

[54] FUEL CONTROL MEANS FOR AN
INTERNAL COMBUSTION ENGINE
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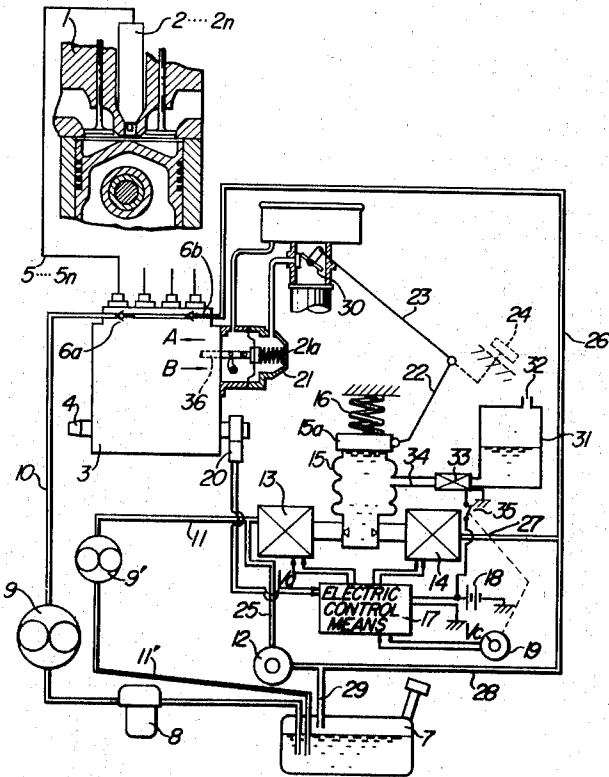
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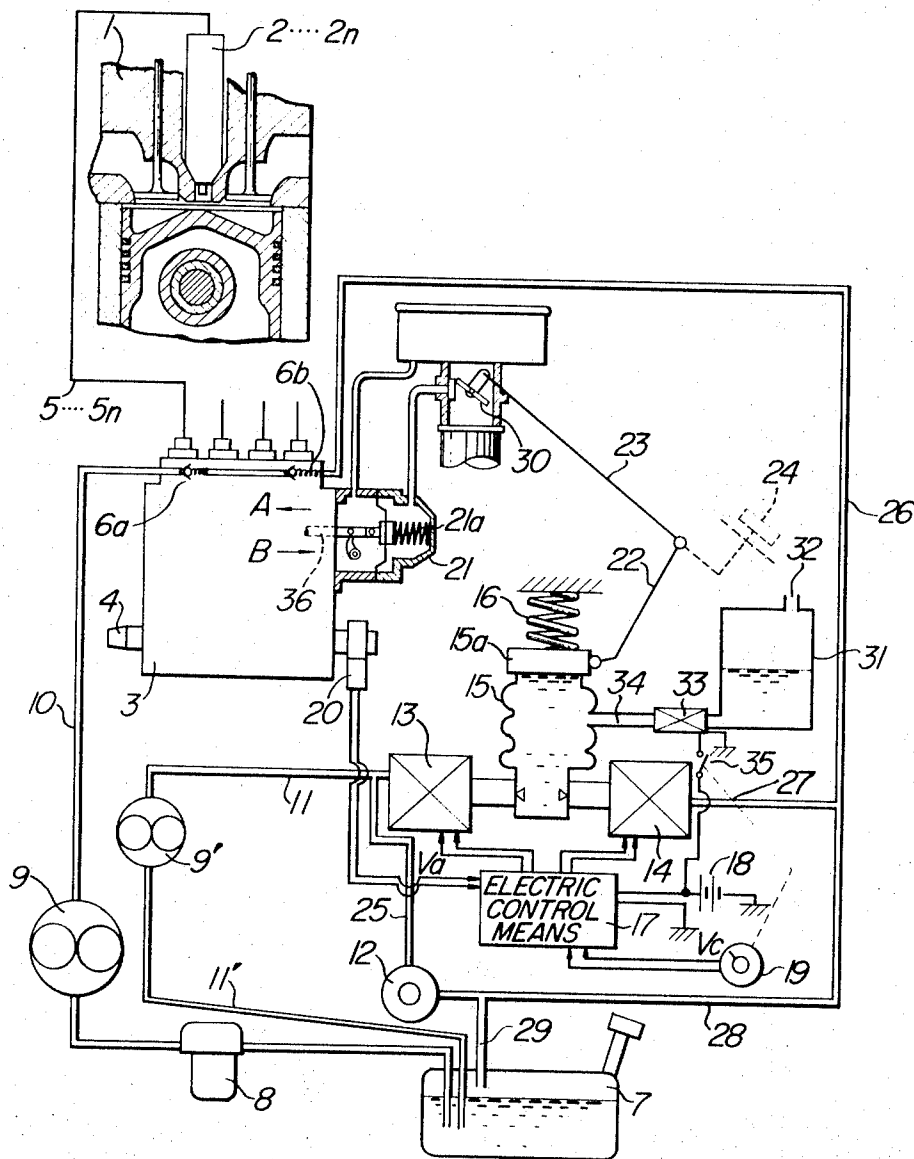
[57] **ABSTRACT**
In an internal combustion engine including a centrifugal or fluid type mechanical governor for normal engine operation, fuel control means additionally comprises, for constant speed operation, electrical control means for comparing the actual and reference engine speeds and producing an output which is used to control an accelerator mechanism of the engine.

1 Claim, 1 Drawing Figure



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FUEL CONTROL MEANS FOR AN INTERNAL COMBUSTION ENGINE

The present invention relates to fuel control means for an internal combustion engine, particularly for a compression ignition type internal combustion engine, which is effective to govern the rotating speed of the engine at a predetermined value irrespective of the variation in load condition.

Conventional speed governor utilized in fuel control means for an internal combustion engine includes a centrifugal type wherein a weight is rotated about an axis to produce a centrifugal force which is utilized as a governing force as well as a fluid type wherein pressure of fluid such as air is used as the governing force in lieu of the centrifugal force. In each of the known types, spring means is utilized so as to counteract to the governing force, whereby the governing pattern such as the rate of change of engine speed can be determined through the adjustment of the spring.

However, in accordance with the prior art, since the governing pattern is determined by means of a pure mechanical control element such as spring means, it is impractical to limit the rate of speed change for the purpose of avoiding hunting due to the mechanical action of the spring. Thus, in the known governor, the ratio of the variation in engine speed to the variation in load becomes relatively large. It should therefore be noted that the known governor mechanism is not suitable in an application where the engine speed must be maintained at a constant value within a relatively narrow range. For example, when an engine is used as a power source for a portable generator, a constant speed governing is desired in conformance with the characteristic of the generator. However, none of the known governor mechanism has been successful to provide a constant speed control with such a small rate of speed change that can eliminate the aforementioned hunting.

The present invention has an object to eliminate the aforementioned disadvantages.

Another object of the present invention is to provide hybrid type fuel control means for an internal combustion engine in which a conventional centrifugal or fluid type mechanism governor is used for normal operation of the internal combustion engine to determine the governing pattern of the engine and, when a constant speed control of engine is required such as in a case in which the engine is used as the power source for a portable generator, an electrically controlled accelerator control means is additionally used for electrically comparing the actual engine speed with a desired engine speed to control the accelerator, so that the engine speed is accurately fed back to the fuel control means to maintain the engine speed at a constant value with a minimum rate of speed variation.

The above and other objects and features of the present invention will now be described taking reference to the accompanying drawing which schematically show a preferred embodiment of the invention.

Referring to the drawing, the reference numeral 1 fragmentarily shows an engine in vertical section. A fuel tank 7 contains fuel which is fed by means of a pump 9 through a filter 8 and a conduit 10 into a fuel injection pump 3 for the operation of the engine 1. The pressure of fuel supplied to the fuel injection pump 3 is maintained at a predetermined value by means of check valves 6a and 6b. The fuel is also fed by the fuel

pump 9' through a conduit 11' into a conduit 11 which has an electric solenoid valve 13. Further, a conduit 25 is branched from the conduit 11 and connected with a pressure regulator 12. The pressure regulator 12 serves to adjust the pressure in the conduit 11 to a value sufficient to overcome the pressure in a diaphragm chamber 15. The diaphragm chamber 15 has a movable wall 15a connected to a second link 22 which is in turn connected to a first link 23 having an accelerator pedal 24 connected at one end thereof. The reference numeral 30 is a throttle valve which is operated by the line 23. Further, the reference numeral 16 shows a spring which is connected at its one end with the movable wall 15a of the diaphragm chamber 15 and at its other end with the fixed part of the engine. The reference numeral 21 diagrammatically shows the major parts of a fluid type governor which may be a known one and responsive to the suction pressure in the engine 1, and 21a shows a governor spring. The reference numeral 20 shows a speed detector which detects the rotating speed of the driving shaft 4 in the injection pump 3 and generates an electric signal corresponding to the speed. The detector may comprise in combination a reed switch and a rotatable permanent magnet for generating a pulse signal representing the rotating speed, which is thereafter converted into an electric voltage. The signal from the detector 20 is then applied to electronic control means 17. The reference numeral 19 shows a knob including a variable resistor for setting the desired rotating speed. Thus, there is produced an electric voltage corresponding to the desired rotating speed determined by the position of the knob 19. The signal from the knob 19 is also applied to the electric control means 17. The reference numeral 18 shows an electric power source. A fuel return circuit includes a conduit 26 for passing a return flow from the fuel injection pump 3 and a conduit 27 for passing a return flow which comes from the diaphragm chamber 15 through an electric solenoid valve 14. The conduits 26 and 27 are combined into a conduit 28 which is in turn connected with a return line from the pressure regulator 12 to form a conduit 29 for connection with the fuel tank 7. The reference numerals 2 - 2n show fuel injection valves, and 5 - 5n fuel injection pipes, the number of these parts being determined in accordance with the number of cylinder of the engine. The reference numeral 31 shows an auxiliary tank having a vent hole 32, and 33 shows an electric solenoid valve provided in conduit 34 for connecting the auxiliary tank 31 and the diaphragm chamber 15. The reference numeral 35 shows a switch for controlling the current to the solenoid valve 33. The switch 35 is interconnected with the knob 19 in such a manner that it is opened when the knob 19 is at the zero-speed position, but closed when the knob 19 is moved to the position corresponding to a desired speed so as to energize the solenoid valve 33. The reference numeral 36 shows a fuel adjusting rod for the fuel injection pump 3.

The operation of the aforementioned arrangement will now be described with reference to an automobile engine. During normal operation of the engine, that is, when the engine is operated for driving the automobile, it would not be necessary to operate the engine at a constant speed. Therefore, in this instance, the knob 19 is adjusted to the zero-speed position. Thus, the switch 35 is opened and the solenoid valve 33 is de-energized to an open position. With this position, the diaphragm

chamber 15 put into communication with the vented auxiliary tank 31 so that the movement of the diaphragm does not produce any variation of the pressure in the diaphragm chamber 15. Therefore, the hydraulic servo mechanism including the diaphragm 15 and the solenoid valves 13 and 14 do not affect on the operation of the throttle valve 30. Accordingly, the speed of the engine can be controlled by adjusting the throttle valve 30 through actuation of the acceleration pedal 24 in accordance with the speed governing pattern of the known fluid type governor 21. Thus, during the normal operation of the engine, the speed governing pattern is determined by the fluid type governor of a known type.

When it is desired to operate the engine at a constant speed, such as when the engine is used as the power source for a portable generator, the knob 19 is adjusted so as to determine the setting of the engine speed. Then, the switch 35 is closed as soon as the knob 19 is actuated, whereby the solenoid valve 33 is energized to close the conduit 34 connecting the diaphragm chamber 15 with the auxiliary tank 31. The electric control means 17 is supplied with a reference speed signal from the knob 19 and the actual speed signal from the detector 20 which are compared in the control means 17 to control the operation of the solenoid valves 13 and 14 in the hydraulic servo mechanism in accordance with the differences between the signals. For example, when the actual engine speed is lower than the reference speed, the signal voltage (V_a) from the detector 20 is lower than the signal voltage V_c from the knob 19. This difference is detected by the control means 17 so that the solenoid valve 13 is opened but the solenoid valve 14 is closed. Thus, the fuel is continuously fed from the conduit 11 through the solenoid valve 13 into the diaphragm chamber 15. Since the solenoid valve 33 is closed at this time, the pressure in the diaphragm chamber 15 is increased to move the wall 15a against the influence of the spring 16. Therefore, the links 22 and 23 connected with the movable wall 15a are actuated to open the throttle valve 30. With this movement, the suction pressure in the engine is decreased, so that the fluid type speed governor 21 serves to displace the fuel adjusting rod 36 toward the direction shown by the arrow A to increase the fuel supply. When the engine speed is recovered until the signal voltage V_a from the detector 20 becomes equal to the signal voltage V_c from the knob 19, the control means 17 serves to close the solenoid valve 13 and 14. Thus, the pressure in the diaphragm chamber 15 is maintained at a constant value, and the positions of the links 22 and 23 and thus the position of the throttle valve 30 are also maintained to operate the engine at a constant speed.

When the load on engine is suddenly decreased, the engine speed becomes higher than the reference speed. Thus, the signal voltage V_a from the detector 20 becomes higher than the voltage signal V_c from the knob 19, and the control means 17 closes the solenoid valve 13 and opens the solenoid valve 14. Thus, the fuel in the diaphragm chamber 15 is allowed to flow out through the solenoid valve 14 when the result that the pressure in the diaphragm chamber 15 is decreased. The pressure in the diaphragm chamber 15 is thus decreased and the movable wall 15a is moved under the influence of the spring 16. This movement of the wall 15a causes the movement of the links 22 and 23 and decreases the opening of the throttle valve 30. As the result, the engine suction pressure is decreased and the

fluid type governor 21 serves to move the fuel adjusting rod 36 toward the direction shown by the arrow B to decrease the fuel supply. Thus, the engine speed is decreased until the signal voltage V_a from the detector 20 becomes equal to the signal voltage V_c from the knob 19. With this position, the electric solenoid valves 13 and 14 are closed. By repeating the cycles of the aforementioned operation, the control means 17 serves to control the throttle opening through the hydraulic servo mechanism so as to maintain the constant engine speed. Thus, the engine can be operated at the constant speed.

By comparing the electric signals representing the actual and reference engine speeds at the electric control means 17 and controlling the throttle valve opening, it becomes possible to operate the engine at a constant speed with minimum speed variation without changing mechanical factors, such as the spring co-efficient of the fluid type governor 21 which may have an influence on the hunting characteristics of the governor.

In the embodiment described above, the speed governing pattern of engine is determined by the fluid type governor 21 during the normal operation, however, it is of course possible to use a centrifugal governor in lieu of the fluid type governor 21. It should be noted that, according to the present invention, the normal governing pattern is determined by a conventional fluid type or centrifugal type mechanical governor and, when it is required to operate the engine at a constant speed, an accelerator control means controlled by the electric control means 17 is used in addition to the mechanical governor.

When a fluid type governor is used, the accelerator may comprise a throttle valve 30, however, when a centrifugal governor is used, it may comprise an adjusting lever for actuating a fuel adjusting rod 36. It would not be necessary to say that the adjusting lever is actuated by an accelerator pedal as in the case of the throttle valve 30.

Further, in the above embodiment, a hydraulic servo mechanism including solenoid valves 13 and 14 and, a diaphragm chamber 15 is used in order to control the accelerator mechanism, however, it is possible to use a reversible electric motor in place of the hydraulic servo mechanism. In such an instance, the electric motor is operated in either direction or stopped to control the accelerator mechanism.

In the previous embodiment, the operation of the hydraulic servo mechanism is controlled through an auxiliary tank 31 and electric solenoid valve 33, etc., however, a clutch mechanism may be provided in the link 22 and the auxiliary tank 31 and the solenoid valve 33 may be omitted. In this instance, the clutch mechanism is released during normal operation of engine so that the hydraulic servo mechanism does not have any influence on the accelerator mechanism but, when it is required to operate the engine at a constant speed, the clutch is engaged so that the accelerator mechanism is controlled by the hydraulic servo mechanism.

Further, when a pressure regulator 12 is used to control the fuel pressure delivered to the fuel injection pump 3, only one fuel pump 9 or 9' may satisfactorily used.

From the above description, it would be clear that, according to the present invention, a conventional centrifugal or fluid type mechanism governor is used during normal operation of engine to determine the gov-

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erning pattern and, when it is required to operate the engine at a constant speed, an electric control means is used in addition to the mechanical governor for comparing the actual and the reference engine speeds and producing an output for controlling the accelerator mechanism. Therefore, according to the present invention, the engine can be operated at a constant speed with minimum speed variation through the action of the accelerator mechanism without producing any hunting. Further, the present invention can readily be incorporated into a conventional engine without requiring any modification of a known type governor.

I claim:

1. A fuel control for an internal combustion engine having a throttle valve for use with a fuel tank comprising:

a fluid tank,
 detector means for generating a signal which varies as a function of engine speed,
 electrical knob means for setting a desired speed and having a position for manually controlling fuel,
 electric control means connected to said detector means and knob means and having a pair of output terminals, said control means comparing the actual engine speed as indicated by said engine speed signal and the desired engine speed as indicated by the setting of said electrical knob means and generating an output signal on one of said output terminals when the desired engine speed exceeds the actual engine speed and on the other output terminal when the actual engine speed exceeds the desired engine speed,

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a diaphragm chamber having a member movable as a function of the fluid pressure therein,

first conduit means including pump means and a first electric valve means and connected between said fluid tank and said diaphragm chamber for supplying fluid from said fluid tank to said diaphragm chamber, said first electric valve means connected to a terminal of said electric control means and opening said conduit when an output signal is on that terminal,

second conduit means including second electric valve means and connected between said fluid tank and said diaphragm chamber, said second conduit means venting the fluid from said diaphragm chamber to said tank, said second electric valve means being connected to the terminal of said electric control means other than the terminal connected to said first valve means and opening said second conduit when an output signal is on that terminal,

an auxiliary tank having a vent hole, a conduit connected to said diaphragm chamber, and third electric solenoid valve means, said auxiliary tank introducing the fluid from said diaphragm chamber thereto, said third electric solenoid valve opening its conduit when said knob means is in said manually controlling means, and

a link member connected between said throttle valve and said movable member of said diaphragm to control said throttle valve of the engine in response to the movement of said movable member.

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