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Shopsky

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[54] **A TEMPERATURE BULB WITH AN INNER LINER TO REDUCE MERCURY CORROSION**

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[52] **U.S. Cl.** .... **73/368,** 29/195 M, 431/66

[51] **Int. Cl.** **G01k 5/00,** G01k 1/08

[58] **Field of Search** .... 73/368.4, 371; 148/6.35; 29/195 M; 220/64

[56] **References Cited**

UNITED STATES PATENTS

1,811,190	6/1931	Tate	73/371
2,366,091	12/1944	Eskin	73/368.4
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2,858,244	10/1958	Long et al.	148/6.35 X
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[57] **ABSTRACT**

Mercury corrosion of the interior of closed metal vessels, such as bulbs of temperature responsive devices, which contain mercury at elevated temperatures and pressures is reduced by providing the vessels with an inner liner constructed of a mercury resistant material which forms a barrier between the mercury and the interior of the vessel. The vessel walls which are normally exposed to an oxidizing atmosphere at their outer surfaces are constructed of a heat resistant ferrous alloy containing chromium and/or nickel. The liner material is essentially free of chromium and/or nickel.

2 Claims, 2 Drawing Figures

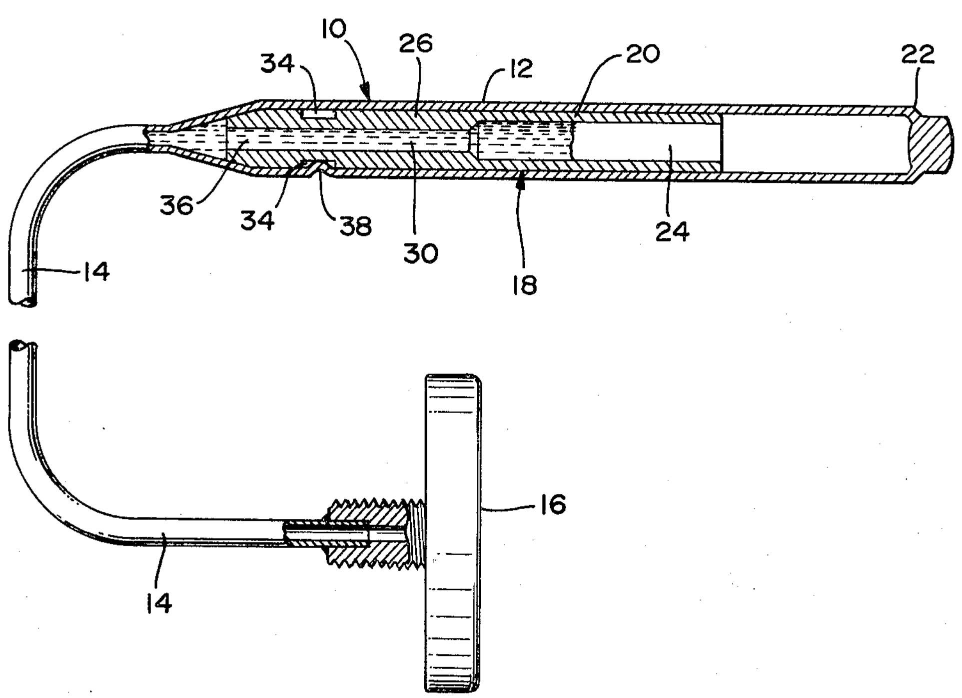
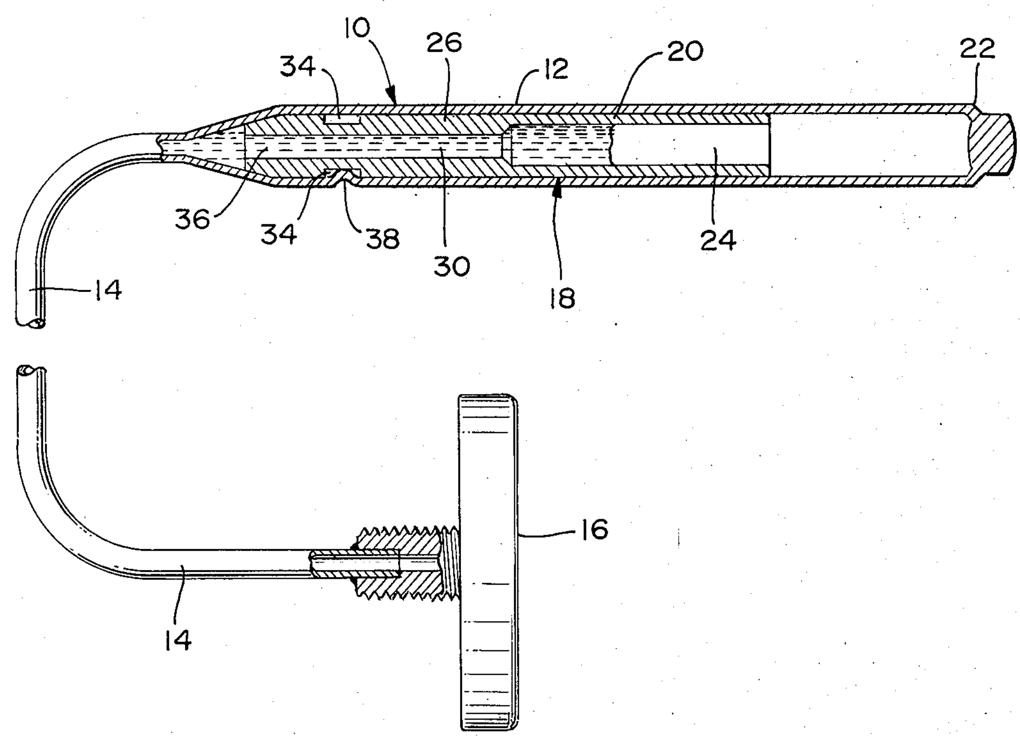


FIG. 1



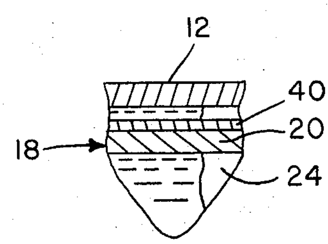


FIG. 2

A TEMPERATURE BULB WITH AN INNER LINER TO REDUCE MERCURY CORROSION

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to the reduction of mercury corrosion in closed metal vessels, such as bulbs of temperature responsive devices, containing mercury at high temperatures and high internal pressures.

Description of the Prior Art

Mercury is utilized in a number of high temperature-high pressure applications, such as in power generation apparatus and in temperature control devices. Mercury has a number of desirable physical properties including a low melting point, high volumetric expansion, vapor pressure, flow ability and stability at high temperatures. In addition, mercury is readily available, low cost and relatively easy to handle.

Unfortunately, however, mercury is difficult to contain in metal vessels at high temperatures and pressures due to its ability to dissolve most common metals. It has a particular affinity for nickel and chromium which are elements required for oxidation resistance in steel alloys at service temperatures between 1000° and 2000°F. The oxidation resistance and service temperature at which these alloys may be used is generally proportional to the amount of nickel or chromium in the alloy. On the other hand, it has been found that the solubility of these two elements, i.e. nickel and chromium, is an exponential function of the temperature of the mercury. In addition, it has been found that the rate of corrosion or solubility of chromium and nickel in mercury is proportional to the percentage of these elements in the steel alloy.

The utilization of mercury in various high temperature-high pressure applications is shown in prior art patents. For example, U.S. Pat. No. 2,366,091 is concerned with the use of special steel alloys to avoid mercury corrosion. U.S. Pat. No. 2,640,313 deals with a mercury filled sensing device.

The prior art patents also show a variety of thermometer designs having a number of layers which are constructed of different materials, primarily for the purpose of dealing with coefficients of expansion, U.S. Pat. No. 1,811,190 shows a thermostatic bulb which includes a capillary 3 composed of two tubular bodies, an inner layer 3*a* and an outer layer 3*b*. The inner layer is formed of a metal immune to attack by mercury and the outer layer is formed of a metal having a coefficient of expansion such that the tube as a whole is equal to glass. U.S. Pat. No. 1,970,715 shows a thermometer having a capillary tube 3 formed either by a composite alloy comprising an inner layer of Invar and an outer layer of copper or a single metal alloy having a coefficient of expansion similar to glass. U.S. Pat. No. 2,415,309 shows a thermometer in which the lower or metal portion 2 of the stem and the bulb 3 are made of a material with which mercury does not amalgamate. A jacket 5 is heat shrunk into intimate contact with the bulb. U.S. Pat. No. 2,487,686 discloses a thermosensitive bulb 5 formed by two metal layers 5A and 5B each having a different coefficient of expansion.

SUMMARY OF THE INVENTION

The present invention is embodied in an apparatus including a closed metal vessel, such as a bulb of a temperature responsive device, containing mercury wherein a liner of mercury resistant material is disposed within the interior of the vessel forming a barrier between the mercury and the interior of the vessel, whereby mercury corrosion is minimized at high temperatures and high internal pressures.

A primary object of the present invention is to reduce mercury corrosion of closed metal vessels at high temperatures and pressures.

A further object of the present invention is to increase the service and material life of closed metal vessels containing mercury at high temperatures and pressures.

A still further object of the present invention is to increase the permissible operating temperature of closed metal vessels containing mercury at high temperatures and pressures.

Other objects and advantages of the present invention will become apparent from the following description taken in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows a plan view in partial cross section of a temperature responsive device embodying a preferred embodiment of the present invention.

FIG. 2 is a detail cross section view of a broken away portion of a modified temperature responsive device.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As illustrated in FIG. 1, a temperature responsive device **10** of the type used in the detection of flame at a burner includes an evacuated and mercury containing temperature sensing bulb **12** connected in fluid communication with capillary tube **14** which in turn is connected in fluid communication to actuating element **16.** The capillary tube **14** and actuating element **16** are of conventional design and thus need not be discussed in further detail herein.

A liner **18** is disposed within the interior of bulb **12** and is generally designed to fit snuggly therein. The liner **18** has a thin-walled hollow cylindrical shell **20** at its outer end **22** defining an outer bore **24** and a thick walled hollow cylindrical shell **26** at its inner end **28** defining an inner bore **30** which is in axial alignment and fluid communication with outer bore **24.** The outer surface or periphery of shell **26** includes several grooves **34.** The interior of temperature responsive device **10** contains mercury **36.**

The bulb **12** should be constructed of a ferrous or steel alloy which is heat resistant and also oxidation resistant, since it will be exposed to a high temperature flame in an oxidizing atmosphere. Thus, the bulb **12** should be capable of operating satisfactorily at elevated temperatures in the range of about 1000° to 2000°F and at high internal pressures of the magnitude experienced when mercury is heated to these temperatures in a closed vessel. The ferrous or steel alloy for bulb **12** should contain a minor proportion of chromium, nickel and/or other elements, or combinations thereof, which increase the oxidation resistance of the alloy at high temperatures. Such alloys are well known in the art.

The liner 18, on the other hand, should be constructed of a ferrous or steel alloy which is heat resistant and also resistant to mercury corrosion, since it will be exposed to mercury at high temperatures and pressures. Thus, ferrous or steel alloys used for liner 18 should be essentially free of chromium, nickel or other elements, or combinations thereof, which are relatively soluble in hot mercury.

The temperature responsive device 10 may be simply constructed by inserting the liner 18 in the bulb 12 wherein it is secured in position by external stakes 38 driven into grooves 34 of liner 18. The outer end 22 of bulb 12 is then sealed as by fusion welding thereby making bulb 12 a closed end vessel.

In the operation of temperature responsive device 10 the interior of bulb 12 is in fluid communication with the interior chamber of actuating device 16 through capillary tube 14. The chamber of actuating device 16 is expandable and prior to being actuated is compressed by an external force which maintains a fixed volume until the internal pressure generated by the mercury vapor, relative to the temperature in the bulb 12, exceeds the pressure generated by the external force. At that point the volume increases which allows the liquid mercury to partially move out of the bulb 12 creating an interface between the liquid and vapor with the interface located in the large outer bore 24 of the liner 18. The interface will remain at this location for a given bulb temperature and external force. The liner 18, therefore, provides a barrier between the hot liquid mercury and the inside wall of bulb 12.

If the liner 18 is inserted into the bore of bulb 12 with a free or loose fit, there will be a thin film of mercury between the outer surface of liner 18 and the inner surface of bulb 12 as shown in FIG. 2. This film will also have an interface at about the same location as the interface in the interior of liner 18. Thus, there will be a thin film of hot liquid mercury in contact with the inner surface of bulb 12 which would tend to create an environment for mercury corrosion of the interior surface of bulb 12. However, it has been found that the liquid boundary layer at the inner wall of bulb 12 attains a saturation equilibrium of the solubles (e.g. chromium, nickel, etc.) in a relatively short time. A very important factor in the rate of attack is the rate of diffusion of the dissolved solubles from the solid-liquid interface into the bulb of the mercury 36. The present invention, however, substantially reduces the rate of diffusion of the solubles from the solid-liquid interface into the bulk of the mercury 36 and thereby reduces the corrosion rate.

In one embodiment of the present invention, shown in FIG. 2, the outer surface of liner 18 is cased with chromium, nickel or a combination thereof so that its exterior surface has a film 40 enriched with such element or elements. The casing step may be carried out by any of the casing processes of the prior art which are well known, such as are described, for example, in U.S. Pat. Nos. 2,874,070 and 3,127,283. In this embodiment of the invention the cased liner serves as a sacrificial element and a barrier.

The temperature responsive device 10 may also be constructed in a manner to reduce the clearance between the interior of bulb 12 and the exterior of liner 18, and thus minimize or eliminate the presence of a film of mercury therebetween. For example, the bulb 12 may be sized after the liner 18 is inserted therein.

Also, the liner 18 may be press fitted in the bulb 12. Further, the liner 18 may be designed in relation to the bulb 12 to have a higher coefficient of expansion when the outer end of bulb 12 is heated.

It has been found that the present invention reduces mercury corrosion to a minimum in an application such as temperature control of a gas or oil burner. This can be accomplished while using common steel materials for construction of the devices of the present invention. Also, the service and material life of the device is substantially increased. It has also been found that the present invention reduces the temperature gradient of the bulb 12 at the mercury interface which also results in reducing mercury corrosion.

In accordance with the present invention a temperature responsive device of the type shown in the drawing was constructed wherein the bulb was made of a straight chromium ferretic stainless steel AISI type 446 and the liner was made of a low carbon steel AISI type 1010. The device of the present invention containing a liner was then tested in comparison with a conventional temperature responsive device without a liner wherein the bulb was made of stainless steel AISI type 446. Mercury corrosion was determined by measuring the thinnest wall section by X-ray. The tests have shown to date that whereas the conventional device failed under test conditions after about 12 months, the device of the present invention exhibited very little corrosion after more than 18 months on test.

Inasmuch as the present invention is subject to many modifications, variations and changes in detail, it is intended that all matter contained in the foregoing description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A temperature responsive device capable of withstanding an elevated temperature in a range of about 1000° to 2000°F. comprising

an evacuated temperature sensing bulb for use in a temperature responsive means containing mercury,

said bulb being constructed of a ferrous alloy containing nickel, chromium, or a combination of nickel and chromium, which alloy is oxidation resistant at the elevated temperature,

a liner inserted within the interior of said bulb for forming a barrier between hot liquid mercury and an inside wall of said bulb, and

said liner being constructed of a ferrous alloy which is essentially free of nickel and chromium and is substantially insoluble in liquid mercury when heated to a temperature at which mercury forms vapor.

2. A temperature responsive device capable of withstanding an elevated temperature in a range of about 1000° to 2000°F. comprising

an evacuated temperature sensing bulb for use in a temperature responsive means containing mercury,

said bulb being constructed of a ferrous alloy containing chromium, which alloy is oxidation resistant at the elevated temperature,

a liner loosely fit within the interior of said bulb permitting a film of mercury between the outer surface of the liner and the inner surface of the bulb, said liner being made from a ferrous alloy which is essentially free of nickel and chromium and substantially insoluble in liquid mercury when heated to a temperature at which mercury forms vapor, and

said liner provided with a chromium rich film on its outer surface to provide chromium to saturate the film of mercury between the outer surface of the liner and the inner surface of the bulb.

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