to patented device wherein the capillary tube has an inserted steel wire core having a non-wettable material such as "Teflon" tape wrapped around said wire core.

While it is not fully understood why the use of the above liquid fills in the presence of "Teflon" have been successful in overcoming super-heating of the liquid fill, when confined in a capillary tube, for example, it is believed that the resistance of "Teflon" to wetting by water or other vaporizing liquids creates a surface condition between the liquid and the dispersed particles of said "Teflon" which permits vapor bubbles to readily form before the boiling point is actually reached. Thus, when the boiling point is reached, there are in existence vapor filled interfaces at which the boiling can occur.

From the foregoing detailed description, it will be recognized that this invention has provided an improved thermally responsive device which is actuable by attainment of a predetermined temperature at any given length along the temperature sensing capillary tube and which is not subject to averaging of the temperatures therealong. It will also be recognized that the use of a mix-

ture of water and other volatile liquid in the presence of a dispersion of said non-wettable material, of which "Teflon" is most preferable, eliminates any likelihood of super-heating and failure of the control device to be actuated.

Although the invention has been described in considerable detail with reference to a preferred form of control device embodying the invention, it is understood that the invention is not limited thereto.

Having thus described our invention, we claim:

1. A thermally responsive power means comprising:
an expansible hollow element,
a volatile liquid in said element, and
particles of non-wettable material of a diameter size rendering the particles capable of suspension in said liquid and dispersed therethroughout.

2. A thermally responsive power means as defined in claim **1** wherein said dispersed non-wettable material is a synthetic resin.

3. A thermally responsive power means as defined in claim **1** wherein the non-wettable material comprises a long-chain synthetic polymeric amide.

4. A thermally responsive power means as defined in claim **1** in which particles of said non-wettable material dispersed throughout said liquid have diameters no greater than about 0.5 micron.

5. A thermally responsive power means as defined in claim **4** wherein said dispersed non-wettable material is a synthetic resin.

6. A thermally responsive power means as defined in claim **4** wherein the non-wettable material comprises a long-chain synthetic polymeric amide.

7. A thermally responsive power means as defined in claim **4** wherein said dispersed material comprises polytetrafluoroethylene.

8. A thermally responsive power means as defined in claim **4** wherein said liquid comprises a mixture of water and ethylene glycol.

9. A thermally responsive power means as defined in claim **4** wherein said liquid comprises a mixture of methyl alcohol and water.

10. A thermally responsive power means comprising an expansible hollow element, a volatile liquid in said element, and particles of non-wettable material having an average particle diameter size of from about .05 micron to about 0.5 micron.

11. A thermally responsive device as defined in claim **10** and comprising a tubular sensing element communicating with the interior of said hollow member and containing said liquid, said material comprising dispersed polytetrafluoroethylene.

12. A thermally responsive power means as defined in claim **10** wherein said dispersed material comprises polytetrafluoroethylene.

13. A thermally responsive power means as defined in claim **12** and wherein said liquid comprises water.

14. A thermally responsive power means as defined in claim **12** wherein said liquid comprises a mixture of water and ethylene glycol.

15. A thermally responsive power means as defined in claim **12** wherein said liquid comprises a mixture of methyl alcohol and water.

16. A thermally responsive power means as defined in claim **15** wherein said dispersed material comprises a long-chain synthetic polymeric amide.

17. A thermally responsive power means as defined in claim **15** wherein said volatile liquid comprises a glycol.

18. A thermally responsive power means as defined in claim **15** wherein said volatile liquid comprises an alcohol.

19. A thermally responsive power means as defined in claim **15** wherein said volatile liquid comprises water.

20. A thermally responsive power means as defined in claim **15** wherein said expansible element and said tube being filled with a mixture of water and another volatile liquid.

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U.S. Cl. X.R.

73—368.3