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2,232,392

AIRPLANE CARBURETOR

Filed Oct. 24, 1936

4 Sheets-Sheet 1

Fig. 1.

Fig. 7.

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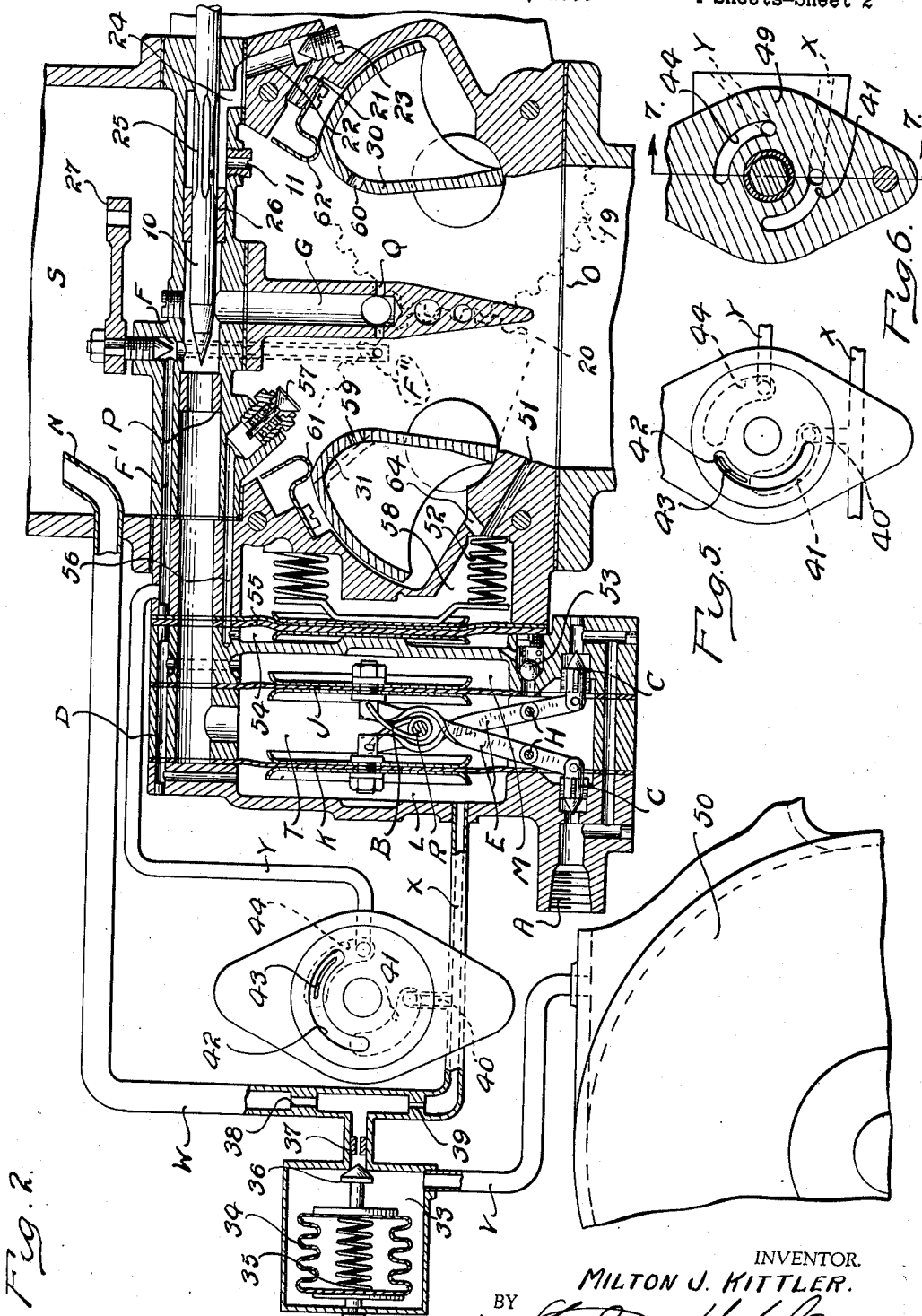
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4 Sheets-Sheet 2



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AIRPLANE CARBURETOR

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4 Sheets-Sheet 3

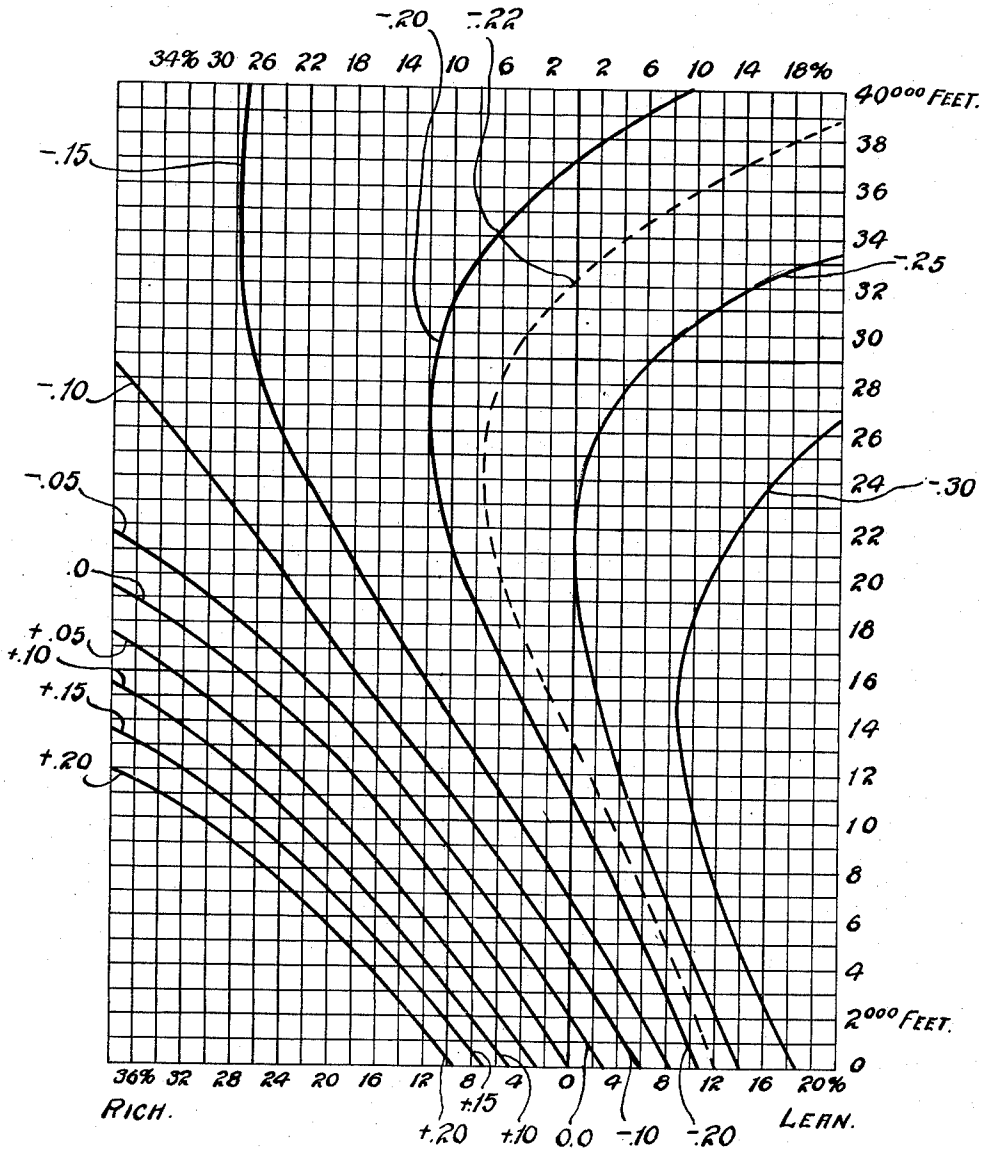


Fig. 3.

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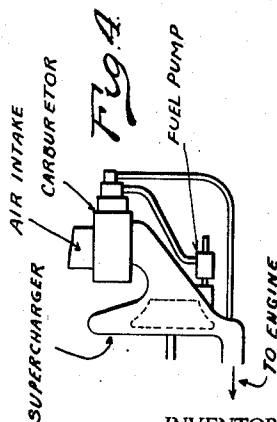
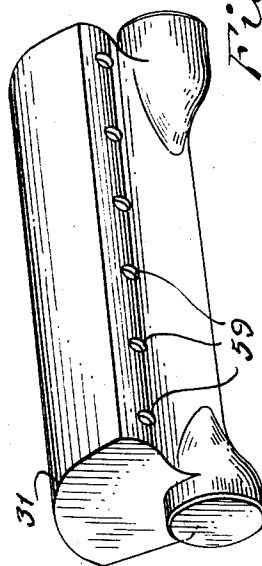
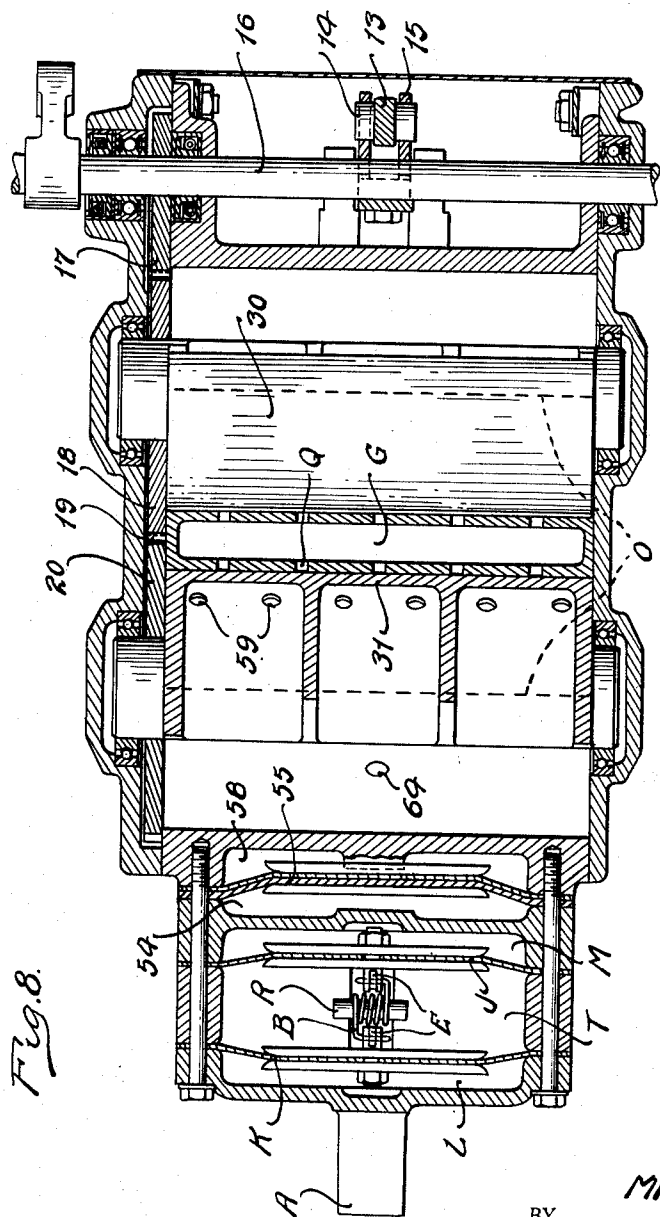
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AIRPLANE CARBURETOR

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Application October 24, 1936, Serial No. 107,386

5 Claims. (Cl. 261—28)

The object of this invention is to provide an improved carburetor for use on airplanes. Specifically the carburetor is of the type in which the fuel is admitted ahead of the throttle and the throttle is formed by two rollers or valves rolling together so as to provide therebetween a variable passage, approximately of Venturi form. The difficulty with such a construction is that the throttle valves, if unbalanced, require too much effort to operate. The carburetor is provided with fuel from a constant pressure supply chamber, the pressure in which may be controlled by a spring and also by the vacuum in the throat of the variable venturi. When a carburetor of this type is connected to a supercharger it is desirable to have an increased flow of fuel and the pressure generated by the supercharger is utilized to change the pressure in the constant pressure fuel supply chamber. Means for doing this so that the fuel supply can be varied, is provided. An important advantage of the construction shown is that the mixture ratio is approximately constant through a wide range of variations in altitude.

Figure 1 shows a cross sectional elevation of a carburetor with the throttle closed.

Figure 2 shows a cross sectional elevation with the throat open and with the mixture controlled for use in conjunction with a supercharger shown in outline only and shows a modification of the carburetor shown in Figure 1.

Figure 3 shows the effect on the mixture of varying the pressure in the fuel supply chamber.

Figure 4 shows diagrammatically the arrangement of the carburetor, supercharger and fuel pump and the connections.

Fig. 5 shows the mixture controlled valve in the rich position.

Figure 6 is a cross sectional plan view taken on plane 6—6 of Figure 7.

Figure 7 is a cross sectional elevation taken on plane 7—7 of Figure 6.

Figure 8 shows a plan view taken on plane 8—8 of Figure 1.

Figure 9 is a view in perspective of one of the carburetor throttles.

In Figures 1 and 2, A is the fuel entrance from a fuel pump supplying fuel at pressures between two to seven pounds. C, C are the two fuel needle valves controlling the admission of the fuel. B is a spring adapted to regulate the pressure in the fuel supply chamber T which is bounded on the left by the flexible fabric diaphragm K and on the right by the flexible fabric diaphragm J. Levers E, E pivoted at H, H connect the dia-

phragms K and J with the needle valves C, C so that as the diaphragms expand or move relatively from one another and increase the volume of the chamber T, the valves C, C are moved to closed position. The effect of the spring B in drawing the diaphragms K, J together is increased by the weight R supported by the spring B. These flexible diaphragms K and J segregate the air chamber L and the air chamber M from the chamber T, and the two chambers L and M are in communication with each other through the passage D. This passage D communicates through a passage F' with a passage G which communicates through nozzle openings Q with the main air passage, the openings Q being located in the most restricted portion of the variable venturi formed between the two throttles 31 and 30 which are geared together, for simultaneously opening and closing movements, by means of the gears 20 and 19.

A valve F controlled by the lever 27 regulates the connection between opening Q and the chambers L and M. In the main air entrance S to the carburetor a pipe N extends facing against the stream of air flowing to the engine. In Figure 1 the passage N communicates with the passage F' through the restriction N' so that the pressure, or more correctly the depression, in the chambers L and M is determined by the restriction N' and by the extent of opening of the valve F.

The fuel flows from the chamber T through a restriction P located above the level of the chamber T. A needle valve 10 controls the fuel flow through this restriction P. This valve is operated by means of a lever 13 which engages with the shoulder 12 at one end and is fulcrumed by the pivot 28 at the other. A throttle control rod 16, when rotated, moves the lever 13 to the right and back again by means of the roller 14 which engages with a box cam 15 bolted to the shaft 16. The gear 17 mounted on the shaft 16 engages with another gear 18 mounted concentrically with the gear 19 and bolted to the throttle 30 so that as the shaft 16 is rotated in an anti-clockwise direction, the valve 10 moves to the right and the throttle valves 30, 31 open up to permit more air to flow past the valve outlets Q, Q. An air entrance 11 permits air to flow around the needle valve 10 and through flutes 25. These flutes are located in the needle valve 10 opposite the guide 26 so that the flutes constitute a by-pass around this guide, thus permitting air to flow from 11 to the fuel outlets Q and to thus reduce the fuel flow past P. This

outlet 11, as shown, is a fixed orifice. A passage 21, 22 is controlled by needle valve 23 and admits additional air over and above that passed through the fixed opening 11. The air flowing through the passage 21, 22 flows into the annulus around the needle valve 10 through the passage 24. The movement of the needle valve 10 regulates the air bleed, that is to say, the quantity of air admitted through the passage 11 and also admitted through the passages 21 and 22. When the throttle is closed and the engine is idling a considerable volume of air is admitted through the flutes 25 in the needle valve 10, which air dilutes the fuel flowing down G and thus reduces the suction on the orifice P.

As the throttle opens, the flutes 25 cease to function as passages for air. The needle valve moves to the right and the admission of air through the openings 22 and 11 is no longer effective because the movement of the flutes to the right cuts off a path for the air. Thus when the throttle is more than half open, no air at all is admitted through the passages 11 and 22. The throttles 30, 31 engage with the flexible seals 61, 62 through a circular arc shown in Figs. 1 and 2 and the lower portions of the throttles 30, 31 fit closely at their ends against the main body of the casting. The hollow space between the throttles 30, 31 and the main body of the casting is maintained at the pressure in the throat of the venturi by means of the openings 59 and 60 so that the effort required to operate the throttle mechanism is thus greatly diminished. The presence of these openings 59, 60 renders the construction practical, as without them the effort necessary to rotate the throttle might make the device difficult to use, commercially.

The depression back of the throttle is naturally greater than in the mixture outlet O. A passage 64 communicates this depression to the chamber 58. This chamber is separated from a chamber 54 by the flexible diaphragm 55. The reduced pressure thus created in 58 causes the diaphragm 55 to move to the right, compressing the springs 52. The opening 51 serves to modify the effect of the depression due to the opening 59 but as 51 is much smaller than 64, the major factor in determining the pressure in 58 is the opening 59. Fuel is admitted to the chamber 54 through an opening from chamber T controlled by the check valve 53 which is spring loaded. A fuel passage 56 serves as an outlet from the chamber 54 and the spring loaded valve 57 serves as a fuel outlet into the air entrance. This whole structure just referred to constitutes the automatic accelerating fuel pump which functions when the throttle is opened wide momentarily to increase the fuel supply and is fully described and claimed in my co-pending application Serial No. 107,961, filed October 26, 1939.

In Figure 2, 50 is the supercharger which is adapted to be connected to the mixture outlet O. A pipe V communicates the pressure created by the supercharger 50 with a closed chamber 33 in which is supported a flexible bellows 34 which is reinforced by a spring 35 and carries with it a valve 36. The compressed air in V thus may be admitted through a restriction 37 to a restriction 39 which leads to pipe X which communicates with the chamber L. A cross passage 40 communicates with the mixture control valve to be described later. A pipe W connects the pipe N in the air entrance S through a restriction 38 with the pipe X. A pipe Y connects the passage F' with the mixture control valve. As stated

above, the passage F' communicates through the valve F with the Venturi throat Q. Considering now the valve shown in Figures 2, 5, 6 and 7, the pressure communicated through passage X is modified by the vacuum communicating through the passage Y, depending upon the position of the valve shown in Fig. 7.

This valve is shown in cross sectional plan and elevation in Figures 6 and 7, and diagrammatically in Figures 2 and 5. In Figures 5, 6 and 7, 47 (Fig. 6 only) is the valve lever carrying a key 46 which causes a disc valve 45 to rotate. This valve is mounted in a casting 48 which is bolted to another casting 49, whose face is the valve seat. In the valve seat there is a groove 44 which communicates through a slot 43 with an annular groove 42 in the disc valve 45. Another groove 41 in the lower half 49 communicates with the pipe X. The groove 44 communicates with the pipe Y. There is thus a connection from the passage Y to the passage X through the narrow slot 43.

In the position shown in Fig. 5, this communication is cut off and in the position shown in Fig. 2 this communication is wide open. In the position shown in Fig. 2 there is thus a relatively free communication from the low pressure in Y through the narrow groove 43 through the slot 42 through the groove 41 through the passage 40 to the pipe X. Obviously, at any intermediate position the pressure in the chamber L can be regulated. It is also obvious that as the pressure created by the supercharger increases, the pressure in the chamber M increases. The pipe W connects the air pressure in the air entrance S through the opening N. This pipe W communicates with the chambers L and M and thus modifies the pressure therein. The relative effect of the pressure in the air entrance S is determined by the restriction 38. The smaller this restriction relative to the restriction 37 the less effective is the pressure in the air entrance S in modifying the effect of the pressure created by the supercharger 50 which is transmitted through the passage V, and through the restriction 37 and so through the restriction 39 and the passage X to the chambers L and M.

Operation

Discussing the construction shown in Figures 1 and 2, when the throttles are slightly open, that is to say, more open than they are shown in Figure 1 in which figure they are shown practically closed, a large suction occurs at the orifice Q. On the other hand, a relatively large bleeding action takes place through the opening 11, so that the channel suction in G is relatively low. As the throttles are opened, the effect of the vent 11, as well as of the air that enters through the low speed passage 22, is restricted because the slot portion 25 of the needle 10 is moved to the right and the bushing 26 restricts the air flowing through the slot 25 into the channel G. Therefore, the depression in G reaches a maximum. When the throttle reaches the position shown in Figure 2, the pressure in G rises again. The position shown in Figure 2, however, is only reached when the airplane is sufficiently high so that the admission of air freely to the carburetor will not cause undue pressure in the cylinder head. Therefore, during the period of time the plane is climbing to the normal flying altitudes, the throttles are gradually opening and the depression in the channel G is gradually diminishing. The effect of this is that the normal tend-

ency for the mixture to get rich at altitude is neutralized by the diminished suction on the fuel orifice P. When the plane reaches the normal flying elevation, the throttles are substantially wide open.

Discussing next Figure 2 and the means whereby the diaphragm chamber T is subjected to the suction in the passage G, there are the following connections.

The passage G communicates with the passage F' through the opening F, controlled by a valve which in its turn is controlled by the lever 27. The passage F' communicates through the passage Y with the channel 44 shown in Figure 6. This channel is formed in the seat of a valve controlled by the handle 47 (see Figure 6). This valve contains an annular passage 42 and the annular passage 42 is provided with a slot 43 which may be brought into the register with the annular channel 44 in the seat of the valve. Obviously the valve may be rotated so that the annular slot 43 is partially or wholly in communication with the annular channel 44. The valve may then be rotated so that the annular slot is disconnected from the annular channel 44, in which case the effect of channel suction in G ceases to have any bearing on the suction or pressure in the diaphragm chamber T.

In the position shown in Figure 2, however, the suction in G has its maximum effect on the diaphragm chamber T because after flowing through the annular slot 43 the suction enters the annular passage 42 which is controlled by the valve lever 47. This communicates with another annular passage 41 also located in the valve seat. This, in its turn, communicates with the passage 40 which communicates through the passage X with the air chambers L and M which are located one on each side of the two diaphragms J and K which constitute the boundaries of the diaphragm chamber T. These two air chambers L and M are connected through the passage D. The pipe 40 is connected through the restriction 39 and through the restriction 38 to the pipe W, which communicates with the tube N which projects into the air entrance S.

37 and has its influence through the restriction 39 in the passage X on the pressure existing in the air chambers L and M located on either side of the diaphragms J and K which form the right hand and left hand boundaries of the diaphragm chambers T.

Discussing Figure 3, the effective level in the diaphragm chamber T is treated as though T were a float chamber, and the location of the orifice P is referred to as the zero level. This level is then varied in twentieths of an inch of mercury and the pressure drop in the throat of the venturi, when wide open at sea level, is adjusted to be exactly one inch of mercury. Now with one inch of mercury drop in the throat of the venturi and with a zero head on the orifice P, assuming that there is no syphoning action—and with the construction shown there is no such syphoning action for three reasons—(1) because of the air leakage past the needle 10, (2) because of the vapor released from the fuel, and (3) because of the great difference in area between the fuel restriction and the passage G—then the mixture ratio follows the well known law, that is, as the plane ascends in the air, the density falls and the flow of fuel caused by the air flow also falls. When the density reaches one-half that of the air at sea level, that is at about 25,000 feet altitude, then the flow of fuel corresponds to the square root of one-half, namely .7 of the fuel flow at sea level. The weight of air taken in, however, is one-half. If we divide .7 by $\frac{1}{2}$ we get 1.4 as the mixture ratio, namely, a mixture ratio 40% richer than the sea level mixture ratio. This, of course, is the very well known square root law upon which all airplane carburetor development work has been done during the past 22 years when airplanes first reached 25,000 feet and when we first had to deal with air densities of half those which prevail at sea level, and when first this problem of rich mixture at altitude became important. During these 22 years that have elapsed it has been customary to provide means for reducing the mixture strength at altitude on the theory that the mixture strength at this altitude of 25,000 feet

Chart

Location	Air density	Fuel pressure	Effective head	Relative		Fuel+air mixture ratio	Change from ideal mixture	Lean or rich
				Fuel flow	Air flow			
On ground.....	1.0	-.15	.85	.922	1.00	Percent 92.2	Percent +7.8	Lean.
2000'.....	.95	-.15	.8	.895	.95	94.2	+5.8	Do.
4000'.....	.90	-.15	.75	.865	.90	96.2	+3.8	Do.
6000'.....	.85	-.15	.70	.837	.85	98.6	+1.4	Do.
8000'.....	.8	-.15	.65	.805	.80	100		
10000'.....	.75	-.15	.60	.774	.75	103	-3	Rich.
12000'.....	.7	-.15	.55	.74	.7	105.2	-5.2	Do.
14000'.....	.65	-.15	.50	.707	.65	108.9	-8.9	Do.
20000'.....	.52	-.15	.37	.607	.52	117	-17	Do.
25000'.....	.44	-.15	.29	.539	.44	122	-22	Do.
30000'.....	.36	-.15	.21	.46	.36	127	-27	Do.
40000'.....	.25	-.15	.10	.317	.25	127	-27	Do.

It is quite obvious that the pressure in L and M must be intermediate the pressure in the air entrance S and the suction in the channel G.

When the supercharger 50 becomes effective, the mixture ratio is enriched by the effect of the pressure created by the supercharger 50. This pressure becomes effective through the pipe V which communicates with the chamber 33, which contains the exhausted bellows 34, which is supported internally by a spring 35. This bellows carries a valve 36 and therefore the air from the supercharger is admitted through the restriction

will become 40% richer unless means are provided to keep the mixture within normal limits. The well known expedients are to reduce the area of the fuel orifice and alternatively to impose a vacuum in the float chamber above the level of the fuel contained therein. These are manual controls and are made automatic by more or less complicated means which introduce certain hazards into the operation of the carburetor.

In the construction shown, however, if there is a negative head, that is to say, if the relative level in the float chamber, or in my invention, 75

the diaphragm chamber, is substantially lower than the level of the fuel outlet from the nozzle P, then this square root relationship, giving the 40% rich mixture, will not exist and a correction will have to be made for the amount the level in the float chamber, or in my case, the diaphragm chamber, is below the level of the fuel outlets. For the same reason, if the level should be higher than the fuel orifice, a correction in the other direction must be made. These calculations have been made and set out in the chart and plotted in Figure 3. Therefore, Figure 3 shows the effect of the correction for variations in the level in the float chamber or its equivalent, and it will be noticed that where there is a level in the float chamber (diaphragm chamber) substantially below that of the level of the fuel outlet from the float chamber, then the characteristic of the curve between mixture ratio and altitude is entirely different, whereas if there is a positive head, the characteristic is unchanged, although the tendency to become rich at altitude becomes more prominent. It is a simple matter of arithmetic to calculate these different points set forth in the chart.

Variations of mixture ratio above 10,000 feet are far more important than the variations of mixture ratio below 10,000 feet. Below 10,000 feet with the modern airplane it is not safe to open the throttle and permit the engine to take in all the mixture that it may breathe in. Engines are designed to function at maximum power at some considerable distance above sea level. Therefore, the throttle is only opened wide at some considerable altitude.

We notice by examining Figure 3 that if we are only concerned with the variations of mixture ratio above, say, 15,000 feet, then with the nozzle located at the fuel level we have a very rapid increase in mixture ratio. With the nozzle located say, .22 of an inch of mercury below the level, then there will be a very gradual increase in richness. Below that height the mixture ratio will be determined by the closing the throttle and the restriction of the orifice P by the needle 10. It follows, therefore, that with the construction shown, the mixture ratio is substantially constant for all practical purposes, and elaborate means for mixture control are not needed.

Figure 9 shows the means whereby the passage F' controlled by the needle valve F, which in its turn is controlled by the lever 27, communicates with the tube F'' which terminates in the center of the variable venturi, the throttle 31 being formed with a recess so that the throttle may close against the nozzle T without interference from the tube F''. The tube F'' is out of plane with the needle valve 10 so that the needle valve 10 can control the fuel orifice P. The advantage of the construction shown in Figure 9 is that the effect of the depression in the throat of the venturi is transmitted directly to the diaphragm chamber through the passage F' uninfluenced by the flow of gasoline down the nozzle G.

An added advantage of my invention is that when the load is increased and the engine slowed down, the mixture automatically becomes leaner with the negative head. This reduction in speed is in practical universal use when an engine is cruising, the propeller being slowed down at the moment the plane has cleared the ground and the buildings near the ground. The propeller is slowed down by an increase in pitch of the propeller which brings about an increase in torque, which brings about a decrease in R. P. M., which

produces a decrease in air flow, which produces a decrease in the suction on the orifice P, which results in a leaner mixture for cruising.

What I claim is:

1. In an airplane carburetor, fuel supply means for supplying fuel under pressure, a fuel supply chamber having a fuel entrance connected with said fuel supply means, a valve controlling the entry of fuel into said supply chamber, a flexible diaphragm for regulating the pressure in said fuel supply chamber and connected with said control valve so as to close against the pressure of fuel from said fuel supply means, a restricted fuel outlet from said fuel supply chamber, said outlet being disposed above said diaphragm, a wall enclosing said diaphragm and forming an air chamber therewith, means providing a passage for air for mixing with the fuel, means providing a venturi in the air passageway, a fuel nozzle discharging into said air passage and connected with said restricted fuel outlet, means providing a passage connecting the air entrance with said air chamber, said carburetor having a mixture outlet, a supercharger having connection with a mixture outlet, means providing a pressure chamber, said pressure chamber having a restricted outlet, a valve for closing the outlet from said pressure chamber, a pressure responsive element within the last said chamber and having connection with said valve, means providing communication between the high pressure side of said supercharger and said pressure chamber, and means providing a passage connecting the last said restricted outlet with said air chamber.

2. In a carburetion apparatus, means providing an air intake passage to an engine, means providing a pressure source of fuel, means including a flexible diaphragm providing a fuel chamber, said chamber being at one side of said diaphragm and having a fuel inlet and a fuel outlet, a valve for controlling said fuel inlet, means associating said diaphragm and valve whereby movements of said diaphragm will control the inlet of fuel into said fuel chamber, means for subjecting the other side of said diaphragm to the pressure in the air intake passage to produce a force normally reacting against said diaphragm tending to open said valve and to maintain a positive pressure in said fuel chamber, a supercharger having its intake side connected with the intake passage leading to the engine and a connection from its discharge side to the said other side of said diaphragm for producing an additional force acting on said diaphragm in the same direction as the first said force producing means upon the attainment of a predetermined pressure in the supercharger discharge thereby to increase the positive pressure in the fuel chamber and to increase the fuel flow from said fuel outlet, a venturi in said intake passage between said supercharger and the entrance to said passage, and means for modifying the force produced by said supercharger in accordance with pressure conditions at the throat of said venturi.

3. In an airplane carburetor, means providing an air supply passage, means for supplying fuel under pressure, means including a flexible diaphragm defining a fuel supply chamber having a fuel entrance connected with said fuel supply means, a valve controlling the entry of fuel into said supply chamber and arranged to close against the pressure of fuel from said supply means, means including said flexible diaphragm

defining an air chamber, said diaphragm being connected with said control valve for operation of said valve for regulating the pressure in said fuel supply chamber, means providing a venturi in said air supply passage, a fuel nozzle discharging into said air passage at the venturi and connected with said fuel chamber, means providing a passage connecting the entrance to said air supply passage with said air chamber, means providing a passageway connecting said air chamber with said air supply passage at a place adjacent to the throat of said venturi, said carburetor having a mixture outlet, a supercharger connected with said mixture outlet, and means providing a conduit connecting the high pressure side of said supercharger with said air chamber.

4. In a carburetion device, an air intake passage to an engine, means providing a pressure source of fuel, means including a flexible diaphragm providing a fuel chamber, said chamber having a fuel inlet and a fuel outlet comprising a restricted metering orifice, a valve for controlling said fuel inlet, means connecting said diaphragm and valve whereby movements of said diaphragm will control the inlet of fuel into said chamber, means including an air chamber at the side of said diaphragm opposite to said fuel chamber and a connection between said air chamber and the air intake passage for producing a force normally reacting against said diaphragm tending to open said valve and to maintain a positive pressure in said fuel chamber, the back pressure in said fuel chamber acting on the diaphragm tending to close the valve, and a supercharger having its intake connected with the intake passage leading to the engine and having a connection between its discharge side and said air chamber for producing an additional sustained force acting on said diaphragm in the

same direction as said first force producing means to increase the positive pressure in the fuel chamber and to increase the fuel flow from said fuel outlet, said additional sustained force increasing as the air flow through said intake passage increases.

5. In a carburetion device, an air intake passage to an engine, means providing a pressure source of fuel, means including a flexible diaphragm providing a fuel chamber, said chamber having a fuel inlet and a fuel outlet comprising a restricted metering orifice, a valve for controlling said fuel inlet, means connecting said diaphragm and valve whereby movements of said diaphragm will control the inlet of fuel into said chamber, means including an air chamber at the side of said diaphragm opposite to said fuel chamber and a connection between said air chamber and the air intake passage for producing a force normally reacting against said diaphragm tending to open said valve and to maintain a positive pressure in said fuel chamber, the back pressure in said fuel chamber acting on the diaphragm tending to close the valve, a supercharger located in the intake passage leading to the engine, and having its discharge side connected with said air chamber for producing an additional sustained force acting on said diaphragm in the same direction as said first force producing means to increase the positive pressure in the fuel chamber and to increase the fuel flow from said outlet, said additional sustained force increasing in proportion as the air flow through said intake passage increases, and a pressure responsive means acted upon by said additional sustained force for controlling the intensity of said force on said first mentioned diaphragm.

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