April 28, 1925. 1,536,035

J. TWARDOWSKY

DIAPHRAGM ACTUATED MECHANISM

Filed Aug. 13, 1923

Fig 2.

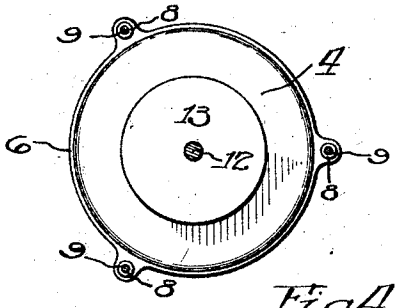


Fig 5.

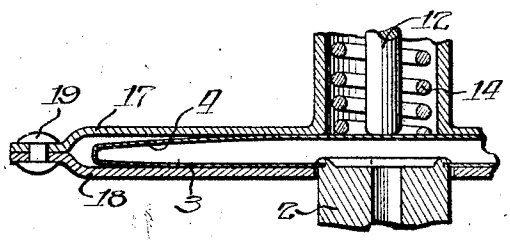


Fig 4.

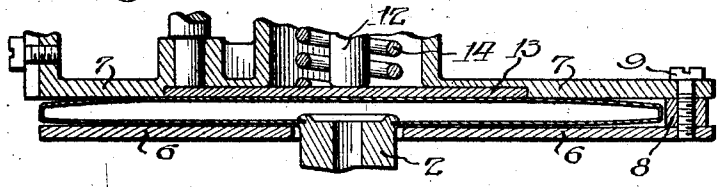
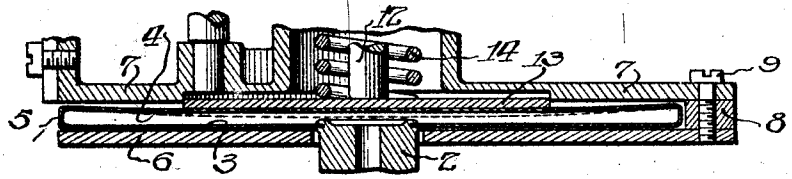


Fig 3.



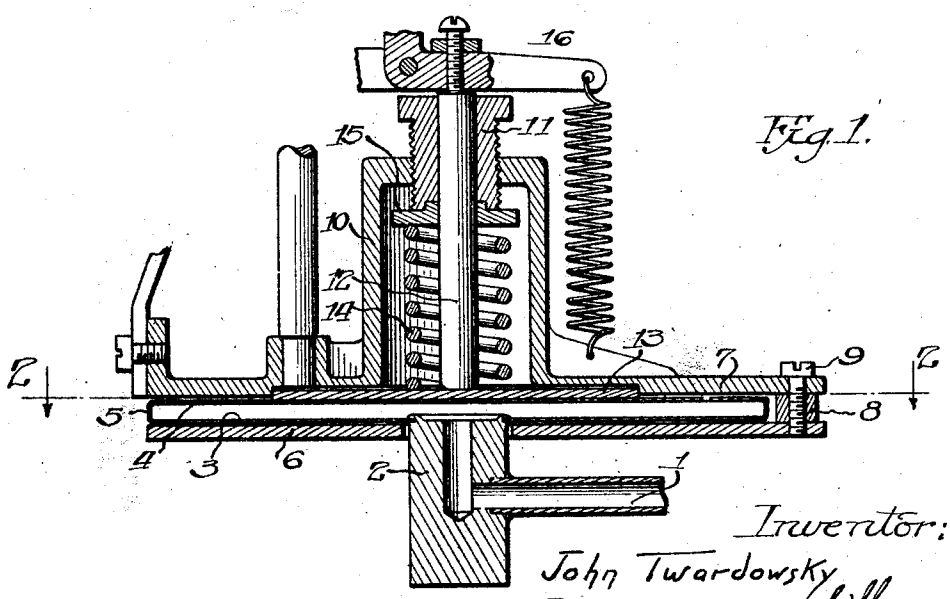


Fig 1.

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UNITED STATES PATENT OFFICE.

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DIAPHRAGM-ACTUATED MECHANISM.

Application filed August 13, 1923. Serial No. 657,268.

To all whom it may concern:

Be it known that I, JOHN TWARDOWSKY, citizen of Russia, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in a Diaphragm-Actuated Mechanism; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to diaphragm-actuated mechanisms and in its general objects aims to provide simple and effective means for limiting the flexing of a hollow diaphragm so as to prevent undue pressure variations from imparting a permanent set to the diaphragm. Furthermore, my invention provides pressure-transmitting means arranged for permitting the employment of a hollow diaphragm of relatively large diameter, thereby securing a high degree of sensitiveness in proportion to the available power. It also provides a simple mounting arranged for retaining the pressure-transmitting means in operative position and also arranged for limiting the flexing of both faces of a hollow and relatively short diaphragm without interfering with the responsiveness of the diaphragm to variations in pressure. Still further and also more detailed objects will appear from the following specification and from the accompanying drawings, in which

Fig. 1 is a central and vertical section through the actuating portion of a diaphragm-actuated switch of a kind suitable for controlling a supply of current to a mechanical refrigerator in response to the pressure in the expansion coil of the refrigerator.

Fig. 2 is a plan view of the same mechanism taken from below the upper guard member, or along the line 2—2 of Fig. 1.

Fig. 3 is a fragmentary vertical and central section through the diaphragm and the adjacent portions of the mechanism, showing these parts as they appear when the pressure within the diaphragm is considerably below the pressure of the outside air, or in other words when the diaphragm is contracted.

Fig. 4 is a section similar to Fig. 3 but showing the diaphragm as it appears when expanded by an internal pressure considerably increasing that of the outer air.

Fig. 5 is a section similar to a portion of Fig. 1 but showing another arrangement of the guards and showing the mechanism as employed without a pressure-transmitting disk.

In one of its immediate commercial applications, my invention is particularly suited for use in controlling the circuit of an electric motor employed as part of a mechanical refrigerator, so as to stop the operation of the motor automatically when the temperature within the refrigerating chamber falls to a certain point and so as to restart the motor whenever the temperature rises beyond this point. For this purpose, I have disclosed a suitable switch in my application #524,991, filed Dec. 27, 1921, on a thermally responsive electric switch. In this application, I am picturing and describing a switch responsive to pressure variations in a hollow diaphragm, this diaphragm having its interior connected to a tube disposed within the refrigerating chamber and containing a controlling fluid which vaporizes at a temperature approximating that which is to be maintained in the refrigerating chamber, so that the variations in the extent of the vaporizing of the fluid within the tube will produce corresponding pressure changes within the interior of the hollow diaphragm.

While mechanism for this purpose can readily be constructed after the manner shown in my said accompanying application so as to be fairly sensitive to temperature variations in the refrigerating chamber, the apparatus must also be able to withstand the much greater temperature differences and corresponding pressure differences in the diaphragm which occur when the refrigerator is not in use. Thus, while the variation in pressure differences within the hollow diaphragm may be relatively small during the normal operation of the refrigerator, these differences are greatly increased when the refrigerator is standing idle at the factory or in transit, as the resulting increase in temperature vaporizes an abnormal portion of the controlling fluid and hence creates an abnormally high pressure within the hollow diaphragm, thereby tending to flex the diaphragm to such an ex-

tent as to impart a permanent set to its walls.

My present invention aims to overcome this difficulty and also aims to provide simple means for limiting the flexing of the diaphragm to certain portions thereof, thereby permitting the effective use of diaphragms of such increased diameters as will afford the desired sensitiveness of action. For this purpose, I provide a mounting for the diaphragm which includes guard formations adapted to be engaged to an increased extent by the opposite faces of a relatively flat hollow diaphragm during the expansion of the valve, and I also employ a pressure-distributing member arranged for limiting the flexing of one face of the diaphragm to its radially outward portions. Furthermore, I provide a mounting which will readily hold the pressure-transmitting member in operative position, which will permit the spacing between the guard portions of the mounting to be varied if desired, and which will readily permit access to the diaphragm for an inspection of the latter or for any other purpose.

In employing such a mechanism for the general purpose described in my copending application, I connect one end of the control tube 1 which houses the controlling fluid through the bore of a cup 2 to the interior of a hollow diaphragm comprising a pair of approximately parallel disks 3 and 4 connected by an approximately cylindrical wall 5, the upper diaphragm face 4 being imperforate while the lower diaphragm face 3 has a perforation which houses the mouth portion of the cup 2 and is sealed to the latter.

This mouth portion of the cup 2 extends through a bore in a base plate 6 which normally bears at least along its radially inner portion against the bottom disk 3 of the diaphragm, while an upper guard 7 is disposed above the base plate 6 and spaced from the latter by hollow bushings 8, the guards 7 and 6 being rigidly secured to each other by screws 9 which extend respectively through the bores of the spacer bushings 8 and which clamp these bushings between the two plates.

The upper guard 7 desirably has integral with it an inverted cup portion 10 which is bored out and threaded at its upper end to receive an adjustable bushing 11. This bushing has a bore affording a guide for the plunger 12 employed for transmitting the variations in the flexing of the diaphragm, and a pressure-transmitting disk 13 is desirably interposed between the lower end of this plunger 12 and the upper wall 4 of the diaphragm. The hollow cup 10 also houses a compression spring 14 which bears at its lower end against the disk 13 and at its upper end against a washer 15 engaging the lower end of the bushing 11. The spring 14 cooperates with the pressure of the outer air in resisting the expansion of the diaphragm and can be adjusted as to the extent of this cooperation by screwing the bushing 11 further in or out, thereby permitting the effective outer pressure to be adjusted so nearly equal to the internal pressure within the diaphragm under operating conditions as to make the diaphragm quite sensitive in action. Then the resulting movement of the plunger 12 is transmitted through a lever 16 to any desired mechanism which is to be operated by the expansion or contraction of the diaphragm. To hold the pressure-distributing disk 13 central, the lower face of the upper guard 7 has a recess slidably housing this disk and desirably of a depth corresponding to the thickness of this disk.

With the parts thus arranged, it will be obvious that the disk 13 limits the flexing of the upper or imperforate wall of the diaphragm substantially to the portions of that wall which are outward of the disk. However, this disk does not interfere with the flexing of the said outward portions of the upper diaphragm wall 4, nor with the flexing of the lower diaphragm wall 3. In practice, a considerable reduction of pressure within the hollow diaphragm causes the combined effect of the outer air pressure and of the spring 14 to compress the diaphragm to the position shown in full lines in Fig. 3, or even that shown in dotted lines in the same figure, while a decided increase in the pressure within the diaphragm above the combined pressure effect of the external air and of the spring 14 will cause the diaphragm to expand to an approximately elliptical section somewhat after the manner shown in Fig. 4. When thus expanded, the lower wall 3 of the diaphragm engages the top of the lower guard plate 6 to an extent increasing radially outward of this wall as the pressure increases, and the same holds true as to the engaging of the upper guard 7 by the top diaphragm wall 4. By suitably spacing the two guards 6 and 7, which can readily be done by selecting bushings 8 of suitable height, I can limit the expansion of the diaphragm quite effectively, so as to avoid having the upper and lower diaphragm walls flexed to such an extent that they would not readily be flexed back when the applied pressure is discontinued.

By using spacer bushings 8 which bring the guards fairly close to the opposite faces of the diaphragm, I can readily limit the flexing of the diaphragm walls in this simple manner, while employing a diaphragm of such a diameter as to insure both the needed actuating thrust on the plunger 12 and the desired sensitiveness of action. Indeed, I have found in practice that by this arrangement I can readily employ a diameter of say 5 inches diameter with a $\frac{3}{16}$ inch height, and can make a diaphragm of this

size sufficiently sensitive to respond to such pressure changes within the control tube 1 as are due to fluctuations of a small fraction of one degree in the temperature within that tube.

While it will be evident that the apparatus as above described can readily be standardized, it will also be evident that by changing the height of the spacer bushings 8 I can vary the extent of the flexing, thereby adapting my arrangement to diaphragms made of different metals or different thicknesses of the same metal, and that I can further control the flexing by varying the size of the pressure-distributing disk 13. It will also be evident that the movement imparted to this disk can be transmitted in any desired manner and for any desired purpose, hence I do not wish to be limited to the employing of my apparatus in connection with an electric switch. Nor do I wish to be limited to the various details of construction and arrangement above described since these might obviously be modified in many ways without departing either from the spirit of my invention or from the appended claims. For example, the pressure transmitting disk might be omitted, as shown in Fig. 5, which figure pictures an arrangement in which the compression spring 14 and the plunger 12 both are in direct engagement with the upper wall 4 of the hollow diaphragm, and which also pictures the upper and lower guards 17 and 18 as spaced from each other by suitable offset portions integral with these guard plates and forming peripheral flanges which are secured to each other by rivets 19.

I claim as my invention:—

1. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm, of a support attached to one head; and a guard supported by the other head; the guard including a pair of guard plates respectively adapted to limit the convexing of the two heads of the diaphragm, and spacing means interposed between the guard plates and free of engagement with the diaphragm.

2. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm, of a support attached to one head; and a guard supported by the other head; the guard including a pair of guard plates respectively adapted to limit the convexing of the two heads of the diaphragm, and spacing means interposed between the guard plates and free of engagement with the diaphragm; and means interposed between the said other head and the guard plate adjacent thereto for holding the said other head out of engagement with the last named guard plate until a predetermined pressure has been reached within the diaphragm.

3. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm, of a support attached to one head, a pressure distributing disk engaging the other head, and a guard supported by the disk and including two rigidly spaced guard plates respectively adapted to engage the heads of the diaphragm so as to limit the convexing of the said heads to areas increasing radially of the heads as the pressure within the diaphragm is increased.

4. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm, of a support attached to one head; a pressure distributing disk engaging the other head, a spring supported by the disk, and a guard supported by the spring and including two rigidly spaced guard plates respectively adapted to engage the outwardly directed faces of the two heads.

5. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm, of a support attached to one head; a pressure distributing disk engaging the other head, a spring supported by the disk, and a guard supported by the spring and including two rigidly spaced guard plates respectively adapted to engage the outwardly directed faces of the two heads, the radially outer portions of the diaphragm being continuously free of engagement with the guard, the guard plate adjacent to the said other head being recessed to permit the pressure disk to hold the said plate away from the said other head when the pressure within the diaphragm is low.

6. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm, of a support attached to one head; a pressure distributing disk engaging the other head, a spring supported by the disk, and a guard supported by the spring and including two rigidly spaced guard plates respectively adapted to engage the outwardly directed faces of the two heads, the guard plate adjacent to the said other head being recessed to permit the pressure disk to hold the said plate away from the said other head when the pressure within the dia-

phragm is low; the pressure disk being forced toward the last named guard plate upon an increase in pressure within the diaphragm and being of such thickness as to present its head-engaging face in a common plane with the face of the last named guard plate facing the said other head, when the diaphragm is expanded by high pressure within the latter.

7. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm and having an inexpansible radially outer wall, of a guard freely spaced from the said outer diaphragm wall and including a pair of inflexible plates rigidly spaced from each other by a distance greater than the height of the said outer wall, the said plates being respectively opposite the two heads of the diaphragm and each adapted to engage the adjacent head to an extent increasing radially of the diaphragm from the axis thereof as the pressure within the diaphragm increases.

8. The combination with a hollow diaphragm of the general nature of a shallow box having relatively flat heads adapted to be convexed away from each other by fluid pressure within the diaphragm and having an inexpansible radially outer wall, of a guard freely spaced from the said outer diaphragm wall and including a pair of inflexible plates rigidly spaced from each other by a distance greater than the height of the said outer wall, the said plates being respectively opposite the two heads of the diaphragm and each adapted to engage the adjacent head to an extent increasing radially of the diaphragm from the axis thereof as the pressure within the diaphragm increases; and a pressure-distributing disk interposed between one of the guard plates and the head adjacent thereto and movable with the last named head and adapted to limit the flexing of the last named head to the radially inner portions thereof until the diaphragm has been expanded to a predetermined extent.

9. The combination with a hollow diaphragm consisting of a relatively short substantially cylindrical portion connecting a substantially flat imperforate disk with a substantially flat perforate disk, of means for connecting the bore of the perforate disk to a source of variable pressure, a guard upon which the perforate disk rests, a second guard parallel to the first named guard, both guards being of greater diameter than the diaphragm, and means for spacing the guards from each other by a distance slightly greater than the normal height of the diaphragm.

10. A diaphragm arrangement as per claim 9, in which the guard adjacent to the imperforate disk has a recess facing that disk and smaller in diameter than the latter, and a pressure-transmitting disk slidably housed by the recess.

11. A diaphragm arrangement as per claim 9, in which the guard adjacent to the imperforate disk has a recess facing that disk and smaller in diameter than the latter, and a pressure-transmitting disk slidably housed by the recess, and of a thickness substantially equal to the depth of the recess.

Signed at Chicago, Illinois, August 10th, 1923.

JOHN TWARDOWSKY.