United States Patent

Ohtani

[15] **3,682,145**

[45] **Aug. 8, 1972**

[54] **FUEL CONTROLLING DEVICE FOR INJECTION TYPE INTERNAL COMBUSTION ENGINES**

[72] Inventor: **Yoshio Ohtani,** Matsuyama, Japan

[73] Assignee: **Diesel Kiki Kabushiki Kaisha,** Tokyo, Japan

[22] Filed: **May 27, 1970**

[21] Appl. No.: **40,884**

[52] **U.S. Cl.**.....**123/32 EA,** 123/102, 123/139 E

[51] **Int. Cl.**.....**F02b 3/00,** F02d 11/10

[58] **Field of Search**.....123/32 EL, 102

[56] **References Cited**

UNITED STATES PATENTS

2,995,898	8/1961	Thorner	123/140 FG
3,407,793	10/1968	Lang	123/32
3,425,401	2/1969	Lang	123/32
3,543,734	12/1970	Mair	123/32
3,548,792	12/1970	Palmer	123/32

Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Ronald B. Cox
Attorney—Larson, Taylor & Hinds

[57] **ABSTRACT**

A fuel controlling device for injection type internal combustion engines which is simple in construction, small in size, and accordingly adapted for use in vehicles, being capable of detecting the variation of rotational speed of the engines electrically and converting such variation into mechanical displacement thereby operating a fuel regulating part by means of a hydraulic pressure servo-motor.

1 Claim, 4 Drawing Figures

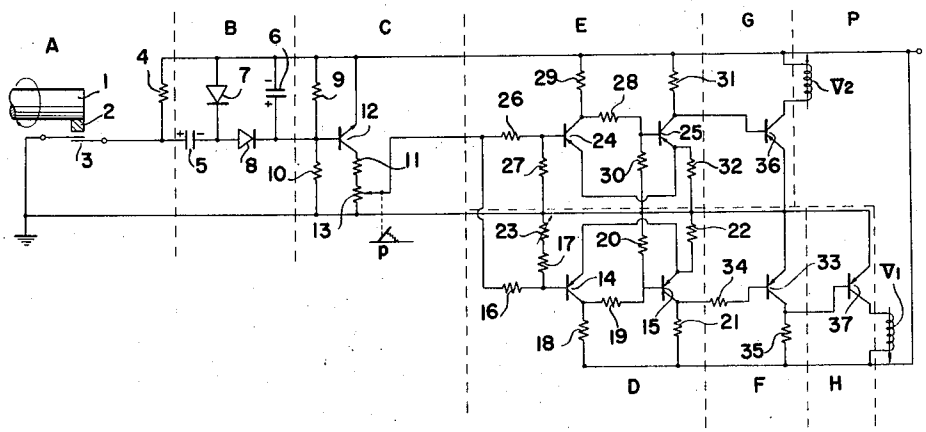


FIG. 4

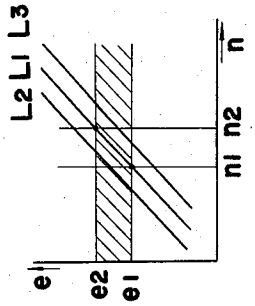


FIG. 3

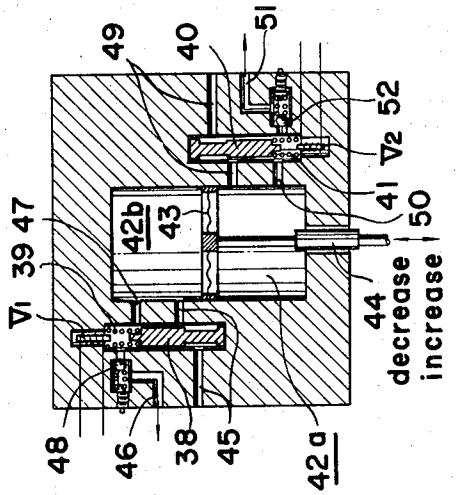


FIG. 1

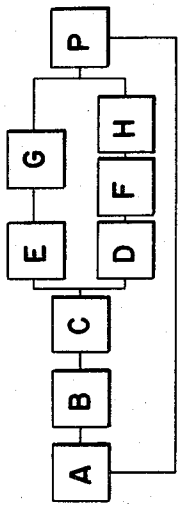
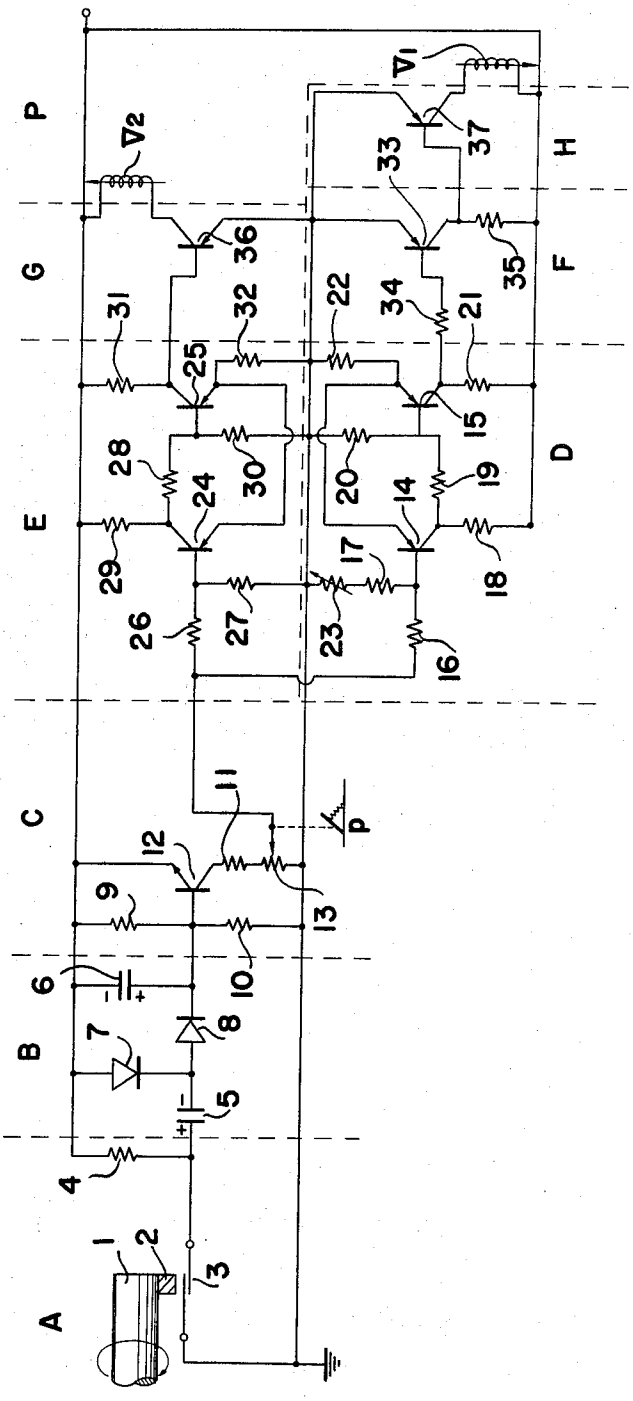


FIG. 2


P
G
E
C
B
A
H
F
D
V1
V2
37
33
36
35
31
32
22
34
21
25
15
28
30
20
14
19
24
29
17
18
26
27
23
16
11
12
9
13
10
6
8
7
5
4
1
2
3
p

FUEL CONTROLLING DEVICE FOR INJECTION TYPE INTERNAL COMBUSTION ENGINES

This invention relates to a fuel controlling device for injection type internal combustion engines employing electrical and mechanical systems of controlling in combination for injecting a supply fuel to the engines.

In known injection type internal combustion engines, particularly in small and high speed engines for vehicles, generally the fuel controlling device has been of a centrifugal or pneumatic or hydraulic governor type. All these however have adopted the direct system for operating a fuel supply regulating or controlling part through a detection part to detect the variation of engine velocity and have therefore had a deficiency in control of a fuel during rotation of engine at a low speed as well as a difficulty reducing the deviation of rotational speed when load is varied or the ratio of speed variation although such devices are simple in construction and small in size. On the other hand, in the indirect system for operating the regulating part by use of auxiliary force providing the speed detecting part and the operating part separate as in governors of the larger type, it is possible to make the performance of speed regulation satisfactory but the construction complicated and large in size so much as not adequate for vehicle engines.

This invention has for its object to provide an electrical speed governor which is simple in construction, small in size, and accordingly adapted for use in vehicles, being capable of detecting variation of rotational speed of engine electrically and converting such variation into mechanical displacement thereby operating the fuel regulating part by means of a hydraulic pressure servo-motor.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings in which:

FIG. 1 is a schematic block diagram showing a fuel controlling device for injection type internal combustion engines according to this invention,

FIG. 2 is a circuit diagram showing an embodiment of the fuel controlling device of this invention,

FIG. 3 is a sectional view showing an embodiment of a controlling mechanism for a fuel regulating rod of engine connected to the circuit shown in FIG. 2, and

FIG. 4 is a diagram for illustrating the operation of the fuel controlling device of this invention.

As shown in FIG. 1, voltage pulses generated in the converter circuit A in response to the rotational speed of engine are detected and varied into a d.c. voltage through a charge-and discharge circuit B. The d.c. voltage from the circuit B is amplified by an amplifier circuit C and applied to two Schmitt circuits D and E through a variable resistor for setting the rotational speed which is adjusted relative to the position of an accelerator lever or accelerator pedal of engine provided on the output side of the amplifier circuit C. The Schmitt circuits E and D are provided with base resistances so as to operate individually with respect to the same input. The output of the Schmitt circuit D is introduced through a phase inverter circuit F and an amplifier circuit H to a hydraulic pressure servo-motor, and the output of the Schmitt circuit E to the hydraulic pressure servo-motor P through an amplifier circuit G for regulating the fuel regulating rod of engine by the hydraulic pressure servo-motor P.

FIG. 2 shows an embodiment of the electrical circuit for the fuel controlling device, in which the converter circuit A is a circuit for obtaining voltage pulses in response to the rotational speed of engine and comprises a permanent magnet 2 connected to a cam shaft 1 of fuel injection pump, a known lead relay 3, and a load resistance 4. The charge-and-discharge circuit B having capacitors 5, 6 and diodes 7, 8 is connected to the output side of the converter circuit A for smoothing and varying intermittent pulses to a d.c. voltage. The amplifier circuit C comprises resistances 9, 10, and 11 a transistor 12, and a variable resistance 13 for setting the revolving speed of engine regulated by an accelerator lever or accelerator pedal *p* of engine and is connected to output side of the charge-and-discharge circuit B. The Schmitt circuits D and E are of known type, both of which are provided for stabilizing the operation of electromagnetic valves V_1 and V_2 of the hydraulic pressure servo-motor P. The Schmitt circuit D comprises transistors 14, 15, resistances 16, 17, 18, 19, 20, 21 and 22, and a variable resistance 23, and the Schmitt circuit E comprises transistors 24, 25 and resistances 26, 27, 28, 29, 30, 31 and 32, each of which circuit is applied output voltage of the d.c. amplifier circuit C previously set by the variable resistor 13 respectively through the resistance 16 and the resistance 26. The Schmitt circuits D and E are almost same in construction with each other but the resistance 27 of a circuit to shunt the base current of the transistor 24 connected to the resistance 26 for varying the operating voltage of the Schmitt circuits D, E is made smaller in value than the resistances 17 and 23 of the transistor 14 connected to the resistance 16 of the Schmitt circuit D. Also by providing the resistor 23 as a variable resistance, it is possible to adjust shunting of the base current of the transistor 14 and make the operating voltage of the Schmitt circuit D adjusted in a limit lower than that of the Schmitt circuit E thereby controlling the difference of the two operating voltages. The phase inverter circuit F comprises a transistor 33 and resistances 34, 35 and is connected to the Schmitt circuit D. The amplifier circuits G, H are formed in the manner that a transistor 36 or 37 is connected to the output side of the Schmidt circuit E or the phase inverter circuit F for amplifying its output, the fuel supply decreasing electromagnetic valve V_2 or the fuel supply increasing electromagnetic valve V_1 of the hydraulic pressure servo-motor P being connected to the output side.

The hydraulic pressure servo-motor P will now be illustrated with reference to FIG. 3. The servo-motor body contains a fuel supply increasing electromagnetic valve consisting of an electromagnetic valve V_1, a sleeve valve 38 corresponding to said electromagnetic valve V_1 and a return spring 34 of the sleeve valve 38, a fuel supply decreasing electromagnetic valve having a same construction as the fuel supply increasing electromagnetic valve and consisting of an electromagnetic valve V_2, a sleeve valve 40 and a return spring 41, and a differential pressure operating servo-motor having pressure chambers 42*a* and 42*b* spaced apart by a flexible diaphragm 43 (or piston) connected to a fuel regulating rod 44. When the electromagnetic valve V_1 is energized, the sleeve valve 38 is operated against the spring 39 and a fluid inlet port 45 passing to the pres-

sure chamber 42*b* is opened, simultaneously a passage 46 from an outlet port 47 of the pressure chamber 42*b* through a pressure regulating valve 48 is closed. Upon the output of the amplifier circuit H being lost and the electromagnetic valve p_1 disconnected, the sleeve valve 38 returns to its original position by means of the spring 39 respectively closing or opening each of said passages. In order to control flow of the fluid in and out of the pressure chamber 42*a* through the sleeve valve 40 by interruption of a feeding to the fuel decreasing electromagnetic valve V_2 effected by the output of the circuit G, there are provided a fluid inlet port 49, an outlet port 50, a flow-out passage 51, and a pressure regulating valve 52. The inlet ports 45, 49 are connected to a fluid pressure generating source, for example, a hydraulic pressure pump to which oil is supplied in constant pressure.

Further, operation of the illustrated embodiment of this invention will be described. When, in the electric converter circuit A, the permanent magnet 2 closes to or recedes from the lead relay 3 by rotation of the cam shaft 1 of the fuel injection pump driven in association with the rotation speed of engine, then the lead relay 3 opens or closes and generates intermittent pulses with a potential difference of power source voltage across the load resistance 4. Therefore, the pulse density per unit hour is proportioned to the rotational speed of engine. A current which is generated while the lead relay 3 is closed passes from the capacitor 5 of the charge-and-discharge circuit B through the diode 8 to the capacitor 6 and the d.c. amplifier circuit C. During this period of time, the capacitors 5, 6 are charged. If the lead relay 3 opens no current flows into the charge-and-discharge circuit B so that the capacitors 5, 6 start to discharge and the discharge current of the capacitor 5 reversely flows from the load resistance 4 to the diodes 7, 8 and simultaneously the discharge current of the capacitor 6 as an output of the charge-and-discharge circuit B flows to the d.c. amplifier circuit C in the same direction as when the lead relay 3 is closed, whereby there will be obtained at the output of the circuit B a d.c. voltage proportioned to the pulse density per unit hour or the rotational speed of engine. The obtained d.c. voltage is amplified by the transistor 12 of the amplifier circuit C and applied to the Schmitt circuits D, E through the variable resistor 13 the setting of which is adjusted in response to the position of the accelerator lever or the accelerator pedal. As the skip voltages of the Schmidt circuits D, E are same and the operating voltage of the Schmitt circuit D is adjusted slightly lower than that of the Schmitt circuit E, neither of the Schmitt circuits D, E actuates until the operating voltage from the amplifier circuit C reaches the set value although the engine is started, whereupon the coils of the electromagnetic valve operates the fuel regulating rod in the direction of fuel supply increase since the fuel increasing electromagnetic valve connected to the phase inverter circuit F is only energized.

FIG. 4 shows characteristic curves of *n–e* taking the input voltage *e* of the Schmitt circuits D, E on the ordinates, the rotational speed of engine as n on the abscissa, and the position L of the accelerator pedal or accelerator lever as a parameter. When the input voltage of the Schmitt circuits rises with the rise of the rotational speed of engine after started and reaches a fixed voltage e_1 at point n_1 on the abscissa, the transistor 14 of the Schmitt circuit D which is received the shunted base current smaller than that of the transistor 24 of the Schmitt circuit E first becomes conductive, the transistor 15 is turned off and the transistor 33 of the phase reversing circuit F is turned on, and the transistor 37 of the power amplifier circuit H is turned off so that the electromagnetic coil of the fuel increasing electromagnetic valve V_1 is unenergized. Accordingly, the sleeve valve 38 of the electromagnetic valve V_1 returns to the original position by the spring 39 and closes the fluid inlet port 45. Since the value of the operating voltage of the Schmitt circuit E has been set at e_2 higher than e_1 and further the fuel decreasing electromagnetic valve V_2 does not operate unless the rotational speed of engine rises up to n_2, the interval between e_1 and e_2 is in a governor-free condition in which speed regulation is not effected. The part of oblique lines in FIG. 4 shows the range of such governor-free condition. As the sleeve valve 40 of said fuel supply decreasing valve is closed of its fluid inlet port 49, the pressure chambers 42*a*, 42*b* are stabilized by pressure of the pressure regulating valves 52, 48. If the rotational speed of engine is not proportionate to the load and rises further up to n_2, then the Schmitt circuit E operates and the transistor 24 of the circuit E turns conductive and the transistor 25 non-conductive and the transistor 36 of the circuit G becomes conductive so that the fuel supply decreasing electromagnetic valve V_2 is energized. Therefore, the sleeve valve 40 opens the fluid inlet port 49 and a pressure fluid is introduced into the pressure chamber 42*a*, while the regulating rod is displaced in the direction of decrease. The width of the oblique line areas between e_1 and e_2 of the governor-free condition in FIG. 4 can be adjusted by the variable resistance 23. By reducing said governor-free areas, it is possible to limit the variation of the rotational speed of engine within range of rotational speed n_1, n_2. Further, the adjustment of the rotational speed of engine is made possible by adjusting the output voltage of the d.c. amplifier circuit C through the variable resistance 13 by the accelerator lever or the accelerator pedal *p*. For example, the position of the accelerator lever p may be displaced from L_1 to L_2 thus enlarging the potential difference through the variable resistance 13, whereby it is possible to obtain output voltage e_1–e_2 to actuate the Schmitt circuits D, E at a low rotational speed of engine, and if the position is shifted to L_3 and the potential difference is adjusted to small, it is not possible to obtain the output voltage e_1–e_2 to actuate the Schmitt circuits D, E unless the engine runs at a high rotational speed. This relationship is apparent from FIG. 4. Therefore, the driver of a vehicle can obtain the desired rotational speed of engine by operating the accelerator lever or accelerator pedal of engine. Further, when the present device is connected to a power source and switched on while the engine is stopped, the fuel supply increasing electromagnetic valve operates the fluid pressure servo-motor in the direction of supply increase and moves the fuel regulating rod to a predetermined increase position thereby permitting the engine to start more advantageously.

As hereinbefore described, this invention proposes an indirect system governor light in weight and small in size and having an operating part consisting of an elec-

trical detection part and a hydraulic pressure mechanism and which is never affected by variation of components of control system such as a spring force before and after control as in conventional eccentric or hydraulic speed regulators of the direct system so that it can put the ratio of variation of the set speed at zero and also prevent the vibration of the pressure receiving member **43** by desirably adjusting the set pressure of the pressure adjusting valves **48**, **52** from outside even though said pressure receiving member **43** is affected by vibration from outer disturbances and engine hunting is produced. The invention further serves to operate the fuel regulating rod **44** by means of a fluid pressure servo-motor and thereby enables a larger controlling force and solves the problem of controlling force usually deficient in conventional speed regulators for vehicles running at low speeds.

While the invention has been described above in connection with specific embodiment thereof, it is to be clearly understood that various changes and modifications may be made without departing from the spirit and scope of the invention, and it is intended, therefore, to cover all such changes and modifications in the appended claim.

What is claimed is:

1. A fuel control device for a fuel injection type internal combustion engine comprising electrical control means comprising means for producing a d.c. voltage proportional to the rotational speed of the engine, said means comprising means for producing electrical pulses in accordance with the rotational speed of the engine, means comprising a capacitor charging circuit for converting said pulses into a d.c. voltage and a simple transistor amplifier for amplifying said d.c. voltage, the output of said charging circuit constituting the sole input to said transistor amplifier; potentiometer means connected in series with the collector of said transistor amplifier, for varying the position of the tap of said potentiometer in accordance with the position of an accelerator operator to produce a corresponding output voltage at said tap, a first Schmitt trigger circuit having a first operating voltage, a second Schmitt trigger circuit having a second, different operating voltage, means for connecting said potentiometer tap to the inputs of said first and second Schmitt trigger circuits, a first, fuel supply-increasing electromagnetic relay responsive to said first Schmitt trigger circuit, and a second, fuel supply-decreasing electromagnetic relay responsive to said second Schmitt trigger circuit, phase inverter means connected between one of said Schmitt trigger circuits and the corresponding electromagnetic relay, and hydraulic servo-motor means comprising a differential pressure chamber including first and second subchambers, a first, fuel supply-increasing electromagnetic valve responsive to said first relay for controlling the inflow and outflow of a pressure fluid to said first sub-chamber and actuated when said output voltage is below the lower of the operating voltages of said Schmitt trigger circuits, a second, fuel supply-decreasing electromagnetic valve responsive to said second relay for controlling the inflow and outflow of a pressure fluid to said second sub-chamber and actuated when said output voltage exceeds the higher of the operating voltages of said Schmitt trigger circuits, pressure regulating valve means for regulating the pressure within said sub-chambers,, and means responsive to the pressure differential chamber for controlling movement of a fuel regulating rod, the last named means causing displacement of said fuel regulating rod in a direction to increase the fuel supply when said fuel supply-increasing valve is actuated, causing displacement of said fuel regulating rod in a direction to decrease the fuel supply when said fuel supply-decreasing valve is actuated, and not causing displacement of said fuel regulating rod when said output voltage is between said lower and higher voltages.

* * * * *