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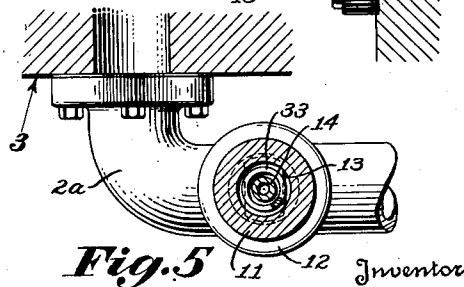
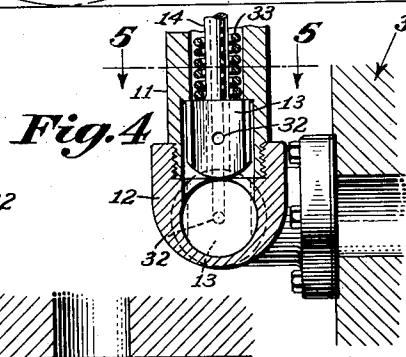
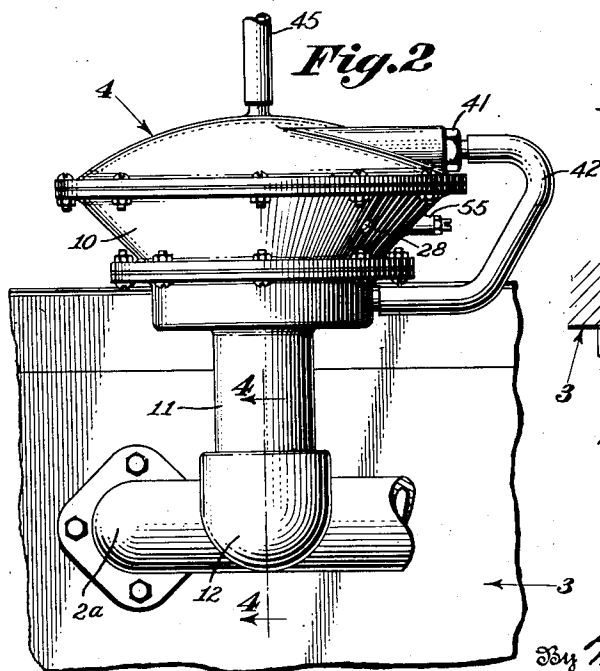
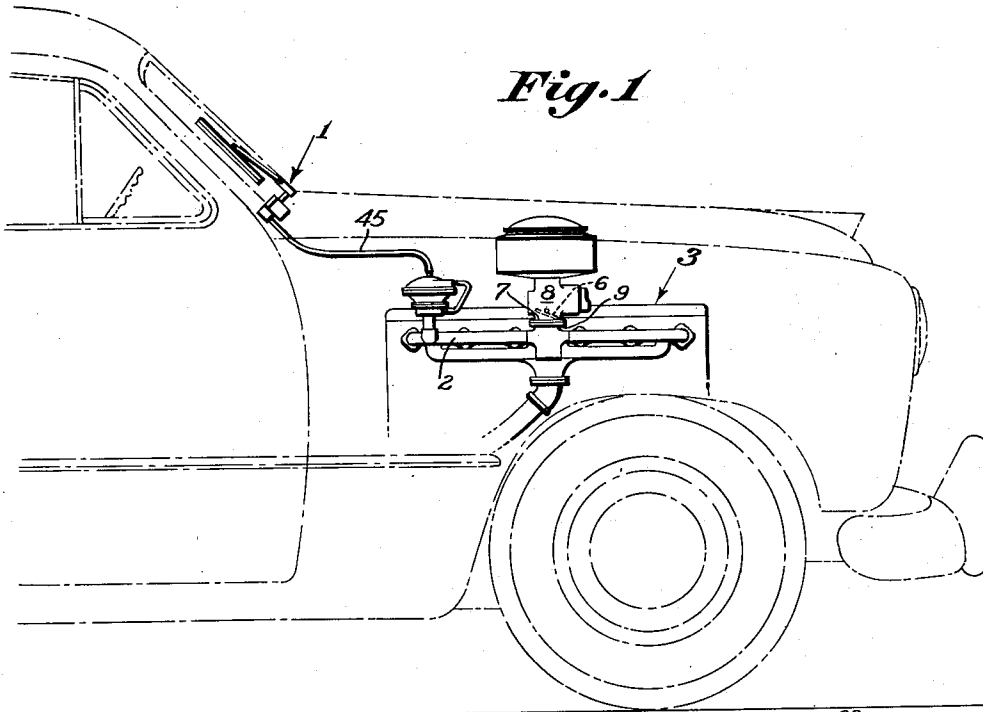
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2,615,299

VACUUM BOOSTER FOR INTERNAL-COMBUSTION ENGINES

Filed Oct. 13, 1948

3 Sheets-Sheet 1



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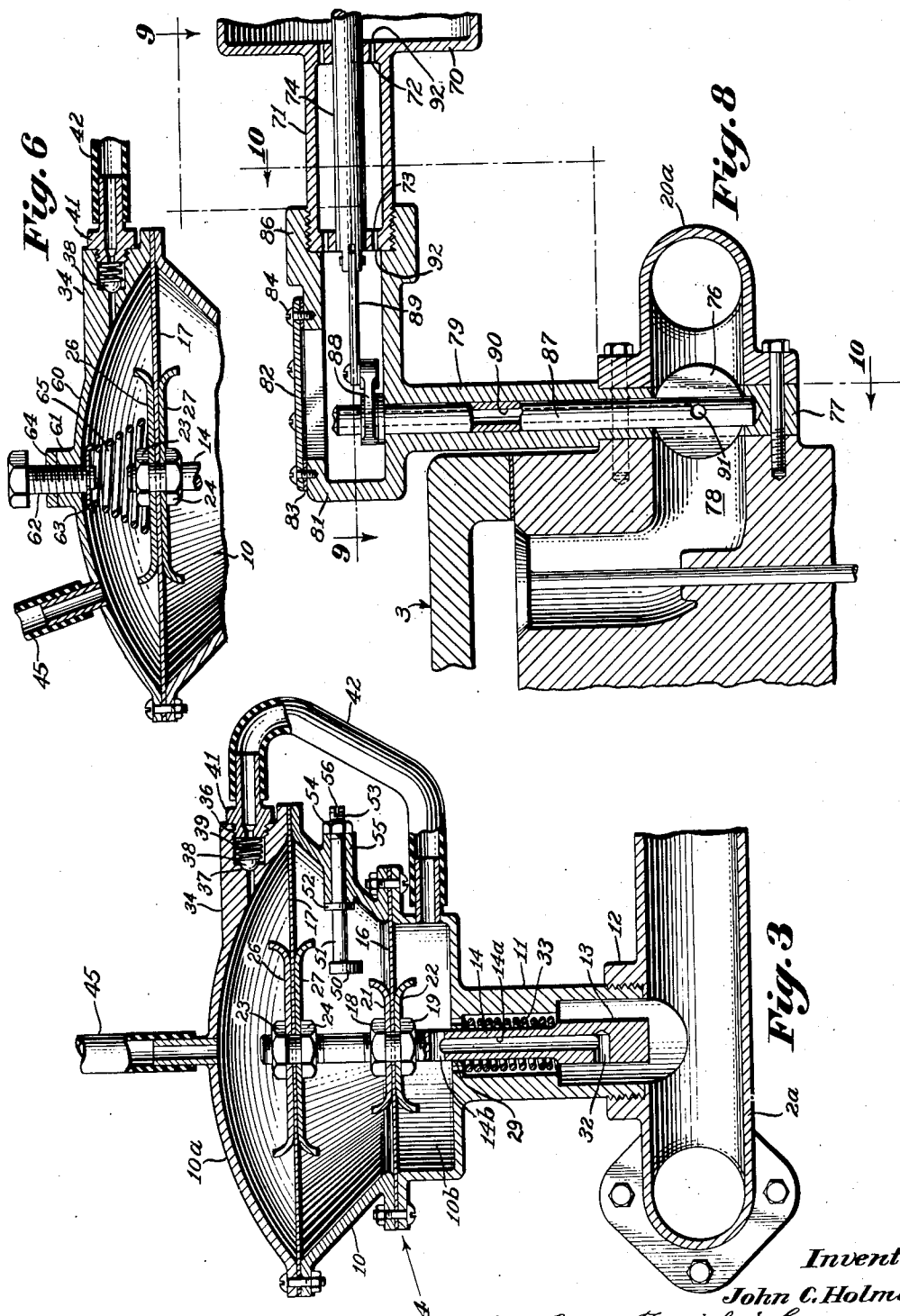
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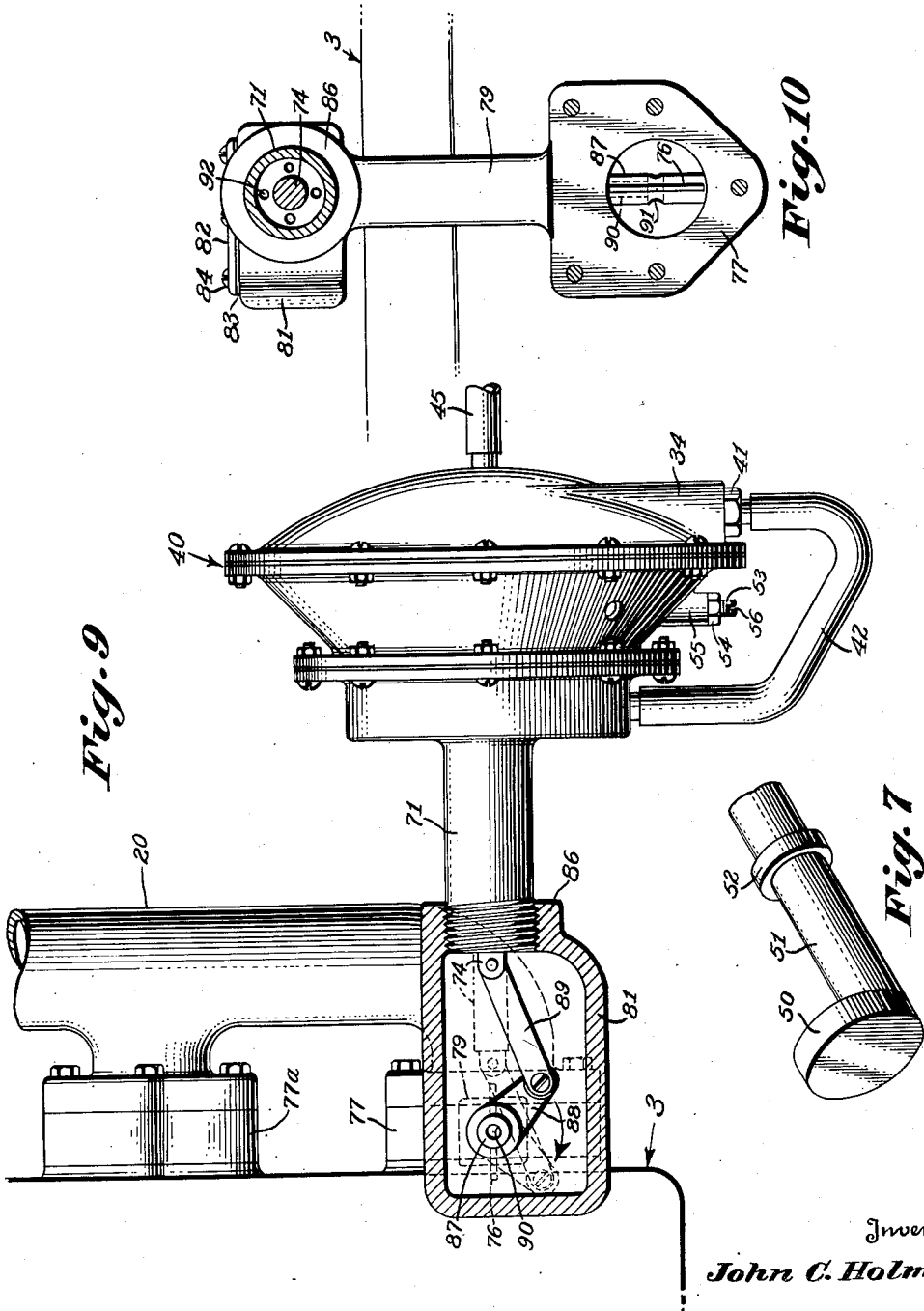
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3 Sheets-Sheet 3



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2,615,299

VACUUM BOOSTER FOR INTERNAL-COMBUSTION ENGINES

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Application October 13, 1948, Serial No. 54,325

11 Claims. (Cl. 60-14)

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This invention relates to an automobile accessory system and particularly to improved means for securing effective and substantially continuous operation of vacuum operated devices such as windshield wipers, horns, fans and the like.

As is well known, for many years it has been common practice to supply vacuum operated accessories for automobiles from the intake manifold. When the devices are operated directly from the intake manifold the operation is very unsatisfactory because the source of vacuum varies greatly, dependent upon the relation of the throttle to the engine speed. For instance, when the throttle is opened suddenly to accelerate the automobile, the vacuum in the intake manifold becomes so low that the windshield wiper for instance, will slow greatly or come to a complete stop. This many times happens when there exists the necessity for the utmost vision. The same condition obtains when the automobile engine is under heavy load as when going up a hill.

Numerous devices have been suggested and used for supplying a more or less constant source of vacuum or at least to reduce the variations. Some of these devices have taken the form of an auxiliary vacuum tank which is exhausted continuously by the intake manifold to build up a reserve for operating the accessories when the engine is being accelerated or under heavy load. Other devices have utilized the exhaust gases from the engine operated through venturis to augment the vacuum from the intake manifold. Various and other sundry devices have been suggested and used including auxiliary pumps. One of the biggest disadvantages of these prior devices is the cost of the extra wearing parts and the attendant necessary maintenance.

The primary object of the present invention is to provide a novel means and method for producing a source of vacuum directly from the intake manifold which will be simple, fool-proof and inexpensive in initial cost and maintenance.

Another object is to provide an automatic device associated with the intake manifold of a multi-cylindrical engine whereby the effect of the sudden opening of the throttle will not appreciably affect the vacuum at one or more of the cylinders, the suction of which is used to operate the accessory device.

A still further object is to provide an automatic device of the type described in which automatic means are provided for automatically restricting the intake to a passage in the cylinder block which feeds some of the cylinders of a

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multi-cylinder engine so that the suction from this passage can be utilized to operate vacuum operated accessories regardless of the position of the main throttle valve.

Other and further objects will become readily apparent from the following description when considered in connection with the accompanying drawings illustrating an embodiment of the invention, and in which:

Figure 1 is a fragmentary diagrammatic elevation of an accessory system in accordance with the present invention applied to a motor vehicle;

Figure 2 is an enlarged elevation of the invention showing its manner of attachment to the intake manifold;

Figure 3 is a sectional elevation of the device shown in Figure 1;

Figure 4 is a partial vertical section on line 4-4 of Figure 2;

Figure 5 is a horizontal section on line 5-5 of Figure 4;

Figure 6 is a partial vertical section of a modified form of the invention shown in Figures 1 to 5 inclusive;

Figure 7 is an enlarged perspective view of regulating cam shown in Figure 3;

Figure 8 is a partial elevational view of a modified form of the invention;

Figure 9 is a partial horizontal section on line 9-9 of Figure 8; and

Figure 10 is a partial sectional elevation on line 10-10 of Figure 8.

An embodiment of the invention is shown as applied to an accessory system for motor vehicles in which the auxiliary vacuum device of the present invention is shown as applied between a suction operated device such as a windshield wiper 1 and a point on the intake manifold 2 of an automotive internal combustion engine 3. Broadly speaking, the invention provides means associated with the intake manifold for restricting the communication between the main intake manifold of the engine and the branch of the manifold which supplies, in some engines, two cylinders, and in other engines an individual cylinder. The invention provides automatic means not only for controlling the communication into one or more of the cylinders of the multi-cylinder engine, but also utilizes a portion of the potential energy of the vacuum existing in these cylinders during the intake stroke of the cylinders to provide directly the source of vacuum for the vacuum operated device and to store a portion of the energy represented by the vacuum condition to actuate a pumping element which is

returned in the opposite direction by spring means whereby the pulsating vacuum condition of the cylinders is converted to a source of steady and constant vacuum for operating the accessory.

Referring to Figure 3, the auxiliary vacuum device 4 of the present invention is shown attached to the intake manifold 2 at a point between the main part of the manifold and the branch conduit or passage 2a into the engine block. It will be readily understood that it is usual in six-cylinder engines for the branches of the manifold such as branch 2a, to feed two cylinders of the engine, while in certain other engines each branch of the manifold feeds an individual cylinder. The important feature of the present invention is that it restricts or reduces the communication between the intake to the cylinder or cylinders which is fed by an individual branch of the intake manifold so that the effect of opening the throttle 6 in the carburetor does not reduce the vacuum in the cylinders fed by this particular branch of the intake manifold to the same extent that the vacuum conditions in the other cylinders are affected. The outlet 7 of the carburetor 8 is connected to the inlet 9 of the intake manifold 2 of the engine in the conventional manner. It will be readily understood that the relation between the position of the throttle 6 and the speed of the engine normally determines the vacuum conditions existing in each of the cylinders. For example, the vacuum conditions existing in the cylinders when the throttle 6 is set for normal operating speed at normal load conditions may be taken as a reference point and therefore if the engine speed should be suddenly reduced by an increased load, it will be readily apparent that the vacuum conditions at the intake of the manifold will be reduced. The vacuum will, of course, be further reduced if the throttle valve is opened further under such conditions. Also, if the engine is idling and the throttle 6 is suddenly opened, the vacuum in the intake manifold will also suddenly decrease. It is under these conditions that the vacuum in the intake manifold will be so reduced that without some auxiliary device such as that made in accordance with the present invention the vacuum will be decreased to a point that the device such as the vacuum operated windshield wiper 1 will momentarily cease to operate.

The broadest phase of the present invention contemplates that one of the branches of the intake manifold such as that shown at 2a, will be restricted immediately in accordance with vacuum conditions present in the cylinders to which the branch is connected. To this end the auxiliary vacuum device 4 comprises a chamber 10, the lower end of which is provided with a stem 11 which is adapted to fit into a hollow boss 12 on the intake manifold. As shown in Figure 3, a gate type valve 13 is adapted to move across the intake manifold to restrict the communication between the main portion of the manifold and the branch 2a. The valve 13 is secured to a suitable valve stem 14 which is actuated by a plurality of flexible diaphragms 16 and 17. In the illustrated embodiment, the chamber 10 is divided into three sections, the lower section being integral with the stem 11. Each of the sections is provided with suitable flanges which may be bolted together with the diaphragms 16 and 17 therebetween in accordance with well-known practice. The upper end of the valve stem 14 is threaded and the diaphragm 16 is

positioned relative thereto by means of suitable nuts 18 and 19 and respective washers 21 and 22. Likewise the flexible diaphragm 17 is positioned on the upper end of the valve stem by means of nuts 23 and 24 and respective washers 26 and 27.

The central section of the chamber 10 between the diaphragms 16 and 17 is open to the atmosphere through the aperture 28. The primary purpose of the lower diaphragm 16 is to serve as a means for sealing the valve 13 and the valve stem 14 against the atmosphere, the diaphragm 17 being relied upon to provide the action of this device. It is for this reason that the lower diaphragm 16 is smaller in diameter than the diaphragm 17 so that the force acting on the diaphragm 17 will always predominate over any force on the diaphragm 16. The valve stem 14 is provided with a suitable guide at 29 and the valve stem 14 is provided with a longitudinal bore 14a which is in communication with the upper transverse bore 14b and lower transverse bore 32 so that that portion of the chamber below the diaphragm 16 will always be in communication with a transverse bore 32 which is subject to the vacuum conditions in the branch passage 2a. A suitable spring 33 is provided between the valve stem guide 29 and the valve 13 and normally urges the latter to its lowermost position across the opening in the intake manifold, it being understood that the force of vacuum acting on the upper side of the diaphragm 17 always opposes the action of the spring 33. The upper dome-shaped portion section 10a of the chamber 10 is provided with a suitable radial boss 34 provided with an opening, the outer end of which is screw-threaded at 36 and the inner end of which is reduced in size to provide a seat 37 for a ball check valve 38. A suitable spring 39 is arranged between the ball check valve 38 and a suitable nipple 41 which is attached to a suitable conduit 42, the other end of which is suitably connected to the lower section 10b of the chamber 10. The space in the upper part of the chamber between section 10a and the diaphragm 17 is connected by means of a conduit 45 to the windshield wiper 1 (or any other vacuum operated device).

It will be readily apparent from the above description that the windshield wiper 1 is connected with the branch 2a of the engine intake manifold through the conduit 45, the upper part of the chamber 10, ball check valve 38, conduit 42, the lower part of the chamber between the lower section 10b and the diaphragm 16, the hollow valve stem 14 and the orifice 32. Therefore, when the engine is operating, vacuum will be applied to the windshield wiper 1. The spring 33 is adjusted so that it is preferably calibrated or adjusted so that during normal vacuum conditions, that is, when the engine is operating in its normal range of speeds and the throttle 6 is set accordingly the force of the vacuum acting on the upper side of the diaphragm 17 will be such as to overcome the force acting on the underside of the diaphragm 16 and the force of the spring 33 so that the valve 13 will be in its uppermost position. Under these conditions the windshield wiper will be operated directly by the normal vacuum in the intake manifold 2. In the event the engine is subjected to an increase in load, or the throttle is suddenly opened or any other conditions take place which increase the pressure at the inlet 9 to the intake manifold with a consequent lowering of the vac-

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uum at the branch passage 2a, the force of the spring 33 will tend to lower the valve 13 across the opening into the branch passage 2a to restrict the opening thereinto and thereby produce a vacuum which is sufficient to maintain the operation of the windshield wiper. It will be readily apparent that the vacuum in the branch passage 2a will vary over a very wide range, having its largest value when the piston is on the suction stroke and will be almost non-existent when the piston returns on the compression stroke. Therefore it would not be practical to operate a vacuum operated device directly from the vacuum existing in branch passage 2a if it is desired to maintain continuous and steady operation. Accordingly, with the present invention, advantage is taken of the potential energy in the suction developed at the branch passage 2a on the down stroke of the piston to store up potential energy by compressing the spring 33, through the action of the vacuum on the upperside of the diaphragm 17 so that during the compression stroke when the suction at branch passage 2a is greatly reduced the spring 33 will return the diaphragm, and consequently the valve 13, to the lower position, the ball check valve 38 closing and the downward movement of the diaphragm 17 serving as a vacuum pump to exhaust air from the conduit 45 and maintain the windshield wiper in operation until the piston again starts on its suction stroke. It will be readily apparent that with the proper calibration of spring 33 and the appropriate relative sizes of the diaphragms that the valve 13 and the diaphragms will automatically move the appropriate amounts to maintain the vacuum conditions on the windshield wiper. For instance, during the normal setting of the throttle 6 when the engine is operating in its normal range of speeds, the vacuum acting on the upper side of the diaphragm 17 will be sufficient to maintain the spring 33 in compressed condition and the valve 13 in non-restricting relation in the intake manifold.

In order to limit the movement of the diaphragms 16 and 17 and the valve 13, a suitable adjustable cam may be provided as shown in Figure 3. This cam is carried on a cylindrical stem 51 having an integral enlarged shoulder 52 and threaded end 53 which is engaged by a lock nut 54. The stem 51 extends through a hollow boss 55 in the middle section 10c of the chamber 10 and may be adjusted in any angular position by means of a transverse screw driver kerf 56. The stem 51 may be held in any desired adjusted position so that the cam 50 will limit the downward movement of the gate valve 13 by means of the lock nut 54. The primary purpose of the adjustable cam 50 is to predetermine the distance the gate valve 13 can move downward across the opening in the branch passage 2a of the intake manifold, thereby predetermining the maximum vacuum applied to the vacuum operated device such as the windshield wiper 1. It will be readily appreciated that the more the gate valve 13 restricts the opening in the branch passage 2a of the manifold, the greater will be the vacuum applied through the auxiliary vacuum device.

Instead of the non-adjustable spring 33 shown in Figure 3, the device may be provided with an arrangement whereby the setting of the spring may be varied for the purpose of varying the degree of vacuum applied to the vacuum operated device within the maximum which is determined by the setting of the cam 50. To this end the

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construction shown in Figure 6 can be substituted for that shown in Figure 3. In Figure 6 the upper section 60 of the chamber 10 which corresponds generally to the upper section 10a of Figure 3, is provided with a hollow boss 61 having a bore which is screw threaded and adapted to receive adjustable cap screw 62, the end of which is provided with a suitable washer 63 which in turn is engaged by a spring 64, the lower end of which rests on the upper side of washer 26 adjacent the diaphragm 17. A suitable lock washer 64 is provided for locking the cap screw in predetermined adjusted position. In this modified form the nipple to which the conduit 45 is attached is placed to one side of the center of the upper section 60 as shown. It will be readily apparent from the above description that by adjusting the cap screw 62 and then locking it in fixed position, the force of the spring 64 acting on the upper side of the diaphragm 17 may be readily varied.

It is desired to emphasize here that one of the important features of the present invention is that the auxiliary vacuum device 4 comes into play and operates only when its operation is needed. For instance, when the control valve on the vacuum operated windshield wiper is closed and the engine is operating in its normal range of speeds and the throttle 6 is set accordingly, the force of the vacuum acting on the upper side of the diaphragm 17 will be such as to overcome the force acting on the under side of the diaphragm 16 and the force of the spring 33 so that the valve 13 will remain in its uppermost position. When the control valve on the windshield wiper is open to initiate the operation of the windshield wiper, the windshield wiper motor, through the conduit 45 and the auxiliary device 4 will be in direct communication with the opening in the branch 2a of the intake manifold and if the vacuum is sufficient to maintain the operation of the windshield wiper, the vacuum above the diaphragm 17 will be sufficient to maintain the valve 13 substantially at the upper end of its stroke. In the event the vacuum in the branch passage 2a of the intake manifold drops due to a change in the position of throttle 6 with respect to the engine speed, the vacuum force acting on the diaphragm 17 will be decreased and the spring 33 will move the gate valve 13 to such a position as to maintain the vacuum at the windshield wiper substantially constant. At high engine speeds with the throttle 6 in open position, the flow of air through the vacuum operated device such as the windshield wiper 1, will produce such a condition in the auxiliary vacuum device 4 that the valve 13 will remain in a substantially stationary position. However, at low engine speeds with the throttle 6 in the open position, there will be a substantial variation in the vacuum existing in the branch passage 2a of the intake manifold and therefore the diaphragms 17 and 16 will tend to vary their positions and that of the valve 13 in immediate response to the vacuum condition existing at the branch passage 2a. When the engine speed is so low that the time interval between suction pulsations at the branch passage 2a is of such duration that the vacuum above the diaphragm 17 substantially decreases, the spring 33 will force the diaphragm 17 downward, allowing the check valve 33 to seat, the downward movement of the diaphragm 17 developing a vacuum pumping action on the windshield wiper 1. In other words, the strong pulsations of suction at the branch passage 2a

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cause the diaphragm 17 to move upward and compress the spring 33, thereby storing potential energy in the spring which is released when the vacuum begins to decrease so that the spring moves the diaphragm downward to maintain a substantially constant vacuum on the windshield wiper 1.

A modified form of the auxiliary vacuum device is shown in Figures 8, 9 and 10, in which the actuating device would be substantially identical to that shown in the previous modification, the modification being primarily in the type of valve which would be substituted for the gate type valve 13. Referring specifically to Figure 8, it will be noted that the section of the actuating device designated by the reference numeral 70 which corresponds to the lower section 10b of the previous modification, is provided with a stem 71 which is provided with plunger guides 72 and 73. A plunger 74 which corresponds to the valve stem 14 of the previous modification is adapted to slide in the plunger guides 72 and 73. The plunger 74 has attached to its outer ends diaphragms corresponding to diaphragms 16 and 17 of the previous embodiment. Instead of the gate type valve 13, a suitable butterfly valve 76 is mounted in an insert 77 between the end of one of the branches 20a of the conventional intake manifold and the opening in the side of the engine block which leads to the combustion chamber of one, or two of the engine cylinders in the case of a six-cylinder engine. In Figure 8 the passage 78 in the cylinder block is shown as leading directly to the combustion chamber for a single cylinder. It will be readily understood that in attaching this auxiliary vacuum device to a conventional motor, inserts or spacers 77a of the same width as spacer 77 would be provided between the other branch passages and the openings in the cylinder block leading to the different cylinders. The insert 77 has integral therewith a hollow cylindrical stem 79 and a housing 81 which encloses the mechanism for operating the butterfly valve 76.

The upper end of the casing 81 is provided with an assembly and inspection plate 82. This plate is sealed to the top of the casing by means of suitable gasket 83 and is held in place by suitable screws 84. The gasket seal is necessary because the casing forms a part of the vacuum channel between the engine cylinder and the vacuum operated device such as the windshield wiper. The housing 81 is also provided with a suitable boss 86 into which the stem 71 is suitably threaded in sealed engagement. The butterfly valve 76 is carried on a vertical valve shaft 87 to the upper end of which is attached a suitable bell crank 88. The bell crank 88 is attached to the plunger 74 by means of a suitable link 89. The valve shaft 87 is provided with a central bore 90 which communicates with a transverse bore 91 so that the casing 81 is always in communication with the passage 78 in the cylinder block. It will be apparent from Figure 9 that when the plunger 74 is moved to the right the bell crank arm 88 will be moved in a clockwise direction which carries with it the butterfly valve 76. Preferably the butterfly valve 76 is slightly smaller than the opening in the intake in which it is located and the transverse bore 91 is provided to prevent complete isolation of the passage 78 in the cylinder block from the branch passage 20a of the intake manifold. It will be readily understood that the operation of this device would be very similar to the device of the embodiment previously described, it being understood, of course, that the plunger

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guides 73 and 72 are provided with the necessary apertures 92 so that the interior of the casing 81, the longitudinal bore 90 of the valve shaft 87, and the transverse bore 91 are in direct communication with the passage 78 of the engine. The actuating device 40 in all other respects may be identical with the actuating device 4 previously described including the modification shown in Figure 6. Likewise it will be understood that the operation will be identical, the diaphragms of the device moving the plunger 74 back and forth to rotate the butterfly valve 76 instead of moving the gate type valve into and out of the branch passage of the intake which feeds one or two engine cylinders. The form of the invention shown in Figures 8 to 10 inclusive, is primarily adapted for attachment to vehicle motors which are already in use because it can be attached without modifying in any respect whatever the intake manifold; it being necessary only to remove the conventional manifold 20 and insert the spacers 77 and 77a. Although in the embodiment of the invention described above, a gate type and butterfly valves are shown, it will be obvious to those skilled in the art that other devices may be used which will reduce the turbulence in the flow and at the same time restrict the communication between the main part of the intake manifold and the branch passages to the cylinder block and also supplement the vacuum produced by the cylinder. Such devices might embody the principles of a Venturi throat.

From the foregoing description it will be readily apparent that the present invention provides a novel auxiliary vacuum device which will produce a substantially constant source of vacuum, or at least a source of vacuum which is sufficient to operate the accessories of the automobile regardless of the variations in vacuum existing at the inlet 9 of the intake manifold of the engine. The auxiliary vacuum device does this by restricting the communication between the main part of the intake manifold and one of the branch passages of the intake manifold which feeds the individual cylinders or two cylinders in the case of the usual six cylinder engine so that the sudden opening of the carburetor throttle does not nullify the vacuum existing at the branch to one of the intake cylinder block openings to which the vacuum operated device, such as a windshield wiper, is connected. Also the present auxiliary vacuum device effectively operates as a pump when necessary when the engine is operating at very low speeds by storing a portion of the potential energy of the suction stroke in the spring 33 so that when the vacuum falls between piston strokes the diaphragm 17 will be pulled down, closing valve 38 and exhaust air from the windshield wiper. Also it will be understood that under any conditions where a vacuum operated device is energized through the auxiliary vacuum device of the present invention, which requires a relatively high vacuum, regardless of the operating conditions of the engine any tendency to reduce the vacuum above the diaphragm 17 will automatically cause the gate type valve 13 or the butterfly valve 76, whichever type is used, to operate to restrict the opening between the intake manifold and the engine cylinder so as to maintain the proper operating vacuum which as previously described can be varied by varying the loading or strength of either the spring 33 or the spring 65. The invention described herein is primarily adapted for use with a multi-cylinder four cycle engine as will be obvious from the above description.

Although the invention has been described in considerable detail, it will be apparent to those skilled in the art that many variations are possible without departing from the inventive concept. It is therefore desired that the invention not be limited except insofar as is made necessary by the prior art and by the appended claims.

What is claimed is:

1. In combination with a multi-cylinder internal combustion engine having a main intake manifold provided with a plurality of branches for supplying explosive charges to the different cylinders, a suction operated accessory, a suction line connecting the accessory to one of said branch passages, valve means for restricting the communication between one of said branch passages and the main intake manifold and a pressure differential element subjected to the vacuum in said suction line and coupled to said valve means for varying passage restriction in said one branch passage by said valve means on occurrence of pressure differentials in said suction line.

2. An auxiliary vacuum device for supplying vacuum operated devices, operable by the suction produced in a suction line connected to the intake manifold of an engine comprising a housing, a movable diaphragm within said housing, one side of said diaphragm being open to atmospheric pressure and the other side of said diaphragm being subjected to the vacuum in said suction line, resilient means coupled to said diaphragm to be compressed by the force of vacuum acting on said diaphragm and valve means in said intake manifold for restricting the same on reduction of the vacuum acting on said diaphragm, whereby when the vacuum on said diaphragm decreases said resilient means will operate said diaphragm and said valve means to augment the vacuum in said suction line.

3. An auxiliary vacuum device for connection in the line between a source of variable vacuum having relatively high peaks and a vacuum operated device, for the purpose of augmenting the vacuum of the source, said auxiliary vacuum device comprising a movable pressure differential element, one side of which is subject to the vacuum of the source, energy storage means intercoupled with said pressure differential element and actuated on occurrence of a high vacuum acting on said element and consequent movement of said element to store potential energy and to reverse movement of said element on relative decrease in the vacuum acting thereagainst to augment the vacuum of said source by such reverse movement of said element.

4. In an auxiliary vacuum device for suction-operated accessories operable by the suction produced in a connecting line coupled to the intake manifold of an internal combustion engine, the combination of a housing, a flexible diaphragm located within said housing and exposed on one side to the atmospheric pressure and on its other side to the pressure within said connecting line, potential energy storage means connected to said diaphragm and actuated by movement of said diaphragm in response to a vacuum thereon coupled from said connecting line to convert a portion of the potential energy represented by the pressure differential on the opposite side of said diaphragm into mechanical energy, said potential energy storage means reversing the movement of said diaphragm in response to a reduction of differential pressure in said connecting

line to augment the vacuum of said source by the reverse movement of said diaphragm.

5. An auxiliary vacuum device connected in a suction line between a source of variable vacuum having relatively high peak values and a vacuum operated device, for the purpose of augmenting the vacuum of the source, said auxiliary vacuum device comprising a housing, a diaphragm in said housing, one side of said diaphragm being subjected to atmospheric pressure and the other side thereof being subjected to the pressure in said suction line, potential energy storage means connected to said diaphragm and actuated by movement of said diaphragm in response to a vacuum in said suction line to convert a portion of the force acting on said diaphragm into potential mechanical energy, said energy storage means reversing movement of said diaphragm when the pressure differential on said diaphragm is reduced to augment said source of vacuum through pumping action resulting from the reverse movement of said diaphragm.

6. In an auxiliary vacuum device for suction-operated accessories operable by the suction produced in a connecting line coupled to the intake manifold of an internal combustion engine, the combination of a housing, a flexible diaphragm located within said housing one side of which is exposed to the atmospheric pressure and the other side of which is subjected to the suction in said connecting line, a check valve in the side of said line between said auxiliary vacuum device and the intake manifold of the engine, potential mechanical energy storage means connected to said diaphragm and actuated by movement of said diaphragm in response to a vacuum in said suction line to store a portion of the energy represented by movements of said diaphragm under the action of the suction in said intake manifold, said energy storage means reversing movement of said diaphragm when the vacuum in said manifold decreases whereby the reverse movement of said diaphragm causes the check valve to close and the movement of the diaphragm serves as a source of vacuum energy for said accessory through pumping action resulting from the reverse movement of said diaphragm.

7. In combination with a multi-cylinder internal combustion engine having a main intake manifold provided with a plurality of branches for supplying explosive charges to the different cylinders, a suction operated accessory, a suction line connecting said accessory to one of said branches, valve means for restricting the communication between said main intake manifold and said branch, an auxiliary vacuum device connected in said line between said accessory and said one branch passage of said intake manifold, a check valve in said line between said auxiliary vacuum device and said manifold adapted to close against the pressure in said manifold, said auxiliary vacuum device comprising a housing, a differential pressure element in said housing, one side of which is open to the atmospheric pressure and the other side of which is subjected to the suction in said line, potential mechanical energy storage means connected to said differential pressure element, said valve means also being connected to said differential pressure element whereby movement of said element in response to the suction in said line will simultaneously store potential mechanical energy and control said valve means and upon decrease in vacuum in said line said potential energy storage means will force said differential element in such

a direction as to serve as a pump to supply vacuum to said accessory.

8. In combination with a multi-cylinder internal combustion engine having a main intake manifold provided with a plurality of branches for supplying explosive charges to the different cylinders, a suction-operated accessory, a suction line connecting said accessory to one of said branches, an auxiliary vacuum device connected in said line between said accessory and said one branch of said intake manifold, a check valve in said line between said auxiliary vacuum device and said manifold adapted to close against the pressure in said manifold, automatic valve means for restricting the communication between said main intake manifold and said branch, said auxiliary vacuum device comprising a differential pressure element, one side of which is open to the atmospheric pressure and the other side of which is subjected to the suction in said line, potential energy storage means intercoupled with said differential pressure element and means intercoupling said pressure differential element and said valve means whereby movement of said differential pressure element in response to a differential pressure in said suction line stores potential mechanical energy which reverses the movement of said differential pressure element when the pressure differential decreases.

9. A combination with a multi-cylinder combustion engine having a main intake manifold provided with a plurality of branches for supplying explosive charges to the different cylinders, a suction operated accessory, a suction line connecting said accessory to one of said branches, an auxiliary vacuum device connected in said line between said accessory and said one branch of said intake manifold, a check valve in said line between said auxiliary vacuum device and said manifold to close against the pressure in said manifold, said auxiliary vacuum device comprising a housing, a diaphragm in said housing, one side of said diaphragm being subjected to atmospheric pressure and the other side thereof being subjected to the pressure in said line, valve means for restricting communication between said main intake manifold and said branch operatively connected to said diaphragm, spring means biasing said diaphragm to oppose the force of suction on said diaphragm, a suction in said manifold normally moving said diaphragm to compress said spring and simultaneously to increase the communication between said main intake manifold and said one branch, whereby a reduction in said suction permits said spring to bias said diaphragm connected to said valve means to restrict the communication between said main intake manifold and said branch

and to simultaneously augment the vacuum in said line between said check valve and said accessory.

10. An auxiliary vacuum device for supplying vacuum operated devices adapted to be operated by the suction produced in a suction line connected to the intake manifold of an engine comprising a housing, a movable diaphragm within said housing, one side of said diaphragm being subjected to the vacuum in said suction line, valve means coupled to said diaphragm for restricting passage in said suction line, spring means coupled to said diaphragm resiliently urging said diaphragm and valve means intercoupled therewith in suction line passage restricting position, the vacuum in said suction line normally urging said diaphragm in opposition to said spring means to store potential energy therein, said spring means biasing said diaphragm to restrict passage opening in said suction line and augment vacuum therein through consequent movement of said diaphragm on occurrence of a pressure differential in said suction line.

11. In combination with a multi-cylinder internal combustion engine having a main intake manifold provided with a plurality of branches for supplying explosive charges to the different cylinders, a suction operated accessory, a suction line connecting the accessory to one of said branch passages, intake manifold branch restricting means in said one branch intercoupled with a diaphragm, resilient means coupled to said diaphragm normally urging the diaphragm in a direction to effect increasing restriction of said one branch by said branch restriction means coupled therewith, and vacuum pressure coupled to said diaphragm from said suction line to oppose the bias of said resilient means and store potential energy in the spring means under normal vacuum pressure conditions in said suction line, whereby said resilient means will bias said diaphragm and intercoupled restriction means to restrict passage in said one branch and augment the vacuum therein on reduction of vacuum pressure on the diaphragm below normal pressure.

JOHN C. HOLMES.

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