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CHARGE FORMING DEVICE

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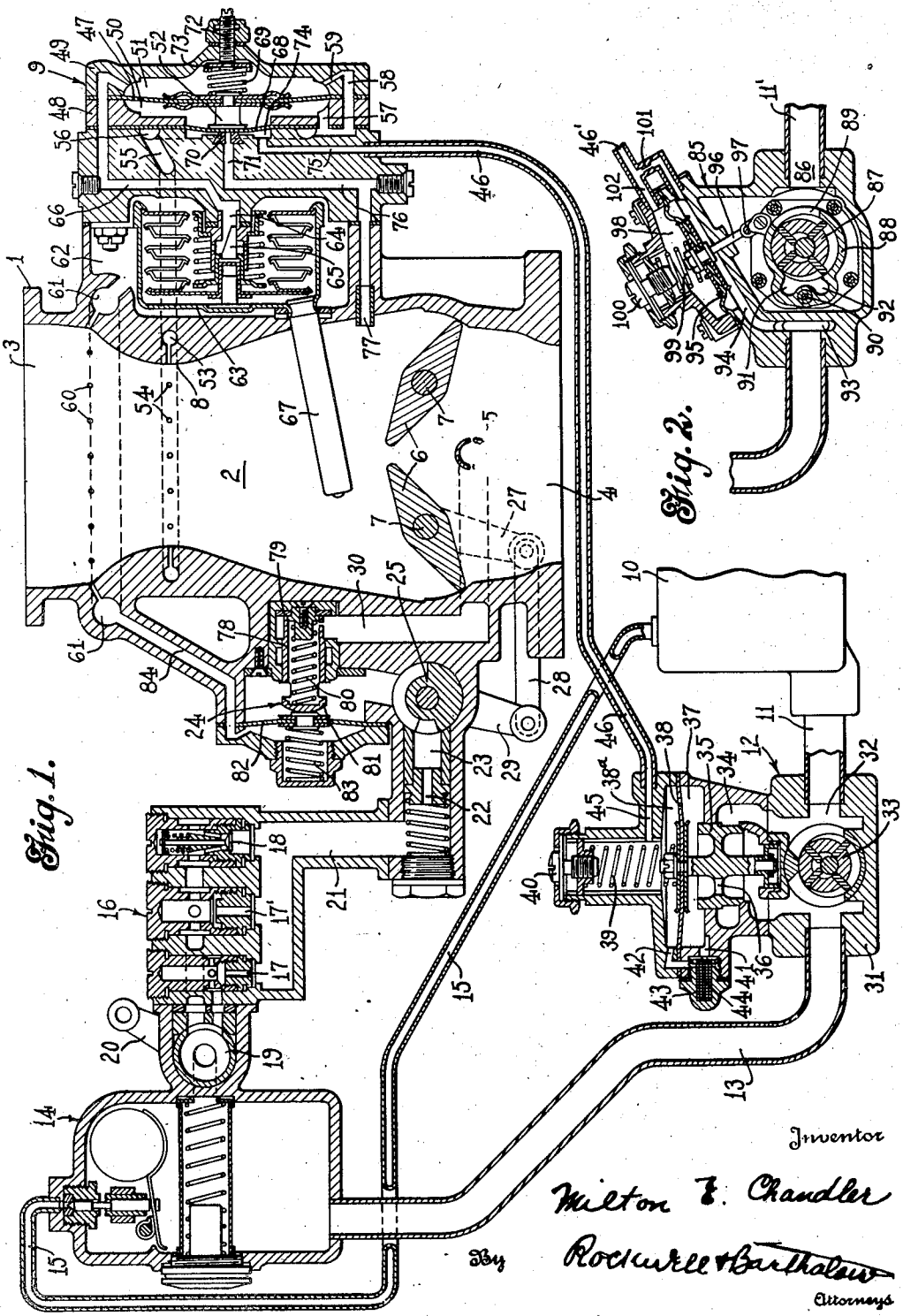


Fig. 1.

Fig. 2.

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CHARGE FORMING DEVICE

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Continuation of application Serial No. 361,239, October 15, 1940. This application February 4, 1943, Serial No. 474,736

7 Claims. (Cl. 261—27)

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This application is a continuation of my application Serial No. 361,239, filed October 15, 1940.

This invention relates to charge forming devices, and while not limited thereto, it has particular reference to carburetors for aircraft engines.

One of the objects of the invention is to provide an improved fuel and air proportioning device for an internal combustion engine.

Another object is to provide an improved device applicable to aircraft carburetors for supplying fuel to the manifold in a manner to compensate for fluctuations in the weight and other characteristics of air supplied to the engine under different operating conditions.

In the accompanying drawing:

Fig. 1 is a somewhat diagrammatic sectional view showing an aircraft carburetor provided with a charge forming device embodying my invention; and

Fig. 2 is a fragmentary sectional view illustrating a modified form of the apparatus.

In the drawing, a carburetor body or casing is shown at 1, the same having an air intake passage 2 extending therethrough provided at one end with an enlarged inlet or scoop 3 and at the opposite end having a portion 4 adapted to communicate with an adjacent part (not shown) of the manifold structure. Located in the main air passage adjacent the end portion 4 is a fuel supply jet or nozzle 5, and upstream from nozzle 5 is a pair of throttle bars or flaps 6 adapted to be turned by means of shafts 7 fixed thereto, said shafts extending completely across the passage.

In the passage, somewhat below the scoop portion 3 (Fig. 1), is a restricted throat or Venturi portion 8. A control device located at the right-hand side of the carburetor and generally indicated at 9 is actuated by variation in the pressure differentials between the scoop 3 and the throat 8, in a manner to be hereinafter described.

The liquid fuel supplied to the nozzle or jet 5 is derived from a fuel tank 10 delivering fuel through a pipe 11 to a fuel pump 12, whence fuel is pumped through a pipe 13 to a vapor trap and filter device 14, and a return pipe 15 leads from device 14 back to tank 10 in order to return to the tank vapor rising to the upper part of device 14. The fuel passing from device 14 passes to a manually adjustable fuel controlling valve 16 having parallel fixed orifices 17 and 17' and a parallel spring-loaded power jet 18. The manual control of the valve 16 is provided by a rotary distributing valve 19 upstream from the orifice 17 and movable by an arm 20 fixed thereto, which

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arm is shiftable by the pilot through connections which it is not necessary to illustrate. From valve 16 the fuel passes through a pipe 21 to a main metering orifice or restriction 22, which, in this instance, is located in the left-hand wall structure of the carburetor part of the manifold. From orifice 22 fuel passes through a passage 23 to a pressure control valve 24 which maintains a minimum pressure in the main fuel conduit, passage 23 being provided intermediate restriction 22 and valve 24 with a rotary controlling valve 25. The valve 25 is turned whenever the throttles 6 are moved, and for this purpose an arm 27, rigid with one of the throttle shafts 7, is connected by means such as a link 28 to an arm 29 rigidly fixed to valve 25. From pressure-controlling valve 24 the fuel passes through a passage 30 which leads to the fuel bar 5.

The fuel pump 12, illustrated in Fig. 1, is a constant pressure pump including in its structure a casing 31 having a chamber 32 in which a rotor 33 is disposed. In the upper part of the pump casing a by-pass 34 is arranged leading back from the discharge side to the inlet side, and this by-pass is opened and closed by a vertically sliding valve 35 which, in the position of Fig. 1, that is to say, its lowermost position, closes the by-pass. The valve 35 is provided with one or more ports 36 establishing communication between the pump chamber and a chamber 37 adjacent the under part of a diaphragm 38 attached to the valve 35, the up and down movement of the diaphragm being effective to raise and lower the valve. Above the diaphragm 38 in a chamber 38a is a coiled spring 39 acting on the diaphragm, which spring biases the valve toward a closed position. The spring 39 is a compression spring and the degree of its compression can be adjusted by means such as an adjusting screw 40 having a nicked head accessible at the exterior of the pump casing.

Fuel at the under side of the diaphragm 38 can pass to the chamber 38a above the diaphragm through a bleed or restriction which, in this particular case, includes a small passage 41 below the diaphragm, a small passage 42 above the diaphragm, and an intermediate or connecting passage 43 of somewhat larger diameter, which last passage, in this particular case, is provided with a screen 44.

Fuel passing from the under side of the diaphragm 38 to the upper side can pass out of the casing by way of a passage 45 to which is connected a pipe 46 (of relatively small cross section compared to the main fuel conduit) constituting a portion of a branch conduit, said pipe

46 leading, as hereinafter described, to a discharge nozzle or vent port which, in this particular case, is located in the main air passage 2.

The control device 9 which is affected by changes in the amount of air entering the main air passage is preferably of the diaphragm type and comprises a diaphragm 47 clamped between an inner member 48 and an outer member 49 so as to provide a chamber 50 at the left-hand side of the diaphragm and a chamber 51 at the right-hand side. Secured to the central portion of the diaphragm within the chamber 50 is a valve body 52, which valve body, as hereinafter described, is a part of a pilot valve mechanism which controls the venting of fuel from the branch conduit of which the pipe 46 is a part, and thereby the position of valve 35.

From the Venturi or throat portion 8 of the main passage, a controlling air pressure connection is made in a suitable manner to the chamber 50, and in the particular form shown, this includes a passage 53 at the throat having small suction openings 54. From passage 53 a passage 55 is extended to an annular passage 56, and passage 56 communicates with a short passage 57 leading to chamber 50, and annular passage 56 also leads to a restricted passage or bleed 58 having a restricted end portion 59 leading into the chamber 51.

In the scoop portion 3 are small pressure inlets 60 to a passage 61 extending around the air passage. This passage 61 communicates with a chamber 62 in the right-hand wall structure of the carburetor, and in the chamber 62 is an aneroid device 63 of usual structure around which air can circulate, having its interior passage 64 controlled by a valve 65 and in communication with a passage 66 leading upwardly and then laterally and then downwardly, as shown in Fig. 1, so as to communicate with the chamber 51 at the right-hand side of the diaphragm 47. A temperature bulb 67 associated with the aneroid device 63 projects into the main air passage of the carburetor somewhat upstream of the throttle bars.

Reverting to the valve 52 carried by diaphragm 47, it will be seen that this valve is adapted to make contact at its left-hand end with, and to be controlled by, a diaphragm 68 which is marginally clamped between suitable members in such a manner that said diaphragm 68 provides a portion of the left-hand wall of chamber 50. A biasing spring 69, which may be a coil spring and which is located in chamber 51, acts on diaphragm 47 so as normally to hold valve 52 against diaphragm 68 and diaphragm 68 in turn against a valve seat 70 controlling a passage 71 which is adapted to vent the branch fuel pipe 46 in a suitable manner. Spring 69 is a compression spring, and the degree of its compression can be controlled by suitable means such as an exteriorly accessible adjusting screw 72 connected to a cup 73 receiving the right-hand end of the spring.

The valve seat 70 is at the exit of a small chamber 74 at the left-hand side of the secondary diaphragm 68. The pipe 46 is in communication with a passage 75 in the carburetor wall, which passage leads to the small chamber 74, and if fuel can pass through chamber 74 and valve seat 70, it will flow into a passage 76. In the particular form shown, the passage 76 is arranged to conduct any vented fuel to the main passage of the carburetor upstream of the throttles, and for this purpose passage 76 leads to a small nozzle or tube 77 which projects into the main passage to a slight extent.

As above stated, the valve 24 serves to maintain a minimum pressure in the fuel conduit downstream of the metering restriction 22. In the form shown, it comprises essentially a sliding hollow sleeve 78 having the right-hand end open and adapted to abut a valve seat 79 in order to prevent fuel from moving into passage 30. When open, the open end of the sleeve is spaced away from the seat 79 so as to permit flow of fuel into passage 30. This valve has an interior spring 80 controlling its position, said spring being confined at the left-hand end by a button 81. The button 81 is adapted to be impinged upon by a diaphragm 82 biased toward the right by a spring 83 and also subject to scoop pressure. The scoop pressure is transmitted to the left-hand side of diaphragm 82 by a passage 84 leading from the passage 61. Thus, the scoop pressure tends to hold the valve closed, and in order to open it a predetermined pressure of fuel has to be built up in that portion of the fuel conduit upstream of the valve.

In the operation of the device, fuel is supplied by pump 12 to the main fuel conduit and the main metering restriction 22 in said conduit. A certain amount of the fuel on the delivery side of the pump passes through the valve 35 into the chamber beneath diaphragm 38 and bleeds around this diaphragm into the upper chamber 38a, and thence to the branch conduit. If valve 52 is in the open position, fuel passes through the branch conduit or auxiliary hydraulic connection 46, 74, 70, 71, 76, 77, into the manifold. Spring 39 normally holds the valve 35 in the closed position, but upon excess pressure being developed at the discharge side of the pump, the valve can rise under some conditions in order to permit fuel to pass back to the inlet side of the pump.

Assuming that the engine is in operation at a relatively high speed, in which case there will be a considerable pressure differential between the scoop and throat portions of the air passage, and the throttles are moved toward the closed position so as to reduce the speed, the pressure differential between scoop and throat will be reduced, and assuming that when the engine is at high speed the valve 52 is closed, the change of speed will be effective to open the valve. With the valve 52 closed, thereby closing the branch conduit intermediate of its ends, a certain amount of hydraulic pressure will have been built up in the conduit and in the chamber above the diaphragm 38, assisting the action of the spring 39, which biases the valve 35 toward the closed position, and the valve 35 will be closed. The opening of the valve 52 will be effective to enable fuel to pass freely out of the branch conduit, which will reduce the pressure above the diaphragm 38 and enable the pressure below said diaphragm to raise the diaphragm and valve 35, moving the valve toward the open position so that fuel is bypassed back to the inlet side of the pump, with the result that the delivery of fuel from the pump to the restriction 22 is decreased. Thus it will be seen that as the air supply to the manifold is decreased the fuel supply to the manifold (or to some other desired location) is correspondingly decreased. In the operation of venting surplus fuel from the branch connection, this relatively small quantity of fuel may be carried into the manifold, as above described, although this is merely by way of example, and other arrange-

ments can be provided in that respect. Assuming now that the speed of the engine is again increased, the resulting increase of air pressure differential in the air passage will cause the valve 52 to be closed again, thereby closing the branch conduit intermediate of its ends and causing pressure to be built up again in that portion which is on the fuel-receiving side of the valve seat 70. As pressure builds up in the branch conduit, it causes pressure to be built up above the diaphragm of the device controlling the effective output of the pump, thereby causing the by-pass valve 35 to be closed, and thus supplying more fuel to the main conduit, as is desirable under these conditions. With a regulating device of the type above described, the result of the building up of pressure in the chamber above the diaphragm is to close down the by-pass valve of the pump so that the pump cannot act in the normal manner but on the other hand, by the elimination of the by-pass action, provides increased discharge pressure and an increased supply of fuel to the fixed metering orifice.

It is also to be understood that, with the throttle in any given setting during engine operation, the valve 52 will have movement from time to time as conditions of air pressure, air density, temperature, etc., vary, so as to cause corresponding compensating movements of the regulating valve which is effective in regulating the amount of fuel supplied by the pump to the main metering orifice.

It is important to note that the spring 39 of the regulating device has the function of acting upon and controlling the position of the regulating valve throughout the entire range of engine operation, said spring throughout said range biasing said valve to a closed position in this particular case. The pressure of the fuel under the diaphragm 37 acts upwardly, opposing the action of this spring throughout the range of engine operation. The pressure of the fuel above the diaphragm, being less than the fuel pressure beneath the diaphragm, act downwardly assisting this spring throughout the range of engine operation. The fuel at the upper part of the diaphragm can pass out of the casing of the regulating device to a discharge, which is provided in this particular case by the pipe 46 and its associated connections, and by building up the pressure of the discharge through the closing of the discharge or vent connection, the position of the regulating valve can be changed in accordance with the varying air supply to the engine. The regulating valve is, of course, moved in the closing direction at any point in the range of engine operation when, the branch connection being closed by the air-supply-controlled valve 52, the pressure above the diaphragm is increased to a point where it, conjointly with the action of the spring 39, will overcome the pressure on the under side of the diaphragm.

In the modified form of the apparatus shown in Fig. 2, the system is the same as above described, but the regulating device for controlling the supply of fuel from the pump to the fixed metering orifice is of a different kind. Here the pump casing is indicated at 85, the same having an inlet 86 from a fuel tank connection 11'. Within the pump casing is an impeller 87 having in association therewith an enclosing pivoted liner 88 provided at the inlet side of the pump with an inlet port 89. This pump, as illustrated, is of the variable capacity construction described and claimed in United States Patent No. 2,318,337, issued to Arthur G. Schlosser, on May 4, 1943. The liner 88 is pivoted in the casing at 90, and the construction is such that, as the liner is swung upwardly from the position shown in Fig. 2, the amount of fuel being discharged by the pump is decreased, whereas when the liner is swung downwardly again the amount of pump discharge will be increased, this being due to the change in capacity of the passage carrying liquid from the inlet to the outlet. Within the liner at the discharge side thereof are passages 91, 92 leading around to and in free communication with a narrow chamber 93 arranged in the pump casing at the discharge side, and the chamber 93 is in free communication with a chamber 94 arranged at an angle to the horizontal in the upper part of the pump casing structure. The chamber 94 is located beneath a diaphragm 95 connected to a rod 96 pivoted at its lower end 97 to the liner 88 so as to be capable of swinging the liner up and down. Above the diaphragm 95 is a chamber 98. Within the chamber 98 is a coil spring 99 adjustable by a screw 100, said spring acting against the diaphragm in such a manner as to bias the rod 96 in a direction to hold the liner in its lowermost position. From the chamber 94 a bleed 101 leads upwardly to provide communication with the space above the diaphragm, said bleed 101 communicating with a passage 102 leading into the upper chamber at one side of the latter. The passage 102 is not only in communication with the space beneath the diaphragm, but also in this instance connects directly with a pipe 46' which corresponds to pipe 46 previously described, and is opened and closed by an air-supply-controlled valve in the manner previously described.

In operation this form of regulating device for regulating the amount of fuel discharged by the pump acts in substantially the same manner as the regulating device of Fig. 1.

By my improvements a very effective and positive control of the proportioning of fuel and air is provided, the control being quite sensitive and at the same time reliable in operation. A very definite advantage arises from the fact that the pressure resulting from differences of air pressure in the scoop and throat, respectively, is not employed by connecting it directly by mechanical means to a heavy device or member requiring shifting for affording control of the metering of the fuel. In the improved apparatus, on the other hand, the relatively small pressure resulting from the differences of pressure in the scoop and throat, respectively, is used only indirectly for effecting the metering of the fuel, and in this operation, as appears from the above description, the fuel pressure, which is always considerably greater than the air pressure developed by the air pressure differentials, is made use of to build up in the branch connection from the main fuel conduit a hydraulic controlling pressure which is substantial in amount and can be used for controlling purposes effectively and with comparative ease. As the fuel metering mechanism is, to a large extent, controlled by the relatively large forces of fuel pressure as distinguished from air intake pressure differential, the tendency toward inaccuracy of fuel metering is very materially reduced. This large metering force also makes it possible to use very small valves for actuating the regulating device in place of relatively large diaphragms that have to be used when the metering force is small.

A further definite advantage arises from the

relative simplicity of the apparatus and from the ready accessibility of the different parts for adjustments and repairs if and when these are necessary. A simple fuel-regulating valve structure is employed, the valve being shifted directly by increases and decreases of pressure in a hydraulic controlling passage which is a branch of the main fuel conduit, the valve structure actuated by variations of pressure in the air intake acting in the nature of a relay controlling the building up of pressure in the branch hydraulic connection, and the pressure in said connection acting directly on the fuel-regulating device. If repairs to the fuel-regulating valve structure on the one hand or to the air-supply-controlled valve device on the other hand are necessary, each can be manipulated independently of the other, and of course it is possible to place these devices at various locations relatively to each other and to the carburetor body, so that the apparatus can be assembled and installed to a large degree in accordance with the dictates of convenience, saving of space, etc. In some cases the fuel can be supplied to the engine in other locations than within the carburetor structure.

While two embodiments of the invention are shown and described, it will be apparent that the invention is susceptible of numerous other embodiments, and that various changes in the organization of parts and in the details can be made without departing from the principles of the invention or the scope of the claims.

What I claim is:

1. In a carburetor, means providing an air inlet passage, means therein producing a differential of air pressures varying as a function of air flow, a fuel pump, regulating means to vary the effective output of said pump, a main fuel conduit extending from the pump to a discharge nozzle in the air passage, a pressure control valve in the conduit to maintain a minimum pressure in said conduit, a metering restriction in said conduit, mechanism for varying the fuel pressure on said restriction comprising a restricted fuel by-pass conduit extending from said main conduit to an auxiliary discharge port in the air passage, means subjected to the differential air pressures to control the fuel flow from said by-pass conduit and to thereby maintain back pressure proportional to said differential of air pressures, and fluid pressure responsive means subjected respectively to the pressures in said main conduit and said by-pass conduit connected to operate said pump regulating means whereby to maintain the fuel flow through said main conduit proportional to the measured air flow.

2. A carburetor for an internal combustion engine, comprising in combination, a first conduit for conveying air for combustion purposes to said engine, means in said first conduit for producing therein a differential of air pressures which varies over a predetermined range as a function of the quantity of air flowing thru said conduit, means for supplying fuel under superatmospheric pressure, a second conduit for conveying fuel from said fuel supply means to said engine, a metering restriction in said second conduit effective to control the flow of fuel therethru as a function of the fuel pressure differential thereacross, said restriction being so proportioned that said fuel pressure differential must vary over a range greater than the range of said air pressure differential in order to maintain fuel flow proportional to air flow, first valve means for controlling the fuel flow thru said second

conduit, a third conduit supplied with fluid fuel from said source and including a restriction, an expansible chamber forming a part of said third conduit and having a movable wall subject on its opposite side to the pressure in said second conduit, said wall being operatively connected to said first valve means for positioning the same, pressure multiplying means for controlling the pressure in said chamber, said pressure multiplying means including second valve means for controlling the discharge of fluid from said third conduit, and means responsive to said differential of air pressures for operating said second valve means.

3. In a fuel and air proportioning device for an internal combustion engine, means providing an air intake passage, means in association with said passage for setting up a differential of air pressures varying as a function of air flow, a control device connected to said last-named means comprising a first diaphagm movable by variations in said differential of air pressures and a valve operated by said diaphragm, a fuel-carrying branch conduit having means cooperating with said valve whereby said branch conduit is opened and closed, a fuel pump, regulating means to vary the effective output of said fuel pump comprising an expansible chamber connected to said branch conduit and having a unitary wall structure movable in a direction to expand said chamber under the influence of the back pressure of fuel therein created by the closing of said branch conduit, a spring acting on said unitary wall structure and constantly biasing it in a direction to assist such back pressure, the other side of said unitary wall structure being subject to the pressure of the fuel being discharged by the pump, a main fuel conduit extending from the pump to a discharge nozzle in the air passage, a metering restriction in the main conduit, and a pressure control valve in the main conduit intermediate the metering restriction and said discharge nozzle.

4. In a fuel and air proportioning device for an internal combustion engine, means providing an air intake passage, means in association with said passage for setting up a differential of air pressures varying as a function of air flow, a control device connected to said last-named means comprising a first diaphragm movable by variation of said differential of air pressures and a valve operable by said diaphragm, a fuel-carrying branch conduit arranged to be opened and closed by said valve as the air pressures vary, a regulating device for the fuel supply including a pair of expansible chambers separated by a movable unitary wall structure, one of said chambers being connected to said branch conduit so that on the closing of said branch conduit by said valve back pressure of fuel is built up on one side of said wall structure, a fuel pump, a main conduit leading from said pump to a discharge nozzle in the air passage, means for subjecting the chamber on the other side of said wall structure to the pressure of fuel being delivered by the pump, a metering restriction in said main conduit, and a pressure control valve in the main conduit intermediate the metering restriction and the discharge nozzle to maintain a minimum pressure in the conduit.

5. A fuel and air proportioning device for an internal combustion engine, comprising a first conduit for conveying air for combustion purposes to said engine, means associated with said first conduit for producing two unequal air pres-

sures whose difference varies over a predetermined range as a function of the quantity of air flowing thru said conduit, means for supplying fuel under superatmospheric pressure, a second conduit for conveying fuel from said fuel supply means to said engine, a fixed metering restriction in said second conduit effective to control the flow of fuel therethru as a function of the fuel pressure differential thereacross, said restriction being so proportioned with respect to said air differential pressure producing means that said fuel pressure differential must vary over a range greater than the range of said air pressure differential in order to maintain fuel flow proportional to air flow, a passage connected in parallel with said restriction, a valve in said passage opening in the direction of fuel flow therethru, means biasing said valve toward its closed position, said valve being operable to open position against the action of said biasing means in response to an increase in said fuel pressure differential above a predetermined value by virtue of the pressure differential acting directly on the valve itself, and means responsive to said air pressure differential for controlling said fuel pressure differential and effective in response to each increment of air pressure differential to produce a greater increment of fuel pressure differential, said last-named means including a valve for controlling the pressure on one side of said restriction, three expansible chambers, first flexible diaphragm means separating two of said chambers, means for supplying said two chambers with air at said two unequal pressures, means for supplying the third of said chambers with fuel at a pressure indicative of the pressure on said one side of said restriction, second diaphragm means of smaller area than said first diaphragm means and subject to the pressure in said third chamber, the difference of said diaphragm areas being effective to permit a small increment of said air pressure differential to balance a larger increment of said fuel pressure, and means operatively connecting both said diaphragm means to said valve so that an increase in the difference of said two air pressures causes a fuel flow increasing movement of said valve and a variation in the fuel pressure in said third chamber in a sense indicative of an increased flow thru said restriction causes a fuel flow decreasing movement of said valve.

6. A carburetor for an internal combustion engine, comprising a first conduit for conveying air for combustion purposes to said engine, means associated with said first conduit for producing two unequal air pressures whose difference varies over a predetermined range as a function of the quantity of air flowing thru said conduit, an auxiliary control device to be operated in accordance with the load on said engine, means for supplying fuel under superatmospheric pressure, a second conduit for conveying fuel from said fuel supply means to said engine, a fixed metering restriction in said second conduit effective to control the flow of fuel therethru as a function of the fuel pressure differential thereacross, said restriction being so proportioned with respect to said air differential pressure producing means that said fuel pressure differential must vary over a range greater than the range of said air pressure differential in order to maintain fuel flow proportional to air flow, a differential pressure responsive member associated with said control device and subject to said fuel pressure differential, and means responsive to said air pressure differential for controlling said fuel pressure differential and effective in response to each increment of air pressure differential to produce a greater increment of fuel pressure differential, said last-named means including a main valve in said fuel conduit for regulating the pressure on one side of said restriction, a diaphragm for operating said main valve, an expansible chamber on the opposite side of said diaphragm from said main valve, a first restricted passage connecting said chamber to said second conduit at a point therein where the pressure is regulated by said main valve, a second restricted passage controlling the flow of fuel from said chamber, pilot valve means for controlling one of said restricted passages, and means responsive to the difference of said air pressures for operating said pilot valve means, said pilot valve means and said chamber being effective in response to a small increment of said air pressure differential to operate said main valve to produce a larger increment of said regulated fuel pressure.

7. A fuel and air proportioning device for an internal combustion engine, comprising in combination, a first conduit for conveying air for combustion purposes to said engine, means associated with said first conduit for producing two unequal pressures whose difference is a measure of the rate of flow of air thru said conduit, means for supplying fuel under superatmospheric pressure, a second conduit for conveying fuel from said fuel supply means to said engine, a metering restriction in said second conduit effective to control the flow of fuel therethru as a function of the fuel pressure differential thereacross, a main valve for regulating the pressure in said second conduit on one side of said restriction, an expansible chamber having a movable wall subject to the pressure in said chamber acting thereon in one direction and to the regulated fuel pressure in said second conduit on said one side of said restriction acting thereon in the opposite direction, said wall being operatively connected to said main valve for positioning the same, a restricted inlet passage connecting said chamber to said second conduit at a point therein where the pressure is regulated by said main valve, a restricted outlet passage connecting the interior of said chamber to a point maintained at a lower pressure, pilot valve means for controlling one of said restricted passages, and means responsive to the difference of said air pressures for operating said pilot valve means.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,909,469	Hubbard	May 16, 1933
2,002,483	Kimball	May 21, 1935
2,165,447	Browne	July 11, 1939
2,224,472	Chandler	Dec. 10, 1940
2,264,347	Udale	Dec. 2, 1941
2,281,411	Campbell	Apr. 28, 1942
2,316,300	Udale	Apr. 13, 1943
2,330,650	Weiche	Sept. 28, 1943

FOREIGN PATENTS

Number	Country	Date
367,310	Italian	Apr. 15, 1938
523,895	British	July 25, 1940
846,774	French	Sept. 26, 1939