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MINUTE CAPILLARY TUBE APPLICABLE TO TEMPERATURE SUDDEN CHANGE ELECTRIC CIRCUIT CLOSERS AND OTHER INSTRUMENTS

Filed Sept. 19, 1923

Fig. 1

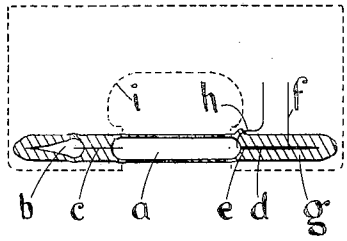


Fig. 2

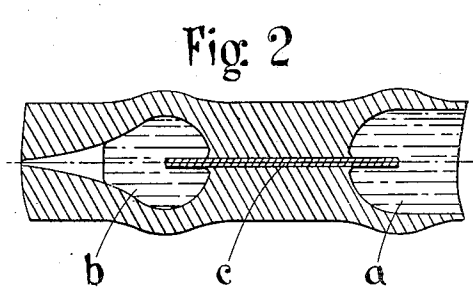


Fig. 3

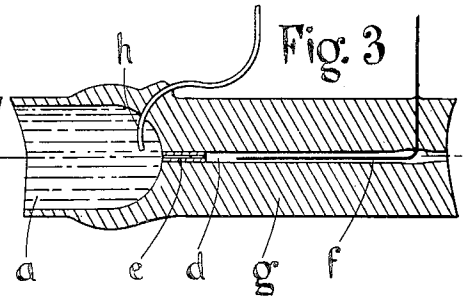
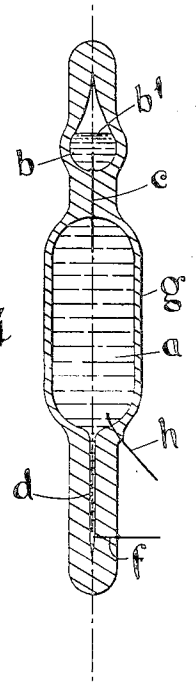


Fig. 4



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UNITED STATES PATENT OFFICE.

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MINUTE CAPILLARY TUBE APPLICABLE TO TEMPERATURE SUDDEN-CHANGE ELECTRIC-CIRCUIT CLOSERS AND OTHER INSTRUMENTS.

Application filed September 19, 1923. Serial No. 663,718.

To all whom it may concern:

Be it known that I, CHARLES LESLIE WALKER, a subject of the King of Great Britain, residing at 44 Carden Place, Aberdeen, Scotland, have invented a new and useful Form of Minute Capillary Tubes Applicable to Temperature Sudden-Change Electric-Circuit Closers and Other Instruments.

The invention relates largely to scientific instruments in which factors of time and fluid-pressure are co-related with the flow of fluid through capillary passages or tubes; the formation of the latter being an important consideration. But the manner of incorporation of such tubes together with the evacuation and charging with operating fluid hereinafter described is also important.

The type of instruments chosen to illustrate and make clear the nature of the invention is that dealt with in my Patent No. 768,098 according to which a sudden change of temperature causes a contained body of expansible fluid to issue into or rise in a normally empty passage, whereas a gradual change of temperature merely causes a displacement through a normally full capillary passage of critical dimension into a partially filled compensation chamber; the action being usable to effect the closure of an electric circuit and so give warning, say, of the abnormal presence of a flame, to open a sprinkler or to effect other action or indication.

Hitherto, in instruments according to the general type described in my said Patent No. 768,098, the capillary compensation passage has been formed of glass, a characteristic having serious disadvantages including great liability of the fine tube to split under only a slight shock and the liability of the fine stream of mercury (if mercury be the fluid used) to become disconnected in transit, in erection or otherwise so as to require expert handling at all times. When, on the other hand, liquid other than mercury has been used as the compensating fluid the fine glass bore with its tapered entrance has proved a trap for minute dust which, in practice, has been found inseparable in smaller or larger degree from light thermometric fluids, thus rendering the original and tested rate of compensation unreliable.

The characteristic features of the present invention, which is designed to overcome these disadvantages, are particularly defined in the claims annexed to this specification and are embodied in the improved instrument illustrated in the accompanying drawings, whereof:

Figure 1 is a longitudinal section of an instrument having a circular cross section. Figures 2 and 3 are largely magnified drawings showing more clearly in detail, respectively, the left and right hand portions of Figure 1. Figure 4 is a longitudinal section of an instrument having also a circular cross section.

In Figure 1 *a* is a mercurial thermometric container or bulb which is entirely filled with mercury. An overflow or compensation chamber *b* contains mercury which, in nomal conditions, is insufficient in quantity to fill its capacity.

A metallic tube *c*, preferably of platinum, is represented by a single line in Figure 1; in Figure 2 (as magnified) the bore of the tube *c* is shown as a single line. The contact tube *d* has at its inner end a platinum tube *e* of relatively large bore and short extent. The tube *e* fits within and is sealed into the contact tube *d* so that communication between the bulb *a* and the tube *d* is maintained only through the bore of the tube *e*, this bore being represented by two lines in Figure 3.

Extending within the contact tube *d* and fused into the glass *g* of the instrument is a functional element consisting of a contactual conductor *f* and into the bulb *a* is sealed a conductor *h*. The instrument, Figure 1 may be mounted in any suitable manner; the dotted outlines *i* indicate a form of mount through the medium of which the instrument may be secured, for example, to a base-plate on a ceiling within a building.

On any normal rise of temperature the mercury expands and instantly creates a pressure within the bulb *a* thus forcing the mercury to flow through the tube *c* into the chamber *b*, and, the more may be the rate of normal increase, the greater becomes the internal pressure in the bulb. But should the rate of temperature-increase be abnormal, as resulting from the presence of a dangerous flame, the pressure in the bulb *a*

rises instantly to a critical amount (say to 1/8 or 1/5 of an atmosphere), because of the smallness and limited capacity of the tube *c*, and the mercury is forced to enter the (normally empty) tube *d*, issuing through the tube *e* and making contact with *f*. It should be noted that substantial pressure is required to force mercury to enter an empty glass tube of small bore and thus the said critical pressure is predetermined by or dependent on the smallness or capillarity of the tube *d*.

It will be understood that the conductors *f* and *h* form a portion of an electric circuit which is normally open at the gap shown between the tube *e* and the conductor *f*.

If the temperature falls, thus causing the mercury to contract within the bulb *a*, a negative pressure is created therein and consequently the mercury flows from *b* through *c* into *a*, so that *a* is thereby kept full and ready to perform its function. It is to be understood that the whole interior of the instrument should be thoroughly deprived of air; this being so, and the interior of the walls of the bulb *a* being of smooth, untapered formation, which formation is made possible by the presence of the tubes *c* and *e*, the said negative pressure is a substantial factor. This peculiar action is according to a principle described by Sir Isaac Newton in connection with experiments performed by him showing the adhesive property of "unbroken" mercury within glass tubes.

Should the mercury be expanded at a normal rate but to an abnormal degree of temperature as the result, say of a smouldering fire the compensation chamber continues to receive the overflowing mercury which at length (at a predetermined degree) is pressed into the tapered interior of *b* until the pressure, rising by reason of the capillarity of the taper, closes the circuit in the contact tube.

If the instrument be broken the admitted air-pressure closes the circuit instantly.

The instrument, Figure 4, differs from that of Figure 1 in that normally the electric circuit is closed and broken only when a sudden or rapid fall of temperature takes place and so causes the mercury to contract.

The contact tube *d*, Figure 4, is made of such ample bore that the head of pressure acting at the level b^1 (representing the surface of the mercury) through the tube *c* normally prevents a rise of mercury at the bottom of *d;* but if the contraction in *a* is rapid a negative pressure causes the rise of the mercury so that it leaves the contactual element *f* and breaks circuit. The reference characters in Figure 4 correspond with those of Figures 1, 2 and 3 to render clear the analogous but reversed action.

The instrument, Figure 4, may be installed on board a ship, for example, in a shunted stream (as in a pipe) of sea water in such manner as to maintain the external sea temperature where it impinges on the bulb. On the ship entering the colder zones of sea water which extend for distances around icebergs the rapid fall of temperature, though the degree of temperature may not yet be an abnormally low one, must cause the instrument to break circuit, and thus sound an alarm. In the example illustrated in Figure 4 the influences of the varying value of the "head" of mercury due to movements of the ship are ignored, but capillary repulsion may be readily substituted for head of pressure to eliminate such influence if desired. If this instrument (Figure 4) be of suitable size and if the contact tube *d* be made of such small bore as to repel or expel the mercury acting gravitationally at the head b^1 it will then function like the detector Figure 1 on a sudden rise of temperature as will be clear. The above-described instruments (of circular section) are unlike any that are known to the inventor to have been made of the type originally described by him in that the several parts are of co-axial formation; this form being of substantial advantage in the making, in the evacuation and charging and in the mounting for use.

It is to be observed that the compensation passage, which is the bore of the tube *c*, terminates abruptly in and protrudes into the mercury, and the proportions of the instrument are such that, whatever the temperature and however violently the mercury may be displaced by shaking or otherwise from the natural position it tends to acquire, the ends of the passage can never be uncovered by the mercury; for the vacuum "bubble" must at all times cling to the interior surface of the chamber *b* or of the bulb *a*. Thus the compensation flow can never be interrupted other than by breakage. Moreover in the absence of air, when heat has once been applied, mercury adheres to and "wets" or "soaks" a clean platinum tube much as a light thermometric fluid adheres to and wets or soaks it.

Mercurial instruments such as the examples described may be thoroughly exhausted of air mechanically and thereafter filled with pure mercury thus eliminating the skilled labour involved in filling by hand.

It should be noted, that, whereas a fine clean capillary glass tube exercises a substantial capillary repulsion towards mercury which may be pressed to enter it, it has been found that a platinum capillary tube, contrariwise, in the absence of air and under the action of heat (if the platinum be not rendered impure by the presence of certain alloys) draws mercury into it by capillary attraction much as it would draw in oil.

To produce metallic tubes of minute bore

and of highly perfect formation as, for example, of circular bore, a comparatively insoluble tube is formed at first with a core of soluble metal and the latter is afterwards dissolved out by chemical means. Naturally the exceptional qualities of platinum render it in general the most suitable metal of which to form such tubes, while silver is eminently suitable for a core.

The platinum, at first in the form of a machined solid cylinder (such as ordinarily is prepared for the production of platinum wire), is co-axially perforated throughout by machine and a core of silver is accurately fitted into the perforation. The mass is thereafter drawn in the fashion usual for wire manufacture. When the "wire" has been drawn down to the size required it is cut (or severed a full half cross) into the lengths required and, by the employment of nitric acid solution, the silver core is entirely dissolved out of the platinum leaving (after cleansing with distilled water) a microscopic circular bore of highly perfect formation and calibre. In this way large numbers, say, thousands, of tubes may be formed out of one piece of metal. It should be added that there has been found no attainable limit in practice to the minuteness of bore of such platinum tubes.

Fire detectors as described are adapted in their rate of compensation for extremely varied local conditions by choosing compensating tubes of suitable sizes. Thus to protect the interior of a vast building such as a cathedral, where the normal changes of temperature are very gradual, extremely fine compensation tubes are incorporated; while, on the other hand, in case, for example, of installation in a bake-house or steam laundry where violent fluctuations of temperature are normal, tubes may be chosen of large enough bore to compensate more than one hundred times quicker than in the former case. Modified standard instruments the "functional elements" in which consist of upright tubes with visual mercurial columns (but without contacts) are used for testing the detector's rate of compensation, and others are adapted for measuring and recording the maximum normal rate of temperature-increase in any apartment or place that may be a matter of doubt.

Instruments according to the invention may be usefully applied where electrical thermometers are inadequate as in a system of lubrication of machinery. Thus an abnormal or dangerous rate of increase of temperature of an oil bath or oil-pump circuit may be indicated if an instrument be immersed in the lubricant; such rate of increase may often occur substantially earlier than the attainment of a dangerous degree of temperature, for the reason that a lubricating system may vary slowly through a wide range of degrees without implying danger in the condition of bearings for example.

The fire detector, it is claimed, is of eminent value as a circuit-closer for automatically opening sprinklers at the moment an alarm is sounded. As such it may be designed instantly to act upon a comparatively small localized store of water or other extinguishing liquid or inert gaseous fluid so as to incur small damage while putting out the fire at its small beginning.

I claim:

1. A combination comprising a vitreous container, a charge of mercury in said container, and a platinum capillary tube sealed into and piercing the wall of said container.

2. A combination comprising a vitreous container formed with compensation and overflow openings, a charge of mercury therein, and a platinum capillary tube sealed into one of said openings and protruding into said mercury.

3. A combination comprising a vitreous container formed with compensation and overflow passages, a charge of mercury therein, a platinum capillary tube sealed into said compensation passage, and second platinum capillary tube sealed into said overflow passage.

4. A combination comprising a vitreous container, a charge of mercury in said container, a compensation chamber, a charge of mercury in said chamber and a platinum capillary tube sealed into and piercing the walls of said container and chamber respectively and protruding into the said charges of mercury.

5. A combination comprising a container filled with mercury, a compensation chamber incompletely filled with mercury, and a platinum capillary tube of minute bore filled with mercury and piercing the walls of said container and chamber respectively and protruding into the mercury therein.

6. A combination comprising a vitreous body formed with two internal spaces and a passage therebetween all evacuated of air, a platinum capillary tube sealed in said passage with its ends abruptly terminating in said spaces, and a content of mercury completely filling one of said spaces and the bore of said tube and incompletely filling the other of said spaces.

7. A combination comprising a container of vitreous material and formed with compensation and overflow openings, a thermometric liquid therein, and a capillary tube of uniform minute bore piercing the walls of the container and protruding into their liquid contents, said tube being formed from a material which will capillarily attract the thermometric liquid and which will be chemically unaffected by said liquid and which has a coefficient of heat expansion

substantially equal to the material of the said walls.

8. A combination comprising a vitreous body formed with two internal spaces of circular cross-section coaxially disposed with a passage therebetween all evacuated of air, a platinum capillary tube of minute bore sealed in said passage and protruding into the said spaces, and a content of mercury completely filling one of said spaces and the bore of said tube and incompletely filling the other of said spaces.

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