United States Patent [19]

Caldwell

[11] **3,739,797**

[45] **June 19, 1973**

[54] **CONTROL APPARATUS FOR EXHAUST GAS RECIRCULATING SYSTEM**

[75] Inventor: **Roland B. Caldwell,** Columbus, Ohio

[73] Assignee: **Ranco Incorporated,** Columbus, Ohio

[22] Filed: **Nov. 29, 1971**

[21] Appl. No.: **202,783**

[52] **U.S. Cl.** ..... **137/85,** 123/119 A, 137/627.5, 137/DIG. 8

[51] **Int. Cl.** **F02m 25/06**

[58] **Field of Search** ..... 137/85, 627.5, DIG. 8; 123/119 A

[56] **References Cited**

UNITED STATES PATENTS

3,125,111	3/1964	Daly	137/116.5 X
3,575,189	4/1971	Smith	137/85

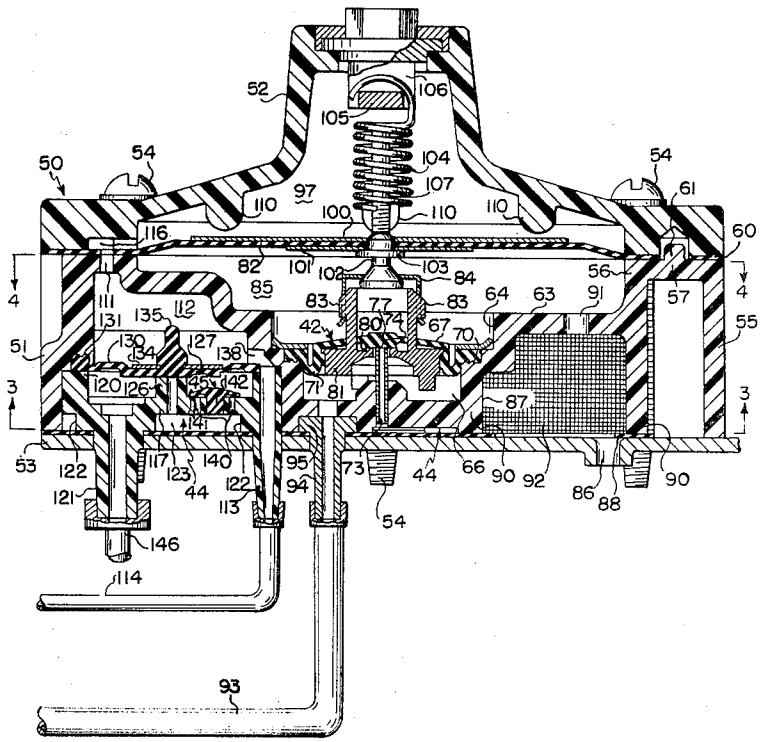
Primary Examiner—Robert G. Nilson

Attorney—Roy E. Raney, Blythe D. Watts, James T. Hoffman et al.

[57] **ABSTRACT**

Control apparatus for regulating the vacuum applied to control an exhaust gas recycling valve of an internal combustion engine comprises a body forming the housing for a vacuum regulator, a vacuum reservoir, a check valve between the reservoir and intake manifold connection of the engine and a relief valve for the reservoir. The construction of the body provides internal connections between the vacuum regulator, reservoir and the check and relief valves and provides readily accessible external vacuum connections to the venturi, intake manifold and recirculating valve.

6 Claims, 5 Drawing Figures



3 Sheets-Sheet 1

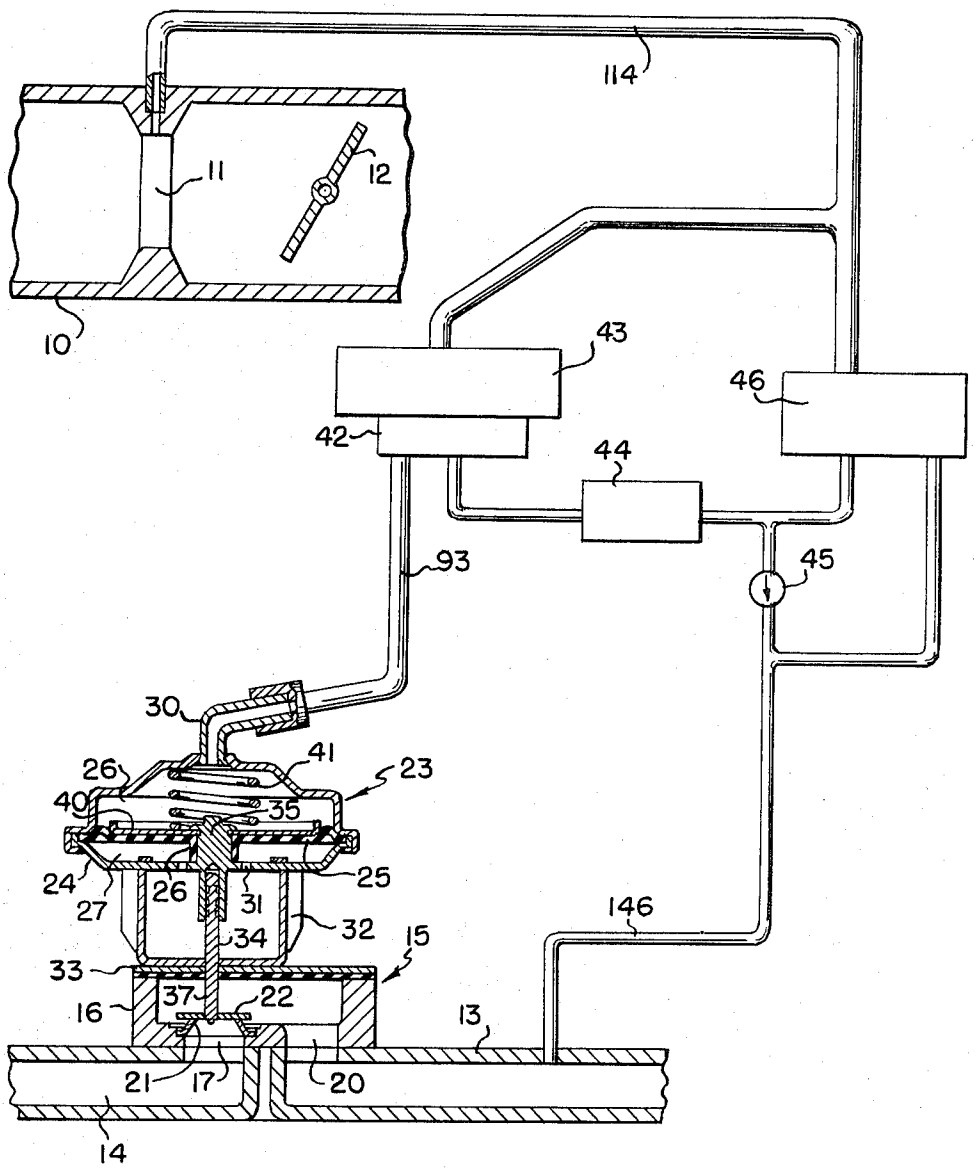


FIG. 1

INVENTOR.
ROLAND B. CALDWELL
BY
Watts, Hoffmann, Fisher & Heinke
ATTORNEYS

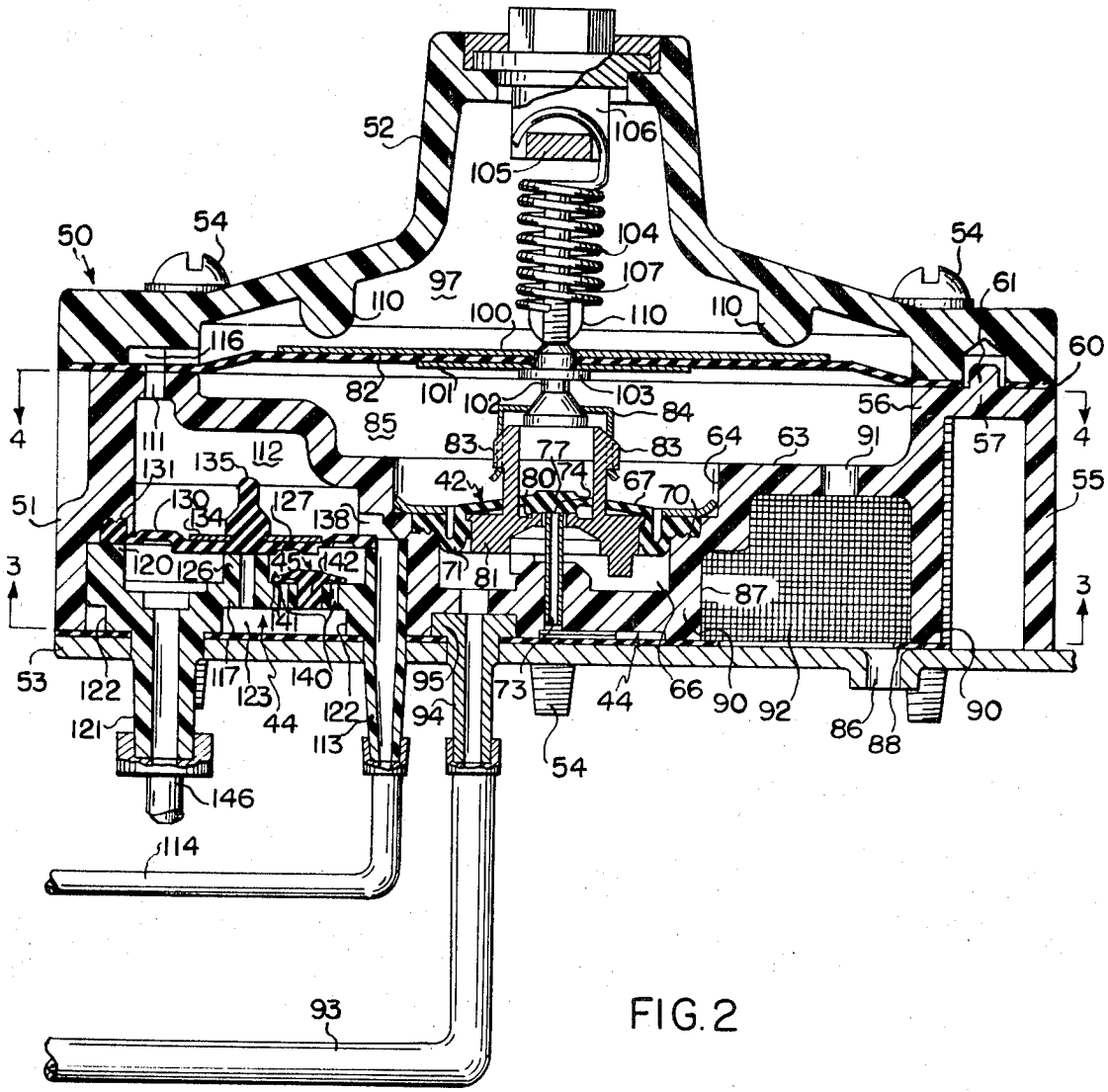


FIG. 2

INVENTOR.

ROLAND B. CALDWELL

BY

Watts, Hoffmann, Fisher & Heinke

ATTORNEYS

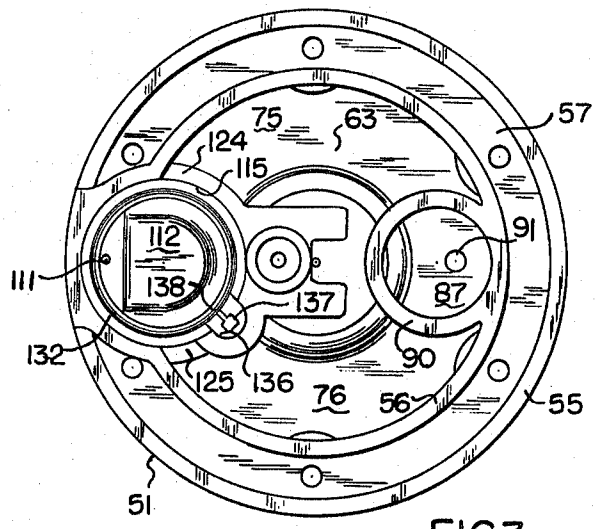


FIG.3

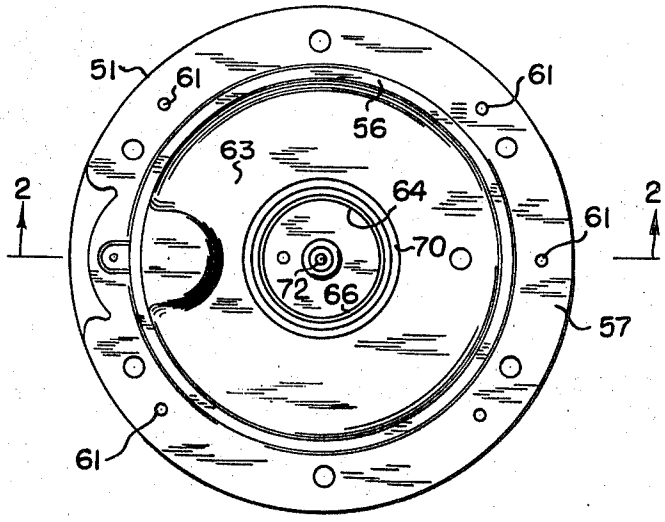


FIG.4

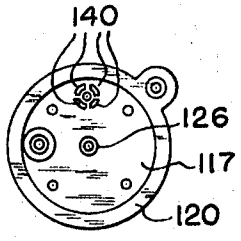


FIG.5

INVENTOR.
ROLAND B. CALDWELL
BY

Watts, Hoffmann, Fisher & Heinke
ATTORNEYS

CONTROL APPARATUS FOR EXHAUST GAS RECIRCULATING SYSTEM

BACKGROUND OF THE INVENTION

It is recognized that the emission of nitrous oxides by an internal combustion engine can be substantially reduced or eliminated by recirculating more or less of the exhaust gases back into the intake manifold of the engine. To maximize performance of the engine, however, it is desirable to recirculate a volume of exhaust gas proportional to the speed of the engine under average operating conditions and to close off the recirculation of exhaust gas during idling, severe loading and high speed operations of the engine. The following U.S. Pat. deal with recirculation of exhaust gases: Nos. 2,154,417; 2,419,747 and 3,507,260.

One system for controlling the recirculation of exhaust gases through an engine is disclosed in the present applicant's U.S. Pat. application Ser. No. 168,595, filed Aug. 3, 1971. In the system disclosed in the application mentioned, a valve for controlling the exhaust gas flow into the intake manifold is actuated by vacuum derived from the intake manifold of the engine. The strength of the valve actuating vacuum, and consequently the extent of opening of the valve, is controlled by a vacuum regulator which has a vacuum output which is an amplification of the vacuum at the venturi of the engine carburetor. The venturi vacuum is directly proportional to the speed of the engine, whereas the vacuum in the intake manifold will vary widely according to engine speed, degree of throttle opening and load on the engine. When the engine is idling, the venturi vacuum is low and the vacuum output of the vacuum regulator is such that the recirculating valve is closed. When the engine is operating at normal engine speeds and under normal loads, the vacuum output of the regulator is such as to open the recirculating valve to a suitable volume delivery, according to the engine speed. When the throttle is depressed for acceleration, the intake manifold vacuum may decrease momentarily and to prevent closing of the gas recirculating valve a reservoir and check valve are provided in the vacuum line between the intake manifold and the vacuum regulator. The reservoir maintains a sufficient vacuum to the regulator and the recirculating valve to prevent closing of the latter during momentary acceleration of the engine. During high speed operation of the engine it is desirable to close the recirculating valve. In this situation the vacuum in the intake manifold is below the vacuum at the venturi. To effect opening of the recirculating valve, a relief valve responsive to the differential in the vacuum at the venturi and that in the intake manifold, bypasses the check valve and opens the reservoir to the intake manifold vacuum.

THE PRESENT INVENTION

An object of the present invention is to provide a compact, easily assembled apparatus for controlling a gas recirculating valve in the type of system mentioned and incorporating in a unitary body the vacuum regulator, reservoir, check and bypass valves, and arranged to provide internal fluid connections and a minimum number of external connections to the automotive engine and the recirculation control valve for the engine.

In carrying out the invention a body is provided comprising a tubular section which is divided by a transversely extending wall. The wall has a pair of recesses

therein which form housings for the vacuum regulating mechanism and the check and bypass valves, respectively, and which likewise form the vacuum reservoir.

Preferably, the body is closed at its ends by covers, one of which forms a panel from which tube connectors extend for connecting the body with the carburetor venturi, the intake manifold and the vacuum operated recirculating valve.

Other objects and advantages of the invention will be apparent from the following description of a preferred form of the invention, reference being made to the accompanying drawings wherein:

FIG. 1 is a schematic showing, partly in section, of a system for controlling the recirculation of exhaust gases through an internal combustion engine;

FIG. 2 is a sectional view of control apparatus embodying the invention and utilized to effect the control system shown in FIG. 1, the sectional view being taken substantially along line 2—2 of FIG. 4 and on a larger scale;

FIG. 3 is an end view of a body of the apparatus shown in FIG. 2, the view being taken substantially along line 3—3 of FIG. 2, but on a smaller scale, and without the elements assembled therein which are shown in FIG. 2;

FIG. 4 is a view similar to that of FIG. 3, taken substantially along line 4—4 of FIG. 2; and

FIG. 5 is a plan view in elevation of a valve plate prior to assembly with the body.

Referring to FIG. 1 of the drawings, a control system is shown for controlling the recirculation of exhaust gases through an automotive internal combustion engine, only certain parts of which engine are shown. The engine includes a carburetor having an air intake 10 incorporating the usual venturi throat 11 and throttle plate 12. The engine also includes a conventional intake manifold 13 and an exhaust manifold 14. In the present instance an exhaust gas recirculation control valve 15 is arranged to control the flow of exhaust gas from the exhaust manifold into the intake manifold for recirculation through the engine so as to reduce or eliminate nitrous oxide emissions.

The valve 15 comprises a body 16 having an inlet port 17, leading from the exhaust manifold, and an outlet port 20 which discharges into the intake manifold. A valve seat 21 is formed about the inlet port 17 and is adapted to be opened and closed by a poppet type circular valve plate 22 shifted to and from the seat by a vacuum motor 23.

The motor 23 comprises a shell-like housing 24 having a flexible diaphragm 25 extending transversely of the interior thereof. The diaphragm 25 is hermetically joined about its periphery to the walls of the housing and partitions the housing into an upper chamber 26 and a lower chamber 27. The chamber 26 is adapted to be connected with a vacuum source through an elbow tube connector 30. The chamber 27 is open to atmosphere through an opening 31 in the lower wall of the housing.

The housing 24 is rigidly supported on the valve body 16 by a bracket 32 attached to a cover plate 33 on the valve body with the opening 31 in coaxial alignment with the valve plate 22. The diaphragm 25 is connected with the valve plate 22 by a stem assembly 34. The assembly 34 includes a plug 35 which extends through a sleeve 36 in the center of the diaphragm 25 and through the opening 31 in the lower housing wall. A

shank 37 is connected at one end to the plug 35 and is connected at the other end to the valve plate 22. The upper end of the plug 35 has a rigid back-up disc 40 attached thereto which lies on the diaphragm 25. A compression spring 41 is interposed between the disc 40 and the upper wall of the chamber 26 and urges the valve stem assembly downwardly to tend to close the valve plate 22 on the seat 21. When more or less vacuum is produced in the chamber 26 of the housing, the diaphragm 25 will be deflected upwardly by the atmospheric pressure in the chamber 27 and cause more or less opening the valve port 21.

The degree of vacuum present in the chamber 26 is controlled by apparatus comprised of a vacuum regulator 42 and a vacuum motor 43 for actuating the regulator 42. The vacuum source for the regulator 42 is obtained through an input connected to the intake manifold 13 and this vacuum source is regulated to provide a vacuum output which is connected with the motor 23 for operating the gas recirculating valve 15. The vacuum regulator is controlled according to the vacuum at the venturi 11 by the motor 43 so as to provide a vacuum output to the valve motor 23 which is an amplification of the venturi vacuum under generally normal running conditions of the engine. Thus, the degree of opening of the recirculating valve 15 will increase as the speed of the engine increases and produces a progressively greater vacuum at the venturi. However, should the throttle plate 12 be momentarily fully opened, the vacuum in the manifold 13 falls below the vacuum called for by the vacuum signal at the venturi and the valve 15 would tend to close. To prevent a sudden momentary drop in vacuum at the input of the regulator 42 a reservoir 44 and a check valve 45 are interposed between the intake manifold and the input of the regulator 42. Thus, a high vacuum in the reservoir provides a continuing source of high vacuum to the regulator 42 during short periods of reduced vacuum in the intake manifold, such as occurs during momentary relatively wide open throttle conditions.

When the throttle plate is positioned for high speed operation, the vacuum in the manifold will fall below the vacuum at the venturi. It is desirable that the valve 15 be closed under these engine operating conditions. Accordingly, the vacuum otherwise maintained by the reservoir 44 is dispersed by bypassing the check valve 45 through a relief valve 46. The relief valve 46 opens when the vacuum at the venturi exceeds the vacuum in the intake manifold which causes the reservoir 44 to be immediately reduced to the intake manifold, or "dumped," and reduce the vacuum output of the regulator 42 thereby closing the recirculating valve 15.

According to the present invention, the vacuum regulator 42, its controlling motor 43, the reservoir 44, check valve 45 and the relief valve 46 are all combined in a compact, unitary structure 50 which may be readily installed in the engine compartment of an automobile. The unit 50 has relatively few parts of simple form which may be conveniently assembled with internal interconnecting vacuum passages. The unit 50 requires external tube connections only to the venturi 11, valve motor 23 and the intake manifold 13.

Referring more particularly to FIGS. 2 to 5 of the drawings, the unit 50 is shown in detail. The unit comprises a relatively short cylindrical tubular body 51 which is preferably formed of a single molded member. The opposite ends of the body 51 are closed by a conical shape cover 52 and a disclike cover 53, respectively. The covers 52,53 are tightly drawn to the end edges of the body by screws 54.

The body 51 has concentric outer and inner cylindrical walls 55, 56. The upper ends of the walls 55,56 as viewed in FIG. 2, are joined by an annular end wall 57. The annular base 60 of the conical cover 52 abuts the end wall 57, and a plurality of locating pins 61 are formed on the end wall and nest in corresponding recesses in the base 60 to angularly locate the body and cover. Openings 62 through the wall 57 receive the assembly screws 54, the lower ends of which are received in threaded openings through the lower cover 53.

A transverse wall 63 substantially closes the area encompassed by the inner cylindrical wall 56 of the body 51. The wall 63 has an annular portion 64 recessed inwardly from the open end of the body 51 and the central portion of the wall has a cylindrical cavity 66 formed therein which provides a housing structure for the vacuum regulator 42.

The vacuum regulator 42 is similar to that disclosed in U.S. Pat. No. 3,125,111. Suffice to say, the regulator 42 comprises the vacuum chamber 66 and a resilient flexible diaphragm 67 which extends across the chamber and has its peripheral edges sealingly engaging the walls of an annular shoulder 70 about the upper edge of the chamber. An annular convolution 71 is formed in the diaphragm 67 to facilitate lateral displacements of the diaphragm.

A boss is formed on the bottom wall of the chamber 66 and has an opening 72 therethrough through which a rigid tube 73 extends. The tube 73 is suitably secured in the boss with its upper end 74 terminating adjacent the diaphragm 67 and forming a valve port. The lower end of the tube 73 opens into a portion of the reservoir 44, the major volume of which is comprised of arcuate areas 75,76 defined by the cylindrical inner wall 56, end wall 57 and cover 53. A pad 77 is formed on the central portion of the diaphragm 70 and is adapted to close the port formed by the upper end of the tube 73. The pad 77 also tends to rest on a port or seat 80 formed on a relatively rigid backing member 81 which underlies the diaphragm 67. The port 80 of the member 81 is concentric with and spaced from the tube 73.

The member 81 is connected with an operating diaphragm 82 of the motor 43 by a pair of tongues 83 which project from the upper side of the member and extend through slots in the diaphragm 67. These slots also provide air passages through the central portion of the diaphragm 82. The tongues 83 are connected with a bracket 84 which is raised and lowered by the deflection of the diaphragm 82, as is described more fully hereinafter. A chamber 85 is formed by the diaphragm 82 and the recessed wall 63, and atmosphere is admitted to the chamber by way of an opening 86 in the cover 50. The opening 86 leads into a filter chamber 87 which is formed by cylindrical walls 90, the end wall 63 and the cover 53. A gasket 88 between the cover 53 and the end of wall 90 seal the chamber 87 from the reservoir sections 75,76. An opening 91 is formed through the wall 63 and interconnects the chamber 87 with the recess 85. A suitable air filter 92 is lodged in the chamber 87.

When the member 81 is raised by the diaphragm 82 from the position shown in FIG. 2, it lifts the pad 77 from the end 74 of the tube 73 thereby effecting communication of the chamber 66 with the vacuum reser-

voir 44. When the member 81 is lowered, the pad 77 first closes on the end 74 of tube 73, and further lowering of the member 81 removes the port 80 thereof from the pad 77 which opens the chamber 66 to the atmospheric pressure in the chamber 85 through the slots which receive the tongues 83. The reduction of the vacuum in the chamber 66 by this action tends to cause the diaphragm 67 and member 81 to be moved upwardly, thereby sequentially closing the port 80 on the flap 77 and then removing the flap from the end of tube 73 thereby connecting the chamber 66 with the vacuum reservoir 44. An equilibrium is established whereby a vacuum of a predetermined value is produced in the chamber 66 according to the upward force applied to the member 81 and diaphragm 67.

It will be seen that the vacuum output of the regulator 42 is established in the chamber 66. This output is utilized to control the vacuum motor 23 of the valve 15 through a flexible hose 93, one end of which is attached to the elbow connector 30 of the motor 23 and the other end is attached to a nipple member 94. The member 94 comprises a stem having a flanged base 95 which is received in a recess formed in the underside of the bottom wall of the recess 66. The stem of member 94 projects downwardly through an opening through the bottom cover 53 and the base 95 is retained nested in the recess by the cover. The seal 88 prevents leakage between the stem 94 and the walls of the recess of the base 95. An opening 96 is formed in the bottom wall of the chamber 66 in registration with the opening through the member 94.

The vacuum regulator operating diaphragm 82 is preferably formed of a thin rubber-like disc having the peripheral edges compressed between the confronting surfaces of the body 51 and the cover 52. The diaphragm 82 and the interior of the conical cover 52 form a sealed chamber 97 over the diaphragm, which chamber is in communication with the venturi 11, as is explained hereinafter. A pair of rigid discs 100,101 are disposed on opposite sides of the diaphragm 82 and a stem 102 projects through a central opening through the diaphragm and discs. The lower end of the stem 102 is flared and engages the undersides of a yoke portion of the bracket 84 so as to exert a lifting force on the member 81. A flange 103 on the stem 102 is attached to the disc 101 and provides a seal between the stem and the sides of the opening through which the stem projects.

In the form of the invention shown, it is desirable that a vacuum be produced in the chamber 66 which is about 10 times the vacuum produced in the chamber 97, which corresponds to the venturi vacuum. This amplification of vacuum is achieved by forming the area of the diaphragm 82 considerably larger than the area of the diaphragm 67 and by mechanically biasing the diaphragm 82. This latter is accomplished by a tension spring 104 supported on its upper end by a bail 105 formed on a rotatable plug 106 seated in an opening through the cover 52. The lower end of the spring 104 is attached to a nut 107 threaded on the stem 102. The tension of the spring 104 can be adjusted by rotating the spring and nut 107 relative to the stem 102 by turning the plug 106. Suitable sealing material, not shown, is placed in the recessed opening through which the upper end of the plug 106 extends to seal the opening. Stops 110 are formed inside the cover 52 to limit upward movement of the diaphragm 82.

The chamber 97 is in communication with the vacuum produced at the venturi 11 through a port 111, valve assembly chamber 112, connector stem 113 and a tube 114. The chamber 112 is formed in the body 51 by a generally cylindrical wall structure 115 which intersects a portion of the inner wall 56. The opening 111 is formed through the portion of wall 57 at the upper end of the chamber 112 and opens into an offset recess 116 in the base flange of the cover 52. The stem 113 is an integral part of a valve assembly plate 117 which nests in the chamber 112. The plate 117 is retained in the chamber 112 by the cover 52, and the stem 113 extends through an opening through the cover.

The valve assembly plate 117 is preferably formed of a molded member generally disc shape with an axially extending end flange 120. A connector stem 121 projects from the underside of the plate 117 and through an opening through the cover 53. Spacer flanges 122 are formed about the stems 113, 121 and space the plate 117 from the cover 53 so as to form a portion 123 of the vacuum reservoir 44. The gasket 88 forms a seal to prevent leakage between the stems 113 and 121 and the cover 53. The lower edges of the cylindrical wall 115 are undercut at 124,125 which form passages to the respective sections 75,76 of the reservoir 44.

A stem 126 projects from the upper side of the plate or disc 117, as viewed in FIG. 2, and the upper end of the stem forms a valve seat. This seat is adapted to be closed by the central portion 127 of a diaphragm 130. The diaphragm 130 is of a rubber-like material having a bead 131 formed about the periphery. When the disc 117 is assembled in the chamber 112, the bead 131 of the diaphragm is compressed into a circular grooved channel 132 formed about the open side of the chamber 112 by the flange 120 of the disc. An annular washer 134 overlies the central portion of the diaphragm 130 and is retained in place by a button 135 formed on the diaphragm and projecting through the opening of the washer.

The recess 112 has an offset 136 which receives the upper end of the stem 113. The end wall of the offset 136 has a rectangular recess 137 and a groove 138 leads from the recess to the portion of the cavity 112 above the diaphragm 130. It will be seen that when the stem 113 is connected with the venturi 11 through the hose 114, the pressures above the diaphragm 130 and 82 will correspond to the venturi vacuum.

The check valve 45 is carried by the disc 117 and comprises four closely spaced openings 140 through the disc which are closed by a relatively flexible flat conical valve member 141. The valve member 141 is integral with a stem 142 secured in an opening through the disc 117 and overlies the openings 140. By this arrangement fluid can flow upwardly through the openings 140 and under the edges of the valve member 141; however, the valve member 141 prevents downward flow of fluid through the openings 140.

The stem 121 of the valve assembly is connected with the intake manifold through a hose 146 and when the engine is operating, a vacuum is induced beneath the diaphragm 130 which is equal to the vacuum in the intake manifold. At the same time, a vacuum is drawn above the diaphragm 130 corresponding to the vacuum at the venturi 11. As long as the manifold vacuum exceeds the venturi vacuum, the diaphragm 130 closes on the stem 126. Should the vacuum in the intake manifold drop below that of the venturi, the diaphragm 130

will be deflected upwardly by the differential air pressures between the chambers **112** and **123** and open the stem **126** which quickly equalizes the vacuum in the manifold and the vacuum reservoir **44.**

The unit **50** can be conveniently attached to an engine or to a part of the automotive vehicle when the vehicle is assembled. It is then a simple operation to connect the tubes **93, 114** and **146** to the valve **15,** the venturi **11** and the intake manifold **13,** respectively. All other connections for the components of the system are internal and require no assembly operation when installed.

I claim:

1. Control apparatus for a vacuum operated device comprising, a housing having a tubular section and first and second end covers substantially closing opposite ends of said section, a wall structure extending transversely of said tubular section and intermediate the ends thereof, said wall structure having a first recess, the open side of which faces said first end cover, a vacuum control valve means including a first flexible diaphragm extending transversely of said first recess, means forming a valve port in the closed end of said first recess, a valve member movable by deflections of said diaphragm and adapted to open and close said port, a second diaphragm extending transversely of said tubular section adjacent said first end cover and facing said first diaphragm, said second diaphragm cooperating with said first end cover to form a first vacuum chamber, means mechanically interconnecting said diaphragms, a second recess in said wall section and having the open side facing said second end cover, a third diaphragm extending transversely of said second recess and cooperating with the walls of said second recess to form a second vacuum chamber, a valve plate extending across said second recess and cooperating with said third diaphragm to form a third vacuum chamber, said valve plate and said second end cover cooperating to form a vacuum area, means carried by said valve plate forming a check valve to admit fluid from said vacuum area into said third vacuum chamber, means forming a valve port through said plate, a valve closure member operatively connected with said third diaphragm and adapted to open and close on the last mentioned valve port, and means forming a vacuum reservoir comprising substantial portions of said tubular section, said wall structure and said second end cover and including said vacuum area.

2. Control apparatus as defined in claim **1** further characterized by said tubular section and both said recesses being cylindrical.

3. Control apparatus as defined in claim **1** further characterized by means forming an air passage through said second end cover and into the space between the first and second diaphragms.

4. Control apparatus as defined in claim **3** further characterized by said air passage means comprising wall means forming an air flow chamber substantially closed at one end by said wall structure and substantially closed at the other end by said second cover, said wall structure and second cover having openings therethrough in communication with said interior of said flow chamber.

5. Control apparatus as defined in claim **3** further characterized by an air filter means in said air flow chamber.

6. Control apparatus as defined in claim **1** further characterized by means forming an air passage between said first and second vacuum chambers, means forming an air passage between said second vacuum chamber and the exterior of said housing, and means forming an air passage between said third vacuum chamber and the exterior of said housing.

* * * * *