

[54] **MANIFOLD PRESSURE CONTROLLER
FUEL LIMITER**

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[22] Filed: **June 6, 1972**

[21] Appl. No.: **260,111**

[52] U.S. Cl.: **123/179 L, 123/139 ST, 123/140 MC,**
123/140 R, 123/140 MP, 123/179 G

[51] Int. Cl.: **F02d 23/02, F02m 39/00**

[58] **Field of Search** 123/179 G, 179 A, 140 MC,
123/119 C, 140 FG, 140 MP, 140 R, 140 J,
139 ST, 179 L

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Primary Examiner—Charles J. Myhre

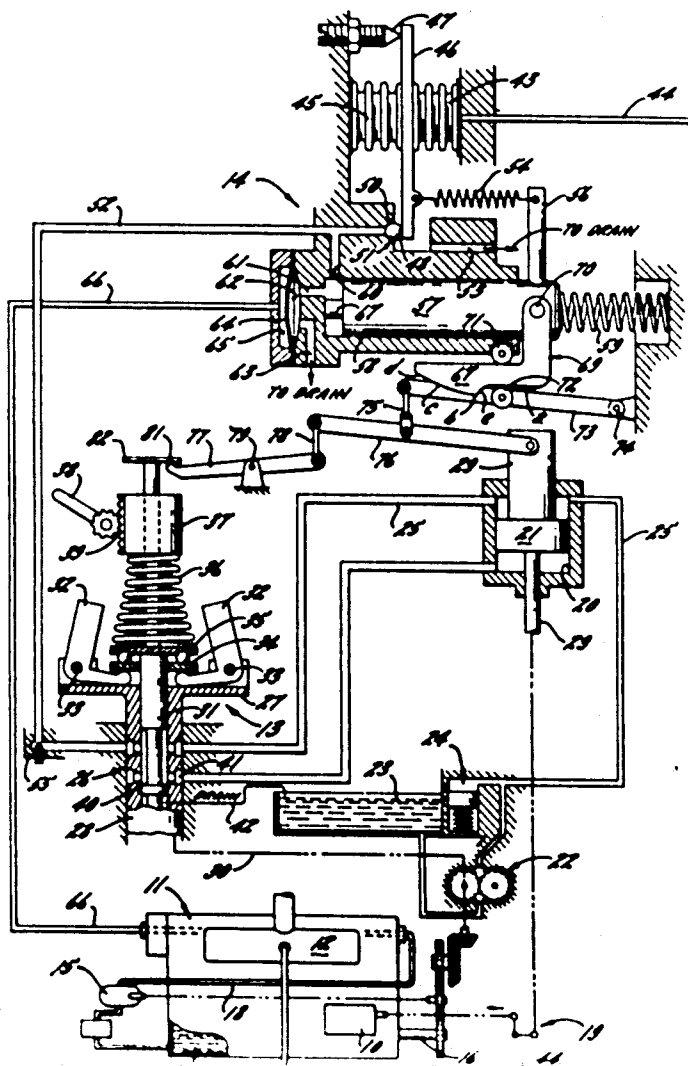
Assistant Examiner—W. Rutledge, Jr.

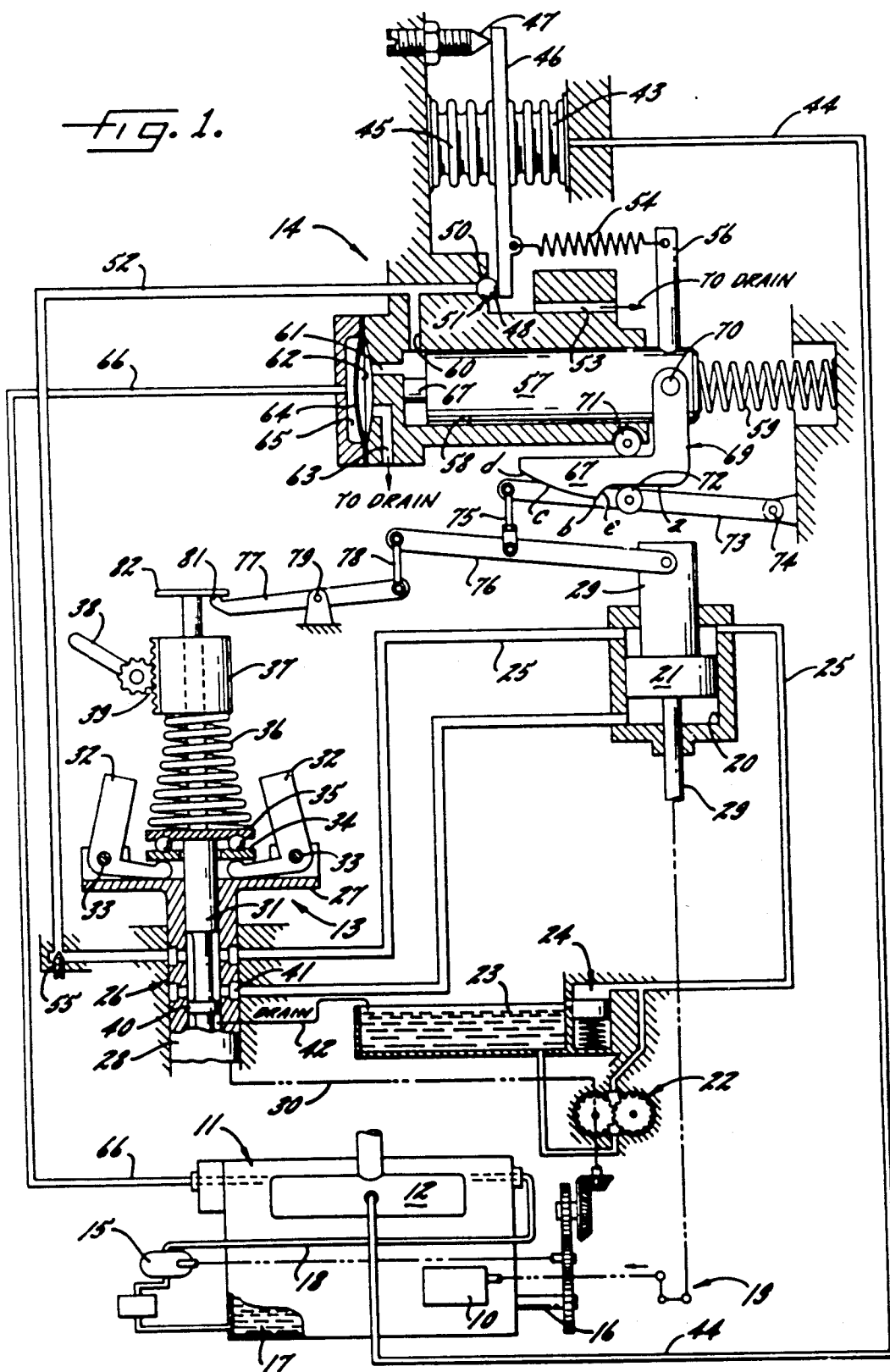
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[57] **ABSTRACT**

The fuel flow for starting a turbocharged internal combustion engine is limited by the starting position of a limit control cam which acts as a stop to establish a fuel flow for starting the engine and then moves progressively to change the fuel limit in response to a combination of a build-up of pressure in the lubricating system of the engine and in the manifold by the turbocharger after starting. The stop is returned to the starting position in response to the lube oil pressure decrease incident to stopping the engine. A fuel rate lower than the cam established limit is provided automatically by the speed governor of the engine if the torque demands on the engine are met with less fuel than such limit.

10 Claims, 4 Drawing Figures

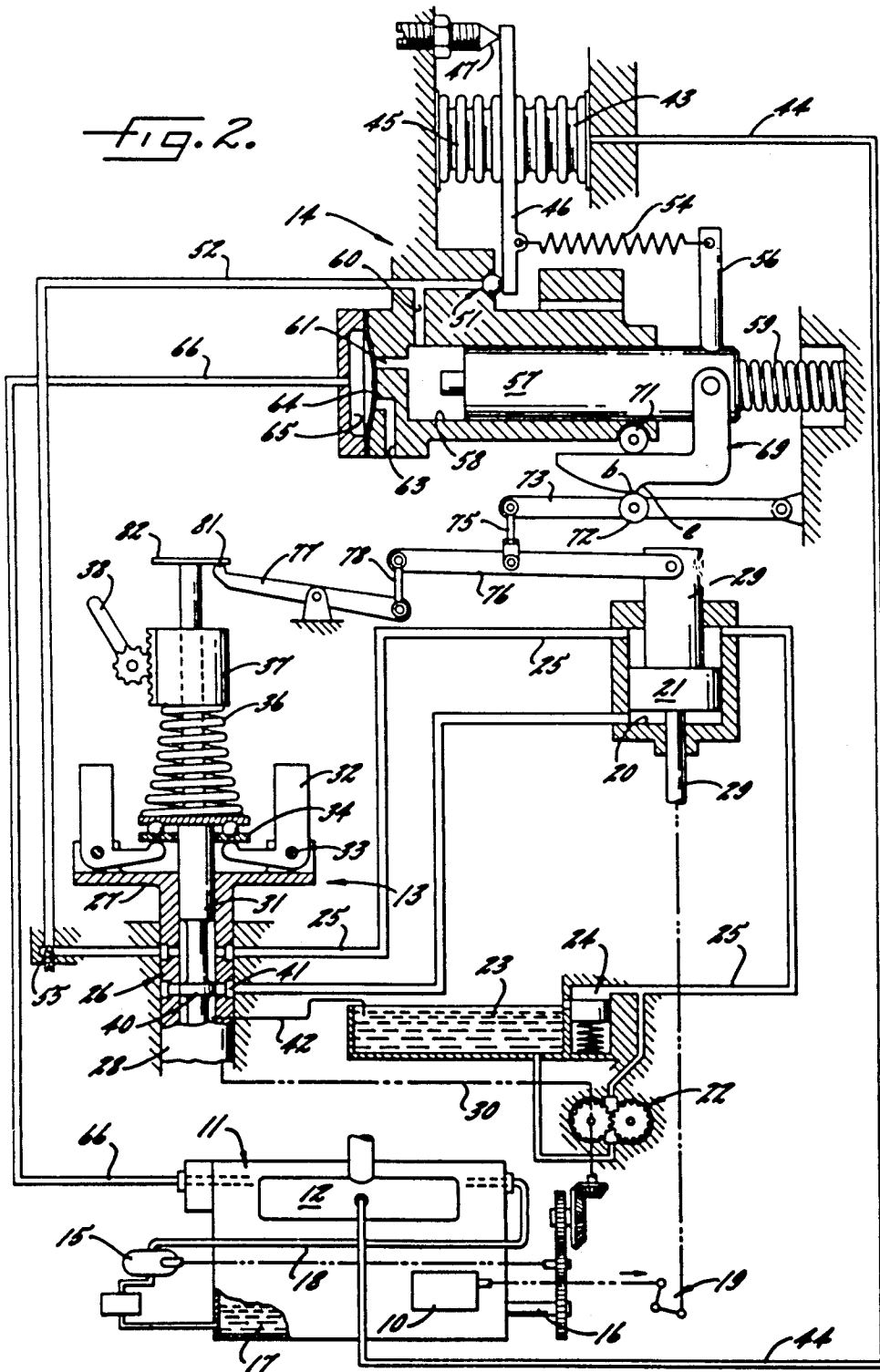




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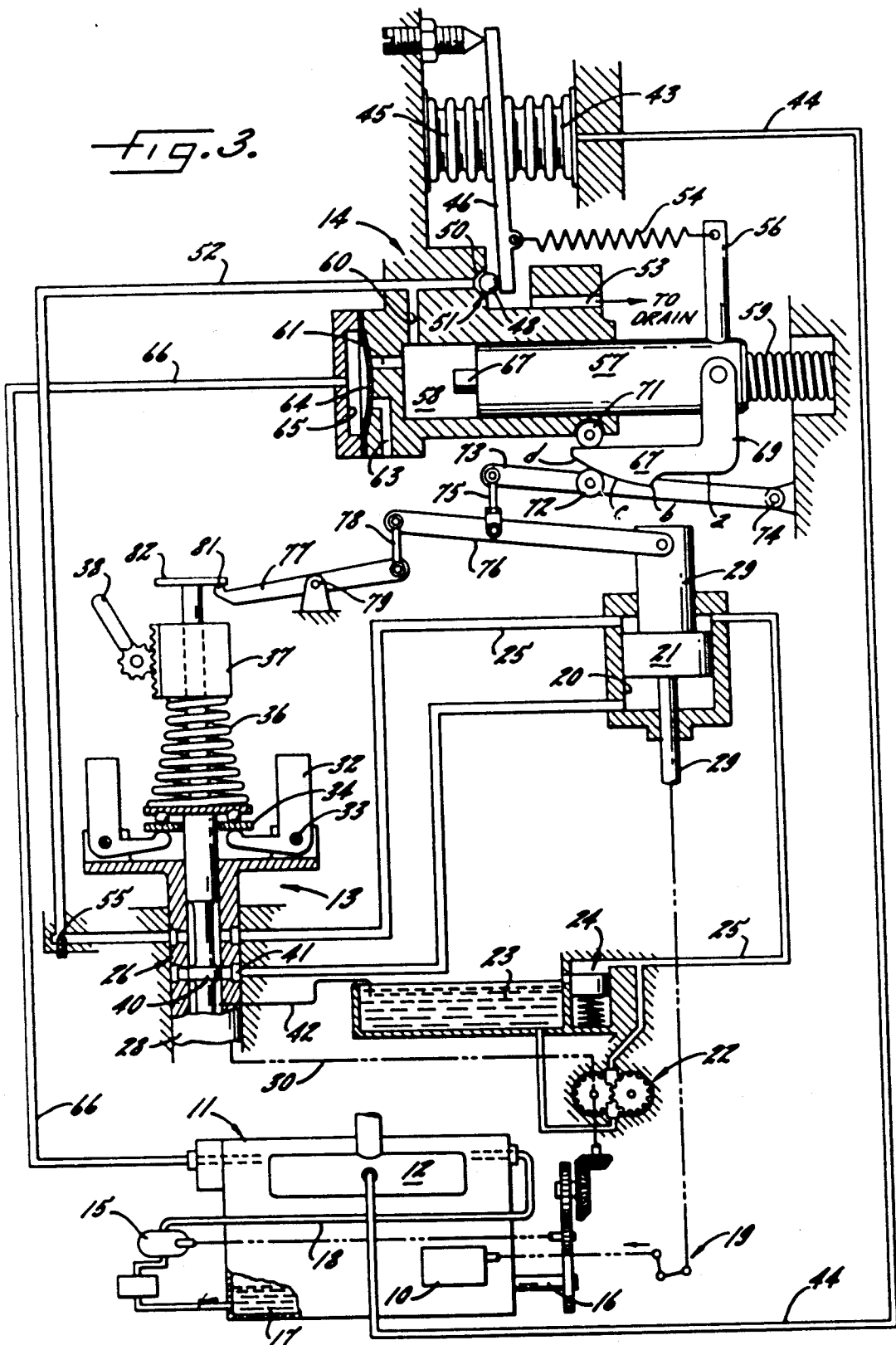


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Fig. 3.



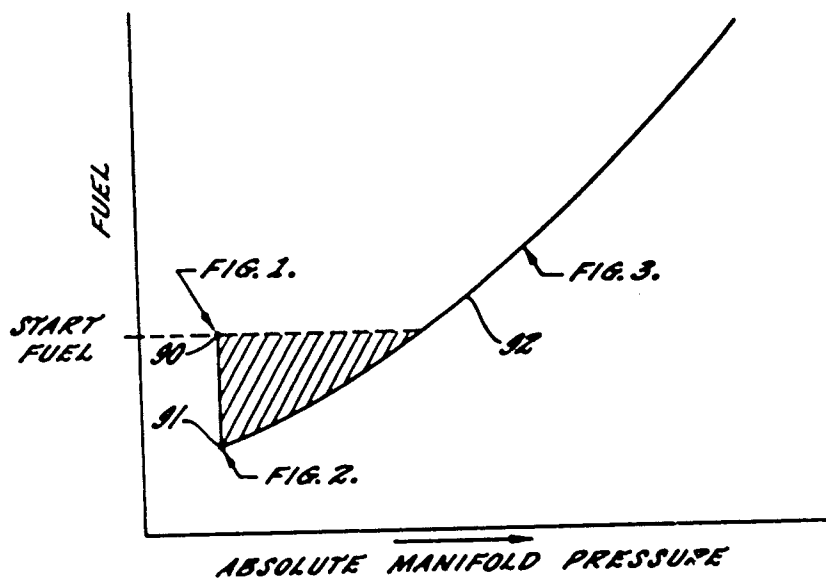


FIG. 4.

MANIFOLD PRESSURE CONTROLLER FUEL LIMITER

BACKGROUND OF THE INVENTION

This invention relates to a mechanism for limiting the throttle of a turbocharged internal combustion engine with changes in the manifold pressure so as to reduce smoking of the engine. More particularly, the invention involves the use of a cam movable as the engine load builds up and operating to schedule the permissible fuel increase in accordance with the build-up of the manifold pressure by the turbocharger.

SUMMARY OF THE INVENTION

The invention provides a limit control of the above character in which the fuel supply is scheduled by a stop of varying contour which limits the fuel supply for starting the engine during cranking and before the turbocharger becomes effective and thereafter is moved to first decrease the limit for no-load operation and then to increase the fuel supply limit progressively as the engine manifold pressure is increased by the turbocharger in accordance with loading of the engine. The movement of the limit scheduling stop out of starting position is initiated in response to the build-up of the pressure in the lubricating system of the engine following starting thereof, the stop being returned to the starting position in response to the decrease in the lube oil pressure incident to stopping the engine.

The fuel limit control is combined in a novel way with a selectively adjustable controller such as an all-speed governor to permit operation of the engine at loads requiring a lesser amount of fuel than the permissible fuel limit established by any prevailing position of the stop.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view and hydraulic circuit diagram of a fuel limiter embodying the novel features of the present invention, the parts being disposed in the engine stopped positions.

FIGS. 2 and 3 are similar views with parts positioned after the initial starting of the engine and for full fuel flow.

FIG. 4 is a curve showing how the fuel flow is varied with changes in the engine manifold pressure.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In the form shown in the drawings, the invention is incorporated in a control for positioning the throttle 10 of an internal combustion engine 11 of the turbocharged type and established a permissible fuel supply adequate for starting the engine and then to schedule and limit the flow in accordance with the build-up of pressure in the manifold 12 by the turbocharger as the engine load increases. The limit control operates in conjunction with a selectively adjustable primary controller such as an all-speed governor 13 which regulates the fuel flow at engine speeds and fuel flows below the values established by the limit control after the engine has been started.

The improved limit control involves the provision of a device 14 activated in response to the build-up of pressure in the engine lubricating system and operating to sense and measure the progressive increase in manifold charging pressure as the engine accelerates. The

lubricating system comprises the usual pump 15 driven from the engine crankshaft 16 and drawing oil from the crankcase sump 17 and delivering the oil under pressure through a pipe 18 to the engine bearings. All of the operating parts of the governor 13, the pressure sensor 14 and the limit control are mounted in a multi-part housing shown schematically by the hatching.

Herein, the throttle 10 is moved back and forth in accordance with the energization of a power operator in the form of a cylinder 20 and a piston 21 reciprocable therein, operating through a suitable linkage 19 connecting the throttle with the piston rod 29. A pump 22 driven from the engine crankshaft draws oil from a sump 23 in the governor 13 and delivers oil at constant pressure determined by a regulator 24 to a passage 25 leading to the upper end of the piston and also to the governor. The throttle is thus pressure biased in the fuel-decreasing direction.

The flow of pressure fluid from the supply passage 25 to the lower end of the servo cylinder and against the larger lower end of the piston is controlled by the degree of opening of the valve 26 of the governor 13 which comprises a ball-head 27 on the upper end of a ported sleeve 28 journaled in the casing and continuously rotated by a shaft 30 driven from one of the gears of the governor pump 22. The stem 31 of the valve is slidable up and down in the sleeve with increases and decreases in the engine speed sensed by flyweights 32 fulcrumed at 33 on the ball-head and having toes bearing upwardly against the lower race of a ball bearing 34. The upper race 35 is urged downwardly by the compression type speeder spring 36 bearing at its upper end against an abutment 37 which may be raised and lowered through a manually adjustable lever 38 and a rack and pinion connection 39. A land 40 on the valve stem cooperates with ports 41 in the sleeve to form the valve 26 and admit pressure fluid from the supply line 25 to the servo 20, 21 when the engine speed falls below the speed setting of the governor. This flow is interrupted when the engine is on-speed or the stem and land moved to the centered position shown in FIG. 2. In response to overspeeding of the engine, the land is raised above the ports 41 allowing fluid to flow out of the servo and drain back to the sump through a line 42.

Absolute pressure changes in the manifold 12 of the engine are sensed by a bellows 43 communicating with the manifold through a pipe 44 and opposed by an aneroid or evacuated bellows 45. The joint between the two bellows is fixed intermediate the ends of a lever 46 pivoted on an adjustable fulcrum 47. At its free end, the lever bears against a ball 48 cooperating with a seat 50 to form a bleed valve 51 for allowing pressure fluid from the end of a pipe 52 to escape through a drain passage 53 when the force exerted by the bellows 43 is less than that exerted by the prevailing force of a selectively adjustable contractile type restoring spring 54. Through a suitable restriction such as a needle valve 55, pressure fluid from the line 25 is supplied to the pipe 52 at a desired slow rate.

The end of the spring 54 opposite the lever 46 is secured to a pin 56 upstanding from the outer end of a piston 57 reciprocable in a cylinder 58 in the casing and urged into the cylinder by a compression spring 59. The inner end of the cylinder communicates short of the bleed valve 51 with the pipe 52 through a passage 60 and also through a passage 61 with the inner end 62

of a chamber divided by a flexible diaphragm 64 of oil resistant material such as synthetic rubber. The inner chamber end also communicates with a passage 63 leading to the drain of the system. The outer end 65 of the chamber communicates through a pipe 66 with the lubricating system of the engine so as to be pressurized from the pump 15 when the engine is running, the pressure being sufficient to flex the diaphragm from the engine-stopped position (FIG. 1) to a position (FIGS. 2 and 3) covering and closing ports at the ends of the passages 61 and 63 when the engine is running. When the manifold pressure and lube oil pressures fall as the engine is stopped, fluid will be forced out of the cylinder 58 by the force of the spring 59 acting on the piston 57 and the diaphragm will be flexed away from the ports (FIG. 1). As a result, the piston 57 will be moved to the position in which its end 67 abuts the end of the cylinder as shown in FIG. 1. It will be observed that the diaphragm and passages 61, 63 form a valve which is opened and closed in response to the build-up and later to the decrease in the pressure in the engine lubricating system.

With the pressure sensing arrangement above described, it will be apparent that when the engine is stopped, the lube oil pressure is zero, and the manifold is at atmospheric pressure, the parts will be positioned as shown in FIG. 1, the bleed valve 51 being closed by the resultant of the two bellows forces. The piston 57 is held to the left by the spring 59. The piston is then disposed in what will be later referred to as the starting position. During cranking to start the engine, the pressure in chamber 64 will rise as lube oil pressure is developed. This moves the diaphragm to the right to partially seal port 61 from the drain 63 and thus cause the pressure in port 61 to essentially equal that in chamber 65. This will not, while cranking, be sufficient to overcome the high preload of spring 59. When the engine starts and comes up to idle speed and the lube oil passages throughout the engine fill, the pressure will then rise enough to close the port 61 allowing pressure to build up in the cylinder 58. This pressure build-up forces the piston 57 to the right against the force of the spring 59 thus causing the tension of the spring 54 to be increased in proportion to the piston movement and until the spring force just equals the force of the bellows system. Thus, the leak past the ball 48 is reestablished and the piston stops. Then, as load is imposed on the engine, the turbocharger becomes effective to build up the pressure in the engine manifold thus causing the bellows 43 to force the valve toward closed position. This results in a further build-up of pressure in the cylinder 58 causing further movement of the piston 57 to the right and readjustment of the force of the spring 54. As a result, the movement of the piston from its position in FIG. 2 to its position shown in FIG. 3 follows the increase in manifold pressure so that the location of the piston within this range of positions corresponds at all times to the value of the absolute manifold pressure.

The present invention utilizes the movements of the piston 57 of the manifold pressure sensor 14 above described to position a stop in the form of a cam 67 having a surface of varying contour in the path of fuel-increasing movement of the servo piston 21 and the engine throttle 10 to establish permissible limits of fuel supply to the engine first as needed for starting before building up of the manifold pressure and then at a value related to the prevailing absolute manifold pressure.

Herein, the stop cam is formed on one leg of an L-shaped lever 69 depending from and fulcrumed at 70 on the outer end of the piston 57 with its horizontal leg backed by a roller 71 on the governor housing. Spaced along the lower edge of the cam are a plurality of surfaces *a*, *b* and *c* which are engageable with a follower roller 72 movable with the servo piston 21 and throttle and carried intermediate the ends of a lever 73 fulcrumed at 74. The free end of the lever is connected through a link 75 to the center of a floating lever 76 which is pivoted at one end on the rod 29 of the servo piston and at the other end and through a link 78 to one end of a lever 77 fulcrumed at 79. The other end 81, bears upwardly against a flange 82 on the upper end of the stem 31 of the governor valve 26. Thus, the position of the servo piston coacting with the point on one of the cam surfaces *a*, *b* or *c* engaged by the follower 72 acts through the linkage to locate the valve land 40 in a position for establishing a flow of pressure fluid to the cylinder 20 and a resultant limiting of the upward movement of the piston 21 to a position corresponding to the maximum flow of fuel permissible at the then prevailing manifold pressure.

When the engine is stopped and therefore in the absence of lube oil pressure, the piston 57 and the stop cam will be urged by the spring 59 to the starting position shown in FIG. 1 and the follower 72 will engage the stop surface *a* if the governor 13 is set by the hand lever 38 for a speed and therefore fuel supply greater than that determined by the throttle position when the follower 72 is in engagement with the surface *a*. The fuel supply rate for starting the engine in the absence of built-up manifold pressure may be as high as 70 per cent of the full load rate depending on the characteristics of the engine being controlled. Usually, the starting rate will be somewhat greater than that determined by the point *b* on the stop cam and desirable for operation of the engine under no load. Beyond the no-load limit *b*, the cam surface *c* rises progressively to the full load supply rate at *d* thus establishing permissible fuel flow limits corresponding to the manifold pressure.

As illustrated in FIG. 4, the fuel supply indicated at 90 and limited by the cam surface *a*, even though the governor may be adjusted for a greater flow, is sufficient to insure quick starting of the engine but more than enough to burn without causing smoking of the engine in view of the limited air supply available before the turbocharger becomes effective to increase the manifold pressure above atmospheric pressure. To minimize the length of the interval that is likely to occur after starting of the engine, the fuel supply is limited at low manifold pressures by forming the stop cam with the rise *c* so as to reduce the fuel limit to the valve 91 while the manifold pressure is relatively low. Then, as the manifold pressure increases during loading of the engine, the ensuing increase 92 in fuel flow as limited by the cam *c* may be fully consumed and further smoking of the engine avoided.

Preparatory to starting of an engine equipped with a fuel limiter of the character described, the land 40 is disposed below the port 41 to admit pressure fluid to the servo for raising the piston rod 29 until the follower 72 abuts the surface *a* of the stop cam. Thus, the upward movement of the servo piston is stopped at a fuel flow limit needed to insure starting of the engine before building up of the manifold pressure.

After cranking to start the engine, the lube oil pressure in the line 66 builds up, flexing the diaphragm 64 (FIG. 2) to close the passages 61 and 63, this usually occurring in advance of the build-up of the manifold pressure by the turbocharger. With the lever 51 closed, pressure fluid is admitted to the cylinder 58 thus initiating movement of the piston 57 to the right and the cam along the roller 72. As the cam rise *e* is presented to and moves past the roller, as shown in FIG. 2, the linkage 76 and 77 is actuated to raise the valve stem 31 and its land 40 above the port 41. Fluid is thus allowed to flow out of the servo to the drain until the fuel supply has, by lowering of the piston 21 and movement of the throttle, decreased enough to center the land 40 on the ports 41 as shown in FIG. 2. The fuel supply is thus reduced to about that required for running the engine at idling speed.

As the engine is loaded and the manifold pressure is increased by the turbocharger, the piston 57 and the cam 67 move further and to the right allowing the roller 72 to rise along the upwardly inclined cam surface *c*, the land 40, by virtue of the higher speed setting of the governor, being disposed somewhat below the port 41 to allow the fluid to flow to the cylinder 20 and the piston to hold the follower against the cam incline and thereby always dispose the throttle in a limit position determined by the prevailing manifold pressure.

With the speed setting lever 38 of the governor in the full speed position, the fuel supply may be increased with the manifold pressure to present the free end portion of the cam surface *c* to the roller 72 as shown in FIG. 3, the fuel flow to the engine then being near the maximum with the engine fully loaded. After a high manifold pressure is attained by the rise in fuel flow permitted by the movement of the cam, a reduction in load on the engine will require that the fuel supply be correspondingly reduced. Under these circumstances, the governor valve will release fluid from the servo and the piston will move downwardly to position the throttle for a decrease in the fuel flow and lower the roller 72 away from the cam surface *c*.

To stop the engine, the flow of fuel to the engine may be interrupted in any suitable way. As an incident to such stopping of the engine and its lube oil pump 15 together with the reduction in the manifold pressure as the turbocharger becomes inactive, the bleed valve 51 is closed and the diaphragm 64 is flexed to the position shown in FIG. 1. Under the force of the spring 59, the piston 57 is moved to the left and back to the starting position thus bringing the cam surface *a* back to the roller 72.

It will be apparent from the foregoing that build-up of the lubricating oil pressure after cranking of the engine is utilized to initiate movement of the piston 57 away from the starting position (FIG. 1) establishing fuel flow limits corresponding to the build-up in the manifold pressure as the engine accelerates and is loaded. Also, the invention utilizes the decrease in lube oil pressure incident to stopping the engine to return the stop cam under the action of the spring 59 to the starting position and thus condition the control for restarting of the engine.

It should also be noted that the stop cam 67, acting in conjunction with the fuel control servo and the linkage coupled to the governor valve, operates to override the governor and limit the fuel supply that can be obtained through the medium of the governor. In other

words, the fuel supply to the engine is limited to correspond with the available air supply as determined by building up of the manifold pressure by the turbocharger after the initial starting of the engine. Of course, a fuel supply less than the limit determined by the stop cam may be obtained as needed to carry the load on the engine, through the action of the governor.

I claim:

1. For scheduling and limiting the flow of fuel to an internal combustion engine having a throttle, a manifold and a lubricating system in which air and oil pressures build up on starting of the engine, the combination of a power actuator coupled to said throttle and selectively energizable to move the throttle in opposite directions to increase and decrease the fuel supply to said engine, a stop limiting the fuel-increasing movement of said throttle and movable away from a starting position to change the limit to which said throttle may be moved by said actuator, said stop, when in starting position, establishing a fuel admission rate adequate for starting the engine in the absence of manifold pressure in excess of atmospheric pressure, a power operator activated in response to a combined build-up by the engine after starting of air pressure in said manifold and oil pressure in said system and acting to move said stop away from said starting position, said operator comprising a fluid servo having a piston slidable in a cylinder and moving said stop away from said starting position by pressure fluid admitted to one end of the cylinder by the action of valve means controlled jointly by the build-up of pressures in said lubricating system and said manifold following starting of the engine, means exerting on said piston a force continuously biasing said stop toward said starting position, a controller selectively operable to govern the energization of said actuator, a motion-transmitting connection coupling said throttle to said controller and acting to adjust the fuel supply setting thereof, if above the prevailing limit determined by said stop, for a lesser supply rate, and said valve means being responsive to a decrease in said lubricating oil pressure upon interruption of said fuel supply and stopping of the engine and enabling said biasing means to move said stop back to said starting position.

2. The combination defined in claim 1 in which the fuel limit established by the stop, when in starting position, is somewhat greater than the limit desired for idling of the engine and, in the movement of the stop away from the starting position, is reduced to said idling value and then is increased progressively to correspond with the increase in said manifold pressure.

3. The combination defined in claim 2 in which a follower movable with said throttle is engageable with a cam forming said stop and shaped to provide, when the stop is in said starting position, more fuel than can be consumed efficiently by said engine when running idly, the fuel being reduced in the initial movement of the stop away from said starting position and then increased progressively in the continued movement of the stop.

4. The combination defined in claim 1 in which said actuator is a hydraulic servo to which the flow of pressure fluid from a supply source is governed by a valve independently adjustable by said controller and said connection.

5. The combination defined in claim 4 in which said valve is actuated by a speed sensor driven by said en-

engine and selectively adjustable to positions covering the full operating speed range of the engine.

6. The combination defined in claim 1 in which said controller is an all-speed governor having a selectively adjustable speed setter and operable to regulate the energization of said actuator when set for an engine speed and fuel supply lower than the prevailing fuel limit determined by said stop.

7. The combination defined in claim 1 including a pressure responsive valve which, in the absence of pressure in said lubricating system, connects said cylinder to a drain and in response to the build-up of lube pressure, closes the drain passage so the cylinder may be pressurized by way of a passage leading from a fluid pressure source.

8. The combination as defined in claim 7 in which said pressure responsive valve comprises an axially flexible diaphragm which covers a port leading to a drain and a second port communicating with said cylinder whereby to uncover both of such ports in the absence of lube oil pressure and close such ports in response to the build-up of lube oil pressure on the side of the diaphragm opposite such ports and the consequent flexing of the diaphragm toward said ports.

9. The combination as defined in claim 7 in which the flow of pressure fluid to said cylinder is regulated by a bleed valve located in said last mentioned passage and having a member urged toward open position by the force of a restoring spring and toward said closed position by pressure from said manifold so that the bleed valve is closed when the manifold pressure exceeds a value determined by the prevailing force of said spring.

10. The combination as defined in claim 9 in which the restoring spring force is increased progressively in the movement of said stop away from said starting position.

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