

July 19, 1938.

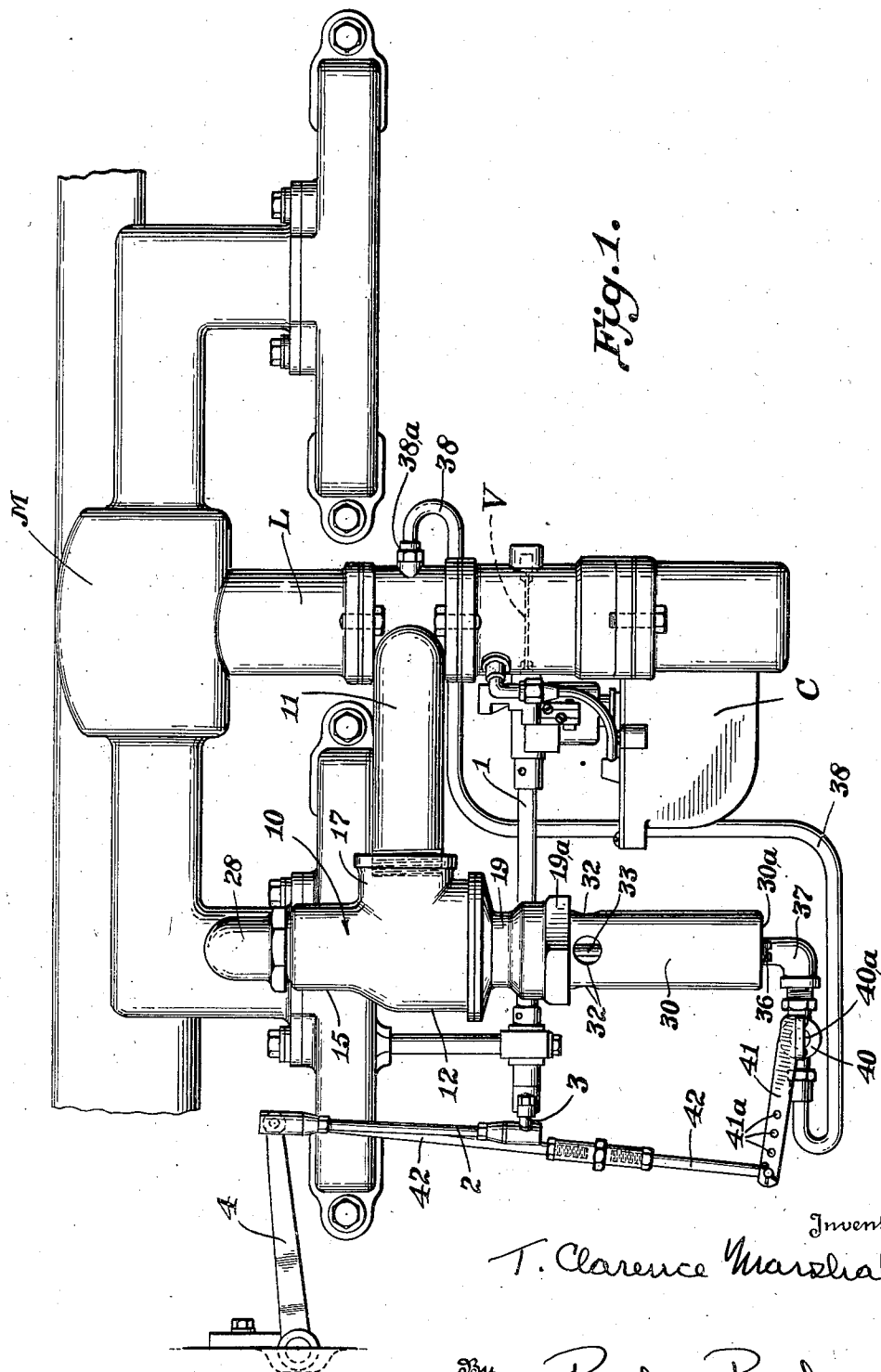
T. C. MARSHALL

2,124,492

INTERNAL COMBUSTION MOTOR

Filed May 19, 1936

2 Sheets-Sheet 1



Inventor

T. Clarence Marshall

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Peck & Peck

Attorneys:

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2 Sheets-Sheet 2

Fig. 2.

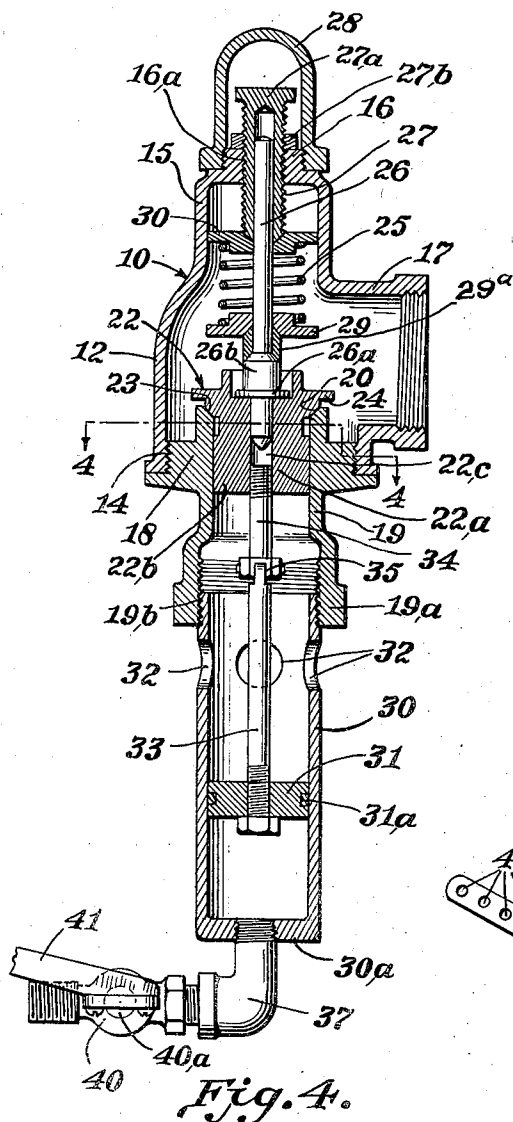


Fig. 3.

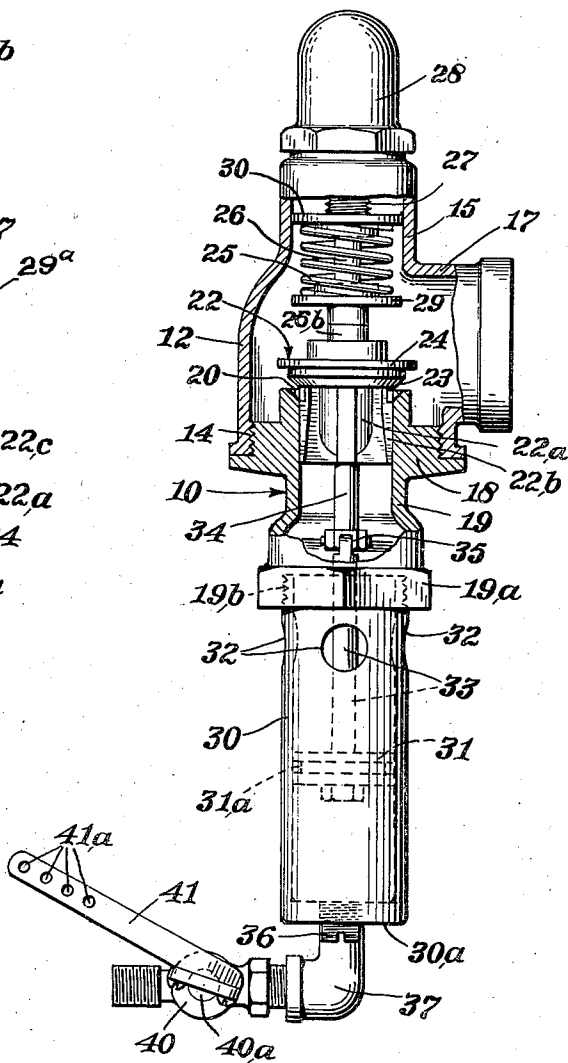
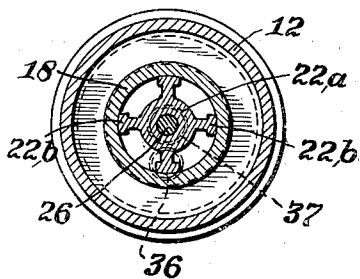


Fig. 4.



Inventor

T. Clarence Marshall

By Peck & Peck

Attorneys

UNITED STATES PATENT OFFICE

2,124,492

INTERNAL COMBUSTION MOTOR

Thomas Clarence Marshall, Yorklyn, Del.

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8 Claims. (Cl. 123—124)

This invention relates to certain improvements in internal combustion motors, and more particularly concerns the automatic control of the motor intake vacuum and fuel mixtures in accordance with motor operating conditions; and the nature and objects of the invention will be readily apparent to and understood by those skilled in the art in the light of the following explanation and detailed description of the accompanying drawings illustrating what I at present believe to be the preferred forms or mechanical expressions of my invention from among various other forms, embodiments, arrangements, combinations and constructions of which the invention is capable within the broad spirit and basic scope thereof.

The invention is concerned with and directed to the problems of controlling the vacuum created in motors or engines of the internal combustion types, and in concurrently varying the fuel mixture for such motors, in accordance with the varying conditions under which the motor operates, for the purpose of materially increasing the efficiency of a motor by reducing the fuel waste and power loss resulting from high motor vacuum and over-rich fuel mixtures which are encountered under certain conditions of motor operation. While not so limited or restricted, the invention is of particular utility in connection with internal combustion motors of automotive vehicles, because it is under the operating conditions encountered by such motors that the disadvantages and inefficiencies resulting from high vacuum conditions and over-rich fuel mixtures are encountered in a very high degree.

One of the features of the invention resides in the provision of an apparatus or device for combination with an internal combustion motor and capable of automatically functioning or operating to establish the different allowable maximum vacuums for the several ranges of motor operation respectively and to automatically prevent the motor vacuum from exceeding such maximums during the operation of the motor in the respective ranges by the admission of air to the motor intake; while the fuel mixture is simultaneously varied by such air admission in accordance with such vacuum control.

Another feature of the invention is found in the utilization of the force exerted by the suction effect of the motor vacuum to automatically assist in the establishment and maintenance of the different allowable maximum vacuum magnitudes for the respective portions of the motor operating range; and further in the

control of the application of such vacuum force by and in accordance with the motor operating conditions corresponding to the positions of the motor throttle valve for the different portions of the operating range of the motor.

A further feature and characteristic of the invention is found in the controlled application of the suction force of the motor intake vacuum to overcome or oppose the force of such vacuum which is simultaneously applied to an air admission valve in a manner continuously tending to open such valve, with the result that for and during a certain portion of the motor operating range the air valve is maintained closed against a motor vacuum of greater magnitude than normally required to open the valve when the opposing vacuum force is removed; such force which opposes air valve opening being removed for normal operation of the valve during the remaining or other portions of the motor operating range.

A more specific feature of the invention is presented by an embodiment of apparatus in which an air valve of a certain area is maintained closed against the direct suction effect on such valve area of motor intake vacuum magnitudes below a predetermined vacuum magnitude by the application of a closing force to such valve, and a suction operated piston of a predetermined area relative to the valve area is provided for actuation by the suction force of the motor intake vacuum to apply an additional closing force opposing opening of the air valve by intake vacuum below a magnitude that is greater than the valve opening maximum vacuum when such additional closing force is removed, the valve being opened against the combined closing forces by a vacuum of or greater than the predetermined maximum.

A further more general object of the invention is to provide a practical design of apparatus embodying the foregoing features and characteristics, which will be positive and efficient in operation and results, and one which lends itself readily to application to or incorporation in an internal combustion motor, while being of relatively low initial cost and requiring a minimum of attention and upkeep in operation and use.

With the foregoing general objects, features and characteristics in view, as well as certain others that will appear from the following description, my invention consists in certain novel features in design and in combinations and arrangements of parts, as well as in the mode or method of operation,—all as will be more fully

and particularly referred to and specified herein-after.

Referring to the accompanying drawings, in which similar reference characters refer to corresponding parts throughout the several figures thereof:

Fig. 1 is a view in side elevation of portions of an internal combustion engine or motor of an automotive vehicle, including the motor fuel intake line, intake manifold, carbureter and throttle valve and a portion of its operating mechanism, with a preferred form or embodiment of apparatus providing the air valve unit of the invention installed and mounted on the motor in operative relation and connection therewith; the motor throttle valve and its operating mechanism being shown as in normal "closed" or motor idling position.

Fig. 2 is a vertical longitudinal section through the valve unit and its operating and control means of Fig. 1, the air admission valve being shown in closed position held against opening by the combined forces exerted thereon by the upper spring and the vacuum operated piston.

Fig. 3 is a view similar to Fig. 2, but showing the air admission valve in raised open position against the force of the closing spring and with the vacuum operated piston released from the suction force of the intake vacuum and inactive to apply forces to the valve opposing opening thereof.

Fig. 4 is a transverse horizontal section through the valve unit, taken as on the line 4-4, of Fig. 2.

An automatically operated air admission valve unit embodying and including the principles and various features of my present invention, is adapted to and intended for application to and use with internal combustion motors generally, but such a unit is primarily adapted to meet the operating conditions encountered with the internal combustion motors or engines of automotive vehicles, especially motor vehicles of the road types, or automobiles. Hence, I have in the present instance, as an example for the purpose of describing and explaining the principles and features of the invention, selected an adaptation or embodiment of the invention which is designed for application to and use with a typical motor of a motor vehicle of the road type. Such motors are more or less standard or conventional and familiar to and well understood by those skilled in the art, and I have considered it only necessary in the accompanying drawings to illustrate those parts or elements of a typical automobile motor with which the apparatus forming an air valve unit of the invention is associated or cooperates in the operation and use of the unit.

As representative of a typical and well known motor vehicle internal combustion engine or motor, I have illustrated in Fig. 1 of the accompanying drawings, the intake manifold M of the motor connected by the fuel mixture intake line L with the carbureter C, through which the fuel mixture is drawn from the carbureter into the usual combustion chambers of the motor cylinders by suction force created in the manifold and intake line by the motor pistons, all in the usual and well known manner. The usual motor throttle or butterfly valve V is shown by dotted lines in Fig. 1, mounted in the motor intake line L for rotation to open and close such line to control the flow of fuel mixture to the motor and thereby control the operation and

performance of the motor. The position of valve V as shown in Fig. 1 is the usual or normal valve "closed" or idling setting of the valve. The valve V is actuated and controlled by the driver of the motor vehicle, through the medium of a throttle valve operating mechanism that includes the rotary shaft 1 coupled to the valve V, and the link 2 pivotally connected between and operatively coupling an arm 3 on shaft 1 and an end of the rocker arm 4. The arm 4 is suitably coupled with and actuated by the usual driver operated foot and/or hand controlled accelerator or the like member (not shown) in the conventional or any desired manner.

The motor throttle valve V and its driver actuated operating mechanism 1-2-3-4, are shown in Fig. 1 of the drawings with the throttle valve in its normal so-called "closed" position or "idling" setting for idling operation of the motor. The throttle valve V is rotated or swung to open positions from the illustrated idling position, by upward swinging of arm 4, which through link 2, rocks arm 3 and rotates the valve to opened positions for increased flow of fuel mixture from carbureter C to the intake manifold M and the motor, to accelerate and increase the speed and power of the motor. The valve is rotated from open positions toward closed or idling position to decrease fuel flow to the motor and decrease the motor speed and power, by reverse movements of the valve operating mechanism, that is, arm 4 is swung downwardly with resulting movements of links 2 and 3 and shaft 1 to close the valve.

With the throttle valve V in its motor idling or "closed" setting of Fig. 1, it was found that the particular motor of the example hereof, developed a vacuum of the order of approximately 20 inches on a vacuum gauge, in the intake line L, manifold M and the motor, against which the idling motor must operate. Such a vacuum condition with the vehicle at rest and the motor idling is not, however, a serious operating condition or one that contributes largely to substantial fuel waste and power loss, particularly when it is considered that a motor and its fuel mixture supply must be adjusted for an efficient idling operation of the motor, and that to obtain such efficient idling operation, a relatively rich fuel mixture must be steadily supplied to the motor in ample quantity by a positive suction force.

From the idling operation of the motor, if the vehicle is placed through the usual shift of gears into high gear with the throttle valve V opened to cause the motor to drive the vehicle at a speed say of approximately 10 miles per hour, then with the particular motor and vehicle of the example hereof, a vacuum in the intake of the order of approximately 20 inches on a vacuum gauge, was found to exist. If then the motor throttle valve V is further opened to increase the speed of the motor and vehicle, the vacuum in the intake drops or decreases rapidly with the opening of the throttle valve, and if the motor throttle valve is opened to maximum open position or full throttle, the vacuum in the intake drops or decreases to a very low degree corresponding to an order of approximately 1 or 2 inches on a vacuum gauge. However, as the motor and vehicle accelerate by the opening of the throttle, the driver naturally slowly closes the throttle with the result that the vacuum in the intake line and motor builds up or increases very rapidly due to the fact that the motor is then acting partially as a pump, and this in-

creasing vacuum will attain the very high degree of the order of 25 to 26 inches on a vacuum gauge. If the motor throttle valve V is then brought to its idling position under such conditions with the vehicle moving at the higher rates of speed, there is developed this very high degree of vacuum instead of the normal maximum of the order of 20 inches with the motor idling and the vehicle at rest. A vehicle motor operates under such high intake vacuum conditions for the majority of the time when the vehicle is being driven in the range from approximately 20 to 60 miles per hour or higher, and the major fuel waste and motor power loss together with the other disadvantages hereinbefore referred to, due to the high vacuum conditions in the motor intake, are encountered in such range of operation.

Following and applying the principles on which my invention is based, I provide for an automatic control of the motor intake vacuum conditions to reduce the high vacuum, and concurrently with and as a result of such reduction I obtain a dilution of the fuel mixture, in the motor intake during and throughout the ranges of motor vehicle driving speeds at which such high vacuum is mainly encountered. I accomplish this vacuum control through the medium of an air admission valve in the motor intake line L intermediate the carbureter C and the motor intake manifold M to the motor, which valve is controlled automatically by forces applied thereto as the differential between the force of the intake vacuum acting to open the valve, and predetermined forces of different magnitudes selectively and independently applied to the valve to close it, the application of such independently applied forces being synchronized with and according to the setting or position of the motor throttle valve V. Such an intake air admission valve may, as in the example hereof, be embodied in a valve unit 10 which is coupled into communication with the intake line L by the conduit or air pipe 11, as clearly shown in Fig. 1 of the drawings, for discharging air into the intake line L to break down or decrease the magnitude of a condition of vacuum therein, and at the same time dilute or reduce the richness of the fuel mixture drawn or sucked up by the motor through the line from the carbureter C.

In the particular form and embodiment of the valve unit 10 illustrated herein as an example, such unit includes a main casing 12, preferably, although not essentially, of generally cylindrical form, having an open internally threaded lower end 14 and a decreased diameter upper end portion 15 terminating in the head 16 (see Fig. 2), providing a vertical boss having an internally threaded axial bore 16a there-through. The casing or housing 12 is formed with a horizontal laterally extended air discharge outlet 17 from one side thereof having a relatively large internal diameter and internally threaded at its outer end for coupling to the air conduit or pipe 11 to place the interior of casing 12 into communication with the motor intake line L.

The lower end of the casing 12 of the valve unit 10 receives a valve seat forming and air intake member 18 that is threaded into the casing and provides a depending vertically disposed air intake tube 19 with the bore of the tube 19 continued axially through member 18 and opening at its upper end into the chamber or space formed within the casing 12. The lower portion 19a of the depending tube or casing 19 is enlarged or belled to provide an increased internal

diameter for the air passage therethrough, and such increased diameter portion 19a is internally threaded at 19b. The upper side or face of member 18 within the casing 12 has the edge thereof around the air inlet passage therethrough beveled to provide a valve seat 20 for receiving the air admission valve to be hereinafter described.

Within the air chamber formed by the valve unit casing 12, for cooperation with the valve seat 20 to open and close the air inlet passage to the chamber, the vertically movable or reciprocal air admission valve 22 is mounted for automatic operation in accordance with the principles of the invention. The air valve 22 in the present example, is mounted in horizontal position on the upper side of the member 18 over the upper inlet end of the air passage through member 18, and is provided with the annular beveled valve face 23 there-around for engaging and seating on valve seat 20 with the valve in lowered, closed position (see Fig. 2). The valve 22 has a diameter greater than the maximum diameter of valve seat 20 and provides the annular flange 24 there-around which extends over the upper end or edge of member 18. The valve 22 is also provided with a depending axial body portion 22a that includes the spaced vertical ribs 22b extending radially therefrom in diametrically opposite pairs (see Fig. 4), which body and ribs extend down into the cylindrical bore forming the air inlet passage through member 18, with the ribs 22b in sliding engagement with the passage walls to form a guiding and centering structure for the valve in its vertical reciprocation between opened and closed positions.

The air admission valve 22 of the valve unit 10 is normally forced downwardly and maintained in seated and closed position as shown in Fig. 2, by a force exerting member or unit, such as the expansion coil spring 25, mounted above the valve. In the particular arrangement here shown, the valve 22 is formed with an axial bore 22c extending downwardly therethrough from the upper side of the valve, and a rod 26 is fitted into bore 22c and supported therein by a flange 26a on the rod which engages and rests upon the upper surface or face of the valve, as will be clear by reference to Fig. 2 of the drawings. The rod 26 extends upwardly through the casing 12 and is slidably received at its upper end in a spring force adjusting tube or member 27 which is externally threaded and screwed down through the internally threaded bore 16a of the end boss 16 of the casing upper end portion 15. The upper end of adjusting tube 27 is formed with the head 27a, and a set or lock nut 27b is provided on the tube between the head and the upper end face of boss 18 for securing the tube in an adjusted position (see Fig. 2 of the drawings). A cover or cap 28 is removably threaded onto the externally threaded boss 18 of casing 12 and encloses and covers the upper end of the adjusting sleeve 27.

The valve spring 25 is mounted around rod 26 within the casing chamber and is held between vertically spaced plate members or washers 29 and 30. The lower of these washers 29 rests upon a spacer 29a which is supported in position on the rod by an enlargement 26b of the rod above the rod flange 26a. The upper spring holding washer 30 is slidably mounted on the rod and is held against upward movement thereon by the lower end of spring force adjusting tube 27. Thus, the spring 25 is held between the lower washer 29 and upper washer 30, preferably under initial

compression, so that the expansive force of the spring, until overcome by a force of greater magnitude acting upwardly on the valve, holds the valve in closed position on its seat 20. The valve 22 and rod 26 are free to move upwardly to unseat the valve to open position by compressing spring 25 between plates or washers 29 and 30. The initial compression and force exerted by the spring on the valve can be adjusted by screwing tube 27 downwardly to increase spring force, and upwardly to decrease the force exerted on the valve by the spring.

In accordance with a further feature of my invention, I make provision for the application of valve closing forces to the valve 22 in addition to the force normally constantly applied by the valve closing spring 25, but such additional closing force is only applied under certain conditions of motor operation as determined by certain motor throttle valve positions or settings. Such additional valve closing force is obtained from the suction force of the motor intake vacuum, and in carrying out this feature of the invention I have in the present example provided a cylinder 30 in which a piston 31 is reciprocally confined, the cylinder being placed in communication with the motor intake at one side of the piston, and the piston being coupled with the air admission valve 22.

For instance, the cylinder 30 may, as in the example hereof, be formed of bronze or other suitable material with one end thereof closed, as by a head 30a which may be welded or otherwise secured, and the opposite end thereof open and externally screw threaded. The cylinder is mounted as an element of the valve unit by screwing the upper open end thereof into the lower enlarged end 19a of tube 19, so that the cylinder forms a depending continuation of tube 19 in substantial axial alinement therewith, with the lower end of the cylinder closed by head 30a, as will be clear by reference to Figs. 2 and 3 of the drawings. The cylinder 30 is provided with a series of spaced air inlet openings or ports 32 through the side wall thereof in the upper portion of the cylinder adjacent the lower end of tube portion 19a. These ports 32 provide the medium by which air is drawn into the valve unit and passes upwardly therethrough into casing 12 and pipe 11, when the air admission valve 22 is in raised and open position.

The piston 31 may preferably, although of course not essentially, be formed of aluminum and is provided with a suitable peripheral groove therearound to receive a usual type of split sealing ring 31a by which the piston is maintained in substantial though not absolute sealing engagement with the wall of cylinder 30. The piston sealing ring 31a is preferably in the example hereof, of very light tension and may be formed of cast iron. A piston rod 33 is provided for piston 31, being secured to the piston in any suitable or desired manner, and extends a distance upwardly from the piston through cylinder 30 and into the lower end portion 19a of tube 19. The piston rod 33 is operatively coupled with the air admission valve 22 in order that downward movement of piston 31 in cylinder 30 will apply downwardly acting closing forces to valve 22 in addition to the closing forces applied by spring 25. Such connection of the piston with the valve is carried out in the present example by securing a rod 34 in an axial bore in the valve body 22a in position depending from such body to the upper end of the piston rod 33 in substantial axial aline-

ment with the piston rod. The adjacent ends of the piston rod 33 and depending valve carried rod 34 are operatively coupled by a pivotal connection 35 which functions in effect as a universal connection in order to compensate for any non-alignment between cylinder 30, tube 19 and valve 22, and prevent any tendency of the piston and associated parts to bind during vertical reciprocation thereof in operation.

The lower closed end or head 30a of cylinder 30 is in this instance provided with a pair of spaced and internally threaded bores or openings there-through (see Fig. 4), one of which receives a closure plug 36 (see Fig. 3) and the other of which receives the end of a pipe line such as provided by the elbow 37 in the specific example hereof. With the cylinder so mounted and arranged the piston 31 is positioned spaced a distance above cylinder head 30a when valve 22 is in lowered closed position, as shown by Fig. 2, while upward movement of the valve 22 to raised and open position, moves piston 31 but a slight distance to the position thereof as shown in Fig. 3.

Referring now to Fig. 1 of the drawings, with the valve unit 10 mounted on the motor and connected with the intake manifold L by the pipe 11 for discharge of air from the unit into the manifold, the cylinder 30 is placed in communication with the intake manifold in such a manner that the suction effect of the manifold vacuum can be applied to piston 31 to cause the latter to apply closing forces to the air admission valve 22. For example a tube 38 is connected to and in communication with the motor intake manifold at 38a and extends to and is placed in communication with the cylinder 30 below piston 31, through the elbow or coupling member 37. A valve unit 40, which as in the example hereof may be of the conventional and well known barrel or plug type, is interposed and coupled into the tube or pipe line 38 for the purpose of shutting off or opening the line and cylinder 30 from and to communication with the motor intake line L. The valve stem or operating shaft 40a (see Figs. 2 and 3) is provided with an actuating arm 41, which in this instance extends in a generally horizontally disposed position when valve 40 is rotated to open position, as shown in Fig. 1 in particular.

The valve 40 is operatively coupled and associated with the actuating mechanism for the motor throttle valve V, and as shown in Fig. 1, such coupling may be provided by an adjustable length link or push-pull rod 42 pivotally connected to and coupling the end of arm 4 with the end of valve actuating arm 41, so that valve 40 is opened and closed in accordance with the position or setting of the motor throttle valve V, that is to say, in accordance with the motor operating conditions of speed and power.

In the example hereof, the arm 41 and rod 42 are set so that with the motor throttle valve V in "closed" or motor idling position, as shown in Figs. 1 and 2, the valve 40 in line or tube 38 is open or partially open, and the linkage is such that upon swinging of arm 4 to move the throttle valve V to opened positions to increase the speed and power of the motor, the valve 40 remains partially opened or is not closed until the motor throttle reaches a predetermined open position from idling position. After the motor throttle valve passes beyond such predetermined opened position, valve 40 is thereupon closed and cylinder 30 and piston 31 are shut or closed off from communication with tube 38 and the intake line

L. The opened position of the throttle valve V at which the valve 40 is actuated to closed position may be determined by adjustment in the operating linkage between valve 40 and the throttle valve actuating mechanism, that is, in this example, the arm 4. For instance, I have provided arm 41 with a series of holes or bores 41a, spaced longitudinally thereof (see Figs. 1 and 3) so that by connecting rod 42 to arm 41 at one of the holes 41a, along the arm, the closed and opened positions of valve 40 relative to the idling and opened positions of throttle valve V may be adjusted and determined. Similarly, for purposes of adjustment and relative setting of valve 40, the push-pull rod 42 is made adjustable as to length to thereby adjust the position of arm 41 relative to arm 4.

The valve unit of the particular example illustrated and specifically described herein, is generally adapted to use with automotive vehicle motors of medium and large size, and I have found in actual construction and operation of such a unit that satisfactory and efficient results are obtained with the intake to the motor manifold formed by a pipe or conduit of approximately one (1) inch diameter, and a valve seat 20 of member 18 of the unit also having a diameter of approximately one (1) inch. The area of the air admission valve 22 may be approximately one inch, while the diameter of the vacuum suction operated piston 31 is accordingly approximately one and one-sixteenth ($1\frac{1}{16}$) inches. The valve closing spring 25 of the example now referred to has a maximum force corresponding or substantially equivalent to a vacuum force represented by approximately ten (10) inches on a vacuum gauge. This spring 25 mounted as herein illustrated is adjustable by member 27 from its maximum compression to exert the above maximum force, down to a condition of zero (0) force, that is, a condition fully expanded.

With the motor of Fig. 1, and with the valve unit 10 having the construction described and mounted and connected as shown, in operation of the motor with the throttle valve V in idling position and the vehicle at rest, the valve 40 in the tube 38 is open or partially open. As with the motor of the given example there is found to be an intake vacuum of the order of approximately 18 to 20 inches on a vacuum gauge, this vacuum condition creates a suction force acting through tube 38 and in cylinder 30 beneath piston 31, with the result that the piston is drawn or sucked downwardly to the position shown in Figs. 1 and 2, to hold air valve 22 in closed position on its seat until a force of greater magnitude acts on the valve to raise it and raise the piston against such suction force. Now, in the illustrated example, the valve closing spring 25 is adjusted to exert a closing force on valve 22 corresponding to a force equal to approximately 5 inches of vacuum, that is, I establish a relatively constant valve closing force to maintain the valve closed against an intake vacuum up to a maximum of five (5) inches. The relative diameters of piston 31 and valve 22 are such that with valve 40 partially opened a required amount and a vacuum of the order of 20 inches in the motor intake, there will be established a vacuum of at least the order of 15 inches in the cylinder acting to draw piston 31 and valve 22 downwardly. Hence, with these conditions prevailing, the valve 22 will be maintained closed against a vacuum of a maximum of the order of 20 inches, so that when the intake vacuum exceeds such maximum

the upwardly acting force on the area of valve 22 will overcome the downwardly acting forces of spring 25 on the suction on piston 31, and the valve 22 will open to admit air to intake line L and break down the vacuum with simultaneous fuel mixture dilution.

At this point attention is directed to the fact that in installing and adjusting a valve unit 10 on a motor there are three major adjustments. First, the force exerted by valve closing spring 25, which is adjusted and set by member 27. Second, the length of connecting rod or link 42 between arm 41 and arm 4, which determines the degree or extent to which valve 40 is opened. Third, the distance between valve stem or shaft 40a and the point of pivotal connection between arm 41 and rod 41a, which in this instance may be selected by employing the desired bore of the series of bores 41a for attaching rod 42 to arm 41. This adjustment determines the range of throttle valve movement during which valve 40 remains in partially opened position, that is, the predetermined open position of the throttle valve at which valve 40 closes.

The vacuum condition in the cylinder 30 is determined after installation by removing plug 36 and attaching a vacuum gauge into communication with cylinder 30. After taking the necessary readings from the vacuum gauge the various adjustments are made as required to obtain the proper degree of opening of valve 40 and the position of closing thereof, and the vacuum gauge is then removed and plug 36 reinserted to close and seal up the cylinder 30.

Referring again to the operation of the unit when installed and adjusted as indicated above, with the motor throttle set for motor idling, valve 40 is open and there is a total closing force exerted on valve 22 by the suction force of the intake vacuum on piston 31 and the force exerted by valve closing spring 25, to maintain the valve closed during normal idling with the vehicle at rest against the intake vacuum of the order of 18 to 20 inches, but if the vacuum exceeds such maximum, then the suction force acting at the upper side of valve 22 in an upward direction will overcome the closing forces and raise the valve to open position.

As the motor throttle valve V is opened from idling position and until the valve reaches a predetermined opened position, say a position corresponding to a motor speed of the order of 600 R. P. M., the idling conditions prevail and the air admission valve 22 is maintained closed by the combined forces exerted thereon by spring 25 and the downwardly sucked or drawn piston 31, and the valve will be maintained closed until a vacuum of greater than 18 to 20 inches is established in the motor intake line L. After the motor throttle valve V reaches the predetermined open position, then arm 41 is rotated by rod 42 to close the valve 40 and thereby shut off cylinder 30 from intake line L, so that, the vacuum suction condition in cylinder 30 is destroyed and the piston 31 is released with the downwardly acting force exerted thereby on valve 22 removed. Thereupon the air admission valve is only held closed and seated by the force exerted thereon by the spring 25, and this condition prevails from the predetermined opened position of throttle valve V throughout the range to maximum or full open position.

When the piston 31 is released from the vacuum suction force and is inactive to merely move with valve 22, I have found that there is usually

sufficient leakage past the piston to permit of sufficiently free reciprocation of the piston in the cylinder. However, if desired a suitable small vent (not shown) may be provided in the lower
 5 end of cylinder 30, or preferably in the elbow 37 to eliminate resistance to piston movement, as will be readily understood.

The force exerted by the spring 25 is of a magnitude to maintain valve 22 closed against a
 10 suction force acting thereon to open the valve, established by a motor intake vacuum of the order say of 5 inches on a vacuum gauge, and such vacuum maximum is substantially maintained as
 15 a constant throughout the motor operating range during which spring 25 is alone active in applying valve closing force. Hence, with the motor throttle valve V in open positions and the piston
 20 31 inactive to apply valve closing forces, the air valve 22 is automatically opened when the intake vacuum exceeds the order of approximately 5 inches, and air is admitted from the inlet tube
 25 19 past valve 22 and through pipe 11 into the intake line L. This admitted air of course breaks down the vacuum and also dilutes the fuel mixture being drawn from the carburetor C, and upon the decrease in vacuum spring 25 forces
 30 valve 22 back to closed position on seat 20, so that further air admission is stopped. As a motor vehicle operating in the range from around 20 M. P. H. and higher, develops an intake vacuum of an order above 5 inches, with the air
 35 valve unit of the example hereof, the intake vacuum through this range is automatically maintained at or below the order of 5 inches, by the opening of valve 22 against the force of
 40 spring 25 whenever the vacuum increases above the indicated allowable maximum. Thus, by the operation of the motor under such reduced intake vacuum conditions the power is increased
 45 with a reduction in motor wear, while a substantial reduction in fuel consumption is attained together with more perfect combustion and a reduction in the carbon conditions in the motor and exhaust lines.

With the motor operating in the range at which the air valve 22 is controlled by the force of the
 50 spring 25 solely, of course, upon rapid acceleration by wide opening of throttle valve V, the intake vacuum reduces rapidly and the valve 22 remains closed, but as the desired rate of speed is attained the throttle valve is slowly closed and
 55 the intake vacuum rapidly builds up until the allowable maximum determined by the force of spring 25 is reached, whereupon valve 22 is automatically opened and air is admitted to the intake to break down the vacuum and maintain it at or
 60 below the allowable maximum. The air so admitted to the intake line dilutes the fuel mixture to effect the saving of fuel and to reduce overcharging with fuel and fouling the motor.

When the throttle valve V is closed to idling position, as shown in Fig. 1, with the motor vehicle coasting, as by deceleration from higher
 65 speed, or in coasting down grade with motor idling, immediately the throttle operating mechanism reaches a position for the predetermined throttle valve setting or partially opened position at which valve 40 in line 38 is opened, the intake
 70 vacuum draws piston 31 down or exerts a downwardly acting force thereon, which is applied as a closing force to valve 22 by rods 33-34, so that the allowable maximum vacuum intake is increased, in the specific example hereof, to the
 75 order of 20 inches. With the vehicle coasting and the motor idling, the motor is functioning

as a pump and a condition of very high vacuum will be established in the motor intake line, but the combined closing forces of spring 25 and
 piston 31 applied to valve 22 will not permit the vacuum to exceed the allowable maximum of say
 5 the approximate 20 inches of the instant example, because as such limit is reached valve 22 is opened to admit air and reduce the vacuum, while at the same time reducing the richness of the
 10 fuel mixture drawn into and charging the idling motor. By maintaining the increased limit of allowable maximum vacuum with the motor idling and in the low speed range, the desired richness of the fuel mixture is maintained, as well as an
 15 ample degree of motor vacuum for vehicle braking effect, while the effects of the normal very high vacuum under such operating conditions are eliminated.

It may be here pointed out that under operating conditions of the higher speed range represented by the motor throttle positions between
 20 the predetermined throttle open positions and the maximum open position, with the sole valve closing force exerted by spring 25 to maintain a relatively low maximum vacuum, such as the
 25 5 inches of the present example, then in the event that air valve 22 should admit too much air at any time for perfect combustion, the motor would tend to slow up and the operator would open the motor throttle to maintain the desired
 30 speed. Immediately the throttle is opened the vacuum in the intake will be broken down below the maximum and the air valve 22 will close under the action of spring 25 and the fuel mixture richness will be restored for proper combustion.
 35

Thus, with an air valve unit embodying the principles of my invention, mounted and connected in operative association with the motor of
 40 an automotive vehicle, the motor is operated automatically under reduced intake vacuum conditions throughout the major portion of its speed range above a predetermined low speed to thereby reduce fuel consumption and increase power and efficiency. The maximum allowable vacuum
 45 maintained for the foregoing range is substantially fixed or constant and determined by the force of the valve closing spring 25. In the range of operations from the predetermined low speed to and including motor idling, the maximum allowable vacuum is increased by the additional
 50 valve closing force derived from the motor vacuum and applied through the medium of the suction actuated piston 31. The maximum vacuum condition permitted in this range may preferably be the vacuum condition obtained
 55 with motor idling and the vehicle at rest, as in the specific example hereof. Under operating conditions with the motor in such lower speed range any increase in vacuum opens the air admission valve to break down the vacuum to or
 60 below the allowable maximum.

It will be evident that various changes, modifications, variations, substitutions, eliminations, and additions might be resorted to without departing from the spirit and scope of my invention,
 65 and hence, I do not desire to limit myself in all respects to the exact and specific disclosures hereof.

What I claim is:—

1. In combination with an internal combustion motor including, an intake line, a throttle valve and actuating mechanism for the valve, a normally closed air valve for opening to admit
 70 air into the intake line to prevent increase of motor vacuum, means continuously applying a
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force to said air valve of a magnitude to maintain the same closed against the valve opening force of a predetermined maximum motor vacuum, means operated by the motor vacuum and connected with the air valve for applying a closing force of a magnitude to the valve in addition to the force applied by said first mentioned means to thereby maintain the valve closed against a greater vacuum force of a predetermined maximum magnitude, said air valve adapted to be opened against the combined closing forces of said means by a vacuum of greater magnitude than the predetermined maximum vacuum, and said vacuum operated means operatively coupled with the throttle valve mechanism and actuated thereby to be rendered inactive for a portion of the operating range of the throttle valve.

2. In combination with an internal combustion motor including the motor intake line, throttle valve and its actuating mechanism, a normally closed air valve for opening by the suction force of the motor vacuum to admit air into the motor intake line to prevent increase in the motor vacuum, a cylinder, a piston reciprocal in said cylinder and coupled with said air valve for positive movement therewith between closed and opened positions of said valve, said cylinder being in communication with the motor intake line for establishing a suction force in the cylinder of a predetermined magnitude acting on the piston in a direction to apply a closing force to the valve to maintain the valve closed against the opening force applied thereto by a vacuum of predetermined magnitude, the closing force applied by the piston being overcome by the opening force on the valve of a motor vacuum greater than the predetermined magnitude, whereby the valve moves with the piston to valve opened position, and means coupled with the motor throttle valve actuating mechanism for opening and closing said cylinder in communication with the motor intake line in accordance with the position of the motor throttle.

3. In combination with an internal combustion motor including the motor intake line, throttle valve and its actuating mechanism, an air valve for opening by the suction force of the motor vacuum to admit air to the motor intake line to prevent increase in motor vacuum, a spring continuously exerting a closing force on said valve of substantially constant magnitude to maintain the valve closed against a motor vacuum of predetermined magnitude, a cylinder, a piston reciprocal in said cylinder and coupled with said air valve for positive movement therewith between closed and opened positions of said valve, said cylinder being in communication with the motor intake for establishing a suction force in the cylinder of a predetermined magnitude acting on the piston in a direction to apply a closing force to the valve in addition to the closing force applied by said spring, whereby the valve is maintained closed against an opening force applied to the valve of a vacuum up to a predetermined magnitude, the combined closing forces applied by the spring and piston being overcome by the opening force on the valve of a motor vacuum greater than the predetermined magnitude whereby the valve moves with the piston to valve opened position, and means coupled with the motor throttle actuating mechanism for opening and closing said cylinder in communication with the motor intake in accordance with the position of the motor throttle.

4. In an internal combustion motor a throttle valve and its operating mechanism, an air valve for opening to admit air to the motor intake to prevent increase in motor vacuum, suction operated means embodying a cylinder and a piston therein positively coupled with the air valve for applying a closing force to the valve of a predetermined magnitude, a suction line connecting said cylinder with the motor intake whereby the motor vacuum creates a suction force in the cylinder to actuate said piston to apply the closing force to the valve, a control valve in said suction line arranged so that in maximum open position only a predetermined maximum suction force can be created in the cylinder irrespective of the maximum magnitude that may be attained by the motor vacuum, and means operatively coupling said control valve with the throttle valve operating mechanism so that the control valve is opened and closed in accordance with the position of said throttle valve.

5. In an internal combustion motor, an air valve mounted for opening to admit air to the motor intake to prevent increase in motor vacuum, yielding means continuously exerting a closing force on said valve of predetermined magnitude, said valve being subjected to the suction force of the motor vacuum acting on the valve in a direction to open the same when the vacuum attains a magnitude to exert a force on the valve to overcome said yielding means, suction operated means embodying a cylinder and a piston therein positively coupled with the air valve for applying a closing force to the valve of a predetermined magnitude, a suction line connecting said cylinder with the motor intake whereby the motor vacuum creates a suction force in the cylinder to actuate said piston to apply a closing force to the valve in addition to the closing force applied by said yielding means, a control valve in said suction line arranged so that in opened position only a suction force of a predetermined maximum can be created in the cylinder to act on said piston irrespective of the maximum magnitude that may be attained by the motor vacuum, and means for opening and closing said control valve to cause said suction operated means to apply closing force to or remove the same from the air valve.

6. In combination with an internal combustion motor, including the motor intake line and the motor throttle valve and its operating mechanism, a normally closed air valve adapted to be opened by the suction force of the motor intake vacuum acting thereon to admit air into the intake line to prevent increase of motor vacuum, means continuously applying a force to said air valve of a magnitude to maintain the same closed against the valve opening force of a predetermined maximum motor vacuum, means operated by the motor vacuum and coupled with the air valve for applying a closing force of a predetermined maximum magnitude to the air valve in addition to the force applied by said first mentioned means to thereby maintain the valve closed against a greater vacuum force of a predetermined maximum magnitude, said air valve adapted to be opened against the combined closing forces of said means by a vacuum acting on the valve of greater magnitude than the predetermined maximum vacuum, and means coupled with said throttle valve mechanism for actuating said vacuum operated valve closing force applying means to render the latter inactive for a portion of the operating range of the throttle

valve between a predetermined open position and maximum open position.

7. In an internal combustion motor, including an intake line and the motor throttle valve and operating mechanism, a normally closed valve for admitting air to the motor intake to reduce motor vacuum, said valve being subjected to the suction force of the motor vacuum acting thereon in a direction to open the valve, means applying a force of predetermined magnitude to the valve in a direction to close the same whereby the valve is maintained closed against the suction force of a vacuum of a predetermined magnitude, means connected with said valve and actuated by the motor vacuum for applying a closing force to the valve of a predetermined magnitude, said valve being maintained closed by the combined closing forces applied thereto by said means and being opened when the motor vacuum attains a magnitude to apply a suction force to the valve sufficient to overcome said combined closing forces, and means operated by the throttle mechanism for rendering said valve connected vacuum actuated means inactive or active in accordance with the position of the motor throttle.

8. In an internal combustion motor, includ-

ing the intake line thereof and the motor throttle valve and actuating mechanism for said valve, a normally closed air valve for opening to admit air into the intake line to prevent increase in motor vacuum, said air valve being continuously subjected to the suction force of the motor vacuum acting thereon to open said valve, force means continuously applying a closing force to said valve of a predetermined magnitude to maintain the valve closed against a motor vacuum of a predetermined maximum magnitude acting on the valve to open the same, means for applying the suction force of the motor vacuum to said valve in a direction acting thereon to close the valve simultaneously with the application of the forces to the valve tending to open the same, and means coupled with and operated by the throttle valve actuating mechanism for rendering said suction force applying means inactive at a predetermined position of said throttle valve whereby said force means then solely acts to maintain the valve closed against the continuously acting suction force applied to the valve in a direction to open the same by the motor vacuum.

THOMAS CLARENCE MARSHALL.