March 12, 1946. A. B. METSGER 2,396,279

CARBURETOR ARRANGEMENT

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Fig. 1.

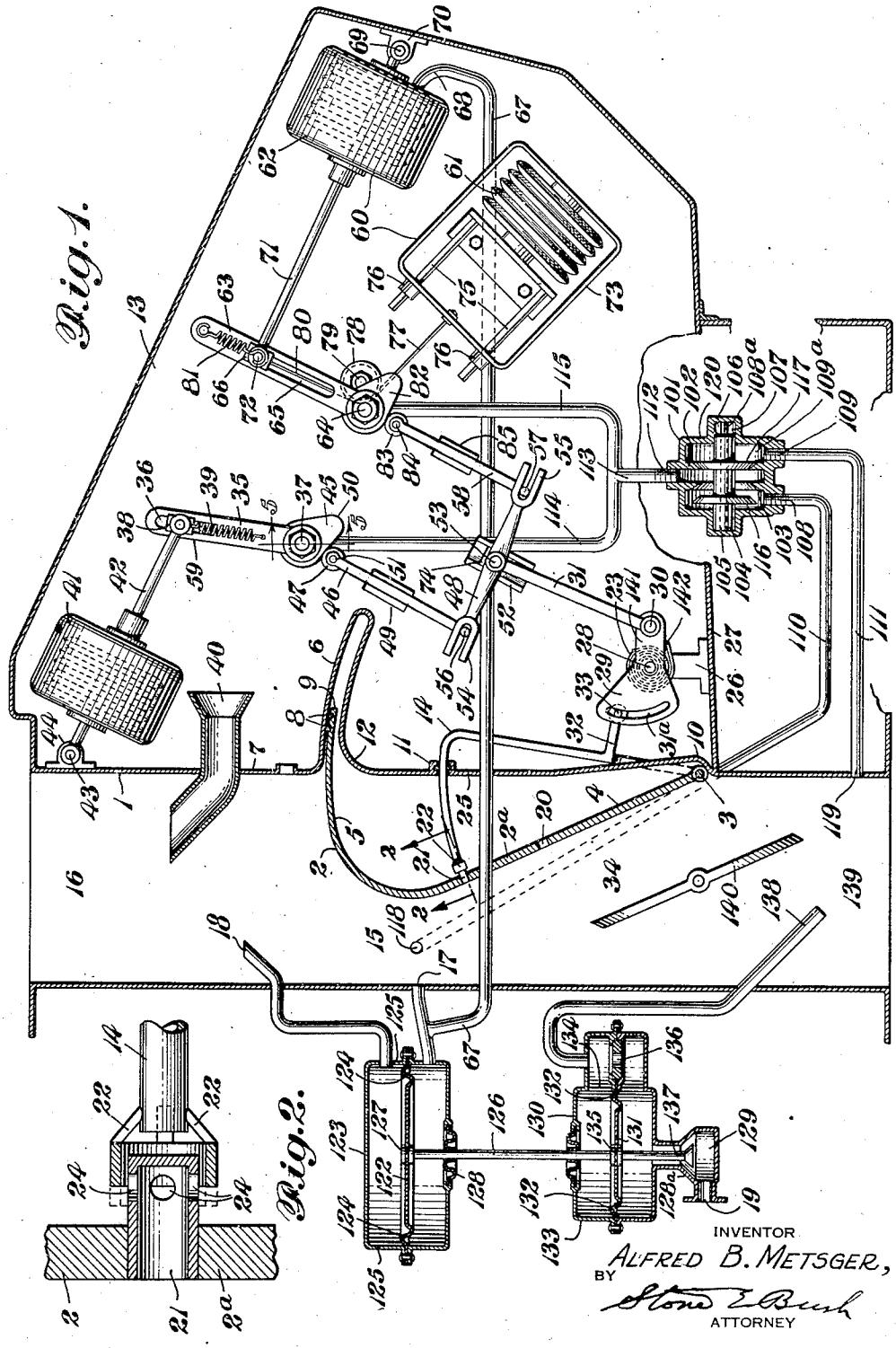


Fig. 2.

INVENTOR
ALFRED B. METSGER,
BY
Stone & Bush
ATTORNEY

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Fig. 3.

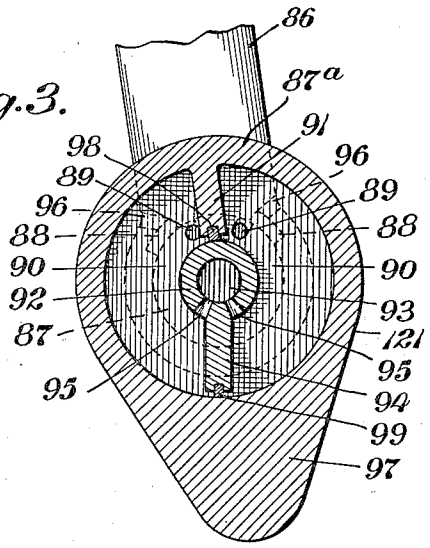


Fig. 4.

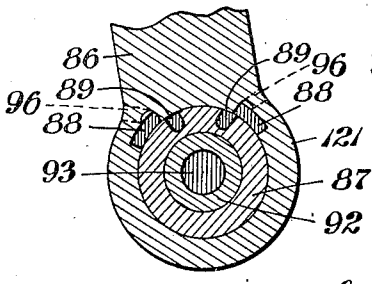
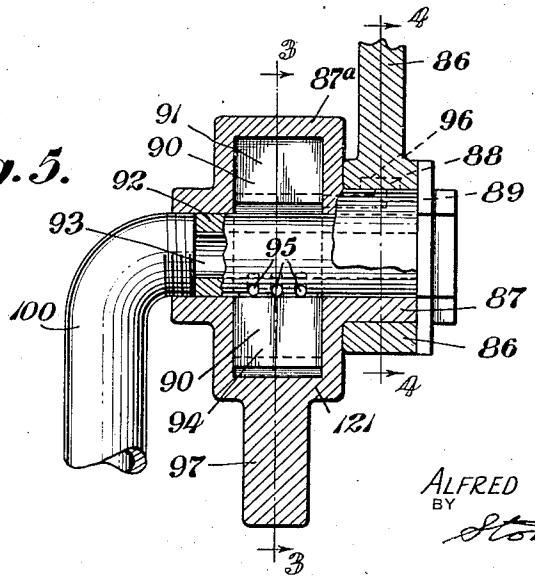


Fig. 5.



INVENTOR
ALFRED B. METSGER
BY
Stone & Bush
ATTORNEY

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UNITED STATES PATENT OFFICE

2,396,279

CARBURETOR ARRANGEMENT

Alfred B. Metsger, United States Navy

Application July 1, 1943, Serial No. 493,139

1 Claim. (Cl. 48—184)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The present invention is intended to permit variation of airflow through a carburetor for a given metering suction, for density and compressibility compensation, and for other purposes.

In accomplishing the above purposes in the present device the following means and/or features are combined to form the complete carburetor arrangement of the present invention.

Some of these means just mentioned comprise a series of devices to accomplish the result as follows:

In order to permit Venturi area control with low control forces, a servo operated Venturi plate is used;

For giving a mechanical indication of the density of a gas, especially air, a device called a density calculator is used;

A means which gives a mechanical indication of the ratio of two gas pressures is used in this present invention, and same is designated a pressure ratio calculator;

For producing an angular motion equal to that of an angular input, but with much greater torque, and deriving operating power from suction and surrounding gas pressure, a suction servo torque multiplier is used;

In order to automatically connect an air or gas suction line with the greater of two sources of suction, a suction selector valve is used; and

A device is provided herein which is used for controlling the amount of fuel admitted to the carburetor which is dependent upon the pressures found in the throat and other parts of the air or gas inlet.

The above features and devices are combined in the present carburetor arrangement to produce a device of singular utility, the features of which will be more fully explained as the description proceeds herein.

In the drawings forming a part of the present specification:

Fig. 1 is a diagrammatic cross-sectional elevation of the present invention showing substantially all the above named parts of same.

Fig. 2 is a longitudinal detail section taken on line 2—2 of Fig. 1, of a controlled vent and cap used in connection with the Venturi plate of the invention.

Fig. 3 is a vertical cross-section on line 3—3 of Fig. 5, which last is a "suction torque multiplier" forming part of this invention.

Fig. 4 is a vertical section on line 4—4 of Fig. 5.

Fig. 5 is a vertical longitudinal section through the above mentioned suction servo torque multiplier, used with this invention.

The variable area Venturi meter

In the drawings is provided a "variable area Venturi meter" which permits variation of airflow for a given metering suction, for density and compressibility compensation and other purposes in which numeral 1 indicates the body of an air carburetor inlet passage to an engine. The numeral 2 represents a "Venturi spoon" which is pivotally mounted on a pintle 3 and is in the nature of a flat metal plate, having an inclined portion 4 and a curved portion 5 thereon, and which slidably engages in a recess or pocket 6 formed in the body portion of the air inlet casing 7 as clearly shown in Fig. 1 of the drawings.

It will be noted that leakage of air is provided against by means of sealing or packing strips 8 on the end 9 of the Venturi spoon 2 where it engages against the upper face of the recess 6 mentioned. The form of the air inlet casing 7 is "shaped" at 10, 11, and 12, to accommodate the various parts necessary in the construction of the device.

The casing 7 has mounted thereon a closed container 13 shaped as shown in Fig. 1 for the purpose of housing various parts of the invention described herein. The "Venturi spoon" has a Venturi shape as shown and forms one side of a Venturi passage of preferably rectangular cross-section, and as above stated is pivoted and movable about the pintle 3 so that when the said plate is moved back and forth by means of the "servo finger 14," the throat portion 15 of the air inlet 16, can be enlarged or diminished automatically or manually as will be described below.

Numeral 17 indicates a static throat "pressure take-off" located in the region of minimum cross-sectional area of the Venturi meter. Impact tube 18 is arranged to obtain the total inlet pressure in the passage 16 and is used for accurate determination of the air pressure admitted to the carburetor at 16 as will be fully described herein. A fixed vent 20 in the wall of the Venturi spoon is positioned in the expanding section of the venturi, at such a point that the effective force or pressure behind the spoon 2 will overcome by a slight margin the effective force on the working face of said spoon.

Numeral 21 indicates a controlled vent which appears in enlarged detail in Fig. 2 of the drawings and is positioned in the wall of the Venturi spoon 2 and has a proper size and location relative to the fixed vent 20 so that it overcomes the effect of the latter and causes motion of the spoon resulting in an increase of Venturi size at the throat 15 thereof when the vent 21 is partially or

completely open. A vent control cap 22 is positioned on the servo finger 14 near the control vent 21 as shown in Fig. 2 detail for the purpose of varying the effective area of the control vent 21 by varying the amount of closure of the orifices 24.

In the enlarged detail of the parts 21, 22, and 14 shown in Fig. 2 of the drawings it will be seen that the cylindrically shaped part 22, which is fastened to the finger 14 moves axially with respect to part 21 varying the effective area of openings 24, 24 for the purpose of varying the pressure "drop" through these openings.

It will be noted that the servo finger 14 is preferably pivoted on the same axis 3 as the Venturi spoon 2 and may be controlled manually or automatically with a reciprcatory movement through the seal 11 formed in the wall 25 of the casing 7. The seal 11 reduces leakage through the said wall 25 around the servo finger 14. The numeral 26 indicates a fixed cam support preferably mounted on the bottom wall 27 of the closed container 13. At point 28 on the support 26 is pivotally mounted a cam 29 which is pivotally connected at 30 with a connecting rod 31. The cam 29 has an arced slot 31*a* therein in which the arm extension 32 of the servo finger 14 engages by means of the pintle 33. It is evident that the servo finger 14 and the control vent 21 can be operated by means of the connecting rod 31, and the actuation of 31 by means of the apparatus shown in the closed container 13 will be fully described below.

In connection with the "variable area Venturi meter" just described, air to be metered to the engine enters the carburetor by passage 34 and through the air inlet 16, and is metered as usual in a venturi, except that the area of this venturi may be varied manually or automatically as described herein. The pressure on the outer side of the Venturi spoon 2 is varied along the direction of airflow or downward as shown in Fig. 1 of the drawings. The fixed vent 20 is placed at a point in the passage 34 where the fluid pressure has recovered to an intermediate pressure value. Leakage by the sides or edges of the spoon 2 is kept at a small value by reasonably small clearances, with the walls of the duct or passage 34.

It is noted the fixed vent 20 alone would lead to a net force or pressure behind the Venturi spoon 2 tending to reduce the Venturi cross-sectional area. Control vent 21 if fully open overpowers the effect of the fixed vent 20 causing the Venturi area to increase in the area of the throat portion 15 of the passage 34. The Venturi spoon would move to the right in Fig. 1 until the vent control cap 22 closes the vent 21 to such an extent that the Venturi spoon is in equilibrium. The Venturi plate 2*a* then, follows the motion of the vent control cap 22 which last is controlled by the servo finger 14, the latter being operated manually or automatically as desired.

The above completes the description of the "variable area venturi" and the operation of the Venturi plate 2*a* used in connection therewith.

The "density calculator"

One of the means used in operating the connecting rod 31 above mentioned comprises what is called a "density calculator" which is used to give a mechanical indication of the density of the fluid used in the present device especially the air portion thereof. A ratio arm 35 having a slot 36 therein is mounted on a revolvable but fixed pivot or pintle 37 within the closed container 13 as shown. A slide 38 is adapted to reciprocate in the slot 36 of the ratio arm. A temperature indicator 39 which in this case is a bimetal coil positions the slide 38 a distance from the pivot point 37 proportional to the inlet temperature obtained by the inlet 40 from the air inlet 16 as shown. The pressure bellows 41 has an operating rod 42 which connects it pivotally with the slide 38 in the ratio arm 35 as shown.

The bellows 41 as it reciprocates according to air pressure gives motion to the rod 42 as is at once seen, and to the ratio arm 35 proportional to the inlet pressure through part 40, in a line of about 90° with the direction of ratio arm 35. The pressure bellows 41, it will be seen, is pivotally mounted at 43 in the support 44 carried on the inner face of the wall 7.

The angular position of the ratio arm 35, it will be noted, varies approximately directly as the inlet air pressure around the bellows 41, and inversely as the corresponding temperature; e. g., it varies as the density of the gas or air surrounding the calculator. It is seen that the ratio arm 35 then is mechanically operated according to the pressure and temperature of the gas or air whose density is being measured. The angular motion of the ratio arm 35 may be used to position a cam 45 and drive an output connecting rod 46 by means of the cam follower 47, and to effect the operation of the connecting rod 31 by means of the cross rod 48. It is noted that the pintle 37 is a fixed axis supported within the container 13 but revolvably mounted therein, and the connecting rod 46 slidably operates through a fixed support 49.

The cam follower 47 follows the edge 50 of the cam 45 and is revolvably mounted at 51 in the end of the connecting rod 46. The cross rod 48 is slidably and pivotally mounted in the fixed support 52 by means of sliding block 74, and pivotally connected at 53 to the connecting rod 31 as shown. The ends of the cross rod 48 at 54 and 55 are forked to slidably receive the pintles 56 and 57 which are on the ends of the connecting rods 46 and 58 respectively.

From the above it is seen that the pressure of the air admitted to the chamber of container 13 through inlet 40 and the temperature thereof operates the "density calculator" 59. The calculator has a mechanical operating effect on the connecting-rod 31, and servo finger 14 and therethrough the movement of the Venturi spoon 2 is conformably operated at the throat 15 of the Venturi meter in accordance with the pressure and temperature of the inlet air from inlet 40. From the above it is seen that the "density calculator" gives a mechanical indication of the density of a gas or of air and can be mechanically used as one of the features or factors in the operation of the Venturi spoon 2 and the venturi.

The "pressure ratio calculator"

The pressure ratio calculator which is used to give a mechanical indication and effect of the ratio of two gas or air pressures may be described as follows:

The numeral 60 represents the whole pressure ratio calculator which comprises two pressure operated bellows 61 and 62. The action of these two bellows controls the angular or arcial movement of the ratio arm 63 on the axis or pintle 64 which is fixedly and revolvably mounted in the closed container 13. The ratio arm 63 is slotted at 65 as shown and the slide 66 operates slid-

ably therein. It will be noted that static gas pressure in the throat 15 of the venturi is taken at points 17 and through the pipe 67 and delivered to the pressure bellows 62 at 68. The pressure bellows 62 is carried pivotally at 69 in the fixed support 70, which is mounted on the inner face of the wall of the closed container 13. It will be at once seen that as the pressure bellows 62 expands or contracts due to the pressure through pipe 67, and affects the operating rod 71 which is pivotally mounted at 72 on the slide 66 that the ratio arm 63 will be angularly operated about the pivot point 64.

The pressure bellows 61 is actuated by the gas or air which is within the closed container 13 and comprises the following parts. The "pressure bellows" 61 is enclosed in the cage 73, and moves the cage 73, which is slidably mounted at 76, 76 on the fixed slide, represented by rods 75, 75. The wire 77 delivers the response of the pressure bellows 61 to the slide 66 by means of the pulley 78 which is mounted on the fixed revolvable pintle 79 carried in the closed container 13. It is noted that the portion 80 of the guide wire 77 is in line with the direction slot of the ratio arm 63, and the spring 81 keeps the "slack" out of the wire 77 when the pull in said wire 77 is lessened by the action of the bellows 74.

It is then seen the angular movement of the ratio arm 63 on the pintle 64 is controlled by the joint effect of the two pressure bellows 61 and 62 and in turn, the cam 82 revolves arcially with the pintle 64. The cam 82 is in continuous engagement with the "cam follower" 83 which is pivotally mounted at 84 in the end of the connecting rod 58 before mentioned. The said rod 58 slidably operates in the fixed support 85 and by means of the pintle 57 said rod actuates the cross rod 48 and in turn the connecting rod 31 of the Venturi control device by means of the cam 29 and its associated parts.

It will be noted that the angle of rotation of the ratio arm 63 varies approximately directly as the output of the bellows 62 and inversely as the output of the bellows 61; e. g., as the ratio of the two pressure bellows outputs. The angular motion of the ratio arm, of course, may be used to position a cam, such as 82 to drive an output "connection rod" 58 and control the parts of a servo finger apparatus, or for other purposes, such as actuating a "suction torque multiplier" described below.

Suction torque multiplier

The suction torque multiplier 121 just mentioned is intended to produce an angular motion equal to that of an angular input but with much greater torque deriving its operating power from suction gas pressure and from gas pressure surrounding the multiplier device. The device in hand comprises the following parts and is clearly shown in Figs. 3, 4, 5 of the drawings. The input lever 86 (which may be the same as ratio arms 35 or 63 above described) is revolvably mounted on the cylindrical exterior of the valve section 87. Two vent slots 88, 88 formed in the input lever 86 act as control valves for this device. The valve section 87 is operable nearly 360 degrees, but if less circular travel is required then said degree of revolution of the body 87*a* of the valve section 87 may be cut down to a sector of a cylinder instead of a complete cylinder.

Each of the valve section vents 89, 89 in section 87 are "ducted" or lead to one of the sub-operating chambers 90, 90 of the multiplier shown in Figs. 3 and 5 clearly, and said vents are controlled by the input lever 86, depending on the angular position of said lever 86 on the valve section 87 as is at once understood. In the operating chambers 90, 90 is located the moving division wall 91 which is preferably made integral with the body of the valve section 87. Centrally of the operating chambers is positioned a fixed shaft 92 (which may be shafts 37 or 64 if so arranged), having a hollow center duct 93 therethrough. A fixed division wall 94 is part of or rigidly mounted on the central shaft 92.

Restricted vents 95, 95 in the central fixed shaft 92 provide communication from the operating chambers 90, 90 to the center or suction duct 93.

It is seen that when the input lever 86 is given an angular or arcial displacement one of the vents 89 is opened partially or fully to one of the proximate corresponding slots 88. This vents one of the operating chambers 90, 90 to the gas pressure surrounding the device itself, through one of each of the inlet ducts 96, ducts 88, and 89 shown in Fig. 5 clearly.

It will be noted that the fixed division wall 94 is integral with and part of the fixed shaft 92 and when gas pressure is admitted to either of the chambers 90, 90 that the body of the valve section 87 which carries the cam 97 will be thrown into a new angular position on shaft 92 and operate said cam. The moving division wall 91 as well as the fixed division wall 94 are suitably "packed" at points 98 and 99 respectively with reference to the exterior periphery of the fixed shaft 92, and the interior wall of the valve section body 87*a* respectively, to reduce gas leakage thereabout. Until the input lever or arm 86 is given an angular displacement, and while both ducts 89, 89 are in closed positions, both of the operating chambers 90, 90 are at the suction pressure delivered by the suction pipe 100, Fig. 5, by means of the suction duct 93 and the restricted ports 95, 95 of the central shaft 92. However, when the much larger controlled vents 89, 88 are opened by means of the actuation of the input lever 86, the gas pressure which surrounds the whole torque multiplier prevails over the pressure admitted by the suction pipe 100 and a pressure inequality is set up between the two chambers 90. The difference in pressure in the chambers 90, 90 tends to act on the division walls 91 and 94 and moves the body 87*a* of the valve section 87, an amount corresponding to the circular motion of the input arm 86.

After this movement of the cam is accomplished, it is seen that the input arm 86 and the body of the valve section 87 resume their equilibrium position through the equalization of the pressure in the chambers 90, 90 so that little or no more external gas is admitted to the chambers 90 through either of the ducts 89 and motion of the various parts of the device ceases. The motion of the cam 97 then, acts in accordance with the relative pressures contained in the suction pipe 100 and the gas surrounding the torque multiplier. The motion of the body of the valve section 87*a* can thus be used to operate a cam 97 and a cam follower such as 47, or 83 Fig. 1, or to drive an output arm or lever.

It will be noted in the above description two kinds of means are used to operate the cam followers 47 and 83, and connecting rods 46 and 58.

In the first instance shown in Fig. 1 of the drawings where no suction torque multipliers 121 (Fig. 5) are used, in transmitting motion from

ratio arms 35 and 63 to the cam followers 47 and 83 respectively, it is seen, said arms 35 and 63 are required to be rigidly mounted on said shafts 37 and 64; likewise cams 50 and 82 are required to be rigidly mounted on said respective shafts. Shafts 37 and 64 are themselves revolvably mounted in their supports (not shown) so that when ratio arms 35 and 63 are angularly moved, said cams are correspondingly operated in order to actuate the cam followers 47 and 83, and rods 46 and 58. The selector valve 120 parts 114, 115, and pipes 110 and 111 in this case are eliminated as they are used only when the torque multipliers 121 are used.

In the second case where "suction toque multipliers" such as 121 (Figs. 3, 4 and 5) are used, conditions are somewhat reversed. The shafts 37 and 64 which correspond to the shaft 92 of Figs. 3, 4 and 5 are then not made revolvable, and the ratio arms 35 and 63 of Fig. 1, (which correspond to input lever 86, Fig. 3), are made revolvable with reference to shafts 37 and 64, as is at once understood from the description of "suction torque multiplier" 121 as explained above. The cams 50 and 82 are also made revolvable with reference to the shafts 37 and 64 when the torque multiplier is used in connection with the device shown in Fig. 1 of the drawings.

It will be noted in the first instance above mentioned that where no torque multipliers are used, the operation of the Venturi spoon is not influenced by the gas pressure taken from the inlet passage 34 at point 119 through pipe 111, nor by the pressure through pipe 110. However, the pressure taken at point 17 at substantially the same point as 118 in the throat 15 of passage 34 has a bearing on the operation of cam 82, and on the Venturi spoon 2 due to the use of the pipe 67 used to operate bellows 62, and arm 63 before described.

The suction selector valve

The suction selector valve 120 used with the present invention comprises the following parts. A valve body 101 is provided having a pair of spaced-apart valve seats 102, 103 which are preferably formed integral with the valve body casting 101. A valve spindle 104 is slidably mounted in recesses 105, 106 in the casing and the spindle is made shorter in length than the overall length between the ends of the recesses 105 and 106, leaving a space 107 on either end of the spindle according to the position of the spindle.

The grooves 108*a*, 108*a* insure the proper venting of the space 107 between the spindle ends and the ends of the recesses 105, 106, when the valve is in a closed position on either side of the valve seat 102 or 103.

The inlet ports 108, 109 are connected with pipes 110, 111 respectively, and suction port 112 connects with the dual ended pipe 113 which forms two branches 114, 115 leading to the torque multiplier 121 above described. The valve heads or discs 116, 117 are arranged to be in contact with either one of the valve seats 103 or 102, but with only one at a time.

The net force or pressure on the valve discs 116, 117 moves either one of them and spindle 104 within the valve, toward the side of lower gas pressure as received from pipes 110 or 111, seating the valve between the source of higher pressure such as 109*a*, in the drawings, and the suction service connection or suction port 112. It is evident that as the pipe 110 connects with the Venturi suction port 118 at the throat 15 of the venturi, and pipe 111 connects with the blower inlet suction port 119 in the passage 34 at a point after the gas pressure in the inlet passage 34 has passed the Venturi spoon 2, that the gas furnished by the suction selector valve 120, to the pipe 113 will have a pressure equal to the lower pressure of gas or air withdrawn through the ports 118, 119 in the carburetor inlet passage 34, whichever point in the passage 34 furnishes lower pressure.

The pipes 114 and 115 lead to the pipe 100 (Fig. 5 of the drawings) of the suction torque multipliers 121 above described and one of which is mounted on each axis 37, and 64 if desired of Fig. 1 of the drawings.

The carburetor assembly

The various elements and devices described above are assembled to form a simplified carburetor in Fig. 1 of the drawings. The Venturi spoon 2 is positioned by the servo finger 14 as before described either manually or automatically, said finger being mechanically positioned by the cam 29. The input to this cam 29 as shown and above described is a function of the sum of the logarithms of the density and pressure ratio corrections above described in connection with the devices shown in and about the closed container 13. Cams 50 and 82 which originally attached to the torque multipliers 121, 121 which are mounted on the shafts 37 and 64, deliver these logarithmic indications to the cam followers 47 and 83 and these motions are aided by the connection rods 46 and 58, by the cross rod 48 and then delivered to the connecting rod 31 which controls the cam 29, and hence the servo finger 14 and the Venturi spoon 2 as is readily understood.

It will be noted that while the arrangements have been made for the cams 50 and 82 of Fig. 1 and the cam 97 of the suction torque multiplier Fig. 3 to push downward the connection rods 46 and 58 and the connecting rod 31 by means of the cross arm 48, it is evident that means must be used to push upward the rod 31 as soon as the cams above mentioned permit such action to be taken. This is provided for by means of a coil spring 23 which is mounted on the pintle 28 which is carried by the fixed cam support 26. The said spring 23 bears against the outstanding arm 141 of the cam 29 at point 142 and pushes the connecting rod 31 upwards when permitted so to do by the cams above mentioned.

This carburetor arrangement automatically controls the size of the throat 15 leading to the inlet passage 34 and places the Venturi spoon 2 automat'cally in position according to the combined operation of the various devices such as 59, 60, 31, 14 as above described. Said devices within the container 13 are, of course, also affected by means of the suction selector valve 120 as before explained. Suction pressure to drive the torque multipliers 121 is taken selectively from the venturi suction port 118 or the blower inlet suction port 119 whichever gives the lesser suction pressure.

The selector valve 120, of course, selects the proper source of suction from the ports 118, or 119 fed to the torque multipliers 121, 121 on the shafts 37 and 64, (Fig. 1), or hollow shaft 92 of Fig. 5.

The metering pressures P1 and P2, taken through parts 18 and 17 respectively, are delivered across the air diaphragm 122 in the "pres-

sure responsive device" 123. The diaphragm 122 which is preferably of stiff material is provided with flexible material at 124, 124 between the central stiff portion thereof and the fixed housing 125 to which it is attached. A central valve stem 126 is mounted at 127 on the diaphragm 122 as shown and a suitable yielding "packed" orifice 128 is used to prevent leakage around said valve stem where it leaves the device 123 as shown.

On the lower end of the stem 126 is a fuel regulating valve 137 which is seated at 128a in the fuel charging box 129 and as stated before, the latter is provided with the fuel charging orifice 19. A second "pressure responsive device" 130 surrounds the valve stem 126 between the charging box 129 and the device 123. Said device 130 is provided with a stiff diaphragm 131 which is attached by flexible material at 132, 132 where it is attached to the walls 133 and 134 of the device 130. Said diaphragm 131 is also rigidly attached at 135 to the valve stem 126, and it is seen that the two diaphragms 122 and 131 co-act upon the valve stem 126 and the valve 127.

The metering pressure across the fuel orifice 136 is also across the fuel diaphragm 131, the total forces on the two diaphragms 122 and 131 are automatically balanced by the action of the fuel regulating valve 137 as long as fuel is supplied to the fuel inlet orifice 19 under sufficient pressure. Fuel is delivered to the carburetor passage 34 through the delivery pipe 138.

A butterfly valve 140 may be inserted in the inlet passage 34 if desired for the purpose of controlling the flow of air passing to the engine.

From the above description of the various parts of the present carburetor arrangement it is seen that a fuel and air mixture is supplied to the engine through the orifice 139 from the passage 34, which is regulated in proportions by a series of factors and devices shown and described in the above specification, and which appear in the Figs. 1 to 5 of the drawings, practically all of which operate automatically, and provide an almost perfectly balanced fuel and air mixture to the engine, corrected for the effect of pressure, density, temperature and other factors as fully described in the present specification.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

In a means for regulating the pressure and amount of supply of gaseous fuel through a carburetor inlet supply pipe which is provided with a venturi therein in accordance with a combination of factors created in the inlet pipe, such as the density of the air at the entrance of the inlet passage, the air pressures found at the throat of the venturi, as modified by the air pressure at the entrance of the inlet passage, and the pressure of air and gas found in the inlet passage at a point beyond and below the discharge from the venturi, comprising a closed pressure responsive device, a flexibly mounted air pressure actuated diaphragm therein, dividing said device into two operating chambers, means for admitting air pressure to the upper chamber from the entrance of the inlet passage, means for admitting fluid pressure to the lower chamber of said device, from the throat of the venturi, a vertically disposed valve stem and head attached to the aforesaid diaphragm, a second closed pressure responsive device, a flexibly mounted fuel pressure actuated diaphragm in the last-named pressure device, rigidly attached to the valve stem, a fuel charging box mounted beneath the second pressure responsive device, having a fuel charging orifice and a valve seat therein, and communicating with the lower portion of the chamber of the second-named pressure responsive device, and means for admitting fuel under pressure from the charging box to the inlet passage at a point below the venturi and also admitting similar pressure to the upper portion of the chamber of the second-named pressure responsive device, the above arrangement of parts being intended to open and close the fuel charging valve upon the joint action of the diaphragms in the two pressure responsive devices, which action is dependent on the various combined factors mentioned, which relate to the density and pressures of air and fuel, found in the various parts of the inlet passage, as desired.

ALFRED B. METSGER.