March 14, 1939. P. KOLLSMAN 2,150,771

SELF COMPENSATING ANEROID

Filed Dec. 17, 1934 3 Sheets-Sheet 1

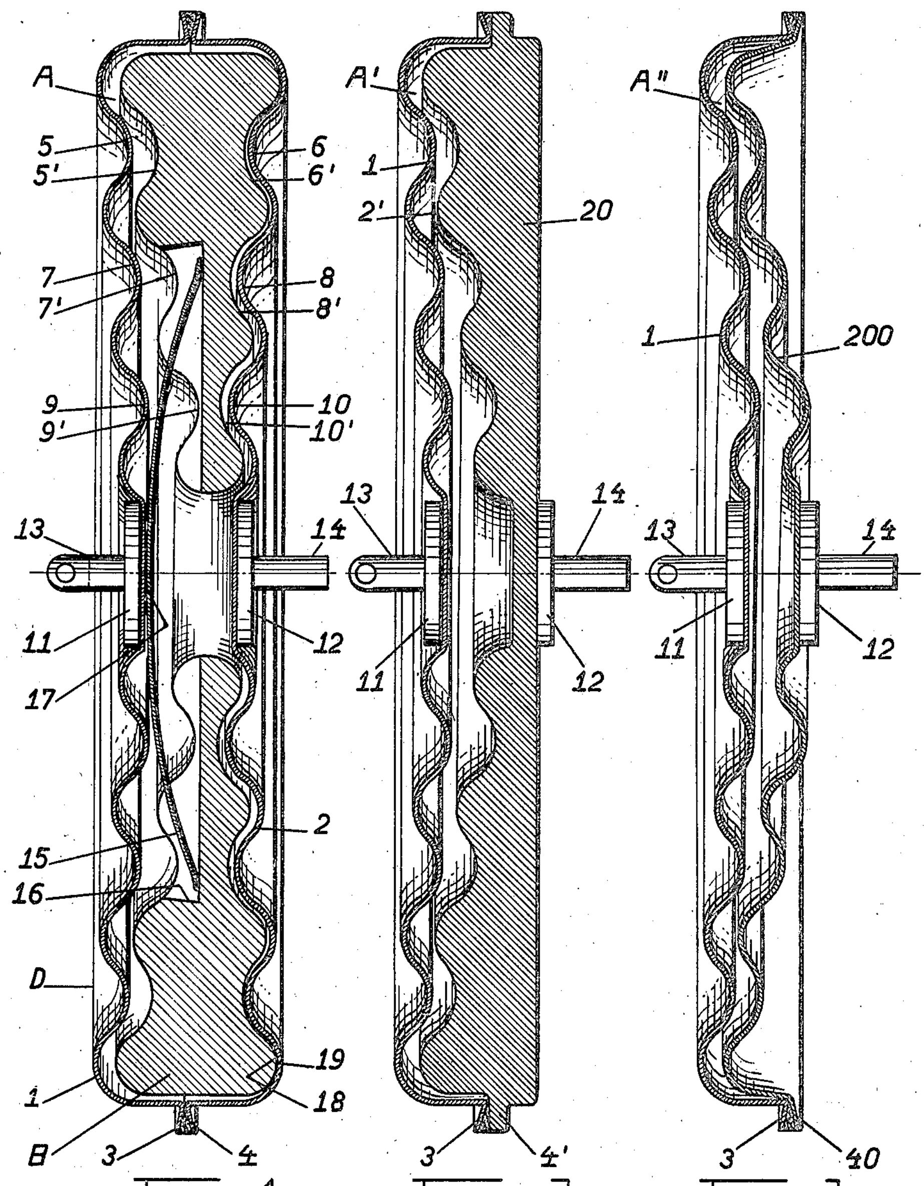

Fig. 1 Fig. 2 Fig. 3

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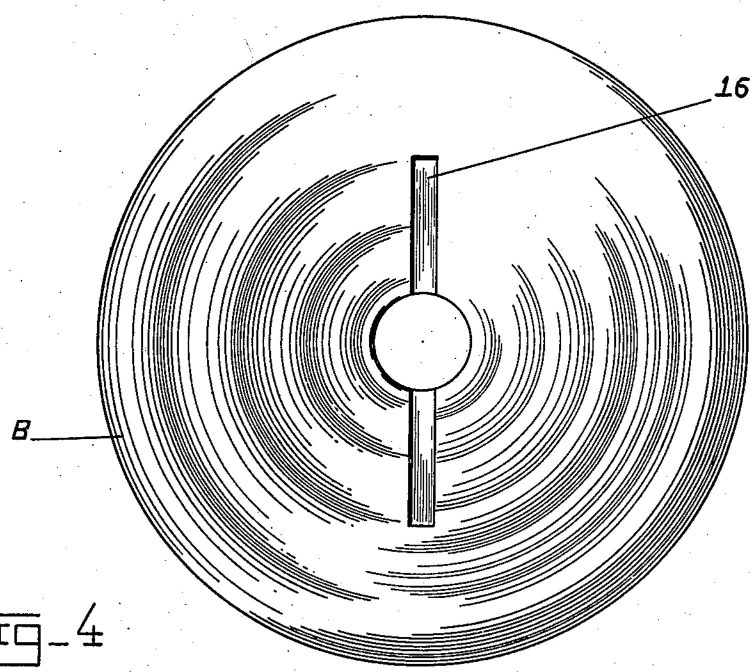

Fig_4

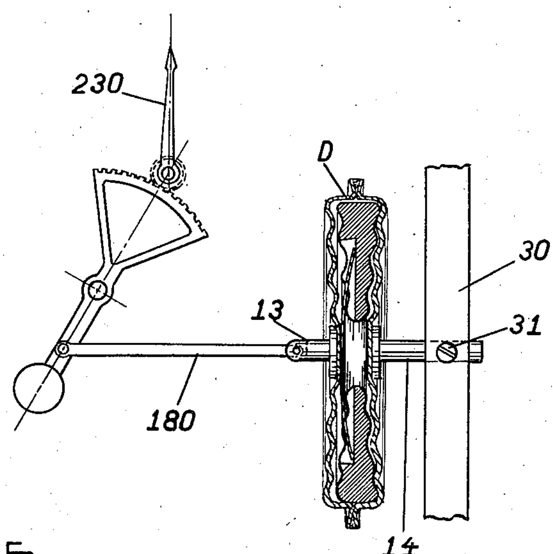

Fig_5

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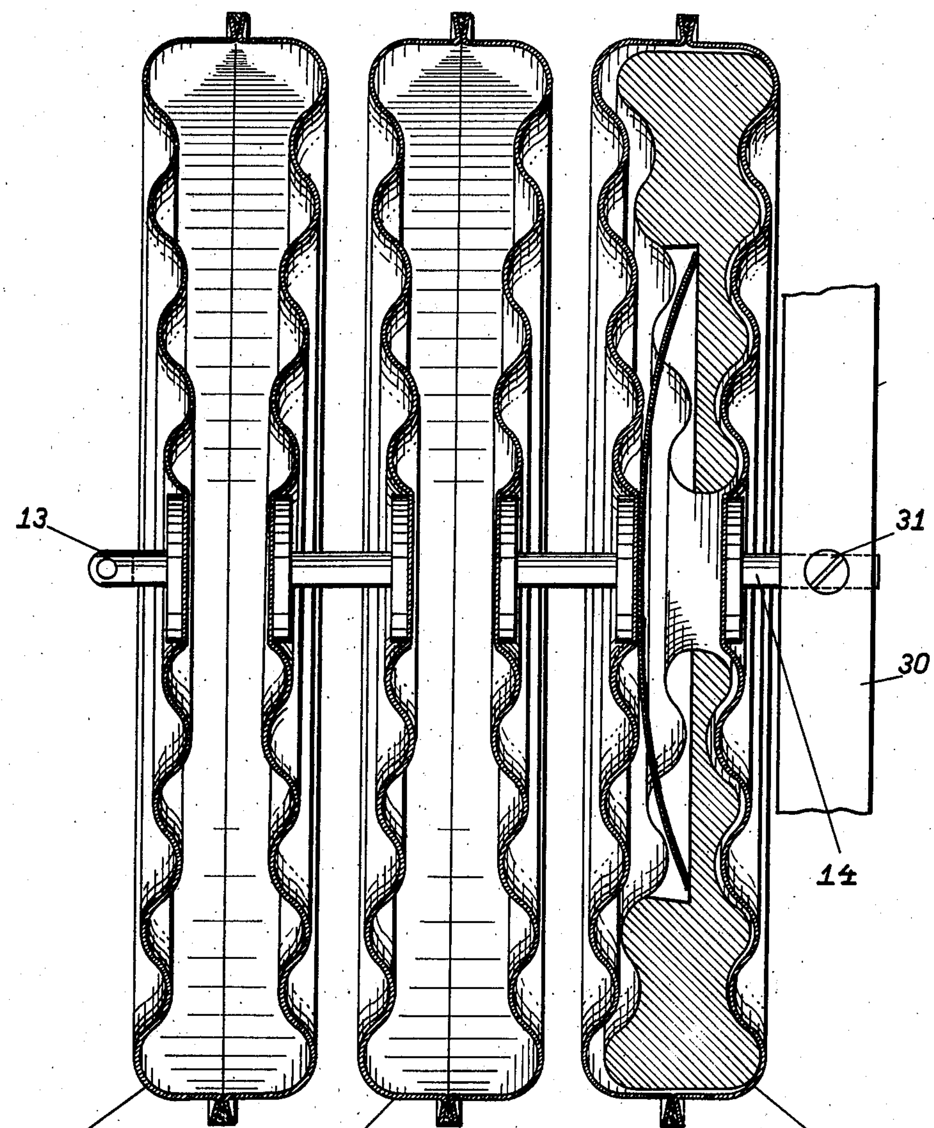

Fig. 6

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SELF-COMPENSATING ANEROID

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Application December 17, 1934, Serial No. 757,789

17 Claims. (Cl. 137—157)

This invention relates to aneroid capsules of the type to be employed to operate an indicating device accurately in response to variations in external pressure. An object is to render such capsules self-compensating against temperature variations. The capsule is particularly well adapted for altimeters and may be made substantially without calibration in quantity production with accurate compensation for temperature changes when functioning over a pressure range for atmospheric pressure varying from sea-level to an elevation of upwards of 30,000 feet.

Aneroid capsules of a preferred type and of the general type to the modification of which this invention is directed are described in my prior Patent No. 1,930,899 for Aneroid and operating means therefor, granted October 17, 1933. This patent generally describes the application to indicating mechanism of aneroid capsules and also sets forth various temperature compensating means, all external to the aneroid capsule.

Heretofore it has been considered infeasible and perhaps even disastrous to the accurate functioning of an aneroid capsule to permit any substantial gas content in its chamber. I have discovered that internal gas properly proportioned in volume to the size, configuration and strength of the capsule diaphragm or diaphragms is one of the best means for compensating against temperature changes. The design of the circular diaphragms of an aneroid capsule must conform to the necessity for faithful response to variations in external pressure. One of the best designs for such an aneroid capsule involves the provision of concentric corrugations or ring-like undulations for the circular diaphragm as described in my above mentioned prior patent. However, the chamber naturally formed in such an aneroid capsule does not have a gas space the volume of which accords with the proper functioning of a filling of gas at low pressure which is capable of functioning to compensate for temperature variations. Wherefore, an important object of my invention is to produce an aneroid capsule preserving all the elements of design necessary for faithful response to variations in external pressure and, at the same time, providing the predetermined volume for gas space in its chamber.

In carrying out the objects of my invention, I have found it expedient to complement the inside contour of the corrugations of the pressure responsive diaphragm on a member lying opposite thereto. In the capsule described in my prior patent a disc shaped metal filler, preferably of aluminum and having on its opposite faces the said complementary corrugations, is satisfactory.

If the capsule is to comprise but a single movable diaphragm, an opposing rigid wall may be provided with complementary corrugations. Possibly, for some purposes, the capsule may comprise one circular corrugated diaphragm substantially of the type described in my aforementioned patent and have the chamber completed by another circular diaphragm having complementary circular corrugations instead of identical or symmetrical corrugations described in my said patent.

My invention is particularly pointed out in the following claims, which are directed to illustrative embodiments of my invention for purposes of illustration only. These embodiments are described in the following specification in connection with the accompanying drawings, which form a part hereof.

In the drawings, Fig. 1 is an axial cross-section drawn to an enlarged scale of a preferred embodiment;

Fig. 2 is a similar view of a modification;

Fig. 3 is a similar view of a third modification;

Fig. 4 is a front view of the embodiment shown in Fig. 1;

Fig. 5 is a diagrammatic illustration of an application to an indicator of my improved aneroid capsule; and

Fig. 6 is a combination of several aneroid capsules, two of which are completely evacuated and are of the general type set forth in my aforementioned Patent No. 1,930,899, and one of which has the gas volume of its chamber regulated for temperature compensation for the combination.

Referring particularly to Figs. 1 and 4, the aneroid capsule D comprises two similar circular diaphragms 1 and 2 soldered together at their peripheral flanges 3 and 4 and having concentric corrugations 5, 6; 7, 8; 9, 10 and so forth. Bosses 11 and 12 may be soldered centrally and externally to the diaphragms and may terminate in connecting shafts 13 and 14. Boss structure 11, 13 is the movable operator and 12, 14 the fixable mount.

In this embodiment the two circular diaphragms employed are identical and when secured together are symmetrical about the central axis and about the central cross-section. Within the capsule is the chamber A.

In order to compensate against temperature changes, I have found that the chamber A is not of the proper volume for any gas suitable for this purpose. For gas such as nitrogen or air, I have found that the gas volume for chamber A should be limited to approximately 0.4 of the entire volume of this chamber at about 30,000 feet altitude. I position within the chamber a filler disc B which may preferably be symmetrical about the central axis and its central cross-section and has provisions on its opposite faces in the form of corrugations 5′, 6′; 7′, 8′; 9′, 10′ etc. complementary to the inside faces of the outer corrugations 5, 6; 7, 8; 9 and 10 etc. This filler may be formed of any suitable solid material such as aluminum, nickel, or it may even be in the form of a rigid metallic shell.

In the form shown in Figs. 1, 5 and 6, leaf spring 15 may be provided reacting between the notch 16 and the inner wall 17 normally to force the ring-like enlargement or corrugation 18 against the inner face of the corrugation 19 to prevent chattering or relative motion between the filler B and the capsule D when the device is subjected to vibration, as in an airplane. This is a provision fixing the filler B against inertia jerks. The spring 15 may also be employed to cooperate with the resilience of the circular diaphragms in opposing atmospheric pressure although this is not necessary.

In the embodiment of Fig. 2 the chamber A′ is formed between the inner face of one circular diaphragm 1 and the complementary corrugated inner face 2′ and the rigid disc-shaped metal closure 20. The flange 3 may be soldered to the flange 4′. In this embodiment the inner projection of the concentric corrugated face 2′ towards the circular diaphragm is regulated so as to make the gas volume and, in this case, the volume itself of chamber A′ that which is desired for temperature compensation from gas at low pressure.

In Fig. 3 rigid closure 20 is substituted by a resilient circular diaphragm 200 corrugated in a complementary manner to the corrugating of the circular diaphragm 1. The flanges 3 and 40 may be soldered together and it may be noted that the diaphragm 200 is reentrant to form, as in the modification of Fig. 2, a gas chamber A″ of a volume predetermined to provide proper temperature compensation.

Fig. 5 shows the shaft 14 of my capsule D adjustably secured to an instrument frame 30 by a set screw 31, the shaft 13 being connected by link 180 through suitable gear mechanism with an indicator 230 in a manner similar to that set forth in my aforementioned patent, although this showing is intended to be merely illustrative of any employment of my new capsule in a pressure indicating instrument.

In all of the embodiments of the invention illustrated herein the circular diaphragm having concentric corrugations of shapes and relative sizes designed to accord best for faithful response to variations in external pressure when said capsule is completely evacuated and functions at constant temperature finds its embodiment in the diaphragm 1 of Figs. 1, 2, 3, 4, 5 and 6. Structure for completing a closure opposite said circular diaphragm 1 and for limiting the volume of the completed chamber has inside circular corrugated provisions, complementary to the inside contour of said corrugations of said circular diaphragm is the diaphragm 2 of Fig. 1 and the filler B held against post 14 by spring 15. This filler B has corrugations 5′ complementary to the inside corrugations of circular diaphragm 1 forming therebetween a gas space predeterminable in volume regardless of the concentric corrugations. In the structure of Figs. 2 and 3 the manner in which the wall structure for completing a closure opposite the circular diaphragm is fixed against inertia jerks is by connecting all parts thereof having substantial inertia directly to the fixed post 14 instead of being held against said post somewhat yieldingly as in Fig. 1.

In Fig. 6 I have illustrated a gang of three aneroid capsules, D as shown in Figs. 1 and 4 and capsules C of the type described in my aforementioned patent and completely evacuated. The functioning movement of this entire gang of capsules is imparted to the shaft 13 of the left-most capsule relatively to the support 30. When employing one of my improved capsules D in a gang, although it is still preferable to maintain the volume of gas space in chamber A approximately 0.4 of the entire volume of chamber A in expanded condition, I prefer to employ a filling of gas such as nitrogen or air at a pressure of approximately three inches of mercury at 0° C. for proper temperature compensation, while the filling of gas in a capsule employed as in Fig. 5 may preferably be at a pressure of one inch of mercury. In this way the capsule D in Fig. 6 compensates for temperature variations for the entire gang of three capsules.

What I claim and desire to secure by United States Letters Patent is:

1. An aneroid capsule comprising a circular diaphragm having a central movable operator and concentric corrugations deeper at the margin than near the center thereby of shapes and relative sizes designed to accord best for faithful response to variations in external pressure when said capsule is completely evacuated and functions at constant temperature; and internal chamber completing and volume limiting structure having an external fixable central mount and provisions tending to hold all said volume limiting structure by said mount against movement due to inertia forces, said structure having a peripheral hermetical seal to the rim of said circular diaphragm and being provided with concentric corrugations complementary to the inner face corrugations of said circular diaphragm whereby the volume of the chamber of said capsule may be predetermined approximately down to zero plus the volume variation due to operative movements of said circular diaphragm.

2. An aneroid capsule comprising two opposed circular diaphragms having concentric corrugations deeper at the margin than near the center and thereby of shapes and relative sizes designed to accord best for faithful response to variations in external pressure when said capsule is completely evacuated and is functioning at constant temperature, said capsule being symmetrical relatively to a central axis and relatively to a central cross-section and forming an internal chamber; an external central operator for one diaphragm; a fixable central mount for the other diaphragm; an internal solid filler having oppositely positioned concentric corrugations complementary to the inside faces of the corrugations of said circular diaphragms; whereby the gas space in said chamber may be predetermined in volume regardless of the chamber space defined by said concentric corrugations of said circular diaphragms; and provisions tending to hold said filler by said fixable mount against movement due to inertia forces.

3. A gang of several tandem connected aneroid capsules, a plurality of which are completely evacuated and one or more of which are characterized as set forth in claim 1 whereby tem-

perature compensation and a wide range of operative aneroid movement result.

4. An aneroid device comprising a corrugated flexible member defining a wall of an aneroid chamber, a filling of permanent gas within said aneroid chamber at less than atmospheric pressure, and means for determining the amount of said gas at the predetermined pressure within said aneroid chamber.

5. An aneroid device comprising a corrugated flexible member defining a wall of an aneroid chamber, a filling of permanent gas within said aneroid chamber at less than atmospheric pressure, and means for determining the amount of said gas at the predetermined pressure within said aneroid chamber comprising a solid filler member occupying a substantial portion of the volume of said aneroid chamber.

6. An aneroid device comprising a corrugated elastic metal member forming a wall of an aneroid chamber, a member having complementary corrugations cooperating therewith to reduce the volume of the aneroid chamber, and a filling of permanent gas in said chamber of such quantity that with atmospheric pressure upon the capsule, the gas pressure within said capsule is a relatively small fraction of atmospheric pressure, the volume of the aneroid chamber being such that at changed temperatures and pressures the elastic effect of said gas compensates for the change in elasticity of the said capsule.

7. An aneroid capsule comprising a pair of corrugated discs, means for sealing the margins of said discs together to form an air-tight chamber, the corrugations of said discs being substantially similar and opposed, and a filler member within said capsule chamber having surface contours upon opposite sides, matching the corrugations of said capsule discs.

8. An aneroid capsule comprising a pair of corrugated discs, means for sealing the margins of said discs together to form an air-tight chamber, the corrugations of said discs being substantially similar and opposed, a filler member within said capsule chamber having surface contours upon opposite sides, matching the corrugations of said capsule discs, and a filling of temperature sensitive permanent gas within said capsule of such quantity as to compensate for temperature changes of ambient air.

9. An aneroid capsule comprising a solid member having surface corrugations, an elastic disc member attached thereto having corresponding corrugations of said plate member, defining an aneroid chamber, and a filling of temperature sensitive permanent gas therein adapted to maintain a pressure within said aneroid chamber variable according to the temperature of ambient air.

10. An aneroid capsule comprising a pair of elastic corrugated members having matching corrugations, one being adapted to enter into an annular portion of another, both members being elastic and adapted to respond to variations of pressure thereon, and a filling of temperature sensitive permanent gas within the aneroid chamber between said corrugated members, the volume of the said aneroid chamber being such that the variations of pressure of said permanent gas with variation of the temperature of ambient air compensates for temperature deviations of the instrument.

11. An external pressure responsive aneroid type device comprising one or more hermetically closed partially evacuated chambers each having an indicator actuating resilient wall construction resiliently responsive to variations in said external pressure and a charge of fixed gas in one of said chambers of predeterminable proportion to the flexible wall construction responsive to said variations in said external pressure, which proportion is independent of the proportion that the natural internal chamber space bears to the resilient wall area and operating in combination with the resilience of a resilient wall portion to effect a predetermined temperature compensation.

12. A pressure responsive device comprising in combination an expansible gas-tight chamber formed at least partly by a resilient diaphragm acted upon on one side by an external pressure, changes of which pressure within the operating range of the device cause an appropriate movement of the diaphragm inward or outward from one position into another; and a charge of gas inside said chamber acting on the other side of the diaphragm, the charge of gas being at a predetermined pressure which is at all times considerably lower than the external pressure, the gas being subject to expansion in substantially inverse proportion to the load acting on the diaphragm up to a multiple of its volume consumed in one extreme position of the diaphragm upon movement into the other extreme position, whereby said diaphragm will be moved in true response to changes in external pressure irrespective of changes in temperature affecting its resiliency, the action of the gas on the diaphragm upon a certain temperature change being relatively strong at high external pressure in which the charge of gas assumes a small volume and the action of the gas being relatively weak at low external pressures at which the charge of gas is considerably expanded.

13. A pressure responsive device comprising in combination an expansible gas-tight chamber formed at least partly by a resilient diaphragm acted upon on one side by an external pressure, changes of which pressure within the operating range of the device cause a movement of the diaphragm from one position into another; a filler body inside said chamber filling the greater part of said chamber when the diaphragm is moved into the one extreme position, whereby the residual volume of the chamber will be greatly enlarged by a movement of the diaphragm into the other extreme position; and a charge of gas inside said chamber and acting on the other side of said diaphragm, the charge of gas being at a predetermined pressure which is at all times considerably lower than the external pressure and being subject to substantial changes in volume upon movements of said diaphragm, whereby said diaphragm will be moved in true response to changes in external pressure irrespective of changes in temperature affecting its resiliency, the action of the gas on the diaphragm upon a certain temperature change being relatively strong at high external pressures in which the charge of gas assumes a small volume and the action of the gas being relatively weak at low external pressures at which the charge of gas is considerably expanded.

14. A pressure responsive device comprising, in combination, a corrugated metallic diaphragm; a wall member having corrugations complementary to the corrugations of said diaphragm and permitting a snug fitting of the diaphragm upon deflection towards said wall member without actual contact, said wall member being tightly connected to said diaphragm at the rim portion of the latter thus completing a gas-tight chamber

enclosing a very small volume in a compressed state and a proportionately greatly enlarged volume in an expanded state; a charge of gas inside said chamber, said charge of gas being at a predetermined pressure which is at all times considerably lower than the external pressures for which the device is designed, said gas being expansible from its volume assumed in one extreme position of the diaphragm corresponding to a greatest external pressure to a relatively greatly enlarged volume upon movement of the diaphragm into the other extreme position corresponding to the lowest external pressure for which the device is designed, whereby said diaphragm will be moved in true response to changes in external pressure irrespective of changes in temperature affecting its resiliency, the compensating action of the gas on the diaphragm upon a certain temperature change being relatively strong at high external pressures in which the charge of gas assumes a small volume and the action of the gas being relatively weak at low external pressures at which the charge of gas is considerably expanded.

15. A pressure responsive device comprising, in combination a corrugated metallic diaphragm; a rigid wall member having corrugations complementary to the corrugations of said diaphragm and permitting a snug fitting of the diaphragm upon deflection towards said wall member without actual contact, said wall member being tightly connected to said diaphragm at the rim portion of the latter thus completing a gas-tight chamber enclosing a very small volume in a compressed state and a relatively greatly enlarged volume in an expanded state; and a charge of gas inside said chamber, said charge of gas being at a predetermined pressure which is at all times considerably lower than external pressures for which the device is designed, said gas being expansible from its volume assumed in one extreme position of the diaphragm corresponding to a greatest external pressure to a relatively greatly enlarged volume upon movement of the diaphragm into the other extreme position corresponding to the lowest external pressure for which the device is designed, whereby said diaphragm will be moved in true response to changes in external pressure irrespective of changes in temperature affecting its resiliency, the compensating action of the gas on the diaphragm upon a certain temperature change being relatively strong at high external pressures in which the charge of gas assumes a small volume and the action of the gas being relatively weak at low external pressures at which the charge of gas is considerably expanded.

16. A pressure responsive device comprising, in combination, a first corrugated metallic diaphragm; a second metallic diaphragm having corrugations complementary to the corrugations of said first diaphragm and permitting a snug fitting of said diaphragms close to each other upon deflection of the same without actual contact, said diaphragms being tightly connected at the rim portions, thus completing a gas-tight diaphragm chamber; and a charge of gas inside said chamber, said charge of gas being at a predetermined pressure which is at all times lower than external pressures for which the device is designed, said gas being expansible upon expansion of said diaphragm or diaphragms to a chamber enclosing a multiple of the volume assumed by the gas in the compressed state of the diaphragm chamber, whereby said diaphragm chamber will be moved in true response to changes in atmospheric pressure acting on the outside of the same irrespective of changes in temperature affecting its resiliency, the compensating action of the gas on the diaphragms in response to a certain temperature change being relatively strong at high external pressures in which the charge of gas assumes a small volume and the action of the gas being relatively weak at low external pressures at which the charge of gas is considerably expanded.

17. In an atmospheric pressure responsive device the combination with an evacuated first resilient diaphragm capsule; of a second resilient diaphragm capsule connected in tandem with said first capsule; a filler member inside said second capsule filling the greater part of the capsule in the condition in which the capsule is compressed and permitting the residual volume to become greatly enlarged upon an expansion of the capsule; and a charge of gas inside said second capsule, the charge of gas being at a predetermined pressure which is at all times considerably lower than the external atmospheric pressure.

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