June 17, 1947. J. C. OSBORN 2,422,365

COMPENSATED POWER ELEMENT

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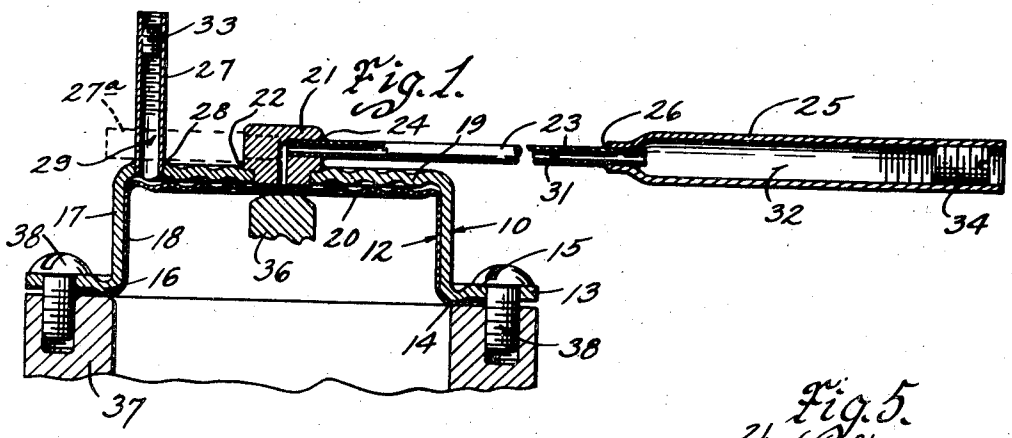


Fig. 1.

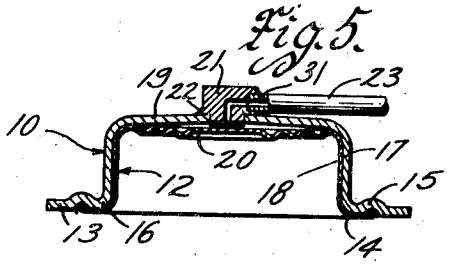


Fig. 5.

Fig. 2.

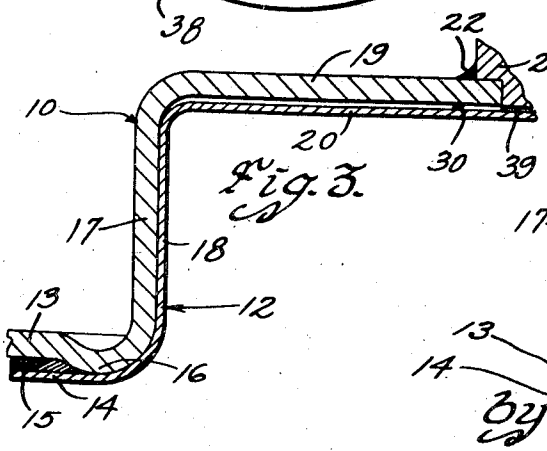


Fig. 3.

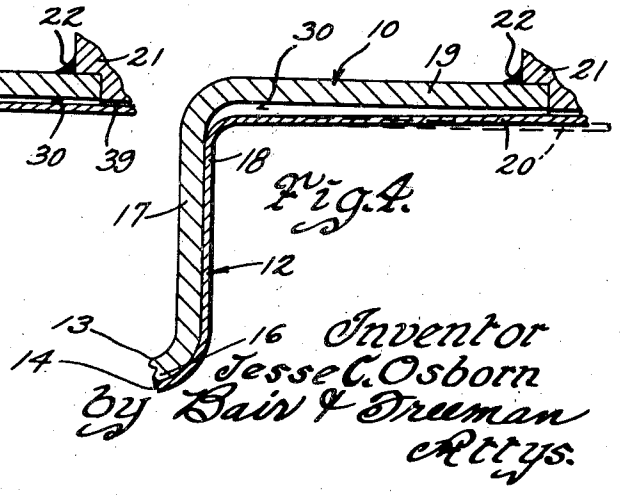


Fig. 4.

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COMPENSATED POWER ELEMENT

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3 Claims. (Cl. 297—9)

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My present invention relates to the transmission of energy resulting from the heating and consequent expansion of a liquid, thereby creating hydraulic pressure, and to the transformation of the created pressure into mechanical movement for control purposes and the like.

The main object of the invention is to provide a power element in the form of a compensated diaphragm structure which can be assembled with the assurance that it will operate properly to secure practically one hundred percent compensation at any predetermined temperature, regardless of variations in manufacture.

Another object is to provide a diaphragm of cup shape for compensating purposes, such as shown, in general, in the Fillo Patent No. 2,331,464 the present application being directed to an improved type of structure wherein the desired compensation can be secured without having to have the inner and outer cups spaced to a very accurate degree.

Still another object is to provide a cup-shaped power diaphragm arrangement wherein an inner cup and an outer cup are formed of materials having different coefficients of expansion to secure the desired compensating effect and the flexing wall of the inner cup is spaced from the adjacent wall of the outer cup a distance predetermined by the stamping operation which forms the cups, the space volume being predetermined to secure exact, under, or over-compensation, independent of the compensation inherent in a power element having cups formed of material having different coefficients of expansion.

Another object is to provide a fitting for connecting the capillary tube to the outer cup, which fitting prevents "sealing off" the diaphragm space from the capillary tube.

A further object is to make provision for a shoulder to prevent the solder (which seals the inner cup relative to the outer cup) passing, while molten, to an undesirable point in the pressure chamber between the inner and outer cups.

Still another object of the invention is to provide means for varying the amount of liquid contained in the effective diaphragm chamber so that perfect compensation may be secured.

With these and other objects in view, my invention consists in the construction, arrangement and combination of the various parts of my device whereby the objects contemplated are attained, as hereinafter more fully set forth, pointed out in my claims and illustrated in the accompanying drawings, wherein:

Figure 1 is a sectional view through a compensated power element embodying my invention;

Figure 2 is a plan view of the same showing a modified variable chamber arrangement;

Figure 3 is an enlarged sectional view to show the relation of the parts more clearly than in

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Figure 1, the parts being cold and the cups being plain instead of corrugated;

Figure 4 is a similar view showing the parts in various positions, as when heated; and

Figure 5 is a sectional view similar to Figure 1 showing a plain outer cup and a corrugated inner cup or actuating diaphragm.

On the accompanying drawing I have used the reference numeral 10 to indicate, in general, an outer cup, and 12 an inner cup. The cups 10 and 12 have flanges 13 and 14, respectively, which are sealed relative to each other, as by solder 15. The outer cup 10 is provided with a shoulder 16 to space the flange 13 from the flange 14 and thereby provide a soldering space for the solder 15. At the same time, the shoulder 16 provides a barrier against the solder 15 going further than the shoulder 16 so that it does not flow to a position between the cylindrical walls 17 and 18 of the outer and inner cups. This is important, because during the operation of the power element, as will hereinafter appear, the cylindrical walls 17 and 18 move or slide relative to each other.

The outer and inner cups 10 and 12 also have adjacent walls 19 and 20 respectively, the wall 19 being rigid, and the wall 20 constituting a flexible operating diaphragm. The walls 19 and 20 may be corrugated, if desired, as shown in Figure 1, or plain, as shown in Figures 3 and 4, or either one may be corrugated, with the other one plain, whichever is more suitable to manufacture to obtain the results desired.

A fitting 21 is secured and sealed relative to the wall 19 of the outer cup 10 as by soldering it thereto, as indicated at 22. The fitting 21 provides communication between a pressure chamber 30 formed within the outer cup between the walls 19 and 20 and a capillary tube 23. The fitting 21 is cross-grooved at 39 so that no "seal off" is possible. I am here referring to the conditions of filling the power element with a "solid charge," such as mercury or the like, it being possible for the two cups to be sealed so tightly together that the liquid will be prevented from entering the space between the two cups if the groove 39 were not provided. The capillary tube 23 is soldered to the fitting 21 at 24, and terminates in a bulb 25. It is soldered to the bulb at 26.

My invention further includes a tube 27 which may be soldered, as at 28, to the outer cup 10 so that it forms a chamber communicating with the pressure chamber 30 in the outer cup and adjacent to all of the parts, especially those forming chamber 30, so that its content is always subjected to the same ambient temperature as the content of chamber 30. The tube 27 is relatively thin so as to quickly respond to ambient temperature. The space within the tube 27, indicated at 29, forms a vari-

able chamber communicating with a liquid system, including the pressure chamber 30 between the walls 19 and 20, a capillary tube chamber 31 within the capillary tube 23, and a bulb chamber 32 within the bulb 25. This liquid system is filled with a "solid charge" or liquid, such as mercury or any other suitable solid or liquid, suitable for the temperatures under which the compensated power element is to operate. The ends of the system are closed by plugs 33 and 34 screwed or soldered into the tube 27 and the bulb 32 respectively.

An alternative arrangement may be provided wherein the tube 27 is connected with the fitting 21, as indicated by dotted lines 27^a in Figure 1. Another arrangement is shown in Figure 2 wherein a capillary tube 27^b takes the place of the tube 27. The tube 27^b may initially extend to the dotted position indicated at 27^c, and be pinched off and sealed by solder at 35 when it is finally determined just how much liquid should be present in the variable chamber formed within the tube 27^b for compensating purposes, as will hereinafter appear.

In operation, an increase of temperature at the bulb 25 will expand the liquid fill (omitted from the drawing, as it would be confusing), thereby causing it to depress the diaphragm 20, as to the dotted position shown in Figure 4. An increase of temperature surrounding the tube 23 also causes the liquid therein to expand, and this increases the movement of the diaphragm 20. Similarly, the liquid in the power element expands upon increase of heat, and, in order to compensate for this expansion of the liquid in the chambers 30 and 31, the inner cup 12 is made of a material having a lower coefficient of expansion than the material of the outer cup 10. For instance, the outer cup 10 may be formed of any suitable material, such as brass or the like, having a relatively high coefficient of expansion, and the inner cup may be made of a material having a very low coefficient of expansion, such as "Nilvar." The downward flexing of the diaphragm 20 causes it to engage an actuating pin 36 connected with a valve, switch or the like, mounted in a housing 37 to which the power element may be secured by screws 38.

As the temperature ambient to the power element increases, the greater expansion of the outer cup will increase the pressure chamber volume, as shown by solid lines in Figure 4, so that the expanding liquid in the capillary tube chamber 31 will be compensated for by entering this enlarged pressure chamber. When, however, the temperature rises adjacent the bulb 25, the expansion of the liquid fill therein will flex the diaphragm 20 as to the dotted position of Figure 4, for moving the actuating pin 36.

This movement will, accordingly, be in proportion to the temperature at the bulb 25, providing, of course, the cups 10 and 12 have been made of proper depth, and the chamber 30 is of the proper size. All of these factors may be predetermined, and the desired results secured. However, there are variations in manufacture which upset such calculations, and this is particularly true because the cups 10 and 12 are formed in a press. Therefore, the size of the chamber 30 may vary a few thousandths one way or the other.

The variable chamber 29 is then utilized for changing the effective size of the pressure chamber 30 after assembly of the parts, since chamber 29 is, in effect, a part of or a unit with chamber 30 and an increase or decrease in the size of

chamber 29 is a corresponding increase or decrease in the effective size of chamber 30. By screwing the plug 33 upwardly and the plug 34 inwardly, the effective pressure chamber 30 is increased so that temperature ambient to the power element has more liquid to work upon, thereby decreasing the compensating effect. By adjustment in the opposite direction the compensating effect can be increased. This is due to compensation being for the purpose of offsetting the effect of the expansion and contraction of the liquid in chamber 30, due to changes in temperature. Therefore, increasing the volume of chamber 30, which subjects more liquid to these ambient temperature changes (that in the chamber 29), decreases the compensating effect of the expansion between the two cups; and, conversely, decreasing the size of this chamber and the amount of liquid contained therein, increases the compensating effect of the expansion between the two cups.

With the arrangement shown in Figure 2 the capillary tube 27 is made long enough to take care of one extreme, and may then be reduced in length when it is found, after assembly, that the effective liquid fill for the pressure chamber 30 should be reduced. In this case an ordinary bulb can be used on the capillary tube 23 without requiring the adjustable plug 34. The tube 27^b can be pinched off at any desired point and then soldered, as at 35, and the pinched-off part, together with its liquid fill, discarded.

With my arrangement all variations in manufacturing tolerances may be taken care of after assembly by varying the volume in the chamber 29, and any degree of compensation (exact, over or under), within reasonable limits, can be secured. Also, compensation can be had for the length and the material used for forming the capillary tube 23, as well as for different depths of power element, providing, thereby, different proportional changes in the size of the pressure chamber 30 in relation to temperature rise or drop.

In general, it may be said that my power element constitutes a bulb, connecting tube and space between a housing and diaphragm charged or filled with a liquid sensitive to changes in the temperature, expanding with increased temperature and contracting with decreased temperature. When heat is applied to the bulb, the liquid expands, creating a hydraulic pressure action on the diaphragm, forcing it downwardly. This movement is in unison with the contraction and expansion of the liquid, and a definite relation exists between the amount of heat applied and the amount of movement of the diaphragm. The bulb may be located a considerable distance from the power element, as in an oven or refrigerator, and the power element located in a different range of temperature, such as room temperature or one intermediate room temperature and oven temperature, as when the power element is located in a gas range. It is the effect of the bulb temperature only that I wish to transmit to the diaphragm, irrespective of any variation of the temperature in which the power element is located. However, the liquid in the power element is sensitive to changes in temperature, in the same manner as that contained in the bulb, and a change of temperature ambient to the power element will cause the diaphragm 20 to move, even though the bulb temperature remains constant.

The construction of the power element is such

that the metal of the inner and outer cups have different coefficients of expansion, thereby securing a desired compensating characteristic. To vary this characteristic, the cups would have to be made of different depths and/or of different thicknesses of materials, and, possibly, the materials themselves would have to vary to secure a range of power elements practical for manufacture, to cover the many different conditions in the field. Accordingly, although the cup arrangement and different materials of the cups are used to secure some measure of compensation, I vary other elements of the system to secure compensation at different temperatures encountered, and thus make a single power element adaptable for many different uses. In other words, I do the proportioning for different results by changing the capacity of the cavity in the power element, thus controlling the amount of liquid therein and consequently the amount responsive to temperature ambient to the power element. I have found it possible to determine this capacity with considerable accuracy, so that, in many instances, it is not necessary to use the additional chamber 27. However, due to methods of manufacture and assembly, variations may occur, affecting the volume of this cavity, and an additional chamber 27 is a means for correcting and controlling the operating characteristics of the power element by changing the effective volume of the space in the power element.

For this purpose, of course, the tube 27 and the liquid in it are subject to the ambient temperature, the same as the liquid in the power element. The cubicle contents of the tube 27 may be changed without changing the distance between the diaphragm 20 and the bottom 19 of the outer cup or housing, thus retaining the capacity of the space between them.

For the practical application of this principle, both the tube 27 and the bulb 25 are shown provided with screw plugs, the movement of which, in unison, provides for the transmission of the liquid from the tube back to the bulb, or vice versa. It will therefore be seen that it is possible to move this liquid from one place to the other without disturbing the position of the diaphragm in its relation to the housing, and without changing the capacity of the liquid space in the power element. Consequently, I am able, with the means provided, to have complete control over the amount of liquid necessary to provide the proper compensation after the entire unit has been completely assembled and charged with liquid.

As an example of the application of my invention, one group of power elements has a normal use which subjects them to variations in temperature of plus or minus 70 degrees from the normal temperature. The highest, in this case, would be 140 degrees and the lowest, zero. In this application, should the ambient temperature variations reach only 20 or 30 degrees above or below room temperature, the compensating effect can be predetermined to be practically one hundred percent throughout the entire range. In other instances, there may be great changes from any given temperature so that compensation throughout the entire range will not be one hundred percent, but may fall even to sixty or seventy percent. It is obvious, therefore, that if we know beforehand the total approximate range of ambient temperature variations, and if we choose the mid-point of these extremes, then, by making the power element one hundred percent compensated for this mid-point, we shall reduce the error to a minimum.

As a second instance, when the power element is used in connection with a domestic gas oven valve it is subjected to variations in temperature as high as from approximately 60 degrees to 300 degrees. If, when assembled, we make this power element perfectly compensated at room temperature or 70 degrees, it is evident that all but ten percent of the total ambient temperature variation is on the high side. Therefore, the error at the extreme of 300 degrees would be magnified. However, in this case, by means of my invention I am able to choose the mid-point between 60 degrees and 300 degrees, namely, 180 degrees, and make my power element perfectly compensated at its temperature. It is then evident that the extreme error from 180 degrees to 300 degrees in one direction, or from 180 degrees down to 60 degrees in the other direction, will be much less than if the power element were compensated for 70 degrees, and all the error was on one side.

In a third example, variation from the ambient temperature may be all on one side, for instance, in the application of a control on an airplane which flies in the stratosphere. In such event, the extreme variation above 70 degrees might reasonably be only 50 degrees, while the extreme variation at low temperature may be much greater, going well below zero. In such cases, I can, by my invention, choose to make the power element perfectly compensated at a temperature half-way between the two extremes, or considerably below room temperature.

These may be examples of what problems may be encountered, and how they can be taken care of to secure a minimum of variation from a perfectly compensated mean.

By actual experiment I have demonstrated repeatedly that predetermining the amount of liquid in the compensated power element will secure almost one hundred percent compensation throughout rather wide ranges of temperature without the necessity of using the tube 27. For instance, in connection with a gas stove valve I simply make the power element over-compensated a predetermined number of degrees, at 70, or room temperature, which is the normal temperature under which the power elements are assembled. In the case of the airplane application, I likewise make the power element under-compensated a predetermined number of degrees at room temperature. Where the variations throughout the operating range are greater than desired, an additional adjustment is had with the use of the tube 27 to change the effective volume in the operating space of the power element.

Some changes may be made in the construction and arrangement of the parts of my device without departing from the real spirit and purpose of my invention, and it is my intention to cover by my claims any modified forms of structure or use of mechanical equivalents which may be reasonably included within their scope without sacrificing any of the advantages thereof.

I claim as my invention:

1. In a compensated power element, outer and inner cups of material having respectively high and low coefficients of expansion, a capillary tube system connected with the chamber between said outer and inner cups, a variable chamber adjacent to and connected with said first chamber, a liquid fill in said power element, said capillary tube system and said variable chamber being thin for ready response of the liquid therein to

ambient temperature, and means for varying after assembly the amount of liquid in said variable chamber while maintaining the same amount in said first chamber to thereby vary the total volume of the liquid receiving space subject to the heat ambient to said power element.

2. In a compensated power element, outer and inner cups, a capillary tube, a bulb and a variable chamber communicating with the pressure chamber located between said outer and inner cups, a liquid fill in said tube, bulb, variable chamber and pressure chamber, said outer cup being of material having a higher coefficient of expansion than the material of said inner cup, the cup shape of said power element effecting a compensation action for temperature ambient to said power element by changes in temperature ambient thereto expanding one of said cups more than the other cup and thereby changing the volume of said pressure chamber, the liquid in said variable chamber being as quickly responsive to temperature ambient to said power element as the power element itself, said variable chamber having a volume that may be decreased and said bulb having a volume that may be increased, or vice-versa, for modifying the compensating action by changing the effective volume of liquid fill space for said power element without changing the volume in said pressure chamber.

3. In a power element, outer and inner cups, the outer one having a high coefficient of expansion and the inner one having a low coefficient of expansion, a capillary tube connected with the pressure chamber formed between said outer and inner cups, a bulb for the terminal end of said capillary tube, and means for compensating the entire assembly of said power element, said capillary tube and said bulb for ambient temperature comprising a variable chamber adjacent said power element, said variable chamber having a wall of no greater thickness than the thickness of the wall of said power element whereby it is as quickly responsive to ambient temperature as said power element, a liquid fill which fills all the interior space in said pressure chamber, said variable chamber, said capillary tube and said bulb, means for adjusting said variable chamber without changing the volume of said pressure chamber, and means for sealing said variable chamber against variation in volume after it has been varied to effect compensation.

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