Dec. 2, 1941. G. E. BEARDSLEY, JR 2,264,869

AIR DENSITY CONTROL DEVICE

Filed Aug. 23, 1938 2 Sheets-Sheet 1

Fig. 1

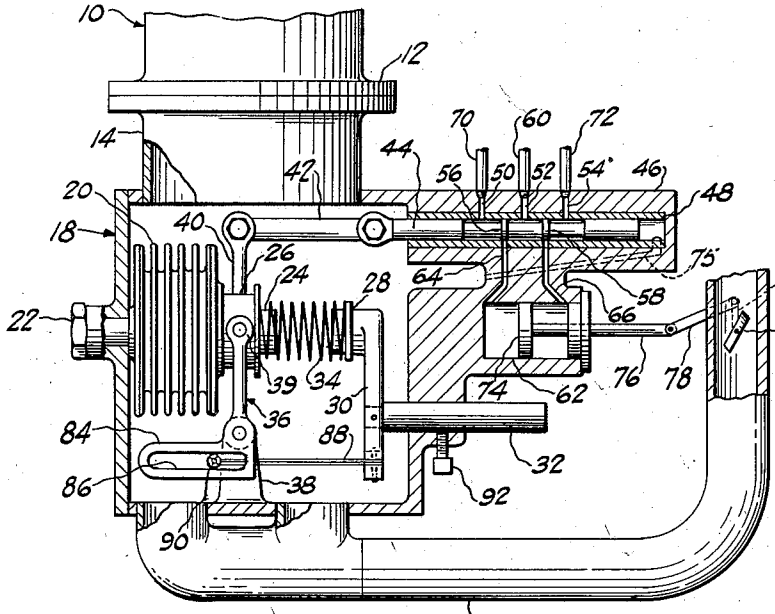
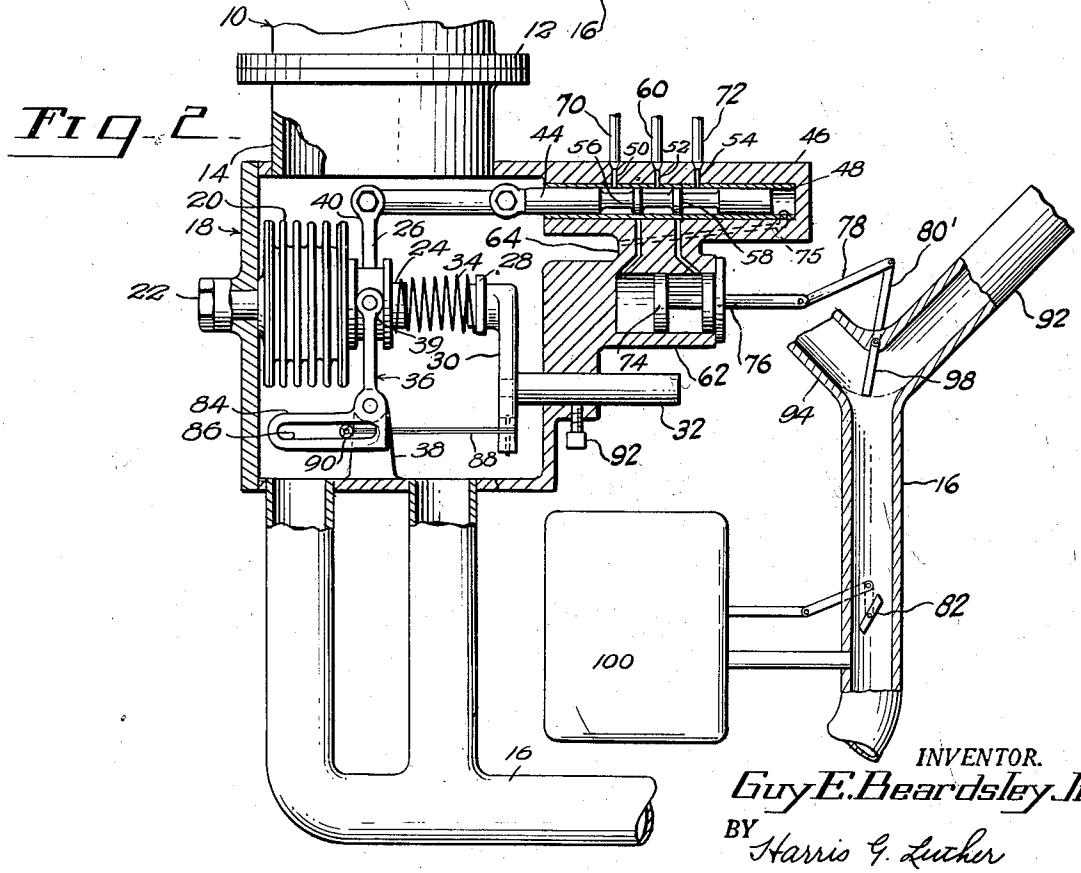


Fig. 2



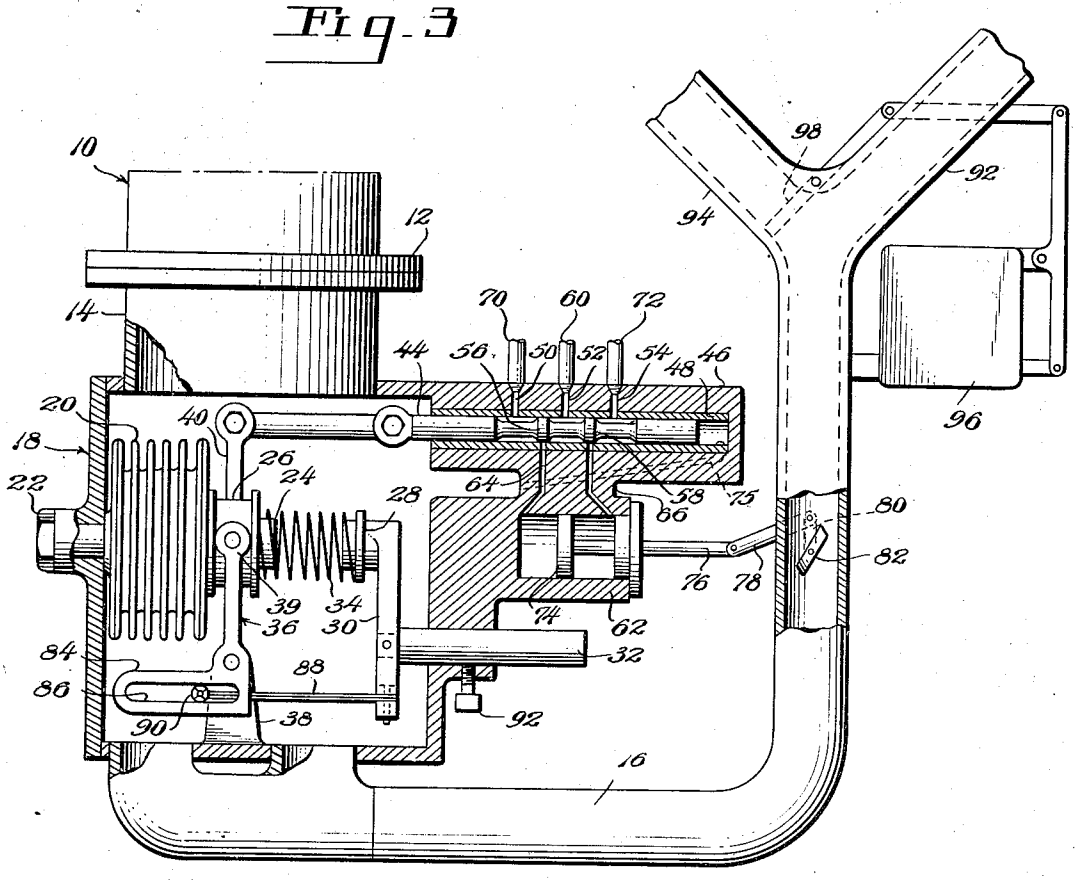
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Fig. 3



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UNITED STATES PATENT OFFICE

2,264,869

AIR DENSITY CONTROL DEVICE

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Application August 23, 1938, Serial No. 226,301

19 Claims. (Cl. 261—39)

This invention relates to improvements in air density control devices and may be regarded as an improvement in the device disclosed in application Serial No. 118,314 filed December 30, 1936, for Density responsive device, by Guy E. Beardsley, Jr., and John S. Hasbrouck, which on January 2, 1940, matured into United States Patent No. 2,185,578.

The present invention relates particularly to the application of an improved density responsive device of the type shown and described in the application referred to above, to control the density of the air, particularly in the carburetor air intake of an internal combustion engine or similar device.

An object of the invention resides in the provision of a power actuated device responsive to both the temperature and pressure of the carburetor intake air for maintaining the air in the carburetor intake at a predetermined density.

A further object resides in the provision of a simplified and highly effective device operative to maintain a predetermined density with a high degree of accuracy.

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

In the accompanying drawings, in which like reference numerals have been used to designate similar parts throughout, there are illustrated a suitable constructional form of the device of the invention. The drawings, however, are for the purpose of illustration only and are not to be taken as in any way limiting or restricting the scope of the invention as set forth in the appended claims.

In the drawings, Fig. 1 represents a vertical sectional view through a carburetor air intake, showing a density control device constructed according to the invention applied thereto.

Fig. 2 is a vertical sectional view through a carburetor air intake showing a density control device actuating a temperature control valve.

Fig. 3 is a vertical sectional view showing a modification of the structure shown in Fig. 1.

Referring to the drawings in detail the numeral 10 generally indicates an engine carburetor, the lower portion 12 of which is flanged to receive the flanged end of a carburetor air intake 14. Air is supplied to the carburetor air intake through an air duct 16, between which and the intake 14 there is disposed a generally cylindrical container, generally indicated at 18, within which there is disposed the improved density control device in such a manner as to be substantially surrounded at all times by the carburetor intake air. The container 18 may be of any other desired shape and may be pneumatically connected with the interior of the air intake by any suitable means.

An hermetically sealed flexible bellows or "Sylphon" 20 is secured at one end to the wall of the container 18 by suitable means, such as the stud bolt 22, and carries at its opposite movable end a spring abutment 24 provided with an annular groove constituting a collar 26. An opposed spring abutment 28 is provided at the end of an arm 30 carried upon a shaft 32 extending through an aperture in the wall of the container 18 opposite the wall to which the bellows 20 is secured. A coiled compression spring 34 is disposed between the abutment 24 and 28 and exerts its force to compress the bellows 20. A forked lever member generally indicated at 36 is pivoted at one end to the lug 38 positioned near the bottom of the container 18 and directly below the collar 26. This lever 36 is provided with a fork 39 which engages in the groove of the collar 26 so that the lever 36 is moved about is pivotal connection with the lug 38 whenever the bellows 20 contracts or expands. One side 40 of the forked lever member 36 extends beyond the other side to a pivotal connection with a link 42 which is in turn pivotally connected to the end of a valve plunger 44 slidably received in the bore of a valve chamber 46 formed integral with or rigidly attached to the container 18. Preferably a cylindrical liner 48 is disposed in the bore of the valve chamber surrounding the plunger 44. The valve chamber 46 is provided with spaced ports 50, 52 and 54 and the valve plunger is provided with a pair of integral piston portions 56 and 58, separated from each other and from the remainder of the valve plunger by intervening portions of reduced diameter, which pistons cooperate with the ports 50, 52 and 54 to control the application of hydraulic fluid under pressure, supplied through the conduit 60, to the cylinder 62, through the passages 64 and 66. The ports 50 and 54 are connected with the respective drain conduits 70 and 72 and the ports and valve pistons and passageways 64 and 66 are so spaced that when the valve plunger 44 is in its center or neutral position, as illustrated, the passages 64 and 66 are blocked by the respective pistons 56 and 58 but when the plunger is moved to the right, as viewed in the figure, from its neutral position, the passageway 66 is connected with the pressure line 60 to apply fluid pressure to the right-hand side of the piston 74 and the passage 64 is connected with the drain conduit 70 to drain the fluid from the space at the left-hand side of the piston 74; and when the valve plunger is moved to the left from the position illustrated, the left-hand side of the piston 74 is connected with the fluid pressure through the channel 64 and the space at the right-hand side of the piston 74 is drained through the channel 66 and conduit 72. The space at the right-hand end of

the valve plunger 44 is vented through the drain channel 15 to prevent an accumulation of fluid in this closed space from interfering with the operation of the valve plunger.

A piston rod 76 is connected to the piston 74 and extends through the end of the cylinder 62 to a pivotal connection with one end of a link 78 the opposite end of which is pivotally connected to the free end of a lever 80 rigidly mounted upon the shaft of a butterfly valve 82 located in the air duct 16.

The pivoted lever 36 is provided, immediately below its pivotal connection with the lug 38, with a right angular extension 84 provided with an elongated slot or groove 86. As shown, the extension or arm 84 extends to the left from the lower end of the substantially vertical lever 36 but it may extend to the right or even in both directions. The arm 30 is provided with a portion extending to the opposite side of the shaft 32 from the spring abutment 28 and to the end of this extended portion of the arm 30 there is connected one end of a bimetallic thermostatic element 88 the opposite end of which is connected to a pin or roller 90 movable in the groove 86.

The present device operates to produce a somewhat different result from that produced by the device disclosed in the application referred to above, for the present device functions as a density control to maintain the density of the surrounding air constant at some preselected value.

Air, or some other suitable gas, is sealed in the bellows 20. The shaft 32 is adjusted to regulate the force exerted by the spring 34 to an amount such that, at the density desired to be maintained in the intake the force of the spring plus the pressure of the surrounding air and the force exerted by the temperature responsive element 88 acting on the bellows 20 will exert enough force on the bellows to bring the valve plunger 44 to the neutral position illustrated. The shaft 32 is then locked in adjusted position by suitable means, such as the set screw 92. As shown in the drawing the spring is exerting no force on the bellows since the temperature compensating element is shown on center.

If the air temperature remains constant, the bellows 20 will be actuated, by any change in air pressure in the container 18, sufficiently to actuate the valve plunger 44. This, in turn will cause actuation of the valve 82 and restore the air pressure acting on the bellows to the value it had before the change. At a constant temperature the density may be maintained constant by maintaining the pressure constant. Hence under the above conditions constant density is maintained simply by maintaining constant pressure.

If, however, there is a change in air temperature there must be a change in pressure to maintain constant density. In the device of this application this is accomplished as follows:

The bellows 20 is maintained at constant volume, hence the contained air is maintained at constant density. If there is a difference between the density of the air inside, and of the air outside of said bellows, a change in temperature, at constant density, changes the pressure of one of the air volumes more than it changes the pressure of the other air volume. The greater the difference in density the greater the pressure change per degree change in temperature. It has been found that the amount of this variation in pressure is directly proportional to the density difference.

For all pressure changes the device functions as described above. For temperature changes the thermostatic strip 88 is so proportioned that, when the member 32 is set to maintain a density equal to that of the air or gas in the bellows 20, it has no effect on the bellows, but, if the member 32 is set to maintain a density other than that of the air or gas in the bellows, a change in temperature from the normal preselected value will cause the strip 88 to exert a force on the arm 84 which will cause a movement of the valve plunger 44 and the valve 82 to change the pressure in the container 18. This pressure change will be just sufficient to maintain the desired density at the new temperature. The greater the desired density difference the further the member 32 is from the neutral position shown in Fig. 1 and hence the further the member 90 is from alignment with the arm 36 and therefore the greater the effective force of the element 88 on the bellows 20 and valve plunger 44. The device, therefore, produces a variation in pressure due to each degree of temperature change directly proportional to the density difference and hence serves to maintain a constant density.

Since the pressure and temperature of the air are both responded to by the mechanism, the mechanism is accurately density responsive. Once the device has been set for a particular air density it will thereafter move in response to any change in density whether the change be in the pressure component, the temperature component or both components. Any tendency toward expansion or contraction of the bellows 18 due to a change in density of the surrounding air will move the collar 26 and swing the lever 36 about its pivotal connection to the lug 38. Any movement of the lever 36 moves the valve plunger 44 to the right in response to a decrease in density, and to the left in response to an increase in density of the air surrounding the density responsive element. If the plunger 44 is moved to the right the piston 74 will be moved to the left, as viewed in the drawing, which movement of the piston decreases the throttling action of the butterfly valve 82 which in turn permits an increased flow of air through the air duct 16 and an increase in the pressure of the air in the container 18. When the bellows 20 contracts in response to an increase in the density of the air in the container 18 the action is reversed. By continuously adjusting the butterfly valve 82 the improved density responsive device will act to maintain a constant predetermined density in the container 18 and in the air intake of the engine carburetor 10, by controlling only the pressure of the intake air.

The improved density responsive device may also be utilized to maintain a constant air density in combination with a carburetor air intake having a supply of heated air and a supply of cold air.

The broken lines in Fig. 1 and the sectional view in Fig. 2 shows the carburetor intake air ducts 16 connected with a cold air inlet 92 and a heated air inlet 94. In such an arrangement the temperature of the air in the ducts 16 may be maintained substantially constant by means of a temperature responsive device 96 connected with the interior of the air duct 16 and arranged to operate a valve 98 disposed between the inlets 92 and 94 in a manner to control the proportion of air supplied to the duct 16 through each of the inlets. A suitable form of temperature regulat-

ing device is illustrated and described in Patent Number 2,082,397 issued June 1, 1937, to T. Hiscock.

In a device such as shown by Fig. 1 including the dotted line portion, if the temperature maintained by the element **96** is the normal temperature at which the strip **88** is set, that strip would have no function, but if any other temperature were maintained or if there was a temperature variation the strip **88** would act as described above in connection with the first considered arrangement to maintain the density constant.

In the arrangement illustrated in Fig. 2 the improved density responsive device is combined with a pressure regulating device **100** such as is also illustrated and described in the Hiscock patent referred to above. In this arrangement the pressure responsive device **100** controls the pressure regulating valve **82** to maintain a constant preselected pressure in the intake and the improved density responsive device is operatively connected through the link **78** and the lever **80'** with the temperature regulating valve **98**.

In such an arrangement the density is maintained constant by variations in the temperature. By properly selecting the density to be maintained by the density responsive device and the pressure to be maintained by the pressure responsive device **100** it is possible to utilize substantially the full capacity of the air heater until the valve **82** is wide open and the pressure regulating device can no longer reduce the pressure. Further decreases in pressure would then cause a decrease in the intake line but the density responsive device would act to maintain constant density by decreasing the air temperature until air at the temperature and pressure of the outside air or of the air in the cold air duct was being fed through the intake.

While a particular mechanical embodiment has been illustrated and described for the purpose of disclosing the invention it is to be understood that the invention is not limited to a device for controlling the density of the air in a carburetor intake, nor to the particular construction so illustrated and described, but that the improved arrangement may be utilized to control the density of any gas in various other mechanisms, and such changes in the size, shape and arrangement of the various parts may be resorted to as come within the scope of the sub-joined 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 combination with a carburetor and an air supply conduit therefor, density responsive means for maintaining the density of the air in said conduit at a preselected value by regulating the pressure of said air comprising, a variable volume container subject to the air temperature and pressures within said conduit, and sealed with gas contained therein and having a neutral position in which the container has a preselected volume and the gas is at a reference density, a throttling valve in the conduit upstream of said container, means operatively connecting said container and said valve so that change in volume of said container from said selected volume will cause a movement of said valve to change the air pressure and restore said container to its selected volume and means including a thermostatic element operative to exert a force on said container compensating for changes in air temperature at densities other than said reference density.

2. In an air density control system for internal combustion engines and the like, means for maintaining the density of air flowing through a conduit, and subject to temperature and pressure variations, substantially constant at a preselected value comprising, an air density responsive device subject to the pressure and temperature of the air in said conduit including an air temperature and pressure responsive element, and an element subject to the temperature of the air in said conduit for compensating the pressure and temperature responsive element for the density variance from said preselected value incident to temperature changes and means controlled by said device to control flow through the conduit at a point upstream of the device and element.

3. In a carburetor intake, or the like, in which air is subject to pressure and temperature changes and whose density is to be maintained constant, means controlling the air pressure in said intake, a device having a pressure and temperature responsive element subject to the temperature and pressure of the air in said intake downstream of said means, and a temperature responsive element subject to the temperature of the air in said intake downstream of said means, and having means connecting said elements to proportion the effects of the air pressure and air temperature on said elements so that said device moves responsively in proportion to changes in density of said air, means operatively connecting said pressure controlling means and said device to control said air density by air pressure changes only.

4. An engine air intake system or the like including a conduit conducting a stream of air subject at its inlet to pressure and temperature changes and whose density is to be maintained at a preselected value, mechanism subject to the pressure of said air and responsive to changes in said pressure, an element subject to the temperature of said air and responsive to changes in said temperature and connected with said mechanism to modify the movements of said mechanism whereby the density is measured and compared with a selected standard, means controlled by said mechanism to vary flow through the conduit at a point upstream of the device and element when departures from the selected standard are measured.

5. In a carburetor intake or the like having a conduit conducting a stream of air subject to pressure and temperature variations and whose density is to be maintained substantially constant, means for controlling the pressure of said air, and a density regulating device responsive to both pressure and temperature variations and subject to the temperature and pressure of said air downstream of said pressure controlling means and means operatively connecting said pressure controlling means and said density regulating device operative upon a density changing variation in the temperature of said air to move said controlling means and change the pressure of said air to compensate for the temperature variation and maintain the density of the air.

6. Means for maintaining the density of air flowing through a conduit in an air density control system for internal combustion engines and the like, and subject to temperature and pressure variations substantially at a preselected value comprising a device having a part movable in accordance with changes in the density of said air

including a variable volume container subject to the air temperatures and pressures within said conduit, and sealed with gas contained therein, a thermostatic element subject to the temperature of the air in said conduit operatively connected with said container to exert a force thereon to correct the deviation of the setting of said device from said selected density due to temperature changes and means controlled by said device to regulate the density of said air by controlling the flow through the conduit at a point upstream of the container and element.

7. In combination with an air supply conduit for a carburetor intake or the like, means for maintaining the density of the air in said conduit at a preselected value under conditions of variable air pressure and temperature in said conduit by controlling one of said variables comprising, an expansible chamber temperature and pressure responsive element subject to the pressure and temperature of the air in said conduit, a temperature responsive element subject to the temperature of the air in said conduit and having a connection with said expansible chamber element to automatically reset said device to maintain said preselected density when there is a temperature change in said air, means for controlling said one variable upstream of said elements and means operatively connecting said expansible chamber element and said controlling means to control the density of said air by changes in said one variable only.

8. In combination with an engine carburetor and an air intake therefor, means for maintaining the density of the intake air substantially constant at a preselected value comprising, an expansible chamber temperature and pressure responsive element subject to the pressure and temperature of the air in said intake, a temperature responsive element subject to the temperature of the air in said intake having a leverage connection with said expansible chamber element to automatically reset said device to maintain said above preselected density when there is a temperature change in the intake air, a servo mechanism actuated by said expansible chamber element and a valve in the air intake actuated by said servo-mechanism to regulate the density of said intake air.

9. Means for maintaining the density of air flowing through a conduit in an air density control system for internal combustion engines and the like, and subject to temperature and pressure variations, substantially at a preselected value comprising, an air density responsive device subject to the pressure and temperature of the air in said conduit including an air temperature and pressure responsive element, and an element subject to the temperature of the air in said conduit for compensating the density variance incident to temperature changes, and means actuated by said device to control the air temperature upstream of said device and element for maintaining the density of said air.

10. Means for maintaining the density of air flowing through a carburetor intake or the like and subject to temperature and pressure variations substantially at a preselected value comprising a device having a part movable in accordance with changes in the density of said air including an air temperature and pressure responsive element subject to the temperature and pressure of said air and a thermostatic element subject to the temperature of said air and connected with said temperature and pressure element to correlate the effect of temperature and pressure factors of said air on said device so that said part always returns to the same position when said air returns to said preselected density value, a source of heat connected with said intake and a valve actuated by said device and controlling the flow of heat from said source to regulate the density of the air by varying its temperature when said part is moved from said same position by a change in the density of said air due to a change in either the temperature or pressure thereof.

11. In combination with a carburetor and an intake air duct therefor, a cold air inlet to said duct, a heated air inlet to said duct, a valve controlling said inlets to regulate the temperature of the air in said duct, a valve arranged to regulate the pressure of the air in said duct, a device having elements subject to the temperature and pressure of the air in said duct and responsive to changes in said temperature and pressure and having means to proportion the effects of the air pressure and air temperature on said elements so that a portion of said device moves in accordance with changes in density of said air, mechanism controlled by said portion operatively connected with said temperature regulating valve to operate the same and a device responsive to the air pressure in said duct for operating said pressure regulating valve.

12. In combination with a carburetor and an intake air duct therefor, a cold air inlet to said duct, a heated air inlet to said duct, a valve controlling said inlets to regulate the temperature of the air in said duct, a valve arranged to regulate the pressure of the air in said duct, a device, having both temperature and pressure responsive elements subject to the temperature and pressure of the air in said duct, operatively connected with said pressure regulating valve for operating the same in response to departure from a selected air density in said air caused by either pressure or temperature changes as determined by said device, and a device responsive to the temperature of the air in said portion of the duct for operating said temperature regulating valve.

13. In combination with a carburetor and an intake air duct therefor, a cold air inlet to said duct, a heated air inlet to said duct, a valve controlling said inlets to regulate the temperature of the air in said duct, a valve for regulating the pressure of the air in said duct, a device movable in accordance with changes in the density of the air in the portion of said duct downstream of said valves from said inlet operatively connected with one of said valves for operating the same, and a device responsive to the component of said air density controlled by the other valve operatively connected with the other valve for operating the same, said density responsive device comprising, an element subject to the temperature and pressure of said air and operative to vary its volume in response to variations in the air pressure in said portion of the duct, an element subject to the temperature of said air and responsive to the temperature of the air in said duct operative to modify the variation in the volume of said first mentioned element, and a fluid motor actuated by the variation in the volume of said first mentioned element to operate said one valve.

14. In combination with a carburetor and an intake air duct therefor, a cold air inlet to said duct, a heated air inlet to said duct, a valve for

controlling said inlets to regulate the temperature of the air in said duct, a valve for regulating the pressure of the air in said duct, a device responsive to the density of the air in the portion of said duct past said valves from said inlet for operating said pressure regulating valve, and a device responsive to the temperature of the air in the duct for operating said temperature regulating valve, said density responsive device comprising, an element operative to vary its volume in response to variations in the air pressure in said portion of said duct, an element responsive to the temperature of the air in said duct operative to modify the variations in the volume of said first mentioned element, and a motor actuated by the variations in the volume of said first mentioned element to operate said pressure regulating valve.

15. Means for maintaining the density of air flowing through a carburetor intake or the like, and subject to the temperature and pressure variations, substantially constant at a preselected value comprising, an air density responsive device subject to the pressure and temperature of the air in said intake including an air temperature and pressure responsive element, and an element subject to the temperature of the air in said intake and operatively connected with said air temperature and pressure responsive element for compensating said temperature and pressure responsive element for the density variance from said preselected value incident to temperature changes and means controlled by said device to control flow through the intake at a point upstream of the device and element and means for adjusting said density maintaining device to select the density to be maintained including means for changing the relation between said pressure and temperature responsive element and said compensating element.

16. Means for maintaining the density of air flowing through a conduit of an air density control system for internal combustion engines and the like, and subject to temperature and pressure variations, substantially constant at a preselected value comprising, an air density responsive device subject to the pressure and temperature of the air in said conduit including an air temperature and pressure responsive element, and an element subject to the temperature of the air in said conduit and operatively connected with said air temperature and pressure responsive element for compensating said temperature and pressure responsive element for the density variance from said preselected value incident to temperature changes and means actuated by said device to control the air temperature upstream of said device and element for maintaining the density of said air and means for adjusting said density maintaining device to select the density to be maintained including means for changing the relation between said pressure and temperature responsive element and said compensating element.

17. In combination with an engine carburetor and an air supply conduit therefor, means for maintaining the density of the air in said conduit substantially constant at a preselected value comprising, a device having a member movable upon changes in the density of said air including an expansible chamber temperature and pressure responsive element subject to the temperature and pressure of the air in said conduit, a temperature responsive element subject to the temperature and pressure of the air in said conduit having a variable leverage connection with said expansible chamber element to correct the deviation from said preselected density when there is a temperature change, means upstream of said device controlled by said device to change the value of a physical property of said air and return the density of said air to said preselected value, means for adjusting said density maintaining device to select the density to be maintained including means for varying the leverage of said variable leverage connection, and means for holding said adjusting means in adjusted position.

18. In combination with an air intake, means for maintaining the density of the intake air substantially constant at any selected density within a predetermined density range comprising a device, including an expansible chamber pressure and temperature responsive element subject to the pressure and temperature of said intake air and a temperature responsive element subject to the temperature of said intake air and having a leverage connection with said expansible chamber element to apply a force to said expansible chamber element to correct the deviation from said selected density to which the device would otherwise be subject when there is a temperature change, means controlled by movements of the expansible chamber element of said device to change the density of said intake air to return it to the selected value upon a density varying change in said air, and means for adjusting said device to select the desired density to be maintained including means for changing the ratio of the leverage connection between the expansible chamber element and the temperature element.

19. Means for regulating the density of fluid flowing through a fluid conduit comprising, a density controlling device in said conduit and a density detecting device subject to the temperature and pressure of the fluid in said conduit downstream of said controlling device operatively connected with said density controlling device, said density detecting device comprising, an expansible chamber element containing fluid subject to said temperature and pressure of the fluid in said conduit, means exerting a force supplementing the fluid pressure outside of said element for maintaining the volume of said expansible element substantially constant to maintain the density of the fluid therein at a substantially constant value, means movable by said expansible chamber element upon an unbalance of the forces exerted by and upon said expansible element controlling the operation of said density control device, means for adjusting said constant volume maintaining means to vary the proportion of force exerted by said means to force exerted by external fluid pressure to establish in said conduit a selected density within a predetermined density range, and a temperature responsive element having a connection with said expansible chamber element adjustable with said volume maintaining means for exerting a force on said expansible chamber means to compensate the operation of said expansible element for the variation in the effect of temperature changes in said flowing fluid when said constant volume maintaining means is in an adjusted position to maintain a density within said conduit different from the density maintained in said expansible element.

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