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Ohtani

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[54] ELECTRONIC GOVERNOR FOR FUEL-INJECTION TYPE INTERNAL COMBUSTION ENGINES

[75] Inventor: **Yoshio Ohtani,** Higashi-Matsuyama, Japan

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

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[51] **Int. Cl.**.....**F02d 5/02**

[58] **Field of Search** .....123/102, 140, 139 E

[56] **References Cited**

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Primary Examiner—Laurence M. Goodridge

Attorney—Larson, Taylor & Hinds

[57] **ABSTRACT**

An electronic governor for fuel-injection type internal combustion engines, in which the number of component parts is minimized, the time constant is enlarged in the output voltage integrating circuit in order to eliminate the possibility of "hunting" phenomenon and thus to secure a stable state under the low-speed running condition of the engine, the speed regulation, that is, the rate of change in fuel regulating rod position for changes in the rotational speed of the engine is therefore expanded for the low-speed range, and a signal arising from the displacement of the fuel regulating rod is applied, as in positive feedback, to the rotational speed setting circuit in order to narrow the expanded speed regulation, so that a small speed regulation comes into play, under the high-speed running condition of the engine.

2 Claims, 5 Drawing Figures

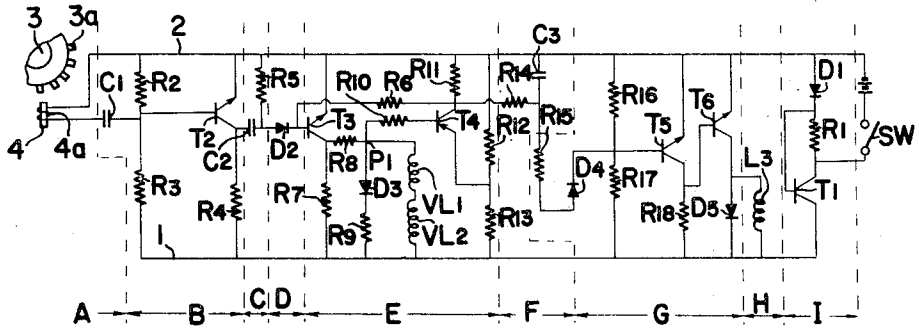


FIG. 1

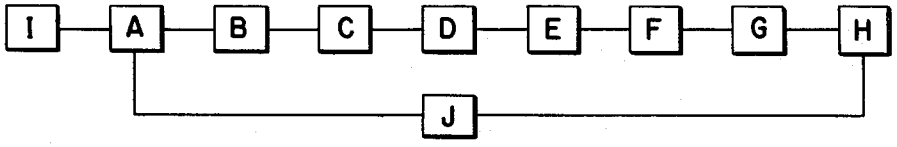


FIG. 2

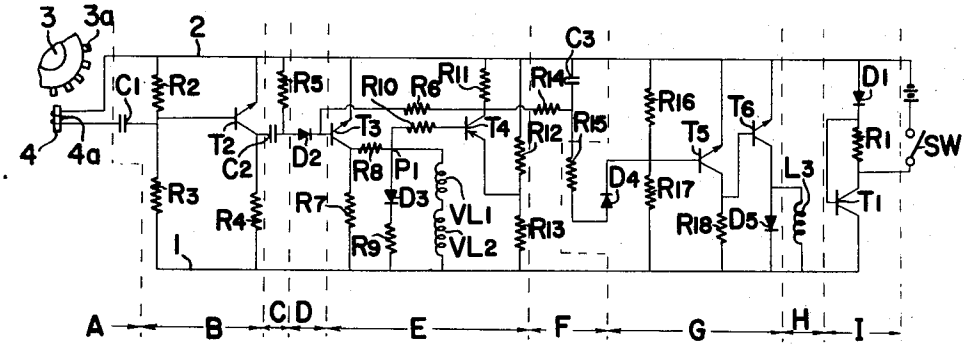
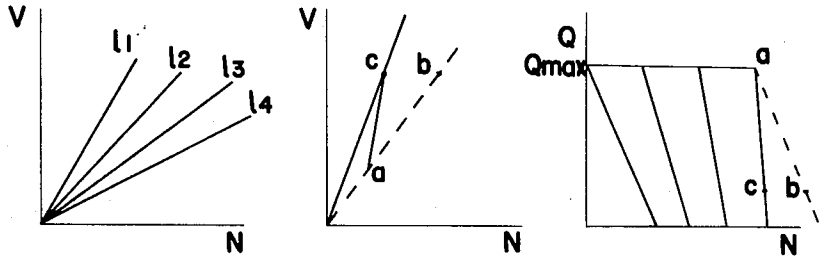


FIG. 3 FIG. 4 FIG. 5



ELECTRONIC GOVERNOR FOR FUEL-INJECTION TYPE INTERNAL COMBUSTION ENGINES

This invention relates to an electronic governor for fuel-injection type internal combustion engines.

Electronic governors of this kind have heretofore been based on a method of control typified by, for example, that disclosed in U.S. application Ser. No. 40,793 which was filed on May 27, 1970, in which the output voltage of an oscillator circuit, operating with an inductance corresponding to the position of an accelerator lever, is applied to a monostable multivibrator, whose output voltage is then integrated and converted into a DC voltage; on the other hand, an electrical signal corresponding to the rotational speed of the engine, generated by an electromagnetic mechanism coupled to the rotating shaft of a fuel injection pump, is applied to another monostable multivibrator, whose output voltage is then integrated and converted into a DC voltage; these two DC voltages are compared with each other to produce an output current proportional to the difference between said two DC voltages; and the resultant output current is used to control a fuel regulating rod in the fuel injection pump. This method is recognized to be satisfactory as far as governor performance is concerned, but is known to have a drawback in that it involves far more component parts and hence costs more than in the case of a comparable mechanical or pneumatic governor.

An object of this invention is to provide an improved electronic governor for fuel-injection type internal combustion engines intended to minimize the number of component parts in the electronic governor and ensure the stability of engine speed under low-speed running condition by providing a wide speed regulation and using a large time constant in the output voltage integrating circuit, thereby fully meeting the stated governor performance requirements.

In an electronic governor according to this invention, therefore, the number of component parts is minimized, the time constant is enlarged in the output voltage integrating circuit in order to eliminate the possibility of "hunting" phenomenon and thus to secure a stable state under the low-speed running condition of the engine, the speed regulation, that is, the rate of change in fuel lever position for changes in the rotational speed of the engine is therefore expanded for the low-speed range, and a signal arising from the displacement of a fuel regulating rod is applied, as in positive feedback, to the rotational speed setting circuit in order to narrow the expanded speed regulation, so that a small speed regulation comes into play, under the high-speed running condition of the engine.

In order that this invention may be more readily understood, a preferred embodiment of this invention will now be described, by way of example only, with reference to the accompanying drawing in which:

FIG. 1 is a block diagram for an electronic governor for fuel-injection type internal combustion engines according to this invention;

FIG. 2 is a circuit diagram representing a preferred embodiment of this invention;

FIGS. 3, 4 and 5 are graphs showing characteristic output curves for the circuit of FIG. 2.

Referring to FIG. 2, T1 through T6 are transistors; D1 through D5, diodes; C1 through C3, capacitors; R1 through R18, resistors; VL1, a variable inductance associated with the position of the accelerator lever of the engine; VL2, another variable inductance associated with fuel regulating rod displacement in the fuel injection pump; L3, a movable coil in the fuel regulating rod control mechanism; 1, a positive conductor; and 2, a negative conductor.

The circuit network composed mainly of the foregoing elements operates as follows:

Section I is a known constant-voltage circuit utilizing the Zener characteristic of a Zener diode, which includes transistor T1, resistor R1 and diode D1. Section A, FIG. 2, is a speed detector circuit comprising a toothed magnetic wheel 3*a* coupled to cam-shaft 3 of the fuel injection pump, and an electro-magnetic transducer assembly having a permanent magnet 4, which is located adjacent to said wheel 3*a*, and detector coil 4*a*. The teeth or peripheral protrusions of said wheel 3*a* revolve past said permanent magnet 4 to induce voltage in detector coil 4*a*. This voltage is converted into a square-wave pulse voltage by saturable amplification in amplifier circuit B comprising transistor T2, capacitor C1 and resistors R2, R3 and R4. Next, said square-wave pulse voltage is differentiated and changed to a trigger pulse in differential circuit C comprising capacitor C2 and resistor R5. Said trigger pulse voltage is detected by detector circuit D consisting of diode D2. In this detecting action, the negative pulses are removed from the voltage to result in a positive trigger pulse voltage, which is fed into rotational speed setting circuit E comprising transistor T3, T4, resistors R6, R7, R8, R9, R10, R11, R12 and R13, diode D3, variable inductance VL1 associated with accelerator lever, and another variable inductance VL2 for signal feedback. In circuit E, arrival of a signal pulse from said circuit D at the base of transistor T3 switches on this transistor to lower its collector voltage, so that, by a voltage determined by dividers R12 and R13 and by base resistors R10 and R8, transistor T4 switches on to change the potential of its collector because of load resistor R11. This changed collector voltage of T4 is fed back to the base of transistor T3 through resistor R6. Thus, once a trigger pulse switches on transistor T3, both T3 and T4 keep on conducting. Under this condition, the potential of point P1, which has dropped, on the collector side of transistor T3 rises at an exponentially increasing rate on account of the current flowing from positive conductor 1 through variable inductances VL1 and VL2, to raise the base potential of T4 toward the potential level of its emitter. When this base potential has risen to equal to that of said emitter, transistor T4 switches off and, consequently, transistor T3 too becomes non-conductive. Thus, with the emitter potential of T4 held at a constant level, the output voltage available from circuit E is a pulse signal, whose pulse width is determined by the concurrent values of two variable inductances, namely, VL1 associated with accelerator lever and VL2 associated with fuel regulating rod displacement. Stated differently, variable inductances VL1 and VL2 are the timing element for determining said pulse width. The output voltage of circuit E so formed is now applied to integrating circuit F comprising resistors R14 and capacitor C3, wherein it is converted into a DC voltage designated as V and plotted on the vertical axis in the graphs of FIGS. 3 and 4. Said resistor R14 and capacitor C3 are sized to present a

large time constant. The horizontal axis in these graphs represents rotational speed of engine N. With accelerator lever position taken as parameter 1, it will be seen in FIG. 3 that the value of inductance VL1 decreases proportionately as the value of accelerator lever position $l_1, l_2, \ldots$ (where $l_1 < l_2 \ldots$) increases, so that the rate of change in output voltage V diminishes proportionately. In other words, the rate of change in engine speed, or speed regulation, increases, For the high-speed range, however, an increased or large speed regulation is not desirable and need to be curbed down. This requirement is met in this invention by feeding back to said circuit E the signal representing the fuel regulating rod displacement. This feedback is accomplished by associating the core of coil VL1 with accelerator lever to displace the core and by connecting coil VL2 in series to said coil VL1 and mechanically linking its core with fuel regulating rod. Under this arrangement, suppose the engine load decreases to cause a rise in rotational speed of engine during operation: this will move the fuel lever in the direction for decreasing fuel supply, thereby increasing the value of inductance VL2. The increase in the value of VL2 has the same effect as an increase, due to accelerator lever movement, in the value of variable inductance VL1. On the other hand, the inductive reactance due to VL1 and VL2 is $2 \pi fL$ (where f is frequency and L is inductance) and varies with frequency, so that, for a given change in inductance, a rise in frequency results in a larger change in the output voltage. Thus, the inductive reactance is relatively ineffective under low-speed conditions but becomes increasingly effective as the engine speed rises or engine load decreases so that the speed regulation becomes small in the high-speed range. This connection is shown in FIG. 4, wherein it will be noted that, for a given position of accelerator lever and hence with a given value of VL1 inductance, engine output power and engine load are balanced at point *a* but, as the load falls or is removed to raise engine speed, the output voltage of the integrating circuit F would rise from *a* to *b* were it not for said feedback. Actually, since the fuel regulating rod moves in the direction for decreasing fuel supply, the inductance value of VL2 increases, so that the balance point shifts from *a* to *c* to raise the output voltage, thereby increasing the rate of voltage change for changes in engine speed. Section G is a power amplifier circuit comprising transistors T5, T6, diodes D4, D5, and resistors R15, R16, R17 and R18, and serving to produce a control current sufficiently large to energize movable coil L3 in the fuel regulating rod control mechanism H. Section J represents the engine.

The governor function of the network described in the above will be considered in relation to engine control by referring to the graph of FIG. 5.

In starting up the engine, closing the starting switch SW causes a large initial control current to flow, because no output voltage is available from integrating circuit F at this time, in movable coil L3 in the fuel regulating rod control mechanism H. Thus, the fuel regulating rod, not shown, moves to the maximum fuel supply position Q_{max} to facilitate the firing up of the engine. As the engine starts and picks up speed, the pulse density at connection point P1 rises, as explained previously, to increase the output voltage of said circuit F, whereby the control current flowing through said movable coil L3 decreases to pull back the fuel regulating rod in the direction for decreasing fuel supply. The operating point representing the control current shifts along the control curve determined by the accelerator lever position, meaning that the control current falls until engine load balances with engine output power to result in a steady engine speed. Assuming that the engine is now running in its high-speed range, the resultant increase in inductance VL2 increases the output voltage of circuit F, so that the speed regulation becomes small, as shown by line $a - c$ in FIGS. 4 and 5. To raise the engine output power, the accelerator lever is to be moved to decrease the value of variable inductance VL1.

The excellence of this invention will be readily understood from the foregoing description in that the invention minimizes the number of component parts in the electronic governor and ensures the stability of engine speed under low-speed running condition by providing a wide speed regulation and using a large time constant in the output voltage integrating circuit, thereby fully meeting the stated governor performance requirements.

While this invention has been described in detail with respect to its preferred embodiment it is to be understood that various changes and modifications may be made without departing from the spirit and scope of this invention and it is intended, therefore, to cover all such changes and modifications in the appended claim.

What is claimed is:

1. An electronic governor for a fuel-injection type internal combustion engine comprising means for sensing the rotational speed of the engine and for generating a corresponding pulse signal having a frequency related to the rotational speed of the engine, rotational speed control means responsive to said pulse signal for controlling the pulse widths of the signal pulses, integrating means for integrating the output of said rotational speed control means and for producing a d.c. control signal in accordance therewith, and fuel regulating means responsive to said d.c. control signal produced by said integrating means for controlling the displacement of the fuel regulating rod in accordance therewith, said rotational speed control means including a timing circuit for determining the pulse widths of said pulses including a first variable inductance device providing an inductance related to the setting of the accelerator operating lever and a second variable inductance device providing an inductance related to the displacement of the fuel regulating rod whereby the amount of speed regulation provided decreases with an increase in speed.

2. An electronic governor as claimed in claim 1 wherein said second variable inductance device includes a movable core mechanically linked to the fuel regulating rod to provide feedback between the fuel regulating means and the rotational speed control means.

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