

United States Patent

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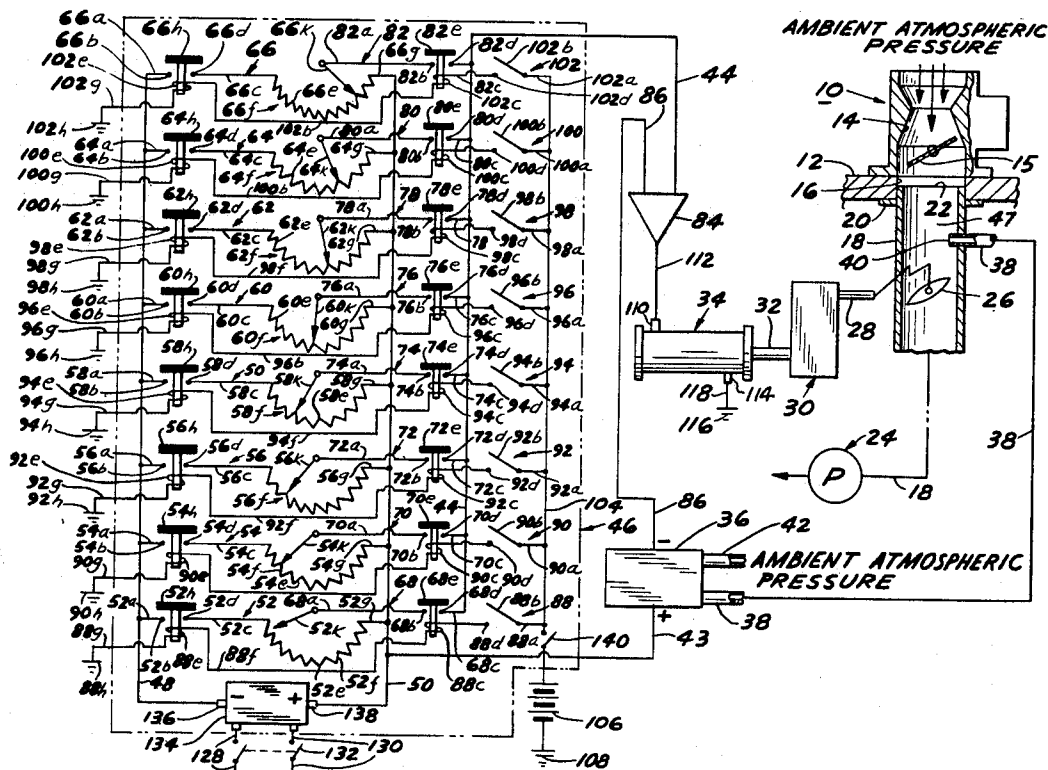
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[54] PRESSURE CONTROL APPARATUS 1 Claim, 6 Drawing Figs.

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G05d 7/03
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486, 426, 501; 318/28(Inquired)

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ABSTRACT: A chamber with ends defined generally by first and second variably positionable valves has a fluid (including gases) pump connected thereto in a manner so as to place the second valve generally between the first valve and the pump. As the pump runs a flow of fluid or gas through the chamber is experienced and a reduction in pressure is experienced between the valves. Differential pressure responsive means, responsive to a reference pressure and the said reduction in pressure automatically causes the rotation of the second valve until a desired pressure is achieved in said chamber in order to obtain a desired predetermined pressure differential across the first valve.



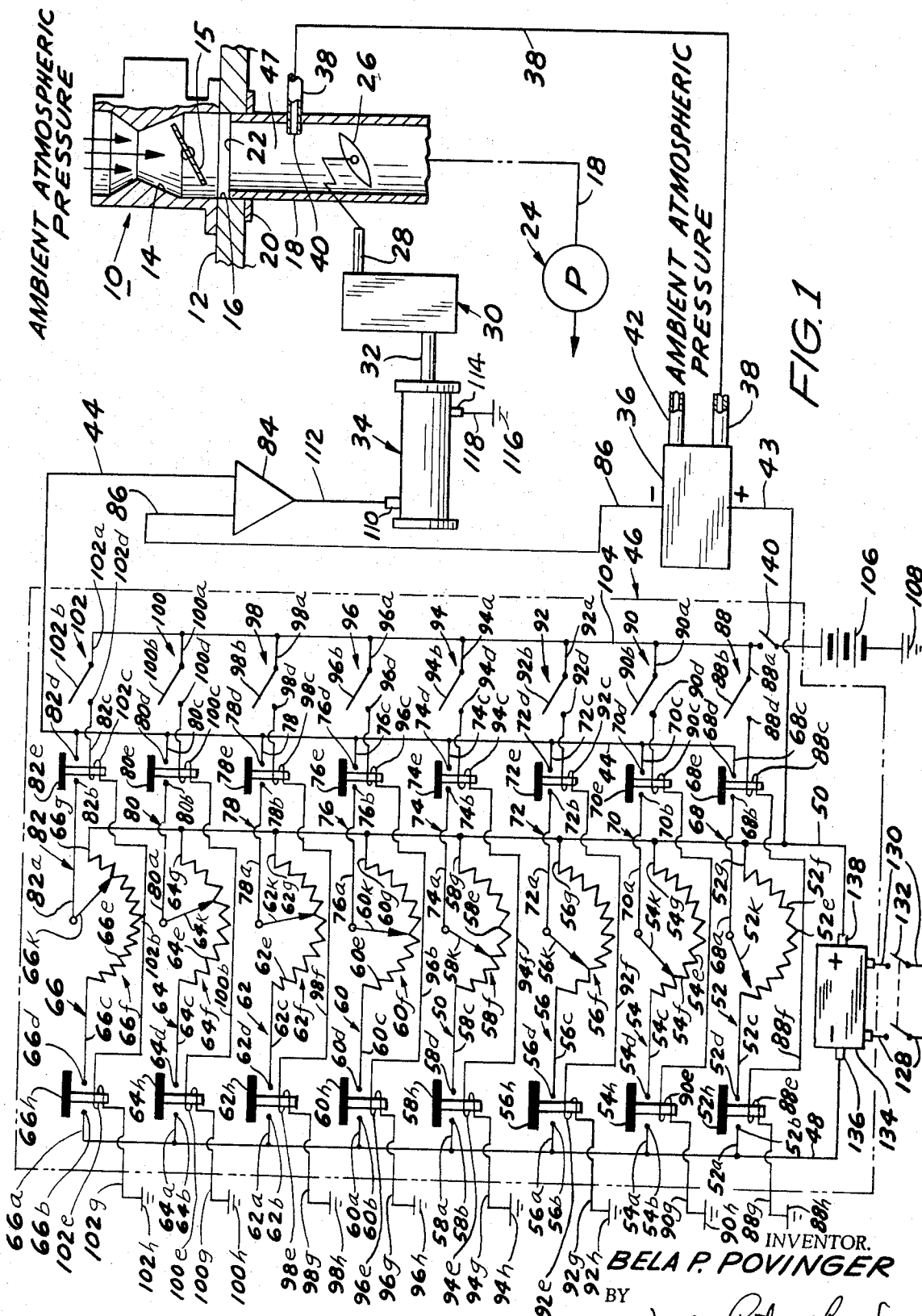


FIG. 1

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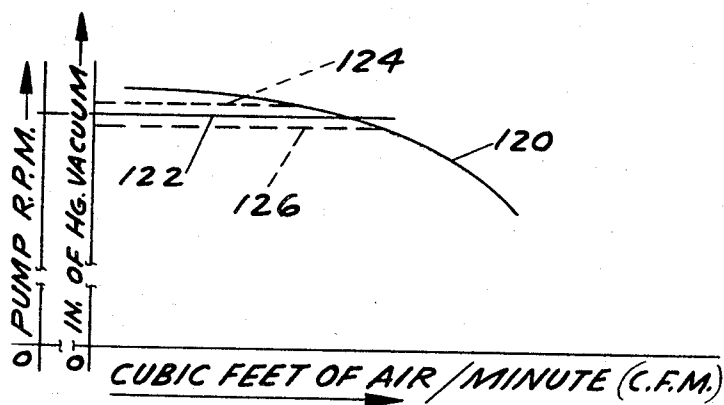


FIG. 2

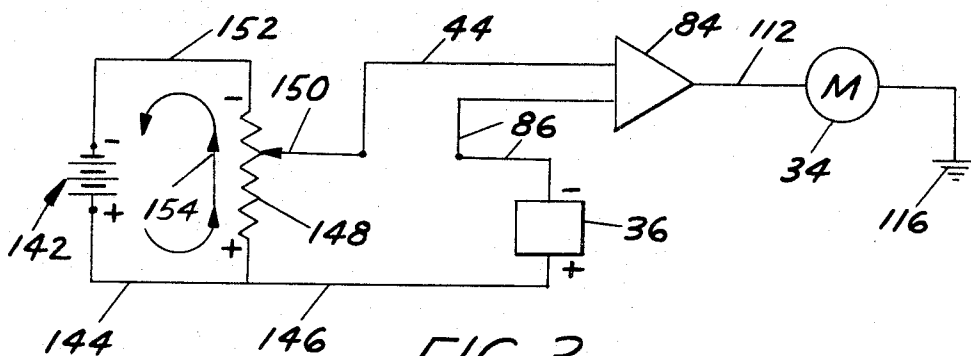


FIG. 3

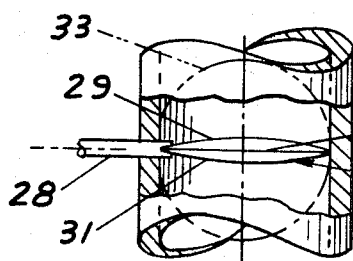


FIG. 4

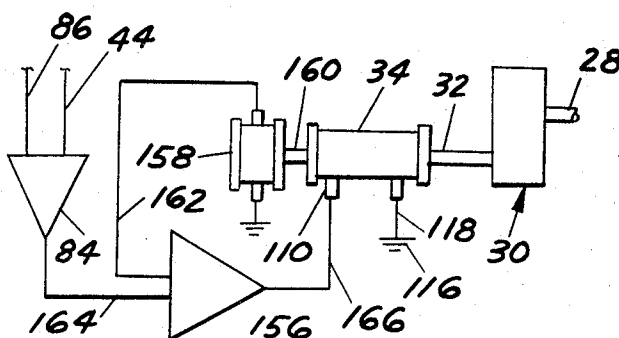


FIG. 5

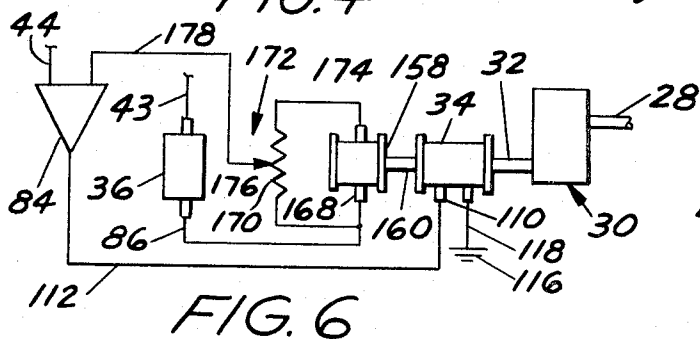


FIG. 6

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PRESSURE CONTROL APPARATUS

BACKGROUND OF THE INVENTION

Carburetors for use in combination with internal combustion engines are required to emit fuel to the engine in a predetermined ratio to the air passing through the carburetor and into the engine. However, in the situations where the engine is employed in transportation vehicles the engine speed cannot remain constant and more often than not, the air fuel ratio has to be capable of change depending upon whether maximum economy or maximum power of the engine is desired. In order to be assured that a particular carburetor does provide proper air fuel ratios for varying engine operating conditions (reflected by the engine intake manifold vacuum) the carburetor is first tested under conditions simulating such engine-operating conditions.

Heretofore it has been the practice to secure the carburetor onto a test fixture and to create an airflow through the carburetor induction passage past the carburetor throttle valve by means of a pump situated downstream of the throttle valve. The pump speed would be varied in order to create a vacuum simulating the engine manifold vacuum. Next, the quantity of air utilized was measured through the principle of displaced volume. Finally, the quantity of fuel (or other liquid having physical characteristics such as those of gasoline fuel) discharged through the carburetor is measured and the air fuel ratio determined by these empirically determined quantities. All of these measurements are susceptible to error. However, the greatest variant is the vacuum created by the pumps because its efficiency varies not only with pump speed but also with atmospheric and temperature variations. Consequently, the finally determined air fuel ratios also vary because of the variation in pump-created vacuum.

In view of the above, it is apparent that the variation in pump efficiency causes corresponding variations in the pressure differentials across the throttle valve of the carburetor being tested and consequently the air fuel ratios determined thereby continuously reflect such variations in undeterminable percentages of error.

SUMMARY OF THE INVENTION

Pressure responsive means, responsive to the differential in pressures existing in the ambient atmosphere as well as the interior of a chamber having an inlet of variable effective area, delivers a signal in accordance with and reflective of said pressure differential to suitable motor means which varies the effective area of an outlet of said chamber in order to attain and maintain a predetermined pressure differential across said inlet.

Accordingly a general object of this invention is to provide for use in combination with a chamber having an inlet of variable effective area and an outlet of variable effective area experiencing a flow of fluid medium therethrough, first means continuously responsive to the pressure upstream of the inlet and the pressure between the inlet and outlet for applying a signal to suitable motor means effective for varying the effective area of said outlet in order to maintain a preselected pressure differential between said upstream pressure and the pressure between the inlet and outlet.

Another more specific object of this invention is to provide for use in combination with a flow-through chamber having an inlet and outlet of variable effective areas, electrical transducer means responsive to the differential in pressures as between the pressure upstream of said inlet and outlet for providing an electrical signal to an electrical motor which in turn varies the effective area of said outlet in order to attain and maintain said pressure differential at a preselected value.

Other more specific objects and advantages of the invention will become apparent when reference is made to the following description considered in conjunction with the drawings.

DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. 1 is a schematic wiring diagram including certain diagrammatically illustrated elements comprising the invention;

FIG. 2 is a graph illustrating characteristic operational curve of a vacuum pump which can be employed in the invention;

FIG. 3 is a schematic and diagrammatic wiring diagram of a modification of the invention;

FIG. 4 is an enlarged fragmentary portion of the apparatus shown in FIG. 1 with portions thereof broken away and in cross section;

FIG. 5 is a wiring diagram illustrating a first modification of the circuitry shown in FIGS. 1 and 3; and

FIG. 6 is another wiring diagram illustrating another modification of the circuitry shown in FIGS. 1 and 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now in greater detail to the drawings, FIG. 1 illustrates, somewhat schematically, a carburetor 10 suitably mounted onto a test fixture 12 in a manner so as to have the carburetor induction passage (or passages if the carburetor is a multibarrel type) 14 in general alignment with an aperture 16 formed in the fixture 12. A conduit 18, which might have a flange 20, has one end 22 situated so as to be in communication with aperture 16. The other end of conduit 18 is in communication with a vacuum (air) pump 24. A butterfly valve 26, located within the conduit 18 between end 22 and vacuum pump 24, is mounted for pivotal rotation within conduit 18 as by a rod or shaft 28. Shaft 28 is preferably rotated by a reduction gear with a gearbox 30 which has an input from the shaft 32 of a direct current (DC) reversible motor 34.

A pressure-responsive transducer 36 is continuously responsive to two variable pressure input signals one of which is accomplished as by a conduit 38 communicating at one end with transducer 36 and communicating at its other end 40 with the interior of conduit 18 at a point generally between butterfly valve 26 and carburetor 10. The second signal applied to transducer 36 is that of ambient atmospheric pressure as by conduit means 42.

Transducer 36 then, in accordance with the differential in pressure between ambient atmospheric pressure, P_a , and the variable pressure, P_i , in conduit 18 between carburetor 10 and butterfly valve 26 delivers a voltage, V_i , which is proportional to said differential. The circuitry generally within a console 46 is comprised of first and second main electrical conductors 48 and 50 and a plurality of branch circuits 52, 54, 56, 58, 60, 62, 64 and 66 connected thereacross. For example, branch circuit 52 is comprised of an electrical conductor 52a, connected to main conductor 48, having an electrical contact 52b. A second conductor 52c, having a contact 52d is serially connected with a resistor 52e of a manually adjustable potentiometer 52f which has its other end connected serially with a conductor 52g which, in turn, is electrically connected to the other main conductor 50. A normally open relay-type switch contact 52h is adapted to be at times moved into electrical engagement with contacts 52b and 52d so as to complete the circuitry therethrough. In each of the branch circuits 52, 54, 56, 58, 60, 62, 64 and 66 the various elements bearing a letter suffix correspond to those elements of branch circuit 52 having a like suffix.

In addition to the above branch circuits, transducer 36 has one of its terminals electrically connected to conductor 50 as by a conductor 43. The other terminal of transducer 36 is electrically connected to one terminal of an operational amplifier 84 by means of an electrical conductor 86.

A plurality of additional branch circuits 68, 70, 72, 74, 76, 78, 80 and 82 are electrically connected with conductor 44 and with wiper contacts 52k, 54k, 56k, 58k, 60k, 62k, 64k and 66k of potentiometers 52f, 54f, 56f, 58f, 60f, 62f, 64f and 66f.

Branch circuit 68, for example, comprises a conductor 68a electrically connected at one end to wiper contact 52k and having a contact 68b at its other end. Another conductor 68c, having an electrical contact 68d at one end is connected at its

other end to conductor 44. A normally open relay-type switch contact 68e is adapted to be at times moved into electrical engagement with contacts 68b and 68d so as to complete the circuitry therethrough. In each of the additional branch circuits 68, 70, 72, 74, 76, 78, 80 and 82 the various elements bearing a letter suffix correspond to those elements of branch circuit 68 having a like suffix.

A plurality of control circuits 88, 90, 92, 94, 96, 98, 100 and 102 are provided for actuation of the normally open relay-type switches existing in both of the previously described branch circuits. For example, control circuit 88 comprises an electrical conductor 88a connected at one end to a main conductor 104 and having a manually operable, normally open, switch member 88b. A first relay coil 88c surrounds the armature portion of switch 68a and is electrically connected to a contact 88d adapted to be at times engaged by switch member 88b. A second relay coil 88e, surrounding the armature portion of switch 52h, may be serially electrically connected at one end to coil 88c as by means of a conductor 88f and connected at its other end by means of a conductor 88g to ground as at 88h. In each of the other control circuits 90, 92, 94, 96, 98, 100 and 102, the various elements bearing a letter suffix correspond to those elements of control circuit 88 having a like suffix. Further, as clearly shown, each of the control circuits is electrically connected to the main conductor 104 one end of which is operatively connected to a source of electrical potential 106. The other side of electrical source 106 is connected to ground potential as at 108.

Conductor 44 is electrically connected to another terminal of amplifier 84 in order to apply a voltage differential to the amplifier 84 when such differential exists as between input conductors 86 and 44. The amplifier then, in accordance with the voltage differential applied thereto, directs an amplified voltage, of a particular value and sign indicative of said differential, to terminal 110 of motor 34 by means of an electrical conductor 112. The other terminal 114 of motor 34 may be connected to ground 116 by a conductor 118.

OPERATION OF INVENTION

Usually a maximum vacuum value of about 19.5 inches of mercury (Hg) is required for testing a carburetor. Accordingly, pump 24 is selected so as to produce about 26 inches of Hg vacuum when the pump is run at a substantially constant speed as suggested by the manufacturer for optimum total pump efficiency. If this is done then vacuum variation becomes a secondary issue because if the recommended pump running speed produces 26 inches of Hg vacuum, fluctuations of even ± 1.0 inches of Hg vacuum will reduce the minimum vacuum to only 25.0 inches of Hg vacuum which is still considerably greater than the 19.5 inches of Hg vacuum required for carburetor testing. FIG. 2 graphically illustrates both the nominal curve 120, determined by the plotting of pump speed (r.p.m.) against cubic feet of air per minute (c.f.m.) as well as the range of Hg vacuum values determined by the plotting of inches of Hg vacuum against cubic feet of air per minute (c.f.m.). It can be seen that if the recommended pump speed is selected as indicated generally by line 122, that a value of 26 inches of Hg vacuum may be obtained, and that variations of ± 1.0 inches of Hg vacuum will result in a maximum vacuum of 27 inches of Hg vacuum as indicated by dash line 124 and in a minimum value of 25 inches of Hg vacuum as indicated by dash line 126. The lowest or minimum value of 25 inches Hg is still considerably higher than the maximum value of 19.5 inches of Hg required for carburetor testing.

Referring again to FIG. 1, an AC (alternating current) line voltage of, for example, a nominal voltage of 110v.-AC, is supplied by conductors 128 and 130, which may include a switch member 132, to a stepdown transformer-rectifier 138 which, for example, supplies a rectified 10.0 v.-DC (direct current) at its terminals 136 and 138. As clearly shown, main conductors 48 and 50 are respectively electrically connected to terminals 136 and 138.

Let it be assumed now that carburetor 10 is to be tested at a pressure differential of 19.5 inches of Hg across the carburetor throttle valve 15 which, at this time is in its closed position. (It should be remembered that when a throttle valve is closed, there is still a predetermined minimum flow of air past the throttle valve and into the engine manifold or as in this instance the conduit 18.) Pump 24 is then started and, preferably, set to run at a substantially constant speed recommended by the manufacturer thereof as being that speed at which maximum pump efficiency is attained. Switch 132 is closed thereby completing the circuit through conductors 128 and 130 to the transformer-rectifier 134 which may be considered as being a bucking voltage supply. Further, switch 140, serially connected in conductor 104 is also closed thereby completing the circuit therethrough. However, the normally open relay type switch members 52h, 54h, 56h, 58h, 60h, 62h, 64h and 66h (which may be spring-biased to the normally open position) preclude current flow through branch circuits 52, 54, 56, 58, 60, 62, 64 and 66 respectively. Likewise, the normally open relay-type switch members 68e, 70e, 72e, 74e, 76e, 78e, 80e and 82e (which may also be spring-biased to the normally open position) preclude current flow through branch circuits 68, 70, 72, 74, 76, 78, 80 and 82.

However, if at this time the manually operable switch 88b of control circuit 88 is closed, a circuit is completed from conductor 104 and through relay coils 88c and 88e causing the respective armatures of relay switches to be pulled downwardly thereby causing switch member 52h to complete the circuit through branch circuit 52 and causing switch member 68e to complete the circuit through branch circuit 68. Consequently, a closed circuit described by terminal 138, conductor 50, conductor 52g, resistor 52e of potentiometer 52f, conductor 52c, contacts 52d and 52b, switch member 52h, conductor 52a and conductor 48 back to terminal 136 of the source of e.m.f. or power supply 134. At the same time, a second circuit is established by potentiometer wiper contact 52k, conductor 68a, contacts 68b and 68d, switch member 68a, conductor 68c and conductor 44 leading to one of the input terminals of the operational amplifier 84.

The circuit may be arranged so that the closing of switch 132 also causes a current flow from terminal 138 of source 134 through conductor 50 to a through conductor 43 to the transducer 36. The transducer 36, as previously mentioned, delivers an output voltage which is proportional to the differential in pressures sensed by the inputs through conduits 38 and 42 which, in this instance, are the ambient atmospheric pressure and the pressure with the chamber 47 generally defined by the conduit 18 and carburetor throttle valve 15 at one end and the modulating valve 26 at the other end. The output voltage from transducer 36 is transmitted as by a conductor 86 to another input terminal of the operational amplifier 84.

The amplifier then amplifies the difference between the transducer output voltage, V_t , and the output voltage of the potentiometer, V_p , and directs such amplified voltage, V_a , to the input terminal 110 of motor 34 as by conductor 112. The other terminal of motor 34 may be connected to ground potential 116 as by a conductor 118.

The amplified voltage, V_a , causes motor 34 to rotate shaft 28 and the valve 26 secured thereto in order to cause a sufficient restriction to the flow of air so as to attain the desired pressure differential across carburetor throttle valve 15. In this case it is assumed that 19.5 inches of Hg vacuum (or pressure differential) is desired across throttle valve 15. If atmospheric conditions of time " T_0 ," should change at time " T ," which is $T_0 + \Delta T$, the transducer 36 of course senses such changes and in accordance therewith produces an output voltage V_t such that $(V_t)_T = (V_t)_{T_0} \pm \epsilon$, where ϵ is the error signal. Hence, $V_a \pm (V_t)_T = \pm V_a$, the momentary differential voltage that by amplifier 84 will be amplified to $(V_a)_T$, causing the motor to rotate valve 26 in a direction to maintain the selected pressure differential across throttle valve 15 of carburetor 10.

FIG. 3 illustrates a circuit typical of the circuit described above as well as those established by the closing of any of switches 90b, 92b, 94b, 96b, 98b, 100b or 102b. For example, if the circuit of FIG. 3 is considered to be the equivalent of the circuit described by the closure of switches 88b, 52h and 68e then the battery 142 is equivalent to the bucking supply voltage source 134, conductors 144 and 146 respectively equivalent to conductors 50 and 43, resistor 148 and wiper contact 150 respectively equivalent to resistor 52e and wiper contact 52k, and conductor 152 equivalent to conductor 48. In view of the above it can be seen that a conventional current flow is established generally in a counterclockwise direction as indicated generally by the path-defining arrows 154.

FIG. 3 clearly illustrates that if a voltage of, for example, 8.0 v. exists at wiper contact 150 and a voltage of, for example, 2.0 v. exists across the transducer 36 then there is a voltage differential, V_d , of 6.0 v. that the amplifier 84 is responsive to. In accordance with the differential of 6.0 v. (amplified), the motor 34 is driven in a first direction causing the variably positioned valve 26 to rotate until the pressure within the chamber 47 is of a value which, as sensed by the transducer 36, is sufficient for establishing the desired pressure differential across the carburetor throttle valve 15 which can be considered, in the broad sense, as being a variable restriction or an orifice of variable effective area. If, on the other hand, only 1.0 v. existed at the wiper contact 150 while 2.0 v. existed across the transducer 36 then there is a voltage differential, V_d , of 1.0 v. that the amplifier 84 would be responsive to. Further, because the sign of the voltage is now reversed, the amplifier would amplify the 1.0 v. differential, of opposite sign, causing the motor 34 to be driven in a direction opposite to the said first direction. Valve 26 would, of course, as before be rotated until the transducer sensed the desired pressure differential at which time there would be no voltage differential to be amplified by amplifier 84— $(V_d)_r = V_d$, i.e. $(V_d)_r = 0$.

The reason for the plurality of potentiometers in FIG. 1, as well as the corresponding number of first- and second-branch circuits and control circuits is to enable the rapid selection of any of a plurality of corresponding pressure differentials across throttle valve 15. That is, each of the wiper contacts 52k, 54k, 56k, 58k, 60k, 62k, 64k and 66k are so positioned along the respective resistors so that actuation of any of the control switches 88b, 90b, 92b, 94b, 96b, 98b, 100b or 102b will create a base or reference voltage in conductor 44 which when matched by the voltage output of transducer 36 will result in a pressure within chamber 47 which, in turn, will create the predetermined desired pressure differential across throttle valve 15. In other words, potentiometer 52f may be set so that closure of switch member 88b will result in 19.5 inches of Hg pressure drop across throttle valve 15 while potentiometer 66f may be set so that closure of switch member 102b will result in 0.5 inches of Hg pressure drop across throttle valve 15. The wiper contacts on potentiometers 54f, 56f, 58f, 60f, 62f and 64f would be respectively positioned along their corresponding resistors in order to produce various pressure differentials between the previous values of 19.5 inches of Hg and 0.5 inches of Hg as limits.

In view of the preceding, it is apparent that any desired pressure differential can be established and maintained across the throttle valve 15. The invention as considered in its broad aspects, provides first means for establishing a base reference voltage (the closure of switch member 88b or any one of the corresponding switch members and the concomitant closure of relay switches 52h and 68e), a chamber having at least one inlet orifice of variable effective area (throttle 15, chamber 47) and at least one outlet orifice of variable effective area (valve 26 conduit 18), a first base pressure (a reference pressure such as the environmental pressure of ambient atmospheric pressure), means continually responsive to the pressure within the chamber 47 and the base pressure (transducer 36) for creating a voltage in accordance with the differential thereof, means (amplifier 84, motor 34) responsive to the differential of said base reference voltage and said

transducer voltage for varying the effective area of said outlet orifice to that effective area whereby no differential exists as between said base reference voltage and said transducer voltage.

In addition to the preceding it has been discovered that the preferred embodiment of the modulating valve 26 takes the form of a precision-built butterfly valve as illustrated generally in FIG. 1 and more exactly in FIG. 4. As can best be seen in FIG. 4, the valve 26 is secured to the pivotally mounted shaft 28 journaled for rotation as in the wall of conduit 18. Preferably, valve 26 is formed so as to have upper and lower opposed convex surfaces 29 and 31 which meet generally at the periphery so as to define a circular periphery 33. When rotated 90° from the position shown in FIG. 4, the outer periphery 33 would have a configuration substantially as shown in phantom line. By having the surfaces 29 and 31 meet to define a somewhat knife-edge periphery 33, the possibility of causing any turbulence or disturbance to the airstream is minimized. Additionally, the performance of valve 26 can be enhanced and air turbulence further reduced by finishing the opposed surfaces 29 and 31 so as to have a smooth surface finish. Further, it has been determined that in an embodiment of valve 26 such as shown in FIG. 4, the gap between the outer periphery 33 of valve 26 and the cooperating interior diameter of pipe 18, when valve 26 is in its closed position, should be in the order of 0.0005 inches.

The above is, of course, the preferred embodiment. It is apparent that other valves and valving arrangements can be used to practice the invention and that variables such as the flow velocity of the fluid medium as well as the weight-rate of flow become considerations in the selection of an appropriate valve configuration.

FIG. 5 illustrates a modification of the invention as shown in FIG. 1. Conductors 86 and 44 of FIG. 5 lead to the remaining circuitry as illustrated in FIG. 1; similarly shaft 28 is operatively connected to the variably positioned valve 26 of FIG. 1. The invention of FIG. 5 operates in the same manner as that of FIG. 1; however, an additional benefit is derived by having a DC tachometer generator 158 which is operatively connected to motor 34 as by the pictorially represented colinear shaft 160. Consequently, shaft 160 will rotate the tachometer generator rotor and produce a voltage output, proportional to the speed of the motor 34, through a conductor 162 to one of the input terminals of a second amplifier 156. The other input terminal of the amplifier 156 has connected thereto, as by a conductor 164, the output of the first amplifier 84. The output of the second amplifier 156 is delivered to terminal 110 of motor 34 as by a conductor 166. The voltage developed by the rotation of generator 158 is of such a sign as to diminish the effective voltage amplified by amplifier 156. Consequently, the starting torque of the motor remains at a minimum; however, when the speed of the motor starts to increase, a voltage signal is created by generator 158 and fed back into the second amplifier so as to effectively diminish the otherwise normal output of the second amplifier. As a result of this, the action of the motor is somewhat damped thereby reducing the chances of having the motor, because of increasing inertia, rotate valve 26 beyond its proper position.

FIG. 6 illustrates another embodiment of the invention which is, in effect, a modification of the voltage feedback arrangement of FIG. 5. In the arrangement of FIG. 5, instead of having a second amplifier, the output conductor 86 of transducer 36 is connected to one terminal 168 of the tachometer generator 158. Additionally, the resistor 170 of a potentiometer 172 has its ends respectively connected to terminals 168 and 174 of tachometer generator 158. The potentiometer wiper contact 176 is then electrically connected as by a conductor 178 to the other input terminal of the operational amplifier 84.

As in the embodiment of FIG. 5, the tachometer generator 158 produces a voltage of such a sign as to oppose the voltage output on conductor 86 from transducer 36. The potentiometer 172 is provided for purposes of adjustment if such is desired.

The feedback arrangements of both FIGS. 5 and 6 can be considered as the equivalent of viscous dampers in that it makes the overall system more stable. This becomes evident when it is remembered that the voltage feedback signal from the tachometer generator increases in magnitude in accordance with the speed of the motor 34.

Although the invention herein has been disclosed and described with reference to its use in the testing of carburetors, it should be understood that the invention is not so limited and can be employed for the regulation of pressure differentials in any situation where a second pressure is to be achieved and maintained in a particular predetermined ratio to a first pressure which, in turn, may or may not be stable.

Accordingly, even though only the preferred form and two modifications of the invention have been disclosed and described, it is apparent that other embodiments and modifications of the invention are possible within the scope of the appended claims.

I claim:

1. A pressure control apparatus for establishing and maintaining a predetermined pressure differential between a first pressure and a second pressure where said second pressure is

existent within a chamber having an inlet of variably effective area and an outlet of variable effective area, comprising first means for creating a base reference signal indicative of a desired predetermined pressure differential between said first and second pressures, second means continually responsive to said first and second pressures and effective for producing a second signal proportionate to the differential of said first and second pressures, third means responsive to the differential between said base reference signal and said second signal and effective for varying the effective area of said outlet in order to vary the value of said second pressure to that pressure value which when compared to said first pressure will exhibit a pressure differential therebetween equivalent to said desired predetermined pressure differential, said first means for creating said base reference signal comprising, a plurality of individual means each singly actuated and each so actuated being effective to independently create a base reference signal the value of which is different from the base reference signal created by the remaining means of said plurality of individual means.

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