Jan. 2, 1940. G. E. BEARDSLEY, JR., ET AL 2,185,578

DENSITY RESPONSIVE DEVICE

Filed Dec. 30, 1936

Fig. 1

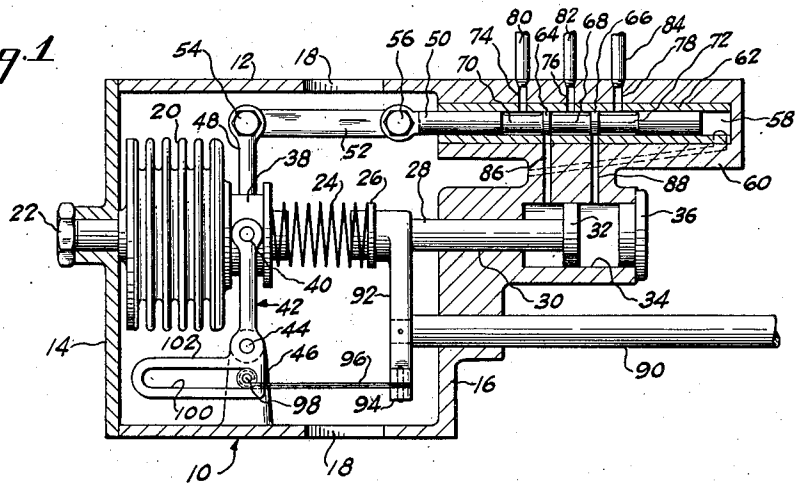


Fig. 2

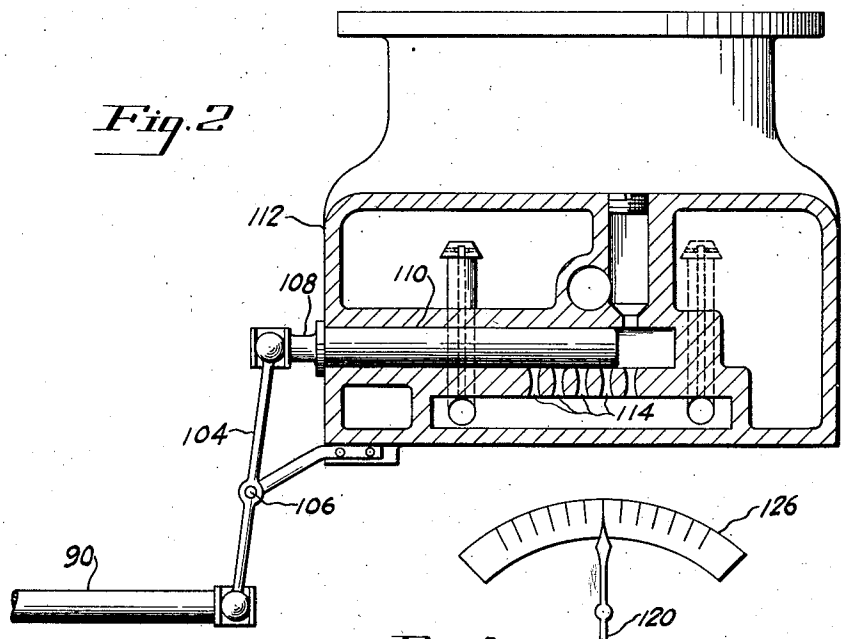


Fig. 3

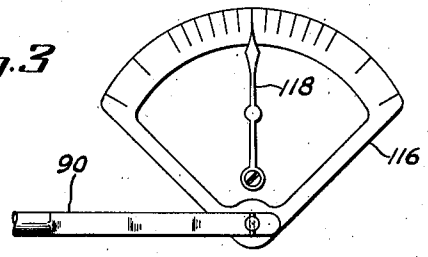
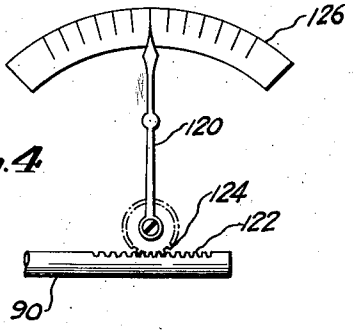


Fig. 4



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DENSITY RESPONSIVE DEVICE

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22 Claims. (Cl. 73—4)

This invention relates to improvements in air density responsive devices, and has for an object the provision of a device which is accurately responsive to changes in air density over a wide range of density variation.

A further object resides in the provision of a device of the character described which has a movable portion which changes its position in response to changes in air density and which movable portion may be used to operate a density indicating means or to control another device which is affected by changes in air density.

A still further object resides in the provision of a device of the character described which is capable of exerting a force sufficient to change the setting of a density indicating device or of an instrumentality which is affected by changes in air density.

Other objects and advantages will be more particularly pointed out hereinafter or will become apparent as the description proceeds.

In the accompanying drawing in which like reference numerals are used to designate similar parts throughout, there is illustrated a suitable mechanical arrangement of what is now considered to be the preferred form of the idea of the invention, together with three exemplifications of the application of the device to practical purposes. The drawing, however, is for the purpose of illustration only and is not to be taken as limiting the invention the scope of which is to be measured entirely by the scope of the appended claims.

In the accompanying drawing, Fig. 1 is a vertical sectional view of a density responsive device constructed according to the idea of this invention;

Fig. 2 is a partly schematic sectional view of a carburetor for an internal combustion engine showing the application of the density responsive device to the carburetor to control the fuel-air ratio of the combustible mixture supplied by the carburetor;

Fig. 3 is a partly schematic view showing the application of the density responsive device to correct the reading of an instrument responsive to a condition other than the density of the air; and

Fig. 4 is a partly schematic illustration of the application of the density responsive device as an air density indicator.

Referring to the drawing in detail, the numeral 10 generally indicates a boxlike casing in which the density responsive mechanism is mounted. The casing is provided with side walls 12 which may inclose a compartment of square, cylindrical, or other suitable form. One end of the casing is closed by a removable end closure member 14, and the other end is closed by an end closure member 16 which, if desired, may be formed integrally with the wide walls 12. Suitable holes or apertures 18 are provided in the side walls 12 to render the interior of the casing 10 subject to the pressure and temperature of the surrounding air.

An expansible metal bellows 20 is firmly secured to the end wall 14 by a suitable anchoring means 22 and is filled with a suitable gas, such as air, at a predetermined pressure which may be selected in view of the purpose for which the density responsive device is to be used. As the present invention contemplates the use of the density responsive device on an airplane in which case it would be responsive to air densities at and below the density of the atmosphere at sea level, the pressure of the gas in the bellows 20 is designed to be slightly above the pressure of the atmosphere at sea level. The end of the bellows 20 opposite the mounting 22 is relatively free to move, but movement in a direction to expand the bellows is opposed by a coiled compression spring 24 disposed between the free end of the bellows and a movable abutment 26 carried upon the inner end of a reciprocable shaft 28. The shaft 28 passes through a bearing aperture 30 in the end wall 16 of the casing 10 and carries upon its outer end a piston 32 reciprocable in a cylinder 34 carried upon or formed integrally with the end wall 16. The outer end of the cylinder is closed by a suitable plug or closure member 36.

From the above description, it will be observed that compression of the spring 24 opposes outward movement of the free end of the bellows 20 incident to an expansion of the bellows and that movement of the abutment 26 by the piston 32 is effective to change the loading of the spring and thereby alter the force with which the spring opposes expansion of the bellows. The free end of the bellows is provided with a suitable collar or other bearing member 38 which receives a fork provided upon a lever member, generally indicated at 42, which is pivotally mounted at its lower end, as indicated at 44, upon the upper or inner end of an apertured lug 46 formed upon or secured to the inner side of the side wall 10. The lever member 42 has an extension 48 extending beyond the connection of the lever with the bearing portion 38, the free end of the lever being connected to a valve rod 50 by suitable means,

such as the link 52 and the pivotal connections 54 and 56.

The valve rod extends into a valve aperture 58 provided in a cylindrical extension 60 formed upon or mounted upon the end wall 16. If desired, the valve cylinder or aperture may be provided by means of a cylindrical insert or bushing 62 disposed in the cylindrical extension 60.

The valve rod is provided with annular valve portions 64 and 66 separated from each other and from the end portions of the valve rod by annular reduced portions 68, 70, and 72.

The cylindrical extension 60 is provided upon one side thereof with ports 74, 76, and 78 which lead into the valve aperture 58 in a direction transverse to the axis of the aperture and which are connected at the exterior of the cylindrical extension with fluid conduits 80, 82, and 84, respectively. Upon the opposite side of the cylindrical extension from the ports 74, 76, and 78 are provided ports 86 and 88 which lead from the valve aperture 58 to the interior of the cylinder 34, the port 86 being disposed approximately midway between the port 74 and 76 and the port 88 being disposed approximately midway between the ports 76 and 78. Fluid under pressure is led through the conduit 82, and the conduits 80 and 84 lead from the valve aperture to drain. The piston 32 is normally disposed between the cylinder ends of the ports 86 and 88.

From the construction so far described, it will be observed that if the bellows 20 tends to expand in response to a decrease in the density of the surrounding atmospher it will move the valve stem 50 to the right as viewed in Fig. 1, thereby causing a movement of the valve portion 66 which connects the port 76 with the port 88 to supply fluid under pressure to the right-hand end of the piston 32, at the same time causing movement of the valve portion 64 which connects the port 74 with the port 86 and relieves the pressure behind the piston 32. This movement of the valve stem causes a force to be exerted upon the piston which moves the shaft 28 inwardly and increases the loading on the spring 24 which opposes the tendency of the bellows 20 to expand. When the bellows has been brought to a position in which the valve portions 64 and 66 close the ports 86 and 88 and the piston is retained in its new position.

A shaft 90 is connected to the shaft 28 by suitable means, such as the crosshead 92 so that it follows the axial movements of the shaft 28. Thus, whenever the piston 32 moves the shaft 28 to a new position to compensate for a change in the density of the atmosphere surrounding the bellows 20, the shaft 90 will also be moved to a different position, and the movement of the shaft 90 may be utilized for various purposes, certain examples of which will be explained hereinafter.

The crosshead 92 extends beyond its connection with the shaft 90 and is provided with an apertured end portion 94 which receives one end of a bi-metallic thermostatic strip 96. The strip 96 is of a nature well known in the art of temperature responsive mechanisms and tends to bend with a certain force upon predetermined changes in its temperature. The end of the strip 96 opposite the end clamped in the crosshead 92 carries a pin or roller 98 movable in a slot 100 provided in an extension 102 provided upon the lower end of the lever 42 adjacent to the pivot 44. The extension 102 and slot 100 extend in a direction substantially at right angles to the remaining portion of the lever 42 and away from the crosshead 92.

From the above description, it will be observed that the bending force of the thermostatic strip 96 will be imposed upon the lever depending upon whether the temperature to which the thermostatic strip is exposed is above or below a predetermined temperature for which the device is adjusted.

When the piston 32 is in the position illustrated in Fig. 1, which position corresponds to the normal pressure of the atmosphere at sea level, the roller or pin 98 is disposed substantially immediately below the pivot 44 so that the thermostat has no material effect upon the operation of the device. This arrangement is provided for the reason that whenever the density of the surrounding atmosphere is substantially the same as the density of the fluid within the bellows no correction for temperature variations is necessary. As the external density differs from the internal density correction for temperature variation becomes necessary, the amount of necessary correction being proportional to the difference in density within and outside of the bellows, with the arrangement illustrated or an equivalent arrangement, the corrective force of the thermostat is applied with increasing effect as the crosshead 92 is moved inwardly by the piston 32.

One possible application of the density responsive device described above is schematically illustrated in Fig. 2 in which the end of the shaft 90 is connected to one end of a lever 104 which is mounted intermediate its length upon a fixed pivot 106 and connected at its other end to a valve member 108 axially movable in an aperture 110 provided in a carburetor 112 to control a plurality of fuel metering jets 114. According to the arrangement illustrated, the valve member 108 will be moved axially of itself upon movement of the shaft 90 to reduce the number of fuel metering jets as the density of the atmosphere decreases to thereby maintain a substantially constant air-fuel ratio in the combustible mixture supplied by the carburetor.

In the application of the device illustrated in Fig. 3, the outer end of the shaft 90 is operatively connected with a dial 116 with which a hand 118 cooperates. The hand 118 is operated by a device responsive to atmospheric conditions such as an altimeter responsive to the pressure of the atmosphere. The instrument such as the altimeter will move the hand or pointer 118 to a position on the dial which will indicate the apparent atmospheric pressure in terms of altitude or some other desired function. At the same time the shaft 90 will move the dial 116 in response to changes in the density of the atmosphere and thereby correct the reading of the pointer to give a corrected reading of absolute altitude, or other desired function.

In the application of the device illustrated in Fig. 4, the shaft 90 is connected with a pivoted hand or pointer 120 by a suitable operative connection, such as the rack 122 and pinion 124 so that the shaft 90 will move the pointer whenever the shaft moves in response to changes in the density of the atmosphere surrounding the density responsive device. The pointer 120 cooperates with a dial 126 marked with suitable indicia which read in units of atmosphere density or other desired units to indicate at all times the current density of the atmosphere surrounding the density responsive mechanism.

While there has been illustrated and described a suitable mechanical embodiment of the idea of the invention and three exemplary applications of the device, it is to be understood that the invention is not limited to the construction so illustrated and described but that such changes in the size, shape, and arrangement of parts may be resorted to as come within the scope of the subjoined claims.

Having now described the invention so that others skilled in the art may clearly understand the same, what it is desired to secure by Letters Patent is as follows.

What is claimed is:

1. In a density responsive device, a movable element, power actuated means for moving said element, a sealed metallic bellows responsive to changes in the pressure of the surrounding medium for controlling said power actuated means, and a thermostat carried by said movable element and responsive to changes in the temperature of the surrounding medium for modifying the action of said bellows in controlling said power actuated means.

2. In a density responsive device, a movable element, power operated means for moving said element, a sealed metallic bellows responsive to changes in the pressure of the surrounding medium for controlling said power operated means, a device responsive to changes in the temperature of the surrounding medium for modifying the action of said bellows in controlling said power operated means, and a connection between said temperature responsive device and said bellows effective to increase the modifying effects of said temperature responsive means on the action of said bellows as the pressure of the medium surrounding said bellows decreases.

3. An air density responsive device comprising, a sealed expansible bellows which tends to expand when subjected to an atmospheric pressure less than the pressure within said bellows, a spring opposing expansion of said bellows, a movable support for said spring, power operated means for moving said support to vary the force exerted by said spring, means actuated by initial expansion movements of said bellows to control said power actuated means, and temperature responsive means variably connected with said control means to modify the effect of said bellows thereon.

4. A density responsive mechanism comprising, an expansible bellows having a fixed end and a relatively free end which tends to move in response to changes in the density of the medium surrounding said bellows, a spring opposing movement of said relatively free end, power operated means actuated by initial movements of said relatively free end to change the loading on said spring and restrain said relative free end of said bellows against movement beyond said initial movements effective to actuate said spring loading device, and temperature responsive means operatively associated with said free end by a connection of variable mechanical advantage to modify the actuation of said power operated means by said bellows.

5. An air density responsive device comprising, a sealed expansible bellows which tends to expand when subjected to an atmospheric pressure less than the pressure within said bellows, a spring opposing expansion of said bellows, a movable abutment for said spring, a hydraulic piston for moving said abutment to vary the force exerted by said spring on said bellows, a valve for controlling the pressure of hydraulic fluid against said piston, means operatively connecting said bellows with said valve, and temperature responsive means operatively associated with said bellows to exert a force thereon to modify the total force exerted thereon.

6. An air density responsive device comprising, a sealed expansible bellows which tends to expand when subjected to an atmospheric pressure less than the pressure within said bellows, a spring opposing expansion of said bellows, a movable abutment for said spring, a hydraulic piston for moving said abutment to vary the force exerted by said spring on said bellows, a valve for controlling the pressure of hydraulic fluid against said piston, means operatively connecting said bellows with said valve, and temperature responsive means having a movable connection with said connecting means to modify the actuation of said valve by said bellows with increasing force as the pressure of the air surrounding said bellows decreases.

7. An air density responsive device comprising, a sealed expansible bellows which tends to expand when subjected to an atmospheric pressure less than the pressure within said bellows, a spring opposing expansion of said bellows, a movable abutment for said spring, a hydraulic piston for moving said abutment to vary the force exerted by said spring on said bellows a valve for controlling the pressure of hydraulic fluid against said piston, a pivoted bell crank lever having one arm pivotally connected at spaced locations to said bellows and said valve whereby said bellows will actuate said valve, and a temperature responsive device having a slidable connection with the other arm of said bell crank lever to modify the actuation of said valve by said bellows with increasing effect as the pressure of the air surrounding said bellows decreases.

8. A density indicating device comprising, a sealed expansible bellows which tends to expand when the pressure of the medium surrounding said bellows is less than the pressure within said bellows, a spring opposing expansion of said bellows, a movable abutment for said spring, power operated means actuated by said bellows and connected with said movable abutment to vary the force exerted by said spring to maintain the volume of said bellows substantially constant, temperature responsive means, a connection of variable mechanical advantage between said temperature responsive means and said bellows for modifying the actuation of said power operated means by said bellows, a member connected to and movable with said movable abutment, a pointer operated by said member and a dial associated with said pointer for indicating the density of the medium surrounding said bellows.

9. In a density responsive device, a power actuated movable element, a substantially constant volume pressure responsive device for controlling the movements of said element to render said movements proportional to changes in the pressure of the medium surrounding said device, and temperature responsive means for modifying the controlling action of said pressure responsive device with increasing effect with increase in pressure variations from a predetermined datum pressure, to render said movements proportional to changes in the density of the surrounding medium.

10. In a density responsive device, an element

which tends to change its volume in response to changes in the pressure and temperature of the surrounding medium, a movable abutment arranged to exert a force on said pressure responsive element to maintain its volume substantially constant, and an element responsive to changes in the temperature of the surrounding medium for modifying the reaction between said pressure responsive element and said movable abutment only when the gas pressure inside of said variable volume element differs from the pressure of the surrounding atmosphere.

11. In a density responsive device, an element which tends to change its volume in response to changes in the pressure and temperature of the surrounding medium, means resisting such change in volume, and means responsive to the temperature of the surrounding medium constructed and arranged to modify the tendency of said element to change its volume by a force proportional to the temperature change and to the difference in density between the inside and the outside of said variable volume element.

12. In a density responsive device, pressure responsive means for exerting a force proportional to variations at a constant temperature in the pressure of the surrounding medium from a predetermined pressure, movable means for exerting a force in opposition to the force exerted by said pressure responsive means, and means for modifying the movements of said movable means by exerting a force proportional to variations in the temperature and pressure of the surrounding medium from a predetermined temperature and pressure, said force assisting or opposed to the force of said movable means according to the character of the pressure or temperature variation.

13. In a density responsive device, means for exerting a force in one direction varying with changes in density due to changes in the temperature and/or pressure of the surrounding medium from predetermined values of temperature and pressure, power actuated movable means for exerting a force in opposition to the force exerted by said first mentioned means, an elastic connection between said first mentioned means and said movable means, and means for applying a corrective force to said first mentioned means whenever there is a temperature change in said surrounding medium accompanied by a difference between the pressure of said medium and said predetermined pressure value.

14. In combination, a sealed bellows containing a fluid having a predetermined density at a predetermined volume, means movable in proportion to changes in the density of the surrounding atmosphere from said predetermined density for varying the pressure on said bellows to maintain said volume substantially constant, said means including a temperature responsive element, and a variable leverage mechanism between said temperature responsive element and said bellows.

15. A density responsive device comprising an expansible chamber or bellows subject to the temperature and pressure of the surrounding gas or atmosphere and sealed with a gas contained therein, and means, including a temperature responsive element, for maintaining the density of the sealed gas constant, said means constructed and arranged to have definite positions in accordance with the density of the surrounding gas, and means associated with the temperature responsive element to vary its effectiveness constructed and arranged so that at a predetermined density of the surrounding gas the temperature responsive element will have no modifying effect but as the density changes from the predetermined value the modifying effects of the temperature responsive means increases.

16. A density responsive device comprising an expansible chamber or bellows subject to the temperature and pressure of the surrounding gas or atmosphere, which bellows requires a uniformly increasing force to maintain its volume constant as the density of the surrounding gas decreases at a constant temperature but which requires a uniformly increasing additional force per degree increase in temperature to produce the same result under varying temperature conditions, means under control of said bellows to maintain the volume of said bellows substantially constant comprising means for applying a uniformly increasing force to said bellows as said density decreases, and means comprising a thermostatic element exerting a constant additional force per degree change in temperature and having a variable ratio lever connection with said bellows for increasing the effectiveness of said additional force as the density decreases.

17. In a density responsive device, pressure and temperature responsive means for exerting a force when the density of the surrounding medium varies from a predetermined density, movable means for exerting a substantially equal force in opposition to the force exerted by said pressure responsive means, and means for modifying the movements of said movable means by exerting a force to assist or oppose the force of said movable means, said modifying means being operative to exert a force proportional to the variations in the temperature and pressure of the surrounding medium from a predetermined temperature and pressure.

18. In a density responsive device, means movable to definite positions corresponding to the density of the surrounding medium, means for causing movement of said movable means to a definite position corresponding to the existing density value comprising, means including a temperature responsive element and connections to restrain said movable means against movement from said position due to the effect of temperature variations of the surrounding medium while said density remains constant but effective to cause movement of said movable means when the temperature variation is accompanied by a change in density.

19. In a device responsive to changes in the weight per unit volume of the surrounding gas, having a body of confined gas maintained at substantially constant density, and in which the pressure difference between the surrounding gas and the confined gas varies at a uniform rate with changes in density at a given temperature but at different uniform rates at other temperatures, a container for confining said confined gas a main means for applying a force to said container opposing and equal to the force created on said container by that part of said pressure difference due to changes in density of the surrounding gas at said given temperature, and additional means for applying a force to said container opposing and equal to the force created on said container by that part of said pressure difference due to a variation in temperature from said given temperature.

20. In combination an expansible chamber device tending to expand or contract with changes

in density of the surrounding medium, mechanism including a temperature responsive element for applying force to said device to maintain its volume substantially constant, a connection, having a variable mechanical advantage, between said temperature responsive element and said device, power operated means controlled by said expansible chamber device for varying said force and said mechanical advantage, said means having the same position for any particular density regardless of temperature.

21. A density responsive device comprising, an expansible container subject to the temperature and pressure of the surrounding gas or atmosphere and sealed with gas contained therein at a reference density, and means having definite positions in accordance with the density of the surrounding medium for maintaining the density of the sealed gas substantially constant, said means including a thermostatic element operative to exert a force on said container in response to changes in the temperature of said surrounding medium at densities other than said reference density.

22. In a device responsive to changes in the weight per unit volume of the surrounding gas, a body of confined gas, the temperature of which remains substantially the same as the temperature of the surrounding gas, means for maintaining the weight per unit volume of said confined gas substantially constant during temperature changes by varying the pressure thereof comprising, means controlled by changes in the pressure difference between the pressure of the confined gas and the pressure of the surrounding gas for varying the pressure of said confined gas, and additional means responsive to temperature changes of said surrounding gas from a base temperature for increasing or decreasing the pressure of said confined gas, and mechanism responsive to changes in the density of the surrounding gas, from a base density, for causing said temperature responsive means to increase or decrease the pressure of said confined gas for each degree of temperature change from said base temperature, an amount proportional to the change in density of the surrounding gas from said base density.

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