

Jan. 6, 1942.

G. E. HOWARD

2,269,204

SPEED REGULATOR

Filed Nov. 9, 1940

4 Sheets-Sheet 1

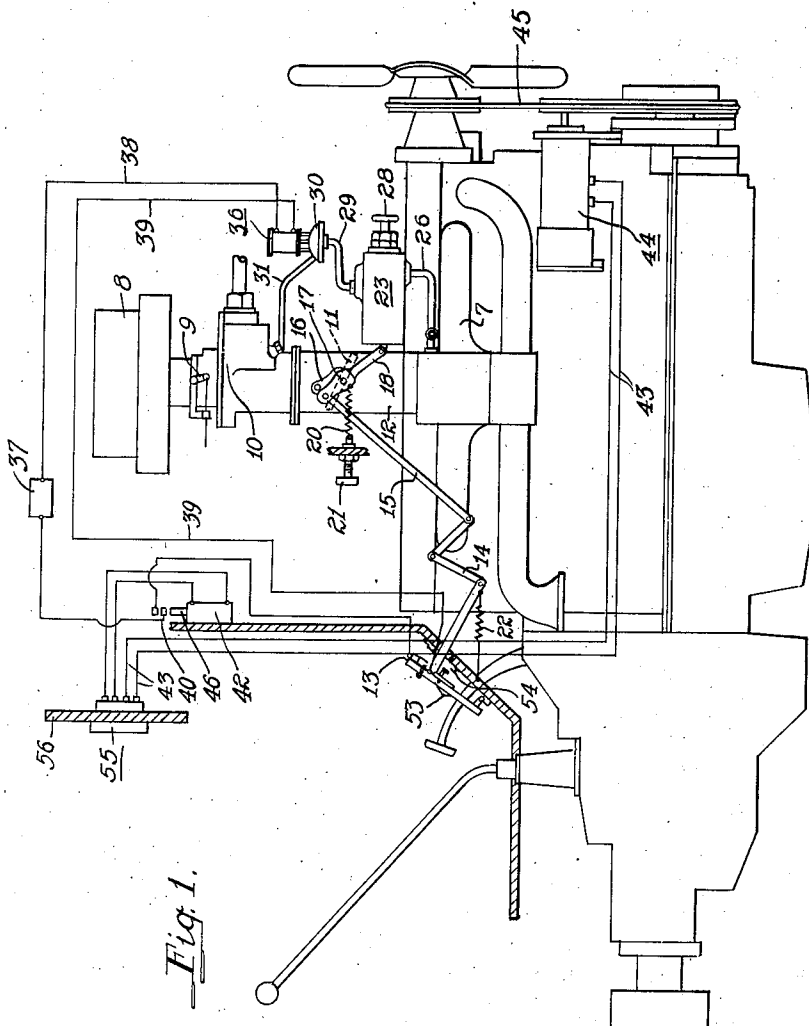


Fig. 1.

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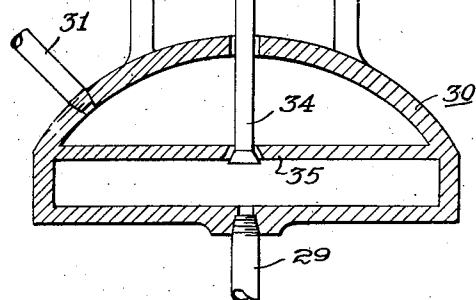
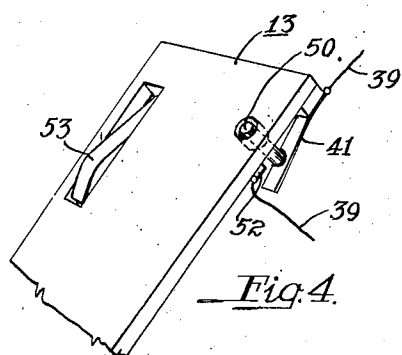
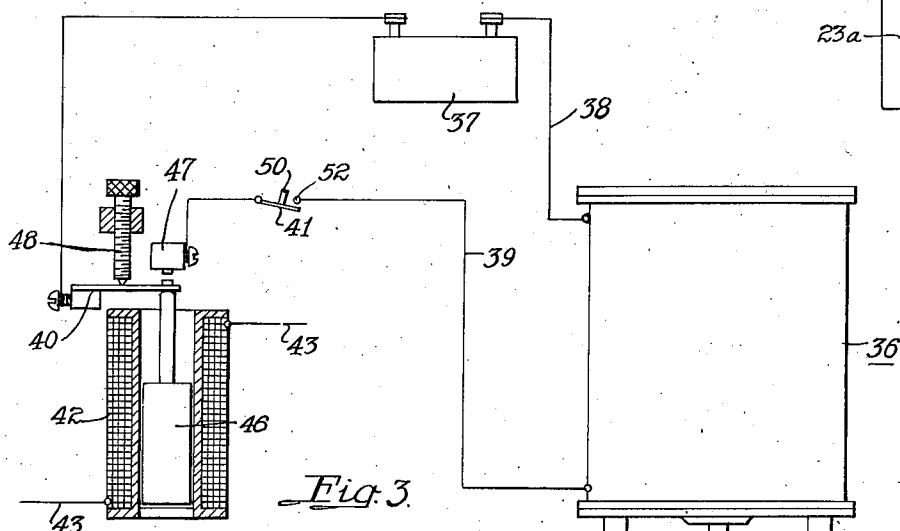
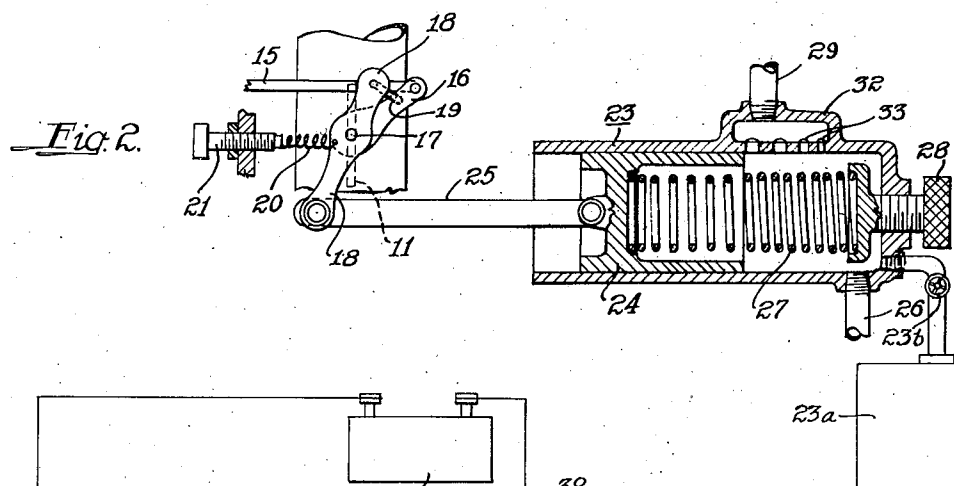
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SPEED REGULATOR

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4 Sheets-Sheet 2



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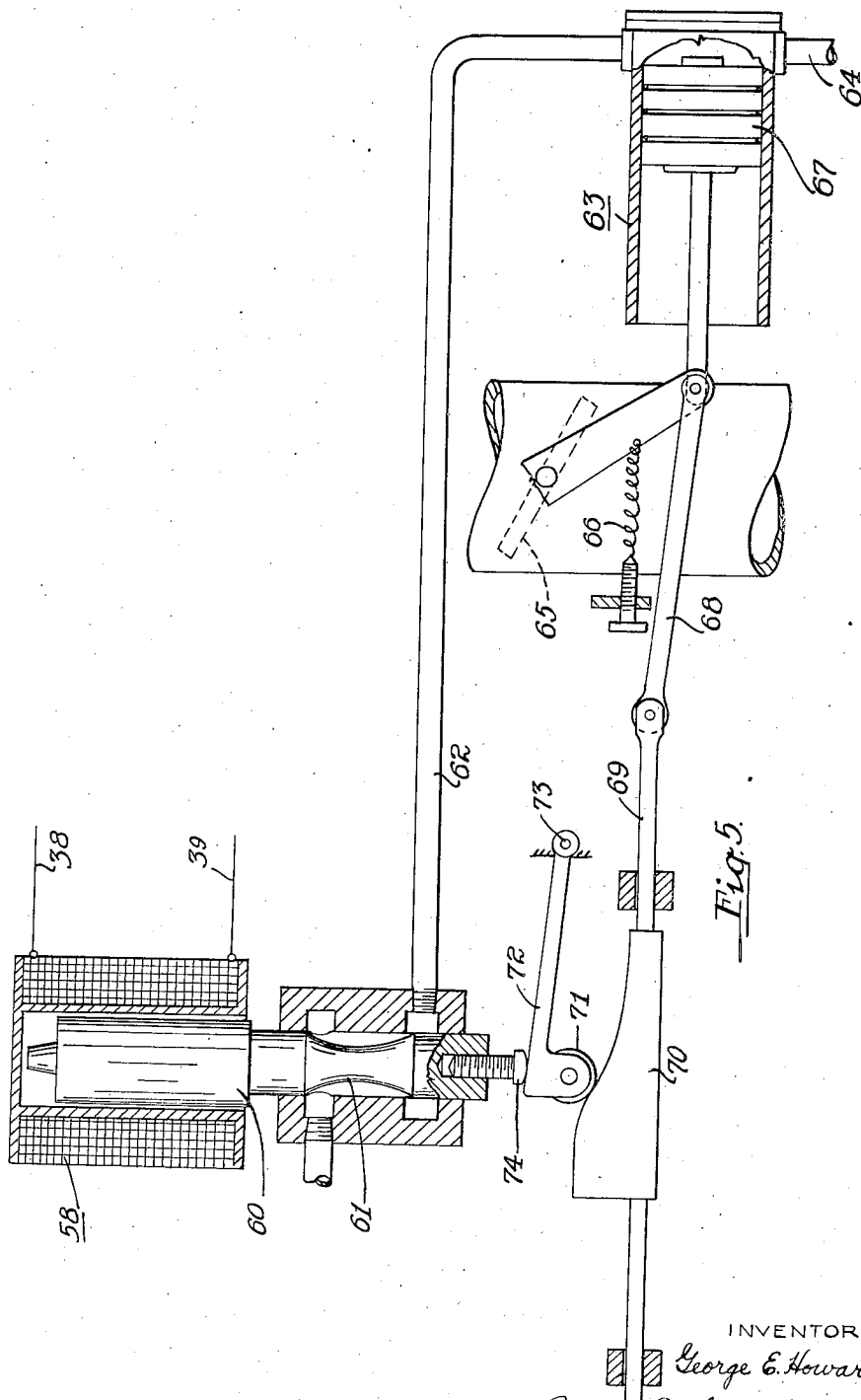
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SPEED REGULATOR

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4 Sheets-Sheet 3



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SPEED REGULATOR

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4 Sheets-Sheet 4

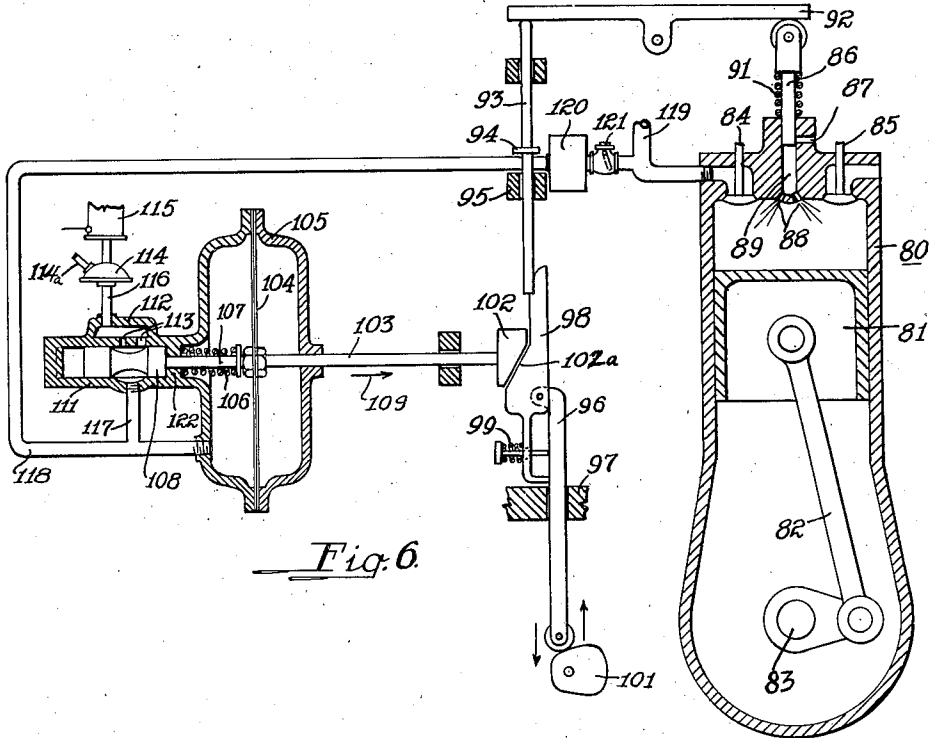


Fig. 6

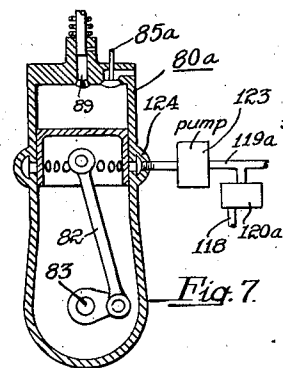


Fig. 7

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2,269,204

SPEED REGULATOR

George E. Howard, Butler, Pa.

Application November 9, 1940, Serial No. 365,025

16 Claims. (Cl. 123—102)

My invention relates to the control of engine speeds, including the control of automobile engines, as well as other types of gasoline and gas engines, steam engines, Diesel engines, and other types of prime movers.

The invention relates to the control of engine speeds, by the use of a suction-operated governor whose action or effectiveness is automatically modified to a degree that varies with changes in engine speed, somewhat after the manner described in my application Serial No. 296,241, filed September 23, 1939 (Patent No. 2,224,600), but is an improvement upon the invention of said application, as well as upon the combination of speed and suction-operated devices of my Patent No. 2,138,100.

It is characteristic of all valves for controlling the input of energy, including combustible gas mixtures and steam, that the rate of admission of motive fluid progressively increases with increase of valve opening. This is especially true in gasoline automobile engines where approximately a half open throttle of the butterfly type permits of 82½% input of power, leaving only an additional 17½% to be admitted upon additional 50% valve opening, which would be fully opened throttle.

With some governors of the suction-operated type, that is, those having a governor piston connected to the throttle valve and the cylinder of the piston communicating through a suction line with the intake manifold, the speed at which the piston will be operated to open the valve, with consequent addition to power, is greatest at light loads. This is because the suctional force in the intake manifold varies from 22" of mercury at no load (valve closed) to 2" of mercury at full load (valve fully open). This condition is aggravated by the fact that at light loads any certain change in valve opening results in from 3 to 5 or more times the change in power than is the case for a similar change in degree of valve opening at heavy loads. Therefore, in a speed regulator of this type, the change in power will be from 30 to 50 times as great at light loads as at heavy loads.

It follows that if the suction line and the area in the governor cylinder are properly proportioned for a correct range of throttle valve movement at light loads, the valve movement at heavy loads will be too slow, thus causing a too great lag at heavy loads and resultant "swing" of the valve past the point at which it should come to rest. Conversely, if the suction line and governor cylinder capacity are properly proportioned for

heavy loads, they will overrun at light loads and swing back too far and too fast, thus causing "fluttering."

In my said application, I disclose means controlled by engine speeds at and near the governed speed, for varying the effectiveness of the suctional force which acts on the valve-operating piston, such means comprising the admission of atmospheric air or bleeding into the suction line or the cylinder, whereby there is a fixed bleed area and consequently greater bleeding into the governing cylinder at light loads than at heavier loads, at any given speed. While such an arrangement is superior to either governing devices operated only by suction, or speed governors such as those of the centrifugal type, I have discovered that a still greater accuracy of control can be secured.

To this end the present invention has for one of its objects the provision of means whereby the effectiveness of suctional force from an intake manifold or the like upon a valve-operating piston is automatically varied in predetermined relation to the position of the throttle valve at the time the suctional force is brought into action to move the valve.

Stated more broadly, my invention provides for the automatic grading of the rate and extent of travel of an element that controls the supply of motive fluid to a prime mover, so that the rate of motive fluid input will be so proportioned at any load as to effect a desired change of fluid supply to meet a load change, without jerking or fluttering, preferably including the use of a speed element that is wholly responsive to changes in engine speed and which is frictionless, so that a minimum time is needed and a minimum speed change, to accommodate the rate or volume of fuel supply to load changes.

Some of the forms which my invention may take are shown in the accompanying drawings wherein Figure 1 is a side view of an automobile engine equipped with my invention; Fig. 2 is a sectional view showing the governor piston of Fig. 1 and its operative connection to the throttle valve; Fig. 3 is a view partially in section and partially diagrammatic showing the bleeder valve of Fig. 1 and the electrical apparatus and circuits for actuating the same; Fig. 4 is a perspective view showing a portion of the throttle-operating pedal and a foot-operated switch for controlling one of the circuits of Figs. 1 and 3; Fig. 5 is a view showing another form of bleeder valve arrangement for the governor piston, with a schematic arrangement of parts for operating

the said valve; and Figs. 6 and 7 show the application of my invention to two forms of Diesel engines.

As shown in Fig. 1, the apparatus includes various conventional parts such as an air cleaner 8; a choke valve 9; a carburetor 10, a throttle valve 11 and a fuel inlet passageway 12 leading to the intake manifold 7. A foot pedal 13 has link connection with a bell crank 14, that is in turn connected to a link 15 that has connection with a rocker arm 16 which is loosely mounted on a shaft 17, that carries the throttle valve 11, as shown more clearly in Fig. 2. It will be seen that when the foot pedal 13 is depressed, the link 15 will be thrust upwardly to rock the arm 16 in a clockwise direction upon the shaft 17. A crank arm 18 is keyed to the shaft 17 and carries a pin or stud 19 that extends across the rocker arm 16, as shown in Fig. 2. A tension spring 20 has connection with the crank arm 18 and is anchored to an adjusting screw 21, whereby the tension of the spring 20 can be adjusted. When the arm 16 is moved away from the stud 19, through depression of the foot pedal, against the tensional force of a spring 22, the spring 20 will rock the shaft 17 to move the throttle valve 11 to its open position shown in Fig. 2.

Automatic movement of the throttle valve 11 toward closed position, through suctional force created within the intake manifold at high engine speeds, is effected by suction created in a cylinder 23 to draw a piston 24 toward the right, the piston operating through a link connection 25 to rock the crank arm and the valve in a counter-clockwise direction against the tension of the spring 20. This suctional force is exerted through a suction line 26 that leads to the intake manifold 7. The piston 24 operates against a compression spring 27 which can be adjusted by a screw 28 to vary the extent to which the piston will move under a given suctional force, and hence serve as one means for adjusting the governed speed point.

Fuel mixture at substantially atmospheric pressure is bled into the cylinder 23 to vary the effectiveness of the suctional force. This bleeding is through a pipe 29 that communicates through a valve 30 with a pipe 31 that leads to the intake line immediately below the carburetor 10, or which may lead from the air cleaner 8. In either case, substantially atmospheric pressure is admitted to the cylinder 23.

An important feature of the present invention and one wherein it differs from my said application resides in the fact that a small chamber 32 is provided on the wall of the cylinder 23, and the cylinder wall 23 is provided with a series of openings 33 that are progressively uncovered as the piston moves toward the position shown in Fig. 2, so that with a given rate of flow through the pipe 29 as regulated by the valve 30, to be hereinafter described, there will be freer flow into the cylinder 23 when the throttle valve 11 is in its open position than when the valve is adjacent to its closed position, the extent to which the ports 33 are uncovered depending upon the position occupied by the piston 24 and hence the position of the throttle valve 11. A single long slot could be provided in lieu of the ports 33.

In Fig. 3 I show the manner in which the valve 34 within the valve chamber 30 controls flow through the pipes 29 and 31. The valve 34 cooperates with a valve seat 35 and is operated by a solenoid 36 which, when energized, will lift the valve 34 to its seated position and thus cut

off flow from the pipe 31 to the bleeder pipe 29. The solenoid may conveniently be supplied with energy from the car battery 37, the circuit being through conductor wires 38 and 39, and the line 39 being provided with switches 40 and 41. Whenever the switches 40 and 41 are closed, the solenoid 36 will, of course, be energized and flow of bleeding air to the cylinder 23 thus cut off.

The switch 40 is actuated by a solenoid 42 that is connected through conductors 43, with a generator 44 that may be driven by a belt 45 from the engine shaft. When the engine speed reaches a predetermined rate, the generator 44 will develop sufficient energy to operate the solenoid core 46, which in turn flexes the spring-like switch arm 40 to move it into engagement with the switch terminal 47 and hence completes the circuit through the solenoid 36, and causes closure of the bleed valve, so that the suction within the manifold 7 will be fully effective to move the throttle valve 11 toward its closed position. The tension of the switch arm 40 can be adjusted by a screw 48.

In explanation of the provision for providing what is in effect graduated bleed through the use of the cylinder ports 33, the bleeder valve 34 is usually in completely open position, so that there is a constant bleed to the governor cylinder 23, and the cylinder 23 is always in communication with the intake manifold. Assuming the throttle valve 11 to be nearly closed and the piston 24 in approximately its extreme right-hand position, communication through the bleed ports 33 will be entirely or almost entirely cut off, so that substantially the full suctional force of the manifold will be available to hold the piston 24 and to resist movement thereof toward the left under the force of the springs 27 and 20. Upon reduction in engine speed and consequent reduction in suctional force, the piston will be moved toward the left by the said springs, and the throttle valve consequently moved toward its open position, but in the initial stages of throttle movement toward open position, a small change in angularity of the throttle valve results in a marked increase in power, as compared to the same angular change when the throttle is nearer to its fully open position. In order to prevent too rapid and great movement of the throttle from its nearly closed position, most of the port area at 33 is covered by the piston 23, so that the suction from the manifold will not be diluted so greatly by the bleed, and will therefore offer greater resistance to throttle opening force exerted by the springs 20 and 27.

However, when the throttle valve and the piston 24 are at about full-open position, as shown in Fig. 2, it is desired that the suctional force be rendered less effective so that valve 11 can be moved through a greater angle under a given change in suctional force that results through change in engine speed, and so that the change in fuel supply for a given change in speed will be approximately equal to the change in fuel supply that is effected upon such degree of speed change which may occur when the throttle 11 is nearer its closed position. To this end, an increased number of the bleed ports 33 are uncovered as the throttle valve 11 moves toward its fully open position, such arrangement permitting the force of the springs 20 and 27 to be more effective in moving the valve against the suctional force and hence giving such valve a greater movement under a given change in suctional force when it approaches its fully open

position than is given to the valve under a like change in engine speed and suctional force when the valve is nearer to its closed position, where the suctional force more effectively counteracts the pull of the springs.

The use of the generator 44 and the solenoids 42 and 36, which elements are substantially frictionless as compared to speed governors of the centrifugal type, for example, contribute largely to the avoidance of lag and overrunning, and to quick responsiveness of the governor at predetermined changes in speed. I make still another provision for effective quick changes of fuel supply, in that there is a by-pass of fuel around the throttle 11 to the intake manifold 7. This by-pass line consists of the pipe 31, valve chamber 30, pipe 29, cylinder 23 and pipe 26. This arrangement provides in effect a two-stage fuel supply change, which may consist of an addition to the fuel which flows past the throttle 11 and under certain conditions will consist in cutting off or increasing the auxiliary fuel supply before the valve 11 has been started toward its closed position or its open position, as the case may be. The valve 34 is more quickly responsive to load and speed change than is the piston 24, because of the inertia of the piston and its associated moving parts, so that for changes in load and speed, this valve-controlled by-pass serves to vary the rate of fuel supply more quickly than if said supply is controlled only by movement of the piston 24. The arrangement, therefore, reduces the time required for balancing load and fuel supply, in that there is less movement of parts and hence less time required for effecting the balance. The by-passing of the auxiliary fuel also softens or dampens the change from one condition of load and fuel supply to another.

While I desire governing apparatus of such form that there is quick responsiveness to change of speed, there are practical limits to the quickness and extent to which the throttle valve should be opened under speed changes. For example, time is required for carburetors to adjust themselves to a sudden and wide opening of throttle. Therefore, in Fig. 2 I have shown means for dampening or delaying the responsiveness of the throttle-operating piston 24. Thus, for example, under heavy load changes, there will not be such sudden and instantaneous response of the piston 24 as will prevent the proper functioning of the carburetor. To this end I provide a reservoir 23a that communicates with the cylinder 23, a valve 23b being provided for controlling the area of communication and hence the dampening effect.

The switch 41 is provided for the purpose of rendering the control apparatus inoperative to move the throttle valve 11, in that when the circuit 38—39 is deenergized, the valve 34 will be in fully open position, and sufficient bleeding air thereby admitted to the cylinder 23, rendering the suction through line 26 ineffective to move the governor piston 24, except at very high speeds. By this means, the driver may in emergencies drive the car faster than at its normal governed speed. The switch 41 is secured to the underside of the accelerator pedal 13, as shown in Figs. 1 and 4, and is provided with a stud 50 that operates as a plunger through the pedal. The switch arm 41 is of spring-like material, and normally lies in closed position against the switch terminal 52. When the operator desires to dis-

connect the control system, he will place his foot upon the plunger 50 to open the switch 41 and may then operate the car without being limited by the set governed speed. Although in that case the main bleed valve is fully open, at any desired speed limit such as at 65 miles per hour, enough suction will be created to move the piston 24 against the springs 20 and 27. These springs, or one of them, will be adjusted to hold the piston against the force of an unbled suction at 40 miles per hour, for example.

The pedal 13 is also provided with a latch lever 53 which is of bell crank form and whose lower leg is movable into hooked engagement with a keeper 54 when the pedal is depressed and the operator's foot moved from the lever 53, as explained more in detail in my said application.

If the operator wishes to drive the car in a normal manner and free of the governing apparatus, he will retain his foot on the switch member 50 and the latch lever 53. When he wishes the engine speed to be controlled entirely by the governing apparatus and without the necessity of holding his foot on the pedal 13, he will depress the pedal and then shift his foot sidewise off the latch lever 53, permitting it to engage the keeper 54 and, of course, take his foot off the switch plunger 50. If he desires to operate the pedal 13, he need only place his foot on the latch lever 53, whereupon he can move the pedal up and down at will. If he keeps his foot from the plunger 50, the governing apparatus will be effective to prevent excessive speeds.

A rheostat 55 is mounted on the panel board 56 of the automobile, in the line 43 which leads from the generator 44 to the solenoid 42. This rheostat serves as a means whereby the operator can readily vary the effectiveness of the solenoid at various engine speeds, and hence serves as a convenient means for adjusting the rate of governed engine speed.

In the solenoid 36, the movable core which carries the valve 34 is normally held in its lower position, under the force of gravity, and will, of course, return to such position when the circuit 38—39 is broken. While solenoids and valves of this character are theoretically frictionless, in practice it is possible for dirt and oil to enter and cause some resistance to movement of the core and valve under the magnetic pull, so that the valve would not always be operated at a certain engine speed. By operating the solenoid 36 from a source of ample power such as the car battery 37, such operation will be effected with certainty whenever the switch 40 is closed, through operation of the solenoid 42, notwithstanding the presence of any friction resulting from oil or grit at the core of the solenoid 36 or the valve 34. Therefore, since the core of the solenoid 36 does not have to be spring-biased and balanced, any desired strength of pull can be exerted and the problem of oil or dirt eliminated as a factor in speed control.

It will be obvious that instead of the generator 44 that effects operation of the bleeder valves 34 or 61 when the engine speed is too great, other speed devices such as a centrifugal governor or pump may be employed for operating the bleed valves, as disclosed in my said application.

Referring now to Fig. 5, I show an arrangement wherein a solenoid 58 is provided for operating a bleeder valve, said solenoid being energized and its circuit controlled in the same manner as the solenoid 36 of Fig. 3. The solenoid core 60 op-

erates a bleeder valve 61 which, through a pipe 62, communicates with the governor cylinder 63. The cylinder communicates through a pipe 64 with the intake manifold of the engine, as in the case of the pipe 31 of Fig. 1.

The throttle valve 65 is spring-biased toward open position by a spring 66 and also may be operated manually in the same manner as is the throttle 11. The valve will automatically be moved against the tension of the spring 66 by the governor piston 67, but in this instance, the bleed into the cylinder 63 will be regulated entirely by the valve 61. A link 68 connects the piston 67 with a slide bar 69 that carries a cam block 70. A cam roller 71 is carried by a camming arm 72 that is pivotally connected at 73 to a suitable stationary support. The arm 72 normally affords vertical support for the valve 61, through the medium of an adjustable screw 74, the camming arm 72 and hence the valve 61 being raised and lowered through movements of the piston 67 and the camming block 70.

When the engine speed exceeds a predetermined rate, the solenoid will effect complete closure of the valve 61. The engine speed at which the solenoid operates will be determined by adjustment of a rheostat such as the rheostat 55 of Fig. 1. However, at all other times the valve 61 will be partly open, the extent of opening being determined by the position of the piston 67. In this case as in that of Fig. 2, when the piston 67 is in its right-hand position and the throttle valve 65 nearly closed, the bleeder valve 62 will also be nearly closed, so that the suctional force of the manifold upon the piston 67 will be sufficient to prevent too great movement of the throttle by the spring 66. When the valve 65 is at a farther open position, the bleed valve 61 will be lower than shown in Fig. 5, so that there is greater bleed and the spring 66 will be effective to move the valve 65 more readily under a given change of suction in the manifold than under the same degree of change in suctional force when the throttle valve is farther toward its closed position.

It will be understood that the contours of valve core 61 and the cam block 70, or either, may be changed so as to secure desired load and speed curves.

Referring now to Fig. 6, I show the application of my graded bleed device to a Diesel engine of the four-cycle type, it being understood that, as in the case of the other figures, the showing is schematic and that the various parts are drawn to a size convenient for the purpose of clarity rather than drawn to proper proportionate dimension.

The engine cylinder is indicated by the numeral 80, the piston being numbered 81, the connecting rod 82 and the crank shaft 83. The engine is provided with an induction valve 84 for admitting atmospheric air to charge the cylinder and to dispel exhaust gases, and an eduction valve 85 is provided to permit scavenging or exit of burned gases. These valves 84 and 85 will be operated in any suitable manner well known in engines of this type.

A piston or pump 86 is periodically operated to force fuel oil into the cylinder 80, such operation being effected through suitable driving connections with the crank shaft 83.

As in the case of all Diesel engines of the four-cycle type, air is sucked past the valve 84 into the cylinder during a down-stroke of the piston 81. On the next up-stroke, this air is compressed to a high pressure and temperature. On the next

down-stroke, oil, which is supplied under pressure through a line 87, is forced by the pump 86 through spray holes 88 into the cylinder where it mixes with the hot compressed air and burns, thus supplying power to force the piston down. A suitable check valve (not shown) is provided to prevent exploding of the combustible mixture in the pump chamber 89. During the next up-stroke of the piston, the valve 85 is opened to permit exhaust of the burnt gases. On the succeeding down-stroke, air will be admitted past the valve 84 and the various movements repeated.

I have shown the pump piston 86 as yieldably held in its raised position by a spring 91. The pump piston, which also serves as a valve to cut off flow from the line 87, is forced downwardly by a rocker arm 92, whose inner end has engagement with the pump piston, and whose outer end is engaged by a bar 93 that is mounted in suitable guides, for vertically sliding movement. The bar is provided with a stop collar 94 that abuts against a fixed guide 95 to limit downward movement of the slide bar 93. A bracket 96 is mounted for vertically sliding movement in a guide 97 and has a pawl 98 pivotally supported thereon, the pawl being normally biased in a counter-clockwise direction by a spring 99. The pawl normally has latched engagement with the lower end of the rod 93, so that when the bracket 96 is raised, the arm 92 will be rocked in a clockwise direction to move the pump plunger 86 down and force a fuel charge from the chamber 89 into the cylinder. The bracket 96 is periodically raised by a cam 101 which has suitable driving connection with the engine shaft 83, so that the cam will be given one rotation during each two revolutions of the crank shaft 83.

In order to regulate the fuel charge, I provide means for disengaging the pawl 98 from the rod 93 and thus reduce the amount of fuel charge when the engine speed is too great. To this end I provide a block 102 which has a beveled surface that cooperates with a similar beveled surface 102a on the pawl 98. The block 102 is carried by a slide rod 103 that is rigidly connected to a diaphragm 104, mounted in a case 105 which, when there is sufficient suction at the left-hand side of the diaphragm, will move the block 102 away from the pawl 98 a distance dependent upon the degree of effective suctional force at the diaphragm, and thereby control the tripping of the pawl 98, and hence the amount of fuel which is injected into the engine cylinder during a fuel feeding stroke.

A spring 106 that surrounds the stem 107 of a slide valve 108 urges the rod 103 in the direction indicated by arrow 109. The valve 108 operates in a valve chamber 111 that has an inlet chamber 112, which communicates through a series of ports 113 with the interior of the valve chamber 111, the chamber 112 and the ports 113 corresponding to the elements 32 and 33 of Fig. 2. A valve chamber 114, which corresponds to the valve structure of Fig. 3 and is actuated by a solenoid 115 which corresponds to the solenoid 36 of Fig. 3, communicates through a pipe 116 to admit bleed air from a pipe 116a to the valve chamber 112. The extent of bleed port area at 113 will depend upon the position of the valve 108 and hence upon the position of the diaphragm 104. A bleed passageway 117 leads from the valve chamber to a suction line 118 that provides communication between the diaphragm chamber 105 and an air intake line 119 through which air is

drawn past the intake valve 84 upon downstroke of the piston 81.

A suction chamber 120 is provided in the line 118, so that a suctional force will constantly be present in said line, notwithstanding that the valve 84 is periodically closed during upstroke of the piston 81. A check valve 121 opens under suctional force in the line 119, but will close when flow through the line 119 is interrupted, thus preserving a condition of subatmospheric pressure in the line 118 during operation of the engine.

The degree of suction at the left-hand side of the diaphragm 104 is primarily dependent upon the suctional force in the pipe 119, the effectiveness of this force, however, being modified in accordance with the position of the slide valve 108. As the wedge block 102 moves to the right, more of the bleed holes 113 will be uncovered, thus reducing the effectiveness of the suction in the pipe 118 and the vacuum chamber, so that movement of the block 102 will be slower than where the parts are in such position that a stronger suction exists and the diaphragm 104 is farther to the left. In the latter position, which is full-load, the actual suctional force will be less, but more of the bleed port area at 113 will be cut off, thus increasing the effectiveness of the vacuum force.

The power of a Diesel engine is proportionate to the pressure stroke of the pump 86, which may cut off the supply of fuel through the jets 88 at one-quarter stroke, one-half stroke, full stroke, or any desired fraction of a stroke. A small difference in cut-off at light load makes a greater power difference relatively than a similar difference in pump plunger stroke at a heavy load. Therefore, the rate of movement of the wedge member 102 should be different at a light load than at a heavy load, in order to produce smooth running.

The extent of movement by the block 102 under the influence of spring 106 is limited by a stop shoulder 122 against which the inner end of the valve 108 abuts. It will be seen that when the cam 101 is moving the bracket 96 upwardly in order to effect a pressure stroke of the pump piston 86, a full fuel feeding stroke will be secured if the pawl 98 is not tripped out of engagement with the bar 93. However, if the suctional force in the diaphragm chamber 105 is at a low point, the cam block 102 will trip the pawl 98, thus releasing the plunger 86 to upward thrust under the pressure of the spring 91 and interrupting the injection of fuel. The point at which this interruption occurs depends, of course, upon the speed of the engine and hence the suctional force in the pipe 119. It will be understood that the solenoid 115 will be energized sufficiently to close the bleed valve 114 when the rate of engine speed reaches a predetermined rate.

To summarize the discussion of this Fig. 6, a source of vacuum is employed for cutting off the supply of fuel oil at a desired point dependent upon speed and load conditions. Movement of the cut-off means (wedge block 102) is effected in one direction by action of the suction against the pressure of the spring 106. When the suction is sufficiently reduced by bleeding air into the line 118, the spring 106 will move the block 102 toward the cut-off position. Bleed area and reduction of effective suction in the diaphragm chamber 105 is lowest at full-load and greatest at light-load, thus causing a slower movement of the cut-off block 102 at light-load—where any

certain linear travel makes a greater difference in percentage of power change, and vice versa.

Referring now to Fig. 7, I show the application of my invention to a Diesel engine of the two-cycle type. In this arrangement, air for scavenging the cylinder and providing an explosive charge is supplied from a pump 123 to a header 124 from whence it enters the cylinder 86a. As in other inventions of this type, fuel is injected from the pump chamber 89 into the heated compressed air in the cylinder, and is burned upon down-stroke of the piston. At the end of the down-stroke of the piston, air is admitted at 124, the exhaust valve 85a being then opened, so that the incoming air will not only force out the burned gases, but during its upstroke (at which time the valve 85a is closed) the piston will compress said air to form a part of a new explosive mixture. In this instance, the diaphragm chamber 105 will have its suction pipe 118 connected to the intake side 119a of the pump 123 through a suction chamber 120a in which a constant suctional force is present during operation of the engine, as in the case of the suction chamber 120.

The term "motive fluid" is employed in a broad sense, in the accompanying claims, to include not only an air and gas or gasoline mixture, but also the air admitted to a Diesel engine to form a combustible mixture with the oil, and steam for moving various types of steam engines.

The term "load change" in the accompanying claims refers to change in amount of work done or resistance encountered at any given speed, which necessarily causes a change in engine speed until there is a change in the supply of motive fluid.

The term "fluid pressure" as employed in certain of the claims is used in a broad sense to include either sub-atmospheric pressure or super-atmospheric pressure.

I claim as my invention:

1. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, an element operated by fluid pressure, for controlling movements of said valve, a bleed device which varies the effectiveness of said pressure in accordance with changes in the position of said element, and means responsive to a predetermined rate of prime mover speed, for controlling flow in the bleed device.

2. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, an element operated by fluid pressure, for controlling movements of said valve, a graded bleed device which varies the effectiveness of said pressure, upon changes in the position of the valve, and means responsive to changes in prime mover speed, for controlling flow in the bleed device.

3. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, an element operated by fluid pressure, for controlling movements of said valve, a bleed device which varies the effectiveness of said pressure in accordance with changes in the position of said element, and means responsive to increase in prime mover speed above a predetermined rate, for cutting off flow in the bleed device.

4. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, a suction-operated piston for moving the valve, a graduated bleed device for varying the extent of bleed in accordance with the position of said piston, and electrical apparatus which is energized by prime mover speed of a predetermined rate, for controlling the supply of air to the bleed device.

5. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, a fluid-pressure-operated piston for moving the valve, a graduated bleed device for varying the extent of bleed in accordance with the position of said piston, a normally-open valve controlling the supply of bleed air to said device, an electro-magnet for closing said valve, and an electrical device responsive to predetermined changes in prime mover speed for making and breaking the circuit of said magnet.

6. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, a fluid-pressure-operated piston for moving the valve, a graduated bleed device for varying the extent of bleed in accordance with the position of said piston, a valve controlling flow of air at the bleed device, electrical apparatus which is energized by prime mover speed of a predetermined rate, for controlling movement of the second-named valve and hence the supply of air to the bleed device, a manually-operable element for moving the first-named valve, and a switch element associated with said element and controlling the circuit of said electrical apparatus, whereby the second-named valve can be caused to remain in fully open position during manual operation of the first-named valve.

7. The combination with a prime mover and a source of motive fluid therefor, of a valve for controlling the flow of motive fluid to the prime mover, means which yieldably urges the valve toward open position, an element which is operated through load changes, for moving the valve in opposition to the yieldable means, a device movable in predetermined relation to movements of said element, for varying the force exerted on said element by load changes, a manually-operable device for limiting the position to which the valve may be moved by the yieldable means, and means associated with said manual element, for rendering the automatic control elements ineffective to regulate the speed of the prime mover.

8. The combination with an engine of the internal combustion type having an intake passageway provided with a throttle valve, of means responsive to changes in engine speed, for moving said valve to control the flow of motive fuel, an auxiliary fuel-supply line communicating with said passageway at a point between the throttle valve and the engine, and means responsive to changes in engine speed, for controlling flow through the auxiliary line.

9. The combination with an engine of the internal combustion type having an intake passageway provided with a throttle valve, of means responsive to changes in engine speed, for moving said valve to control the flow of motive fuel, an auxiliary fuel-supply line communicating with said passageway at a point between the throttle valve and the engine, and means more quickly responsive to changes in engine speed than is the

first-named means, for controlling flow through the auxiliary line.

10. The combination with an engine of the internal combustion type having an intake passageway provided with a throttle valve, of means responsive to changes in engine speed, for moving said valve to control the flow of motive fuel, an auxiliary fuel-supply line communicating with said passageway at a point between the throttle valve and the engine, and means more quickly responsive to changes in engine speed than is the first-named means, for controlling flow through the auxiliary line, the said line being maintained open by its control means at normal running speeds, to admit fuel to the engine.

11. The combination with an engine of the internal combustion type having an intake passageway provided with a throttle valve, of means responsive to changes in engine speed, for moving said valve to control the flow of motive fuel, an auxiliary fuel-supply line communicating with said passageway at a point between the throttle valve and the engine, and means more quickly responsive to changes in engine speed than is the first-named means, for controlling flow through the auxiliary line, the said line being maintained open by its control means at normal running speeds, to admit fuel to the engine, and being closed as soon as the engine speed exceeds a predetermined rate.

12. The combination with an engine of the Diesel type, having a fuel inlet and an inlet line for combustion air, together with a pump element for injecting the fuel, of a device for moving said element, a fluid-pressure-operated element which is movable to limit the travel of said device during its injection of fuel, and means responsive to load changes at any given speed of the engine, for varying the effectiveness of said pressure element.

13. The combination with an engine of the Diesel type, having a fuel inlet and an inlet line for combustion air, together with a pump element for injecting the fuel, of a device for moving said element, a fluid-pressure-operated element which is movable to limit the travel of said device during its injection of fuel, and means responsive to load changes at any given speed of the engine, for varying the effectiveness of said pressure element in such manner that it will operate more rapidly at full loads than at light loads.

14. The combination with an engine of the Diesel type, having a fuel inlet and an inlet line for combustion air, together with a pump element for injecting the fuel, of a device for moving said element, a suction-operated element which is movable to limit the travel of said device during its injection of fuel, and means responsive to load changes at any given speed of the engine, for varying the effectiveness of said suction element, the suction element being energized by suction created in the air inlet.

15. The combination with an engine having an intake passageway provided with a throttle valve for controlling the flow of motive fluid to the engine, of a conduit leading from the passageway at a point between the valve and the engine, a device actuated by fluctuations of the suctional force that are transmitted through said passageway, and having operative connection with the valve for moving the same in response to said fluctuations, and a fluid-containing reservoir communicating with the conduit, to supply limited quantities of dampening fluid thereto for periods of short duration.

16. The combination with an engine having an intake passageway provided with a throttle valve for controlling the flow of motive fluid to the engine, of a conduit leading from the passageway at a point between the valve and the engine, a device actuated by fluctuations of the suctional force that are transmitted through said passageway, and having operative connection with the

valve for moving the same in response to said fluctuations, a fluid-containing reservoir communicating with the conduit, to supply limited quantities of dampening fluid thereto for periods of short duration, and a valve for regulably restricting the rate of flow between the reservoir and the conduit.

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