

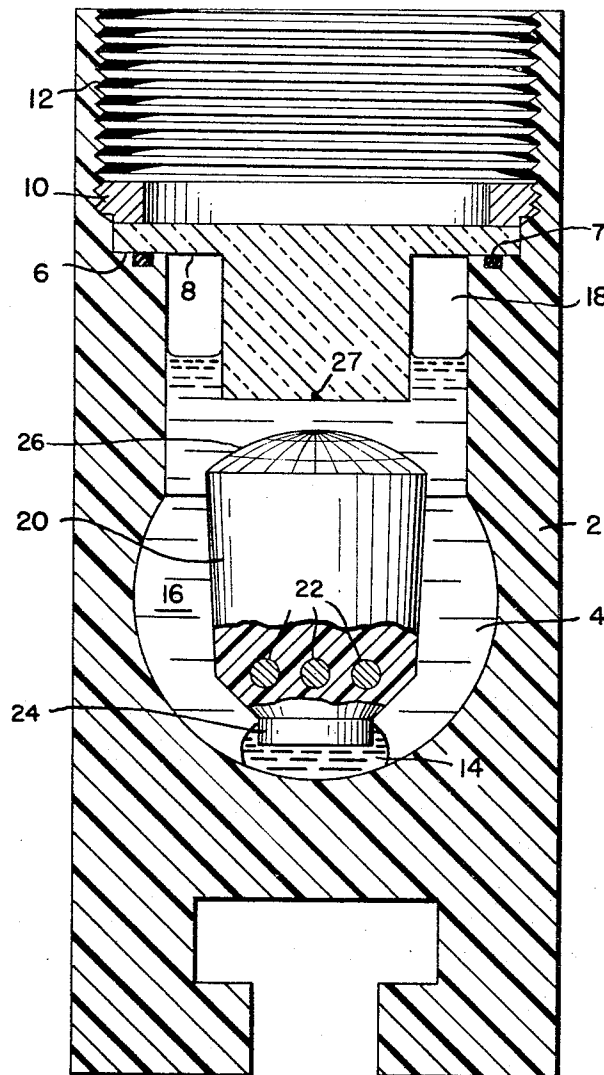
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C. E. HAWK

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ANTI-FRICTION MOUNTING

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INVENTOR  
CHARLES E. HAWK

BY

*Bussor, Smith & Hardy*  
ATTORNEYS

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## ANTI-FRICTION MOUNTING

Charles E. Hawk, Houston, Tex., assignor to Sperry-Sun Well Surveying Company, Sugar Land, Tex., a corporation of Delaware

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### ABSTRACT OF THE DISCLOSURE

An anti-friction mounting for indicating instruments and the like comprises a spherical chamber filled with a heavy liquid, and a bead of mercury resting on the spherical wall of the chamber. A float, having a disc formed from a material which is wettable by mercury is situated within the spherical chamber with the disc in contact with the mercury bead.

This invention relates to anti-friction mountings of the type particularly suited for use in conjunction with compasses, inclinometers and other instruments having movable indicators in which it is necessary that the movement be substantially free of static friction.

Various devices have been proposed which accomplish the object of avoiding static friction by providing a pool of mercury for the flotation of an indicating element. The high specific gravity of mercury permits the flotation of rather heavy elements, and centering of the floating element on the pool of mercury is accomplished by taking advantage of the surface characteristics of mercury. Slight traces of impurities in mercury and the presence of certain gases in contact with the mercury surface affect the surface characteristics of mercury and are particularly detrimental. These problems are more fully discussed in United States Patent 3,023,512 issued Mar. 6, 1962 which relates to a construction by which the deleterious effects of impurities to the mercury surface are reduced.

In many of these devices, however, problems in the nature of contamination arise from a continuous rubbing of the walls of the mercury chamber by the float particularly where the instrument is subjected to rough handling, for example, when it is used in conjunction with a well-surveying instrument. Minute quantities of material removed from the walls or from the float by rubbing are capable of destroying the desired surface characteristics of the mercury pool. A continuous abrasive action is capable of removing engraved markings from the float and occasionally causes shattering of the window at the top of the mercury chamber.

The abrasive action also causes the formation of smooth areas on the inner surface of the mercury chamber. Since mercury tends to stick to the smooth areas, the mercury pool is no longer symmetrical, and error results in the indication of the instrument.

A further problem occurs when the mercury pool is broken up by violent movement. Mercury beads with dirty skins will not rejoin the main mercury pool. These beads have an adverse effect on the accuracy of the instrument since they may cause the main pool to be displaced from a desired central position.

Another problem arises from the dissolution of metal such as silver, of which floats are commonly formed in part, in the mercury pool. Crystals of this dissolved metal are often redeposited unevenly on the float. As a consequence, the float becomes unbalanced causing further rubbing of the inner wall of the chamber. Redeposition of crystals is particularly detrimental where the part of the float which contacts the mercury surface is in the form of a large diameter ring since an uneven deposit can result in a relatively high unbalancing torque.

In accordance with this invention, a float chamber is provided which is almost entirely filled with a liquid having a high specific gravity. The lower part of the chamber is spherical, and a relatively small amount of mercury compared to the amount generally used in mercury flotation devices is provided within the chamber and displaces its volume of the heavy liquid. The float, with the indicator at its upper end, has a high center of buoyancy and a low center of gravity so that it tends to remain vertical when immersed in the heavy liquid. The weight of the float is such that it sinks in the heavy liquid. At the bottom of the float there is provided a disc formed of a material wettable by mercury. The float then sits lightly on the mercury bead, and if the chamber is tilted, the float follows the mercury bead about the spherical wall of the chamber. As a consequence, the axis of the float always passes through the center of the spherical part of the chamber.

An object of the invention is to provide a frictionless mounting utilizing mercury in which the effect of impurities in the mercury is not to interfere with the functioning of the mounting.

Another object is to eliminate contamination of the surface of the mercury used in accordance with the invention and to eliminate harmful abrasion between the float and the walls of the housing and other detrimental effects which might otherwise occur as a result of violent movement of the housing.

A third object of this invention is to eliminate the detrimental effects resulting from redeposition of metal dissolved in mercury in a device in which mercury is used to maintain a float in a central location.

Still another object is to insure that beads of mercury will not separate from the main bead except by violent motion, and to insure that individual beads so separated from the main bead will rejoin the main bead readily.

Other objects will become apparent from the following description when read in conjunction with the accompanying single drawing showing a vertical section of a combination compass and inclinometer of the type used in conjunction with a well-surveying apparatus and incorporating the preferred form of the present invention.

A cylindrical housing 2 adapted to form a part of a larger well-surveying instrument is provided with an internal cavity 4 partially in the form of a sphere and having a cylindrical portion extending toward an opening in the housing. At the upper end of the cylindrical portion of the cavity, there is provided an annular flange 6 in the inner wall of the housing provided with a groove in which rests an annular packing ring 7. A transparent window 8 is clamped against ring 7 by means of a ring 10 threaded to threads 12 at the upper end of the inner wall of the housing. The diameter of window 8 is such that it can be inserted through the upper opening of the housing without being interfered with by threads 12.

Threads 12 extend some distance above ring 10 and are provided for the mounting of a photographic recording apparatus which is provided to record the position of the float when the instrument is lowered into a well. A suitable recording apparatus might be, for example, of the type disclosed in United States Patent 2,616,187, issued Nov. 4, 1952.

At the bottom of the spherical portion of cavity 4, there is provided a small bead of mercury 14. It will be noted that the mercury does not wet the wall of the cavity, and the housing, or at least the wall of cavity 4, should be formed of a material which is not wettable by mercury. The size of the bead of mercury does not have to be so large as to support the float by itself, but its size is determined by the dimensions of the float, and it must be large enough so that the bottom of the float will follow it in its movement about the wall of the

cavity. It will be apparent that the size of the bead of mercury necessary to perform this function can be much less than the size of a bead sufficient to support a float without the aid of any additional support.

Additional support for the float is provided by a liquid 16 which fills cavity 4 almost completely, there being provided a space 18 below window 8 to accommodate expansion. Liquid 16 is desirably a relatively heavy liquid such as perfluorotributylamine, which has a specific gravity of approximately 1.88. The liquid should, of course, have a lower density than that of mercury and should neither react with nor be miscible with mercury. When the apparatus is used as an indicating compass or the like, the liquid should be transparent. The substance chosen for liquid 16 should have a specific gravity which is slightly lower than the effective specific gravity of the float, so that the float will be supported primarily by the liquid 16 and only partially by the mercury bead 14.

A float 20 is provided within the spherical part of cavity 4. Transversely through the float there extends a plurality of parallel magnets embedded in the material of which the float is formed. This material may be solid plastic of a type capable of withstanding high temperature. On the other hand the float might be hollow and formed of a metal such as aluminum or titanium. Fixed to the bottom of the float there is provided a cylindrical disc 24 which is formed of a material wettable by mercury such as silver or platinum. Platinum, being less soluble in mercury, is preferred. This disc sits very lightly on the surface of mercury bead 14, and, because its sides are wet by the mercury, it follows the mercury bead as it travels along the wall of the cavity under the action of gravity. Because the disc 24 is wettable by mercury, it tends to remain centered on the bead since this is the position in which the potential energy of the system involving the float and the bead is at a minimum. The bead, since it does not wet the inner wall of the housing, seeks its lowest position under the action of gravity so that when the housing is vertical, the center of the bead coincides with the axis of the housing.

At the top of the float, there is provided a spherical portion 26 having suitable markings to indicate both direction and inclination. There are also provided suitable markings or cross hairs 27 on the lower horizontal surface of window 8 so that the photographic apparatus mounted above the window records the relative relationship of the markings on the window and on portion 26. Direction and inclination can be determined simultaneously. The position of the float within the housing is desirably such that the spherical portion 26 is concentric with and of smaller diameter than spherical cavity so that portion 26 cannot come into contact with the wall of the cavity.

The magnets 22 are desirably mounted near the bottom of the float, so that their weight and the weight of the disc 22 combine to provide the float with a relatively low center of gravity. The body of the float has a relatively high center of buoyancy. Consequently, the float has a high degree of stability.

It is desirable to provide strong magnets in the float in order to give the float a large magnetic moment sufficiently strong to overcome any skin friction that might develop on the surface of the mercury bead.

It will be apparent that the bead of mercury acts as a very low friction bearing for the lower end of the float. For the mercury bead to remain effective as a bearing, the float must remain in contact with the mercury bead at all times. Hence, the float must be heavy enough so that it does not float on liquid 16 at any temperatures encountered in use.

The mercury bead does not have to be so large as the pool or mercury used in apparatuses in the prior art in which mercury alone served as the support for the float. The size of the mercury bead in the present invention has

only to be consistent with the size of disc 24. The size of disc 24 is limited, in turn, primarily by the necessity for the float to have a low center of gravity. Since bead 14 can be quite small in size, the amount of metal from disc 24 which is capable of going into solution in the mercury bead is limited by the size of the bead. Since the bead 14 can be quite small, very little metal will dissolve from disc 24. It follows that very little dissolved metal can be redeposited on the float to unbalance the float. Furthermore, since disc 24 is relatively small in diameter, even a very eccentric deposit of metal on it will result in only a very slight unbalancing torque. If disc 24 is formed of platinum, no problem at all will result from dissolution and crystallization.

Since the densities of the float and liquid differ only by a small amount, the liquid tends to damp the motion of the float, and only extremely violent accelerations are capable of bringing the float into contact with the walls of the cavity. The float is therefore unable to rub the walls of the cavity under normal conditions of use, and no particles either from the housing or from the float contaminate the mercury. Since no rubbing of the cavity wall will occur, no smooth areas form which deform the mercury bead.

Mercury in an air medium quickly acquires a coating of oxide which prevents individual beads from joining one another easily. The liquid medium, however, prevents the formation of the coating and any beads which separate from the main bead quickly rejoin it. In the liquid medium, violent shaking is required to produce separation of the mercury into smaller individual beads.

It will be apparent that the invention is not limited to well-surveying apparatuses, and that the description has been limited to the application of the invention to such an apparatus only because it represents a typical application of a combination of a compass and an inclinometer. The invention is equally applicable to compasses alone, and it is not necessary that the top of the float be spherical in shape. It will be apparent that the wall of the cavity is not necessarily spherical and that it only has to be concave inwardly over the part of the wall on which the bead of mercury rests in order that the bead may seek the lowest position under the action of gravity. In ordinary compasses for example, the function of the mercury bead is to center the float. In an inclinometer, on the other hand, it is desirable that the wall of the cavity be spherical so that the scale of the markings on the spherical top of the float can be linear. The invention can be applied to any movements such as galvanometer movements and the like where low static friction is desired. Accordingly, various modifications can be made to the invention without departing from its scope as defined in the following claims.

What is claimed is:

1. An anti-friction mounting comprising a chamber having a concave surface at the bottom of its interior, said concave surface being formed of a material not wettable by mercury, a bead of mercury within said chamber and resting on said concave surface, a liquid having a lower density than mercury within said chamber, and a float within said chamber having an element at its bottom formed of a material wettable by mercury, said element being smaller than said bead, the density of said float being greater than that of said liquid and less than that of mercury, said float having its center of buoyancy farther from its bottom than its center of gravity, and said element at the bottom of said float having sides in contact with said bead of mercury.

2. An anti-friction mounting comprising a chamber having a spherical surface at the bottom of its interior, said spherical surface being formed of a material not wettable by mercury, a bead of mercury within said chamber and resting on said spherical surface, a liquid having a lower density than mercury within said chamber, and a float within said chamber having an element at its bottom formed of a material wettable by mercury, said

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element being smaller than said bead, the density of said float being greater than that of said liquid and less than that of mercury, said float having its center of buoyancy farther from its bottom than its center of gravity, said element at the bottom of said float having sides in contact with said bead of mercury, and said float being completely immersed in said liquid.

3. An indicating instrument comprising a housing having an enclosed chamber in its interior, said chamber having a transparent window at one end, a wall of said chamber being concave inwardly and formed of a material not wettable by mercury, a bead of mercury resting on said wall, a transparent liquid within said chamber, a float within said chamber having a greater density than said liquid and immersed in said liquid, said float having at one end an element formed of a material wettable by mercury, said float also carrying indicating means visible through said transparent window, said element being smaller than said bead and having sides in contact with said bead, said float having a center of gravity between its center of buoyancy and said element, and means

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causing relative motion between said housing and said float in response to a change in a variable to be indicated.

4. An indicating instrument according to claim 3 in which said element wettable by mercury is a disc formed of a material selected from the group consisting of silver and platinum.

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20 LEONARD FORMAN, *Primary Examiner*.

L. ANDERSON, *Assistant Examiner*.