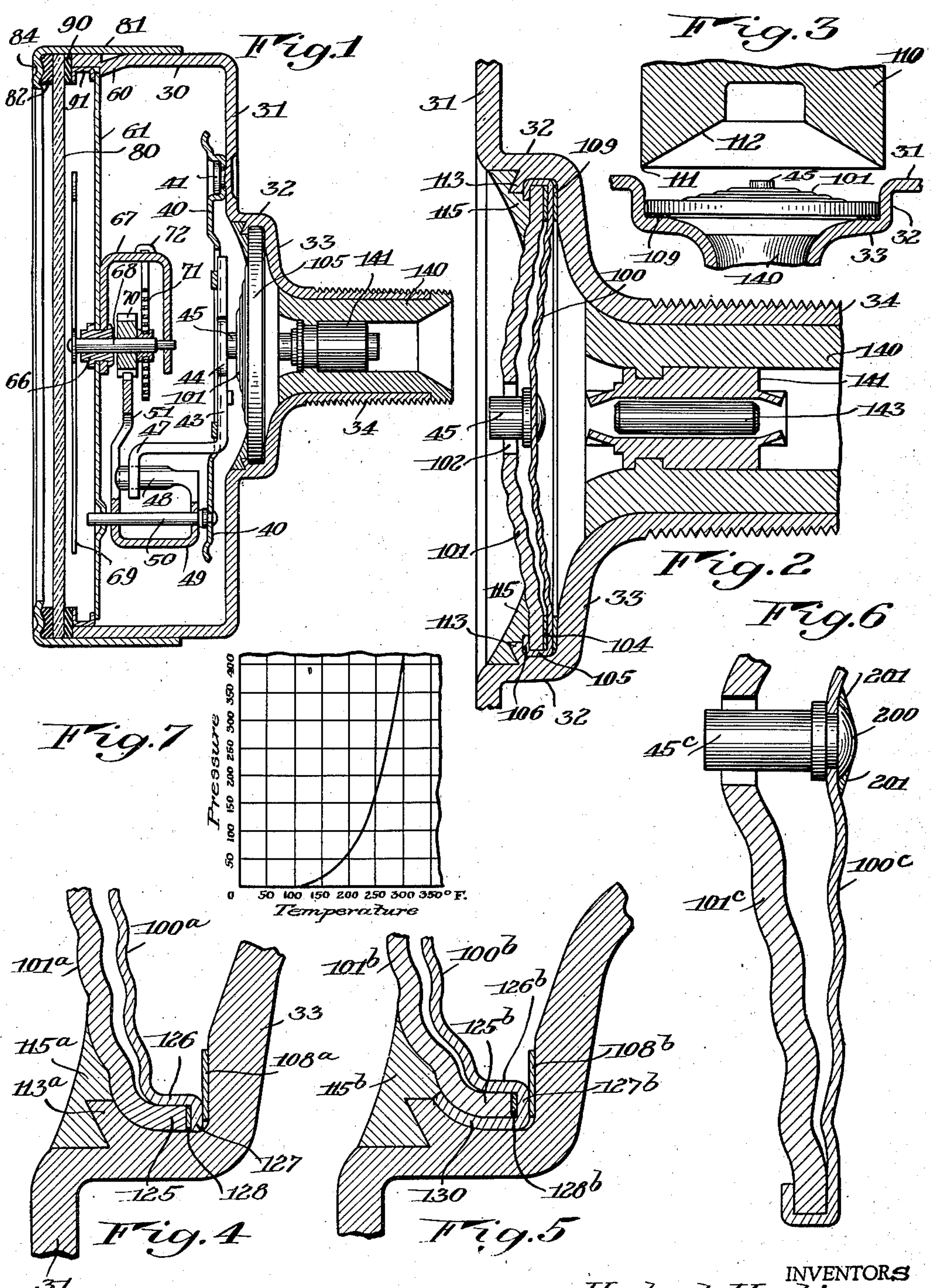
Nov. 12, 1940. H. HASTINGS ET AL 2,220,902

GAUGE DIAPHRAGM MOUNTING

Filed April 8, 1937



INVENTORS
Herbert Hastings
BY George E. Ford
Cumpston & Shepard
their ATTORNEYS

UNITED STATES PATENT OFFICE

2,220,902

GAUGE DIAPHRAGM MOUNTING

Herbert Hastings, Brighton, and George E. Ford, Rochester, N. Y., assignors to Rochester Manufacturing Co., Inc., Rochester, N. Y., a corporation of New York

Application April 8, 1937, Serial No. 135,758

2 Claims. (Cl. 137—157)

This invention deals with a gauge, and more particularly a pressure gauge, although some features of the invention are applicable also to gauges of other types.

An object of the invention is the provision of a generally improved and more satisfactory gauge, so designed and constructed that it may be made economically and quickly, of few parts, and will be sturdy and reliable in operation.

Another object is the provision of an improved diaphragm construction, and of improved means for holding the diaphragm in place.

Still another object is the provision of a diaphragm construction particularly useful in instruments for registering temperature in accordance with the vapor tension of a fluid whose vapor tension is not a straight-line function of the temperature to be measured.

A further object is the provision of a novel and improved method of constructing the diaphragm holding means.

To these and other ends the invention resides in certain improvements and combinations of parts, all as will be hereinafter more fully described, the novel feaatures being pointed out in the claims at the end of the specification.

In the drawing:

Fig. 1 is a section taken centrally through a gauge constructed in accordance with one embodiment of the invention;

Fig. 2 is a section through the rear end of the gauge shown in Fig. 1, on a larger scale, illustrating additional details;

Fig. 3 is a diagrammatic view illustrating the method of making the construction shown in Fig. 2;

Fig. 4 is a view similar to a fragment of Fig. 2, showing a modification of the diaphragm means;

Fig. 5 is a view similar to Fig. 4 showing another modification thereof;

Fig. 6 is a view of diaphragm means constructed in accordance with still another embodiment of the invention, particularly for use in vapor tension thermometers, and

Fig. 7 is a graph illustrating the vapor tension curve of a typical fluid for which the construction shown in Fig. 6 is designed.

The same reference numerals throughout the several views indicate the same parts.

This application is a continuation in part of our copending application for patent on Gauge construction, Serial No. 84,662, filed June 11, 1936, issued July 12, 1938 as Patent No. 2,123,532. Certain subject matter disclosed but not claimed in the present application is claimed in said application No. 84,662, or in our companion application for patent on Gauge damping construction, Serial No. 134,588, filed April 2, 1937, issued February 14, 1939 as Patent No. 2,147,031.

In one form of gauge herein disclosed as a preferred example of the present invention, the gauge includes a casing having a main cylindrical portion **30**, which contains the principal operating parts of the gauge. At the rear end of this portion **30** is an annular inwardly extending wall **31** connected to the forward edge of another cylindrical wall portion **32**, of smaller diameter and shallower than the portion **30**. The cylindrical wall portion **32** forms a pocket which receives the pressure responsive diaphragm means. At the rear edge of the portion **32** is an inwardly extending flange or wall **33** which merges into a stem portion **34** which may be threaded internally or externally, as desired, for connection to a conduit, tank, or other suitable article subject to the pressure to be indicated.

Within the main chamber formed by the cylindrical wall portion **30** is a mounting plate **40** held in place by suitable means such as studs **41** passing through the plate and integral with the rear wall **31** of the chamber. Struck up portions on the mounting plate **40** form journals or bearings for a shaft **43** which extends approximately diametrically with respect to the casing **30** and which is provided near its middle with a crank portion **44** which overlies a stud **45** mounted on the pressure responsive diaphragm, as described in greater detail below.

As the diaphragm moves in response to pressure variations, the stud **45** moves in a direction axially of the gauge and, by acting upon the crank portion **44**, turns the shaft **43**. A larger crank **47** at the lower end of the shaft **43** is thus moved in accordance with the movements of the diaphragm. The crank **47** lies against one side of and transmits its movements to an arm **48** formed as an extension of one arm of a generally U-shaped member **49** loosely pivoted on a bearing pin **50** secured to the mounting plate **40**. The other arm of the U-shaped member **49** is extended at **51** in a general direction toward the center of the casing **30**, and the extension is provided with an arcuate portion having gear teeth thereon concentric with the pivotal axis **50**. Thus as the stud **45** of the diaphragm is moved, the motion thereof will be transmitted to the gear segment, but the gear segment will have a greatly enlarged extent of motion relatively to that of the stud **45**, not only because of the enlarging effect due to the size of the crank arm

47 with relation to the size of the crank 44, but also because of the further enlarging effect due to the distance of the gear teeth on the arm 51 from the pivot 50, with respect to the distance of the arm 48 from the pivot 50.

At suitable spaced points around the circumference of the cylindrical casing portion 30 cuts are made in the wall 30 and portions of the wall are forced inwardly as indicated at 60, to form ledges or seats on which the dial plate 61 may rest. The dial plate is provided with a hole of the proper size and in the proper location to receive the end of the pin 50, so that when the dial plate is impaled upon the pin 50, as shown in Fig. 1, the dial plate is properly oriented with respect to the operating mechanism of the gauge. In the center of the dial plate is a bushing 66 in the form of a hollow rivet which extends through the plate and serves to connect the plate firmly to a U-shaped bracket 67 supported by the plate. The needle shaft 68 extends through the bushing or hollow rivet and is journaled therein near its forward end, the rear end being journaled in the bracket 67. The front end of the shaft 68 carries the needle or pointer 69 which sweeps over suitable scale graduations on the front face of the dial plate 61. A pinion 70 fixed to the shaft 68 behind the bushing 66 meshes with the gear teeth on the member 51, while behind the pinion 70 is a coiled hair spring 71 having one end secured to a hub or collar on the shaft 68, and having its other end secured at 72 to the bracket 67. This hair spring constantly tends, with a slight force, to rotate the needle in one direction, thus taking up backlash between the pinion 70 and the gear teeth on the member 51, and holding the crank 44 always against the stud 45.

In front of the dial plate 61 and the needle 69 is a transparent plate 80 of glass or other suitable material the periphery of which may rest upon the front edge of the casing portion 30. The glass may be held in place by a bezel having a cylindrical portion 81 fitting over and surrounding the casing portion 40 and forming a tight press fit therewith, if desired, the bezel also having an annular inwardly extending portion 84, which overlies a washer or gasket 82 and retains this gasket in place against the front face of the peripheral portion of the transparent plate 80. A second gasket 90 may be placed beneath the glass 80, and a sleeve or spacing ring 91 may be placed between the gasket 90 and the dial plate 61 to hold the dial plate firmly seated against the abutment 60.

The parts above described constitute an illustrative embodiment of a gauge body and means for operating the needle from the movements of the diaphragm, but such parts may be varied at will and do not, of themselves, constitute part of the present invention. The invention herein claimed relates to the construction and manner of mounting the diaphragm means, and one embodiment thereof will now be described with reference particularly to Fig. 2 of the drawing.

The diaphragm means in this first embodiment of the present invention comprises a pressure responsive diaphragm 100 of relatively thin metal, preferably corrugated concentrically to render it more flexible, and a relatively stiff and unyielding guard plate 101 of substantially thicker metal, preferably correspondingly corrugated so that if the diaphragm 100 be sufficiently displaced axially, as by subjecting it to heavy pressure, substantially the entire face of the diaphragm may come into contact with the guard plate 101 and be supported thereby against rupture. The operating stud 45 previously mentioned is secured to and projects forwardly from the front face of the diaphragm 100 at its center, and the guard plate 101 is provided with a central opening 102 through which the stud 45 extends.

A gasket 104 is placed between the diaphragm 100 and the guard plate 101 adjacent their peripheries. This gasket is preferably of a substantially incompressible material. One of the principal purposes of the gasket is to provide a sharp line of separation between the diaphragm and the guard plate, so that as the diaphragm of this embodiment of the invention moves back and forth under the influence of pressure variations, the effective diameter of that part of the diaphragm which is subject to movement will remain constant so long as the diaphragm is not subjected to such excessive pressures as will cause it to lie flat against the guard plate. In other words, in this embodiment of the invention, the diaphragm during its normal fluctuations or movements does not come into contact with any part of the guard plate, and has at all times a constant effective diameter subjected to the pressure to the right of the diaphragm. Only when excessive pressure is applied to the diaphragm does it contact with and become supported by the guard plate 101.

The peripheral edge of the diaphragm 100 may be, and preferably is, bent into cylindrical shape, to extend forwardly past the periphery of the guard plate 101, as indicated at 105, and is then bent radially inwardly as at 106, thus securely locking together the members 100 and 101 of the diaphragm assembly or diaphragm means. This diaphragm assembly is placed within the small cylindrical chamber formed by the cylindrical wall portion 32 of the casing and is seated against a gasket 109 which lies against the flange 33 and prevents the diaphragm assembly from moving in one direction, that is, in a direction axially backwards or toward the right when viewed as in Figs. 1 and 2. According to the present invention, novel and improved means is provided for holding the diaphragm assembly against movement in the opposite direction, that is, in a direction axially forwardly or toward the left when viewed as in Figs. 1 and 2. This improved holding means is formed by the method indicated diagrammatically in Fig. 3, to which reference is now made.

After the diaphragm assembly has been placed within the cylindrical wall portion 32, a tool 110 is alined concentrically with this cylindrical portion 32. The tool 110 has, around its entire periphery, a sharp annular cutting edge 111 of a diameter slightly greater than the external diameter of the diaphragm assembly, or the internal diameter of the cylindrical wall portion 32. This tool 110 may constitute part of a press. The tool is then forced downwardly from the position shown in Fig. 3, so that the sharp cutting edge 111 cuts into the metal of the wall 32 all the way around the periphery of the diaphragm assembly, and cuts, in effect, an annular slice from such metal, extending all the way around the periphery of the diaphragm assembly. The inclination of the lower surface 112 of the tool causes this annular slice of metal to be bent inwardly and downwardly upon or onto the periphery of the diaphragm assembly, as indicated at 113 in Fig. 2. The portion 113 remains attached to and forms an integral part of the metal of the wall portion 32, and constitutes an excellent abutment or pressure resisting means for holding the diaphragm assembly properly seated in the casing and preventing forward movement thereof under the influence of pressure on the rear side of the diaphragm. The operation of cutting down the side walls 32 and bending them inwardly over the edge of the diaphragm may be conveniently referred to as a "staking" operation.

Frequently the integral flange or deformed portion 113 provides a sufficient fluid tight seal around the periphery of the diaphragm assembly, but usually it is preferred to employ additional sealing means. This is conveniently in the form of a body 115 of solder, applied in a continuous annular body around the entire periphery of the diaphragm assembly, in a molten state, and usually to a sufficient extent to cover completely the flange 113 and extend a substantial distance axially outwardly along the wall 32 and radially inwardly along the guard plate 101, as readily apparent from Fig. 2. It is found that solder thus applied in a molten or substantially molten condition and then allowed to solidify forms an excellent seal at this point and prevents all possibility of fluid leakage past the diaphragm assembly. It is also to be noted that the solder contacts directly with the portion 106 of the diaphragm 100, and thus directly seals the joint between the diaphragm 100 and the casing, so that it does not leak whether or not there is a perfect fluid tight joint between the periphery of the diaphragm 100 and the periphery of the guard plate 101.

An alternative form of diaphragm assembly is indicated in Fig. 4, in which the diaphragm is shown at 100*a* and the guard plate at 101*a*. Instead of using a gasket 104 between the diaphragm and the guard plate in order to obtain constant working diameter of the diaphragm, the arrangement here employed is to extend the guard plate rearwardly at its periphery to form a cylindrical flange 125, the inner surface of which is substantially truly cylindrical for a material distance. The diaphragm 100*a* has a similar cylindrical flange 126 fitting within the flange 125 of the guard plate, and it may terminate in an annular radial flange 127 spaced from the rear edge of the flange 125 by an interposed gasket 128. The diaphragm 100*a* is so shaped that it curves away from and leaves the guard plate 101*a* at a point on the flange 125 where the flange is still truly cylindrical. Thus, notwithstanding flexing of the diaphragm, the effective diameter thereof does not vary, but always remains the same so long as the diaphragm is not subjected to such excessive pressures that it is actually made to lie against the guard plate.

A gasket 108*a* may be employed between the diaphragm flange 127 and the casing portion 33, and the whole diaphragm assembly may be fastened in place by a staking operation, which forms a flange 113*a* similar to the flange 113 above mentioned. A sealing body 115*a* may be employed, corresponding to the sealing body 115 of the previous embodiment.

In Fig. 5 of the drawing there is shown another embodiment similar in general to that indicated in Fig. 4. This embodiment includes a cylindrical flange 125*b* on the guard plate 101*b*, and the diaphragm 100*b* has a cylindrical flange 126*b* fitting within the flange 125*b*. As before, the separation between the diaphragm and the guard plate occurs at a point where the flange 125*b* is cylindrical, so that axial movements of the diaphragm do not result in changes in the effective working diameter thereof.

At 127*b* the diaphragm is extended radially outwardly past the rear edge of the guard plate flange 125*b*, and then at 130 the diaphragm is bent forwardly along the outer edge of the guard plate 101*b*, to a point where it will contact with the sealing body 115*b*. A gasket 128*b* may be interposed between the rear edge of the guard plate flange 125*b* and the diaphragm flange 127*b*. The advantage of this construction over that shown in Fig. 4 is that the sealing body 115*b* here contacts directly with the metal of the diaphragm itself, and seals the diaphragm to the casing, irrespective of any leakage which might occur between the diaphragm and the guard plate. In the construction shown in Fig. 4, however, the sealing means 115*a* does not come directly into contact with the diaphragm 100*a*, and if the construction were somewhat defective, leakage might occur around the edge of the diaphragm and into the space between the diaphragm and the guard plate, after which the fluid could easily escape into the gauge through the opening 102 in the guard plate.

Except for the differences above mentioned, the alternative constructions described in connection with Figs. 4 and 5 may be identical with the construction previously described in connection with Figs. 1 and 2.

In the constructions described with reference to Figs. 2, 4, and 5, provision has been made for maintaining the effective working diameter of the diaphragm constant during flexure of the diaphragm, except when excessive flexure causes the diaphragm to come into contact with the guard plate. This maintenance of constant working diameter is highly desirable in various types of measuring instruments, such as straight pressure gauges, where the scale on the dial plate 61 is graduated in terms of the pressure acting on the rear side of the diaphragm. In such cases, the extent of displacement of the center of the diaphragm is substantially a straight-line function of the pressure acting upon the diaphragm, so long as the effective working diameter of the diaphragm remains constant, and the graduations on the dial 61 can be spaced approximately evenly or uniformly.

For certain types of measuring instruments, however, the foregoing arrangement is not wholly satisfactory. For example, if the particular instrument in which the diaphragm assembly is employed is a vapor tension thermometer, the vapor tension or pressure behind the diaphragm may not be a straight-line function of the temperature of the fluid behind the diaphragm. Hence, a temperature increase of one degree at one point in the temperature range of the instrument would cause a different pressure increase acting on the diaphragm than would be caused by a similar temperature increase of one degree at another point in the range of the instrument. Unless provision is made for compensating for this difference, the scale on the dial plate 61 could not be graduated evenly or uniformly, but would necessarily be graduated in a non-uniform manner, with the graduations representing equal temperature differences farther apart at one part of the scale than at another part of the scale.

As an example, to illustrate this difficulty, there is shown in Fig. 7, somewhat schematically or diagrammatically, a part of a vapor pressure curve of a typical fluid frequently used in vapor tension thermometers, namely, dichlormethane or methylene chloride. The graph in Fig. 7 is graduated horizontally, along the bottom of the figure, in degrees Fahrenheit, and is graduated vertically along the left hand side of the figure, in pounds pressure per square inch. It will be seen that, especially in the portion of the curve below 250° F., the vapor tension or pressure is not a straight-line function of the temperature, and a temperature change from 125° to 150° would cause quite a different pressure change than a temperature change of the same amount, from 225° to 250°.

A diaphragm assembly particularly designed for use in situations of this kind is illustrated diagrammatically in Fig. 6. Here the diaphragm is shown at 100c and the backing plate at 101c. The backing plate is so shaped that it curves gradually farther and farther away from the diaphragm in a direction from the periphery toward the center, as will best be understood from a study of Fig. 6. In other words, the backing plate is corrugated to correspond to the corrugations of the diaphragm, as shown, but the general shape of the backing plate, along a radial section, is curved in the same general direction as the curvature of a pseudosphere rather than being straight or conical as in the case of the backing plates of Figs. 2, 4, and 5. A radial line drawn through the tops of the successive corrugations on one side of the backing plate will be a curved line, curving farther and farther away from the diaphragm from the periphery toward the center, in this form of construction shown in Fig. 6, instead of an approximately straight line as in the previous embodiments. The gasket 104 is omitted with this construction, and the diaphragm and the backing plate are preferably in direct contact with each other near their peripheries.

With this construction, as will be readily apparent by careful study of Fig. 6, pressure acting on the back of the diaphragm and displacing it rightwardly when viewed as in Fig. 6 will gradually decrease the effective working diameter of the diaphragm as the extent of displacement increases. In other words, as the diaphragm flexes, a greater and greater extent of its periphery or margin comes into contact with and lies flat against the backing plate, and the part of the diaphragm thus lying against the backing plate is no longer an effective working part thereof, so that the effective working diameter of the diaphragm decreases until finally, in the extreme position under high pressure, substantially the whole diaphragm lies against the face of the backing plate.

This arrangement of diaphragm assembly permits the scale on the dial plate 61 to be graduated approximately evenly or uniformly, notwithstanding the fact that the units of measure used on the scale (such as degrees of temperature) are not a straight-line function of the pressure acting upon and displacing the diaphragm. In other words, when the pressure acting upon the diaphragm is relatively low, an increase of a certain amount in that pressure moves or displaces the center of the diaphragm to a certain extent, the diaphragm then being of relatively large effective diameter. When the pressure acting on the diaphragm is higher, however, the diaphragm has a smaller effective working diameter, and then the same increase in the pressure acting upon the diaphragm would cause a lesser displacement of the center of the diaphragm, thus compensating for the fact that at higher pressures a given increase in pressure should not cause as great a movement of the temperature indicating needle as the same increase in pressure should cause at a lower part of the scale.

The diaphragm 100c, like all of the previous diaphragms, may carry a centrally located stud 45c for operating upon the crank 44 of the operating shaft 43, and this stud, as in the case of the studs on the preceding diaphragms, may be secured and sealed to the diaphragm by forming a rivet head 200 on the end of the stud which passes through the diaphragm, and by sealing around the edges of the rivet head by means of a sealing body 201 of solder or the like.

To eliminate or reduce unnecessary fluctuations in the diaphragm, the gauge may be provided with pulsation damping means, including, for example, a sleeve 140 sealed within the stem portion 34 of the diaphragm, another sleeve 141 sealed within the sleeve 140, and a plunger or plug 143 movable longitudinally through the sleeve 141 through a limited range of movement, the plunger 143 being of slightly smaller diameter than the opening through the sleeve 141 in which it is located, so that there is a small annular space surrounding the pin 143 through which the pressure variations to the right of the damping device may reach the diaphragm to the left of the damping device. This damping device is not claimed per se in the present application, but is claimed in one of the copending applications previously mentioned.

While certain embodiments of the invention have been disclosed, it is to be understood that the inventive idea may be carried out in a number of ways. This application is therefore not to be limited to the precise details described, but is intended to cover all variations and modifications thereof falling within the spirit of the invention or the scope of the appended claims.

We claim:

1. A pressure gauge of the type including a casing wall having a substantially cylindrical section of substantial length and extending approximately radially outwardly at one end of said cylindrical section and approximately radially inwardly at the opposite end of said cylindrical section, and a diaphragm assembly within and extending across said cylindrical section and seated against said inwardly extending part of said wall, said cylindrical section of said wall being of materially greater axial length than the axial thickness of said diaphragm assembly at its peripheral edge adjacent said wall, characterized by the fact that a portion only of the thickness of said cylindrical wall section between said diaphragm assembly and said outwardly extending part of said wall is partially cut from the remainder of the thickness thereof around substantially the entire periphery of said diaphragm assembly and deformed inwardly and downwardly into overlying relation to the periphery of said diaphragm assembly to hold said assembly seated against said inwardly extending part of said wall.

2. The combination of a casing including walls forming a hollow cylindrical portion of substantial axial length, said walls extending approximately radially inwardly for a distance at one end of said cylindrical portion and approximately radially outwardly for a distance at the opposite end of said cylindrical portion, a sheet metal guard plate having an opening through the guard

plate adjacent the center thereof and having a series of annular corrugations between said opening and the periphery of the plate, a flexible sheet metal diaphragm lying adjacent said guard plate and having a projection alined with said opening in said guard plate and also having a series of annular corrugations substantially mating in complementary fashion with those of said guard plate when said diaphragm is displaced to its maximum extent so as to lie substantially against said guard plate, said diaphragm and said guard plate together lying in said cylindrical portion of said casing and being seated approximately aganist said inwardly extending walls, and a flange formed integrally from a part only of the thickness of said cylindrical wall portion and bent inwardly and downwardly into overlying relation to said diaphragm and guard plate to hold the marginal edges of said diaphragm and guard plate against displacement in a direction away from said inwardly extending radial walls.

HERBERT HASTINGS.
GEORGE E. FORD.