

[54] **FUEL-AIR RATIO CONTROL FOR SUPERCHARGED ENGINES**

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[51] Int. Cl. **F02d 1/06**

[58] Field of Search **123/140 MP, 140 MC**

[56] **References Cited**

UNITED STATES PATENTS

3,077,873	2/1963	Parks et al.	123/140 MP
2,835,240	5/1958	Braun.....	123/140 MP
3,313,283	4/1967	Miller.....	123/140 MC

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[57]

ABSTRACT

A fuel-air ratio control device for a super-charged engine having a governor means connected to a fuel-adjusting member and a supercharger for supplying air through an intake manifold. The control device is directly engageable with the fuel-adjusting member and is responsive to intake manifold air pressure and to engine oil pressure. The device is inoperative to restrain the adjusting member during start-up of the engine and remains so until such time as a predetermined intake manifold pressure is attained at which time the control device moves to a position which permits the metering of engine oil therethrough to permit normal governor operation and proportional increases of fuel with air pressure increases. The control device is automatically shiftable to a position which blocks the metering of engine oil therethrough and which provides a hydraulic lock and positive connection between the control device and the fuel adjusting member to preclude any undesired increase of fuel supply.

13 Claims, 3 Drawing Figures

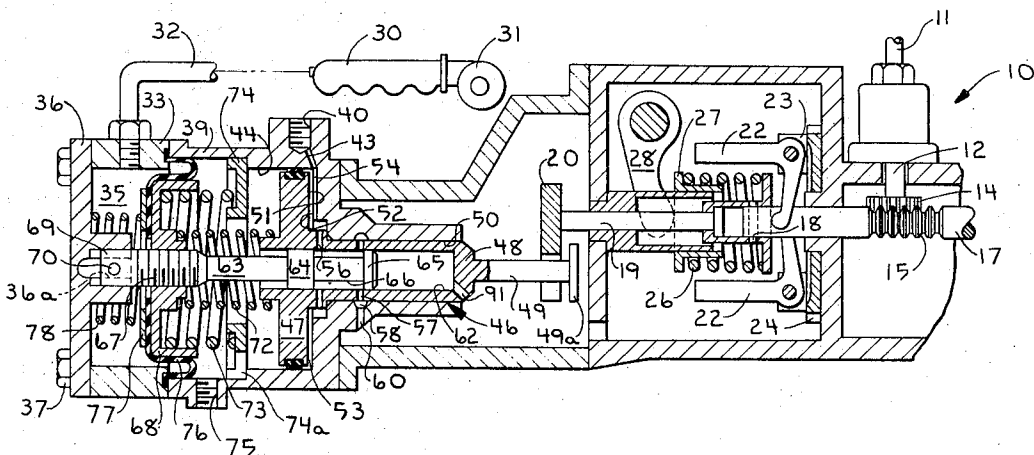


FIG. 1

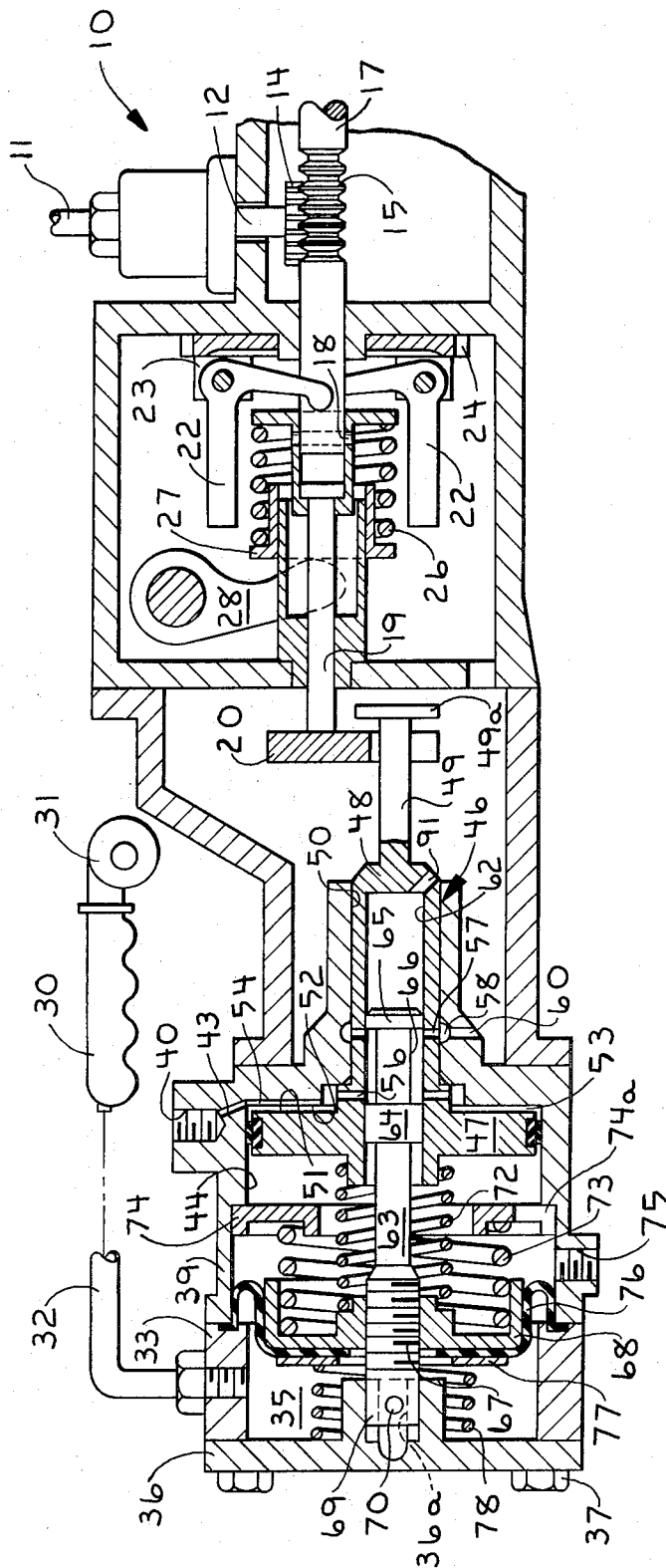


FIG. 2.

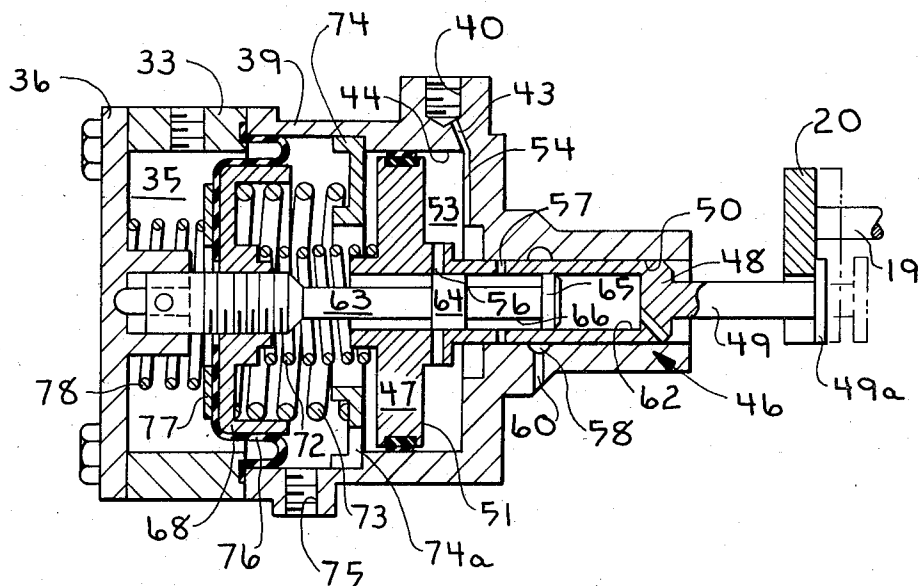
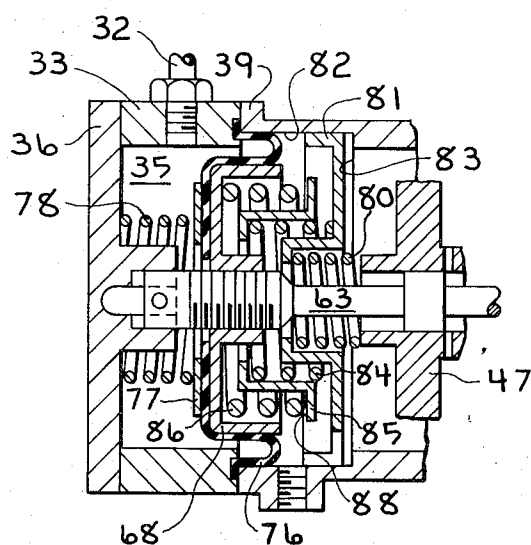


FIG. 3.



FUEL-AIR RATIO CONTROL FOR SUPERCHARGED ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a fuel-air ratio control device for overriding an engine governor means to preclude an increase of fuel to the engine during a reduction of air pressure in the engine intake manifold. Supercharged engines, and, in particular, engines with exhaust-driven supercharges will produce heavy and objectionable exhaust smoke emissions when rapidly accelerated. This is because the engine's fuel-adjusting member can be advanced faster than the speed of the engine, and the supercharger can build up to provide sufficient air for the combustion of all the fuel being injected. This results in the expulsion of large quantities of unburned fuel as exhaust smoke.

Additionally, engines equipped with superchargers of the above type smoke badly under lug. Lug is encountered when resistance or load on the engine is increased to the extent that engine speed is reduced below that which is indicated by the governor setting. Under these conditions, the engine governor attempts to regain the engine speed indicated by the governor setting by automatically advancing the engine fuel rack to supply more fuel, but, due to the reduction in supercharger speed caused by the reduced engine speed, insufficient air is supplied to the engine to support complete combustion of the additional fuel being injected.

The patent to Parks, U.S. Pat. No. 2,767,700, of common assignment herewith, teaches a system intended to overcome the above problems by utilizing a pressure-responsive mechanism which is opposed by a spring member and which interacts with and restrains a fuel-adjusting member through a movable stop. As disclosed in the Parks patent, a lack of inlet manifold pressure allows the spring member to move the movable stop and, therefore, the fuel control member toward a decreased fuel position. As inlet manifold air pressure increases, the pressure-responsive mechanism compresses the spring member and the main governor spring is permitted to move the movable stop and fuel adjusting member toward an increased fuel position.

While theoretically operable, it has been found that this type of fuel-air ratio control imposes certain restrictions on overall engine performance. First, it is difficult to provide sufficient fuel for starting because the spring member holds the movable stop and fuel-adjusting member toward the decreased fuel position. Second, the governor spring must be allowed to perform its primary purpose of moving the fuel-adjusting member toward the increased fuel position to maintain engine speed with an increasing load or to increase engine speed. At the same time, the spring member which interacts with the pressure-responsive mechanism must provide sufficient force to restrain the governor spring until the pressure-responsive mechanism is actuated by inlet manifold air pressure. If the preload force on the spring member is greater than that on the governor spring, acceleration of the engine will be impeded to an extent which is detrimental to engine performance. If the spring member preload force is less than that on the governor spring, the fuel control member will not be positively restrained by the movable stop and acceleration will be increased, but overfueling and, therefore, objectionable smoke will occur. Thus, the initial preload force on the spring member must be made greater

than that of the governor spring and a stop means must be utilized to establish the predetermined preload. The fuel-adjusting member is permitted to move toward an increased fuel position prior to engaging the movable stop. While allowing the governor spring to move the fuel control member to an increased fuel position, the spring member provides sufficient restraint until its force against the fuel control member is counteracted by increasing inlet manifold air pressure. Thus, a compromise between engine acceleration and engine smoke is produced.

Also, in certain conditions such as when accelerating from a low speed, light load, it is characteristic for the supercharger to lag in supplying air to the intake manifold. This results in the production of a negative pressure in the intake manifold. The fuel-air ratio control device of the above-designated patent could not respond to such negative manifold pressure because the pressure-responsive mechanism therein is normally disposed against an adjustable stop which is initially used to establish the preload force of the spring member.

U.S. Pat. No. 3,077,873 to Parks et al., of common assignment herewith, overcomes some of the above-noted disadvantages by providing a servo mechanism which has a movable member acting upon a valve member while a pressure-responsive mechanism acts upon a valve spool. Hydraulic fluid pressure is utilized to provide a balance of forces between the governor spring, spring member and the intake air pressure responsive mechanism. The use of the servo unit permits the spring member to be balanced for improved response when interacting with the pressure-responsive mechanism. However, the main disadvantage of this device lies in the necessary maintenance of a servo piston as a separate unit and in the use of an intermediate movable member to provide control of the valve. The resultant configuration is complex and relatively costly.

SUMMARY AND OBJECTS OF THE INVENTION

A fuel-air ratio control device for supercharged engines having a governor connected to a fuel control member and a supercharger supplying air through an intake manifold to the engine having an integral servo piston and valve unit placed in a restraining relationship with respect to the fuel control member. The servo piston is activated by a fluid force controlled by movement of a valve spool which slides in an opening and closing manner relative to ports in a portion of the servo piston. The valve spool is secured to a pressure-responsive mechanism which communicates with the engine intake manifold. Resilient means oppose the reaction of the pressure-responsive mechanism to intake manifold pressure. During engine start-up, the valve spool and ports of the servo piston are in an open condition to render the servo unit inoperative and to permit unrestricted operation of the fuel control member. The servo unit is subsequently activated when a predetermined increase in manifold air pressure shifts the valve spool relative to the servo piston ports and blocks and meters the flow of hydraulic fluid to the servo piston. During subsequent reductions in manifold air pressure, the servo unit is effective to restrain the fuel control member against movement toward an increased fuel position. The servo unit's restraint of the fuel control member precludes any disproportionate increases in fuel to the engine when the air available in the intake

manifold is insufficient to support proper fuel combustion.

It is an object of this invention to provide an improved fuel-air ratio control device for overriding the governor and controlling the injection of fuel to a supercharged engine in strict proportion to the air pressure available in the engine's intake manifold to insure complete combustion of fuel by the engine.

Another object of this invention is to provide an improved governor overriding fuel-air ratio control device which is responsive to both intake manifold air pressure and to engine oil pressure with the control device automatically permitting unrestricted movement of the fuel adjusting member on the engine during cranking to insure sufficient fuel for dependable starting, but thereafter automatically restricting the injection of fuel into the engine to precisely that amount required for operating the engine at maximum efficiency.

Other objects and advantages of the present invention will become more readily apparent upon reference to the accompanying drawings and following description.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal vertical section through the fuel-air ratio control device of the present invention which also schematically illustrates a supercharged engine intake manifold, a governor, and a fuel pump mechanism with the control device being shown in engine start condition.

FIG. 2 is a longitudinal vertical section through the fuel-air ratio control device of the present invention similar to FIG. 1 but omitting the governor and showing the fuel-air ratio control device in engine operating position.

FIG. 3 is a partial longitudinal vertical section through a modified embodiment of the fuel-air ratio control device of the instant invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring particularly to FIGS. 1 and 2 in the drawings, a fuel pump 10 has a plunger 12 vertically reciprocal during engine operation to supply fuel through a fuel injection line 11 to one of the cylinders of the engine, there being one pump for each engine cylinder. Longitudinal movement of a fuel adjusting member 17 having rack teeth 15 moves a gear 14 secured to plunger 12. The pump is of the metering type in which angular adjustment of the plunger 12 results in a variation of the quantity of fuel injected upon each stroke.

The fuel adjusting member 17 is secured to a riser 18 having an extending link 19 with a stop member 20 attached to its distal end. A pair of flyweights 22 carried upon a yoke 23 are driven by a gear 24 which is rotated by the engine's timing gear (not shown) at a speed proportional to engine speed. Radially outward movement of the flyweights due to centrifugal force causes portions of the flyweights to act leftwardly upon the riser 18. A spring 26, disposed between the riser and a collar 27, opposes the biasing action of the flyweights. A movable lever 28 is positioned to provide a predetermined selectable preload force for the spring 26 to act against the force of the flyweights 22.

An engine air intake manifold 30 is supplied with air under pressure by an engine-driven supercharger 31. A conduit 32 communicates between the intake manifold

and a chamber 35 formed by an adapter 33 having a cover 36 secured by bolts 37.

A control housing 39 has an inlet 40 connected to a fluid pressure source such as engine lubrication oil. An orifice 43 communicates inlet 40 with a bore 44 formed in the housing 39. A servo unit 46 has a piston portion 47 slidable within bore 44 and a valve means 48 integral with a piston portion and slidable within a bore 50 formed in the housing. The valve means has an extending portion 49 with a shoulder 49a thereon which is positioned to engage the stop member 20 under conditions to be explained hereinafter. An expansible chamber 53 is formed by a face 51 of the piston 47, a surface 52 of housing 39, and bore 44. Fluid from inlet 40 is permitted to enter chamber 53 by way of a groove 54 in the surface 52 which is intersected by the orifice 43.

A first set of passages 56 in valve means 48 communicate the chamber 53 with a bore 62 in the servo unit. A second set of passages 57 of valve means 48 communicate the bore 62 with an annular groove 58 formed in the bore 50. The annular groove, in turn, is intersected by a drain passage 60 in housing 39. Another passage 91 is provided to communicate any fluid which might leak through the servo unit to the drain.

A valve spool 63, slidable in the bore 62, has an annulus 66 formed between a pair of lands 64 and 65. When the land 64 is disposed as shown in FIG. 1, the passage 56 is open and land 65 is disposed so that passage 57 is open and chamber 53 is in communication with the drain passage 60.

A threaded portion 67 of valve spool 63 is secured to a cup member 68. An end 69 extends from the threaded portion 67 and has a pin 70 which engages a slot 36a in the cover 36.

A first spring member 72, having a first spring rate, is disposed between the piston 47 and cup member 68. A second spring member 73, having a second spring rate, is disposed between the cup member and a seat member 74. A diaphragm 76 is secured between the adapter 33 and the housing 39 and is supported by the cup member 68. A washer 77 disposed adjacent to and rearwardly of the diaphragm 76 acts as a seat for a third spring member 78 which resides between the cover 36 and the washer. The rates of the three spring members are such that forces on the diaphragm are balanced when no pressure is extant in the chamber 35 to provide sensitivity in the servo unit.

OPERATION

Prior to engine start-up, the fuel-air ratio control of the present invention assumes an inoperative position in the following manner. Spring member 72 urges the servo unit 46 toward the right, as shown in FIG. 1, and removes the shoulder 49a from engagement with stop 20. Any movement of the lever 28 in a counterclockwise direction compresses spring 26 and moves the fuel adjusting member 17 rightwardly toward an overfueling position. During engine cranking or upon initial start-up of the engine, the valve spool 63 is maintained in this position which provides communication between passages 56 and 57 through annulus 66 by means of the balanced condition of the spring members 73 and 78 which act upon the diaphragm 76. Fluid under pressure which enters the chamber 53 from the inlet 40 is drained off through passages 56, 57, and 60 thus preventing the exertion of a fluid force upon the piston 47 and consequent leftward movement.

After the engine has started and speed is increased a predetermined amount, air pressure in intake manifold 30 builds up and the pressure in chamber 35 increases. At such time, diaphragm 76 is acted upon by the increasing air pressure in chamber 35. This tends to compress the spring members 72 and 73 and to move valve spool 63 toward the right. Such movement eventually causes the land 64 to cover passages 56. Fluid is thus prevented from draining from the chamber 53 and fluid pressure begins to build therein to force the piston 47 toward the left into a control operative position. During this leftward movement, the shoulder 49a engages stop member 20 and moves the fuel-adjusting member 17 to a decreased fuel position such as is shown in FIG. 2. The mechanism is cocked and operative when it is disposed as shown in FIG. 2.

When the engine is operating at idle, air pressure in the intake manifold and in chamber 35 together with the bias of spring member 78 would not be sufficient to overcome the bias of the spring members 72 and 73 acting upon the diaphragm 76. The valve spool 63 would be restrained in a leftward position by the diaphragm member 76 and the piston 47 would be in the operative position wherein land 64 would effectively restrict the passages 56 to permit only a predetermined amount of fluid to be metered from chamber 53 to maintain the piston 47 in the position shown in FIG. 2. The passages 57 would be out of alignment with the annular groove 58 and the drain passage 60 to prevent fluid drainage.

As previously described, when the lever 28 is moved counterclockwise, the spring 26 is compressed to cause loading and movement of the fuel-adjusting member 17 rightwardly toward an increased fuel position. However, with the fuel-air ratio control device operative, the spring members 73 and 78 would tend to position the valve spool 63 toward the left. Therefore, the servo unit 46 and the shoulder 49a would permit only a slight movement of the fuel control member toward the increased fuel position.

If a negative pressure occurred momentarily in the manifold 30 and chamber 35, such as when the engine was accelerating from a low speed at light load, the diaphragm 76 would be drawn to the left causing the servo unit 46 to be moved slightly in the same direction. The shoulder 49a would engage the stop 20 as the stop tended to move rightwardly to increase the fuel supply to meet the demands. As engine speed increased, however, air pressure in chamber 35 would increase slightly and would move the diaphragm 76 and valve spool 63 to the right. The land 64 would move and slightly uncover the passages 56 to permit fluid to be metered out the opening and drain to the outlet 75 through a passage 74a. Fuel adjusting member 17 would then be permitted to pull the servo unit to the right as long as the air pressure in chamber 35 was increasing and the valve spool 63 was moved rightwardly to allow fluid to drain from the chamber 53.

With the engine operating within a predetermined speed and load range, as determined by the governor flyweights, sufficient air will be available within the chamber 35 to maintain the fuel-air ratio control device in a position which does not restrict the slight movements encountered by the governor in maintaining that speed. However, if engine load is increased to the point of decreasing engine speed, then air pressure in the chamber 35 will be reduced by a proportionate

amount so as to cause land 64 to restrict the passages 56 and allow fluid forces in chamber 53 to move the piston 47 slightly leftwardly to cause shoulder 49a to restrain the stop 20 and prevent a disproportionately-larger amount of fuel to be injected relative to the available air. If the operator moves the lever 28 to accelerate the engine, the stop 20 will be restrained by shoulder 49a until such time as sufficient air becomes available in chamber 35 to permit the servo unit 46 to be moved to the right by the fuel-adjusting member 17.

DESCRIPTION OF MODIFIED EMBODIMENT

A modification of the instant invention is shown in FIG. 3. A different plurality of spring members are provided to oppose the air-pressure-responsive diaphragm 76 in a manner somewhat similar to the first form of the invention. Elements common to both forms have identical reference numerals. The modification permits a variable biasing force to act upon the diaphragm for more precise tailoring of the fuel-air ratio control device to the needs of a particular engine, as will be described.

The spring rate of a single spring opposing the pressure-responsive diaphragm is linear. However, the intake manifold pressure of a supercharged engine does not always increase at a linear rate. Such a rate disparity could lead to short periods when the increasing air pressure is temporarily reduced while the fuel-adjusting member is moving toward an increased fuel position. This could lead to a phenomenon referred to as secondary exhaust smoke plumes. The fuel-air ratio control device, shown in the version of FIGS. 1 and 2, eliminates or limits these secondary plumes to acceptable limits in most engines. It has been found, however, that in certain engines the exhaust plumes are slightly above an acceptable limit. For these engines, it becomes necessary to provide a plurality of springs in series or a variable-rate spring to oppose the pressure-responsive diaphragm. With this provision, it is possible to tailor the fuel-air ratio control device functions to particular engine characteristics.

As shown in FIG. 3, a first spring member 80 is disposed between a seat member 81 and the piston 47. Seat member 81 is slidable within a bore 82 in the housing 39. A second spring member 84 is disposed between the seat member 81 and an intermediate cup-shaped member 85. A third spring member 86 is disposed between a flange 88 of the cup-shaped member and a cup member 68. A fourth spring member 78 is disposed between the cover 36 and the washer 77, as in the primary embodiment. Each spring member has a particular predetermined spring rate.

For instance, the rate required of the third spring member 86 is calculated by determining the amount of rack movement (deflection) relative to the force (load) acting on the diaphragm 76 during a given period of engine operation. A spring equation, Deflection (third spring member) = $(\text{Load}/K4 + K3)$ is used where K4 (fourth spring member 78), deflection and load are known establishes the rate of K3 (third spring member 86). The rate required of the second spring member 84 is calculated by the amount of rack movement (deflection) relative to the force (load) acting on a diaphragm 76 during a given period of engine operation just prior to that period of engine operation controlled by the third spring member 86. A spring equation, deflection

(of second spring member)=[Load/K4 + (1/1/K2 + 1/K3)]

where K4, deflection, load and K3 (third spring member) are known establishes the rate of the second spring member K2. The rate required of the first spring member is calculated by the amount of deflection relative to the load acting on diaphragm 76 just prior to that period controlled by the second spring member. Spring equation, Deflection (of first spring member)=[load/K4 + (1/1/K1 + 1/K2 + 1/K3)]

where K4, deflection, and load are known, and K3 and K2 have previously been determined establishes the rate of the first spring member K1.

OPERATION OF MODIFIED EMBODIMENT

In operation, the first spring member 80, with a relatively low rate, is utilized initially to move the seat 81 slidably toward the left within the bore 82. Thus, initial air pressure in the chamber 35, which would be slight, would be working against a relatively weak spring. As air pressure increased further, the spring members 85 and 86, having relatively higher forces than spring member 80, would act against the spring 80 through the seat member 81 until the seat member would move against a stop 83, at which time the second spring member 84, having a slightly greater spring rate than the spring member 80, would oppose the air pressure in chamber 35. A still further increase in air pressure in the chamber 35 would compress the spring member 84 through the spring member 86, which member has a still higher spring rate than spring member 84. At a predetermined air pressure in chamber 35, cup-shaped member 85 will bottom against seat member 81 and air pressure in chamber 35 will begin to act upon the spring member 86. Thus, a selectively, progressively-increasing spring rate will be available to oppose the variably-increasing air pressure in chamber 35.

In the primary embodiment the use of a single spring produces a linear force to oppose the variably-increasing air pressure force. In the modified embodiment the use of different rate springs provides a linear force in combination with a geometric change of force to more evenly match the change of force of the air pressure.

Valve spool 63 will act in the manner previously described in the primary embodiment. Compression of the springs by the pressure-responsive diaphragm will act to permit fluid to be metered out of chamber 53. This will permit the fuel-adjusting member 17 to move rightwardly toward an increased fuel position. The plurality of springs permits the pressure-responsive diaphragm to be more responsive to the air pressure characteristics of the supercharger.

While the invention has been described and shown with particular reference to the preferred embodiment, it will be apparent that variations and modifications would fall within the spirit of the present invention and the scope of the appended claims.

What is claimed is:

1. In an engine having an intake manifold, a governor-controlled fuel supply means, said fuel supply means having a control member means adapted to move in a first direction to increase the supply of fuel to the engine and in a second direction to decrease the supply of fuel to the engine, and override means for selectively overriding said governor to prevent movement of said control member means in said first direction,

said override means comprising; a piston means slidable within a first chamber means, a portion of said piston means being capable of directly contacting a portion of said control member means to prevent movement of said control member means, diaphragm means movable within a second chamber means within said override means, first resilient biasing means physically disposed between said piston means and said diaphragm means for acting upon and biasing said piston means toward said first direction and for acting upon and biasing said diaphragm means toward said second direction, means for supplying fluid pressure to said first chamber means to move said piston means toward said second direction against the bias of said first resilient means, valve passage means in said piston means for selectively draining off said fluid pressure from said first chamber to allow said piston means to move in said first direction, valve spool means connected to said diaphragm means for selectively opening and closing said valve passage means, means for communicating said intake manifold to said second chamber means to supply intake manifold pressure thereto to move said diaphragm means and said valve spool means toward said first direction in opposition to said first resilient biasing means, second resilient means separate from said first resilient means for acting upon said diaphragm means and biasing said diaphragm means and said valve spool means toward said first direction, and third resilient means separate from said first and second resilient means for biasing said diaphragm means and said valve spool means in said second direction.

2. The override means of claim 1 wherein the biasing force exerted upon said diaphragm means by said second resilient means is substantially balanced by the opposing forces exerted upon said diaphragm means by said first and third resilient biasing means.

3. The override means of claim 1 wherein fourth resilient biasing means are provided for biasing said diaphragm means toward said second direction.

4. The override means of claim 3 wherein said first, third and fourth resilient biasing means act in series upon said diaphragm means in opposition to the biasing forces exerted upon said diaphragm means by said second resilient biasing means and said intake manifold pressure extant in said second chamber means.

5. A fuel-air ratio control device for an engine having a governor-controlled, fuel-adjusting member means and a supercharger to supply air through an intake manifold to the engine comprising; resilient means responsive to intake manifold air pressure, valve means for interacting with said resilient means and for movement responsive to engine lubrication fluid pressure toward and away from said resilient means during normal governor-controlled engine operation, said valve means being selectively engageable in interfering relation with said fuel-adjusting member means for constraining movement of said fuel-adjusting member means upon a reduction in manifold air pressure but for disposition in non-interfering relation with said fuel-adjusting member means during cranking of the engine so that sufficient fuel is supplied to said engine upon starting in accordance with requirements set by the governor, said valve means also being effective subsequent to start-up for interfering with said fuel-adjusting member means to assure optimum fuel-air ratio for said engine and to prevent overfueling during periods of reduced pressure in said intake manifold, said resilient

means comprises a diaphragm means of resilient flexible material and a plurality of separate spring means arranged on opposite sides of said diaphragm means in normally-balanced relationship to said diaphragm means and selectively acting to hold said valve means in said non-interfering position with respect to said fuel-adjusting member means.

6. The control device of claim 5 wherein said valve means includes a piston means, a valve spool means connected to said diaphragm means, said valve spool means and said piston means being in a non-interfering relation with said fuel-adjusting member means until said valve spool means is moved in a first direction, chamber means for receiving engine lubrication fluid under pressure to urge said piston in a second direction, means communicating between said chamber means and said valve spool means wherein initial movement of said valve spool means in the first direction permits said piston means to be urged in the second direction and movement of said valve spool means in the second direction prevents said piston means from moving in the first direction and causes said piston means to engage said fuel-adjusting member means in interfering relation therewith.

7. A fuel-air ratio control device for an engine having a governor-controlled, fuel-adjusting member means and a supercharger which supplies air through an intake manifold to the engine, said control device comprising: pressure-responsive means in communication with said intake manifold, servo unit means for engagement with said fuel-adjusting member means and for actuation by engine lubricant pressure and having an integral piston portion and valve portion, said valve portion of said servo unit means having a bore and port means, a valve spool means connected to said pressure-responsive means and slidably disposed within said bore and having an annulus for cooperating with said port means in a sliding relation thereto for controlling the flow of engine lubricant to actuate said servo unit means, resilient means on one side of said pressure-responsive means for positioning said annulus with re-

spect to said port means to permit substantially unrestricted flow of lubricant through said servo unit means during engine start-up to render said servo unit means inoperative and to permit unrestricted operation of said fuel-adjusting member means, said servo unit means being subsequently actuated upon a predetermined increase in manifold air pressure at which time said pressure-responsive means and said valve spool means are shifted relative to said port means to restrict and meter the flow of lubricant through said servo unit means so that during any subsequent reduction in manifold air pressure said servo unit means is effective to restrain said fuel-adjusting member means against movement to preclude any disproportionate increase in fuel supply to the engine as determined with respect to the air available in the intake manifold.

8. The fuel-air ratio control device of claim 7 wherein the said servo unit means has an extended member which has a stop means for selectively constraining said fuel-adjusting member means.

9. The fuel-air ratio control device of claim 7 wherein said servo unit means is disposed in substantially axial alignment with said fuel-adjusting member means.

10. The fuel-air ratio control device of claim 7 including resilient means acting in opposition upon opposite sides of said pressure-responsive means and holding said pressure-responsive means in a normally-balanced condition.

11. The fuel-air ratio control device of claim 10 wherein said opposing resilient means are positioned in substantially axial alignment with said servo unit means and fuel-adjusting member means.

12. The combination of claim 11 wherein said resilient means include spring means having a selectively-variable spring rate.

13. The combination of claim 12 including a plurality of spring means, said spring means being activated cumulatively and in a series by said pressure-responsive means.

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