

March 19, 1963

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3,082,353

ELECTRIC GOVERNOR FOR INTERNAL COMBUSTION ENGINE OR THE LIKE

Filed Nov. 3, 1958

3 Sheets-Sheet 1

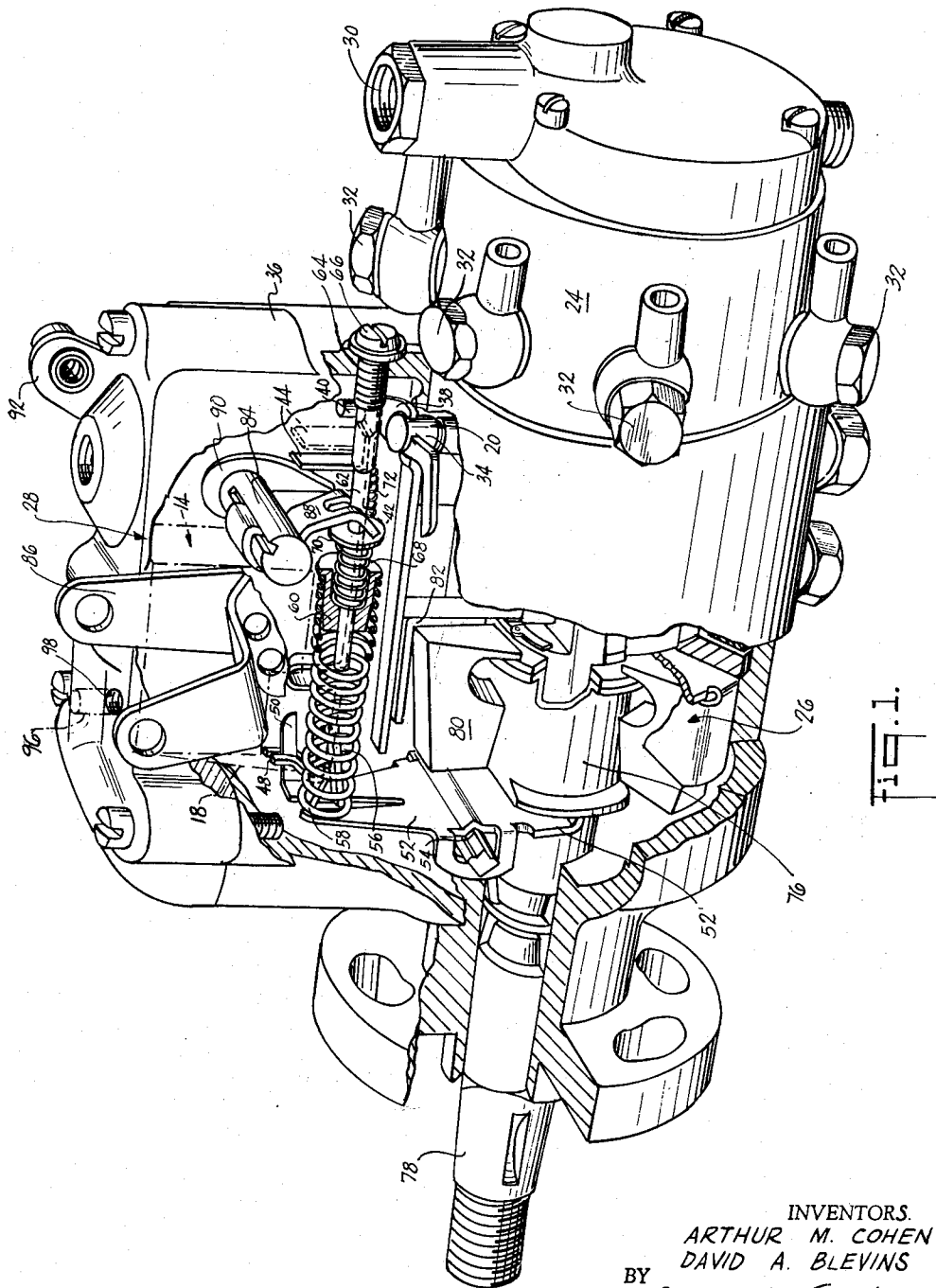


FIG. 1.

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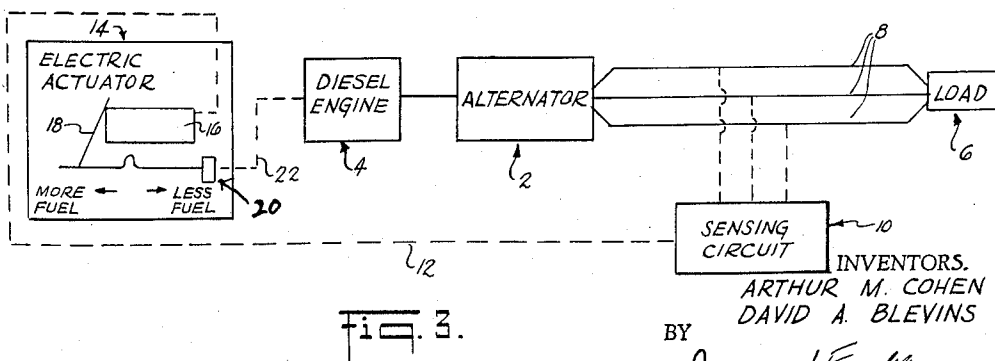
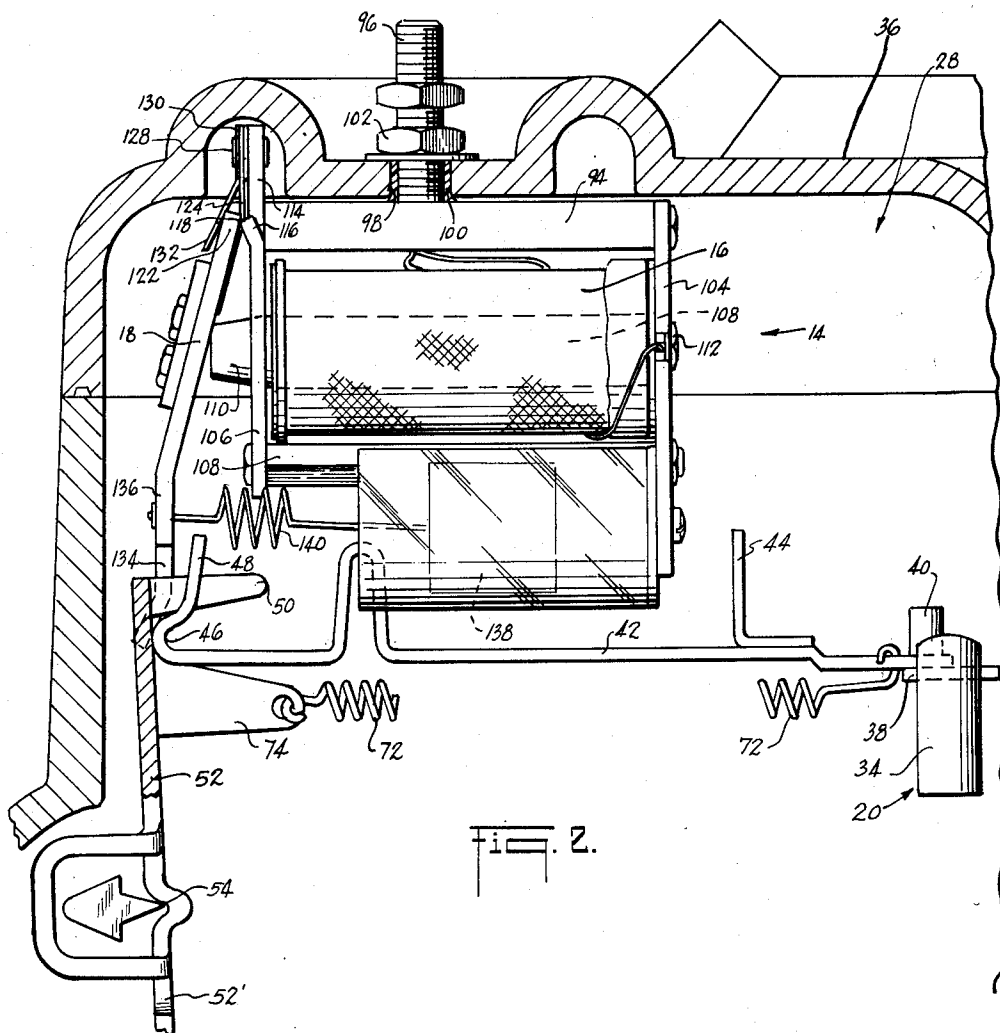
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3 Sheets-Sheet 2



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3 Sheets-Sheet 3

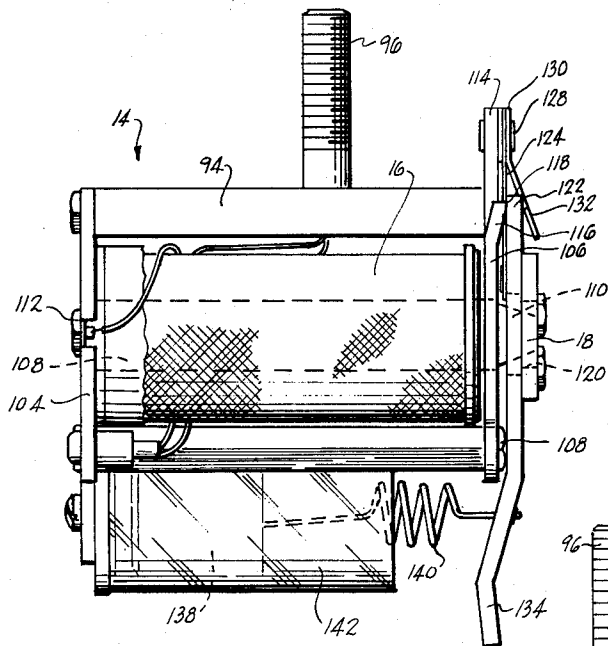


Fig. 4.

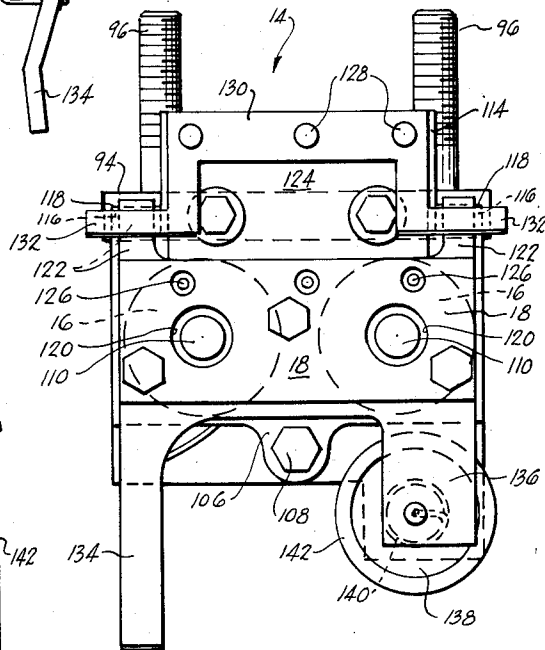


Fig. 5.

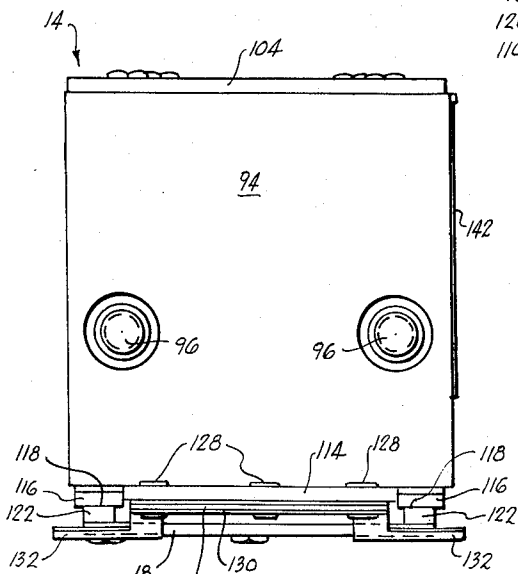


Fig. 6.

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ELECTRIC GOVERNOR FOR INTERNAL COMBUSTION ENGINE OR THE LIKE

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Filed Nov. 3, 1958, Ser. No. 771,307

14 Claims. (Cl. 317—5)

The present invention relates to the electrical control of an internal combustion engine, and particularly to such a control capable of varying the speed of rotation of the engine and/or maintaining it closely at a predetermined value, and to the specific structure of an electrically energized actuator designed to control the flow of fuel to the engine.

The speed of operation of internal combustion engines has in the past been controlled largely by mechanical means, e.g. throttle linkages and centrifugally actuated governors which are effective, when a predetermined speed of rotation is exceeded, to decrease the flow of fuel to the engine and thus cause it to slow down. While these mechanical controls are effective for many purposes, they have proved to be ineffective where accurate control of the speed of rotation is required, as, for example, when the engine drives an alternator the frequency of output of which, dependent upon the speed of rotation of the engine, must be maintained constant to a high degree of accuracy, with a high speed of response, and with no hunting, even upon the sudden application or removal of full load on the alternator.

Even apart from the problem of governor action, there are many instances where remote control of an engine is desired. Mechanical linkages to permit such remote control impose definite limitations on the distance over which they can be operative and involve direct mechanical connection, thus limiting the applications where they can be used. In addition, they are essentially imprecise, because of problems of lost motion, friction and the like, and they present maintenance problems which are quite severe.

Electrical controls for internal combustion engines have either been of a gross (on-off) nature, or else elaborate and complex hydraulic systems have been interposed between the electric control unit and the engine itself. In the latter case the control units are expensive, add materially to the weight of the overall installation (a factor most important in airborne equipment or equipment which must be carried from one location to another) and which present substantial maintenance problems.

In accordance with the present invention an electrical control is provided directly active on the fuel supply to the engine and capable of controlling that fuel supply continuously over a wide range. Because this electrical control is sensitive to the magnitude, and if desired also the duration, of the electrical signal fed thereinto, it is capable of use where the actual control, manual or automatic, is carried out at a very great distance from the engine, and no physical connection between the controlling station and the engine is required. Thus the control of the present invention is well adapted for telemetering applications. The only limitation on its use in this regard is that some means of electrical communication, whether conductive or wireless, be established between the control station and the engine.

Moreover, through the use of electric control a much higher degree of accuracy can be attained than with prior available mechanical controls, and with a degree of dependability which meets the most exacting requirements. Indeed, in the specific application above mentioned where the engine is used to drive an alternator the frequency of the output of which must be kept constant (in connection

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with which embodiment the present invention is here specifically illustrated) the frequency of output of the alternator may be directly sensed and the signal derived therefrom may be directly applied to the control instrumentality of the present invention, thus permitting the use of an all-electric sensing and control system active directly upon the fuel input to the engine. With the actuator of the present invention the frequency of output of an engine-driven alternator may be maintained within $\frac{1}{4}$ of 1% of rated value at constant load, with frequency modulation not exceeding one cycle per second, and frequency can be maintained within $1\frac{1}{2}$ % of rated frequency and re-established within the $\frac{1}{4}$ % band within one second upon any sudden change in load, even from full load to no load or vice versa. All this may be accomplished by means of an electromagnetic actuator unit which is small, inexpensive and substantially maintenance-free and which is, moreover, capable of meeting the above mentioned requirements in any position and under severe conditions of vibration, shock and acceleration. In addition, and most significantly, the control unit of the present invention may be used with presently existing engines without requiring redesign thereof.

Where desired for safety purposes, a conventional mechanical governor may also be employed, that governor being capable of taking over if the electrical system should fail, but not interfering with the electrical control while the latter is operating.

The system of the present invention, unlike all other systems, employs no mechanical flyballs (except as a safety feature), hydraulic systems, throttle linkages or other exposed mechanical parts or hydraulic devices. Instead it consists of a compact unit comprising an electromagnetic coil and an armature adapted to be attracted thereby, the coil being energized by an appropriate control signal and the armature being directly active upon the fuel system of the engine in order to control the amount of fuel fed to the cylinders. The entire unit occupies a space less than two inches in each direction, and consequently may be housed within a casing on the fuel control element of the engine, thus being protected at all times. The mounting of the armature, its relation to the electromagnetic coil, and its connection to the fuel control system are such that an extremely sensitive and effective control of the engine is realized.

To the accomplishment of the above, and to such other objects as may hereinafter appear, the present invention relates to the design of a system for providing direct electrical control of the speed of operation of an internal combustion engine, and to the construction of the unit which provides that control, all as defined in the appended claims and as described in this specification, taken together with the accompanying drawings, in which:

FIG. 1 is a three-quarter perspective view, partially broken away, of a standard fuel injection pump for a diesel engine in which the control unit of the present invention has been incorporated;

FIG. 2 is a side elevational view, on an enlarged scale, showing the control unit and the manner in which it is mounted in the injector pump housing and operatively connected to control the amount of fuel fed to the cylinders;

FIG. 3 is a block diagram illustrating the manner in which the control unit of the present invention can be used to control the speed of rotation of the engine in order to maintain constant the frequency of the output of an alternator driven by the engine;

FIG. 4 is a side elevational view of the actuator unit;

FIG. 5 is an end elevational view thereof; and

FIG. 6 is a top plan view thereof.

In this exposition the electrical control system and unit are specifically disclosed embodied in a governor sys-

tem for controlling the frequency of output of an alternator driven by a diesel engine provided with a fuel injector pump known as the "Roosa Master Model D" pump manufactured by the Roosa Master Fuel Injection Division of the Hartford Machine Screw Company, the essentials of operation of which are shown in Roosa Patent 2,353,188 of July 11, 1944, but it will be apparent, as the description proceeds, that the invention is not limited thereto.

Having reference to FIG. 3, which illustrates schematically the specific system here chosen to exemplify the use of the system and unit of the present invention, an alternator 2 is driven by a diesel engine 4. The output of the alternator, here shown as three-phase, goes to a load 6 via electrical lines 8. A sensing circuit generally designated 10, which may, for example, be constituted by the circuitry disclosed in copending application Ser. No. 770,864 of October 30, 1958, of John F. Hysler, now Patent No. 2,969,467 of January 24, 1961, and assigned to the assignee of this application, senses the frequency of the voltage in the lines 8 and generates a signal corresponding thereto, which signal, as indicated by the broken line 12, is fed to the electrical actuator or control unit generally designated 14, that unit comprising a coil 16 energized by the signal 12 and an armature 18 attracted by the coil 16 in accordance with the energization thereof and directly mechanically connected to a fuel control element 20 which, as indicated by the broken line 22, controls the amount of fuel fed to the engine 4. As indicated by the legends in FIG. 3, attraction of the armature 18 toward the coil 16 causes it to move in such a direction as to reduce the amount of fuel fed to the engine, while movement of the armature 18 in the opposite direction away from the coil 16 results in an increase in the amount of fuel to the engine 4.

Having reference now to FIG. 1, that drawing discloses a diesel engine fuel injector pump of the type described above. It comprises a pump generally designated 24, a mechanical governor generally designated 26, and a control linkage generally designated 28, all mounted within a single unitized casing. Fuel enters the pump portion 24 via port 30 and is pumped in controlled amounts to the engine cylinders via the ports 32. The fuel, in passing through the pump 24, must traverse a metering valve controlling the amount of fuel which can pass there-through, and therefore constituting the fuel control element 20, this metering valve being adjustable by means of the rotary head 34 positioned above the pump 24 and inside the upper casing portion 36. As viewed in FIG. 1 rotation of the rotary head 34 in a clockwise direction results in a decrease in the amount of fuel which reaches the engine cylinders. A standard control linkage for the injection pump is mounted within the upper casing portion 36. (See FIGS. 1 and 2.) The control head 34 for the metering valve is provided with an arm 38 having an upstanding stud 40. Mounted on the stud 40 is a longitudinally extending link 42 having an upstanding lug 44 at one end thereof and a curved tip 46 at the other end thereof with a forked upward extension 48. Received within the fork 48 is a longitudinally extending finger 50 at one end of a lever 52 pivotally mounted at 54 and having a longitudinally extending portion 56 adjacent the finger 50 around which one end of biasing spring 58 is received, that spring end abutting against the lever 52, the other end of that spring abutting against a thimble 60 mounted on adjusting rod 62 threadedly engaging a wall of the casing portion 36 at 64 and having an externally accessible head 66. A second spring 68 is received between the thimble 60 and a washer 70 slidable along the rod 62. A third spring 72 is tensioned between the part 74 extending from the lever 52 and the link 42, being connected to the latter adjacent the stud 40. The lever 52 has a portion 52' extending below the pivot point 54, where it is engaged by collar 76 mounted on the pump drive shaft 78 and adapted to be acted upon by centrifugal

weights 80 which rotate with the shaft 78 and which are pivoted at 82. The elements 76, 80 and 82 constitute the mechanical governor 26. A throttle shaft 84 is provided in the upper casing portion 36 and is connected to manual throttle arm 86, that shaft 84 carrying a forked arm 88 adapted to engage the washer 70 and, when the shaft 84 is rotated in a clockwise direction, to compress the spring 68. When this is done the lever 52 is pivoted in a counter-clockwise direction, the link 42 is moved to the left as viewed in FIG. 1, being pulled in that direction by the spring 72, the metering valve control head 34 is pivoted in a counter-clockwise direction, and more fuel is fed to the engine, thus causing it to rotate at a greater speed. If that speed should exceed a predetermined speed, as determined by the initial tension on the spring 58 controlled by the setting of the adjusting rod 62, the centrifugal force exerted by the governor weights 80 will exceed the force of the spring 58, those weights will cause the lever 52 to pivot in a clockwise direction, the link 42 will be pushed back thereby, and the metering valve control head 34 will be pivoted in a clockwise direction so as to reduce the amount of fuel to the engine. A cam 90 is rotatably mounted on the shaft 84 and is controlled by external arm 92, that cam being active upon the upwardly extending portion 44 of the link 42 and being effective, when rotated counter-clockwise from its direction shown in FIG. 1, to move the link 42 to the right against the action of the spring 72 (as indicated by the broken lines in FIG. 1) to a degree sufficient to completely cut off the supply of fuel to the engine by rotating the metering valve control head 34 in a clockwise direction.

The operation of the metering pump as above described has been with reference to its normal use independently of the electric actuator 14. That actuator 14 is mounted within the upper casing part 36 and comprises a mounting plate 94 provided with upstanding studs 96 which pass through apertures 98 in the upper wall of the housing portion 36, those apertures 98 being lined with insulating tubes 100, the mounting plate 94 being held in place within the casing portion 36 by means of nuts 102 receivable on the outside of the studs 96. Top and bottom magnet plates 104 and 106 are secured to the mounting plate 94 and extend down therefrom, a spacer 108 connecting the remote edges of the plates 104 and 106. The electromagnetic coil 16 is mounted on the plate 104, extends toward the plate 106, and is provided with a core 108 the end 110 of which extends through the plate 106. While but a single coil 16 could be employed, it is preferred, as may be seen from FIGS. 5 and 6, that a pair of series connected coils 16 be employed, each with its own core 108, screws 112 being employed to mount the cores in position on the plate 104. Electrical connection to the coils may be made via the studs 96. The plate 106 is provided with a centrally located portion 114 extending upwardly from the mounting plate 94, and with a pair of laterally spaced upstruck fingers 116 having edges 118. These fingers 116 are, as may best be seen from FIG. 5, positioned one on each side of the central plate portion 114 and substantially in line with the mounting plate 94.

The armature 18, formed of magnetically attractable material, is positioned over the coils 16 and is provided with apertures 120 into which the core tips 110 are freely receivable. The armature 18 is provided with rearwardly extending fingers 122 at each side thereof, those fingers extending over and engaging the edges 118, those edges 118 constituting the fulcrums about which the armature 18 is adapted to pivot. A flat leaf spring 124 is secured to the underside of the armature 18, as by rivets 126, and is secured to the upwardly extending end plate portion 114, as by rivets 128. This spring 124 prevents movement of the armature 18 in the direction of its plane, permits substantially frictionless pivoting of the armature about the edges 118, and provides a resilient

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force which urges the armature portions 122 into engagement with the edges 118. In addition, a stop, preferably formed of resilient material such as Phosphor bronze, has a portion 130 secured to the upwardly extending end plate portion 114 and has laterally extending arms 132 which extend over the armature portions 122 and are preferably slightly spaced therefrom so as to provide a substantial restoring force on the armature portions 122 in the event that shock, vibration or acceleration might tend to cause those portions 122 to rise from the edges 118.

The armature 18 is provided with a finger extension 134 which engages the outer edge of the curved portion 46 of the arm 42. It is provided with a second extension 136 to which a piston 138 is connected by means of spring 140, that piston being movable within cylinder 142 mounted on end plate 114 to provide dashpot damping action.

When the electric actuator 18 of the present invention is to be employed the mechanical throttle is opened sufficiently to permit the engine to operate at somewhat above rated speed and is secured in that open position. Hence the lever 52 is pivoted in a counter-clockwise direction, the link 42 is pulled by the spring 72 to the left into engagement with the lever 52, the armature 18 pivots about the edges 118 to a position remote from the coils 16, and the metering valve control head 34 is rotated in a counter-clockwise direction to what may be considered for this purpose its fully open position. The engine 4 will commence to operate and the alternator 2 will begin to generate. A signal will be produced by the sensing circuit 10 corresponding to the frequency of output of the alternator 2, and as that frequency approaches the desired frequency the magnitude of that signal will increase. Hence the coils 16 will become energized, and increasingly energized as the frequency increases toward rated value. The armature 18 will be attracted by the energized winding 16, and will pivot in a counter-clockwise direction as viewed in FIG. 2. As it does so it will push the link 42 to the right against the action of the spring 72, the lever 52 remaining in its counter-clockwise position because the mechanical governor 26 is adjusted so that at these speeds it will not exert sufficient force to overcome the action of the spring 58. In pushing the link 42 to the right the armature 18 will cause the control head 34 to pivot in a clockwise direction and thus reduce the amount of fuel to the engine. When the engine has come up to its desired speed such that the frequency of output of the alternator 2 is at the desired value, the signal from the sensing circuit 10 will energize the coils 16 sufficiently so as to just balance the force of the spring 72 which tends to return the link 42 to its left hand position, and which therefore is biasing the armature 18 to pivot away from the coils 16. The engine will therefore remain at this speed, since it is now receiving just enough fuel for that speed.

If now the speed of the alternator-engine combination should decrease for any reason, as if the load on the alternator should increase, the reduction in the frequency of the alternator output will be sensed by the circuit 10, the coils 16 will receive less energization, the spring 72 will then be able to pull the link to the left and move the armature 18 away from the coils 16, the control head 34 will be pivoted in a counter-clockwise direction, and thus more fuel will be fed to the engine in order to bring it up to speed while working against this greater load. The opposite result will obtain if the speed of the alternator-engine combination should increase, as if the load on the alternator should lessen. It will be appreciated that the particular speed at which the electrical governor system will function will be determined by the magnitude of the signal energizing the coils 16 and the characteristics of the spring 72, which acts as a reference biasing spring against which the electromagnetic attraction of the coils 16 acts.

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In this particular installation it should be noted that for as long as an error exists (for as long as the alternator frequency departs from its desired value) there will be a force active on the armature 18, and hence on the metering valve control head 34, tending to move it in a direction such as to compensate for the error. A time integration effect is thus achieved, so that a true servo system is effectuated.

It will be understood, of course, in connection with the above description of the system as used for governor operation, that the mechanical governor 26 shall have been set, by means of screw rod 62, for a speed somewhat above the desired speed of operation at which the electrical governor system is operative. For example, where operation at 1800 r.p.m. is desired, the mechanical governor 26 may be set to operate at 1850 r.p.m. Hence during normal operation of the system the mechanical governor 26 is inoperative. However, if the electrical system should fail, as if there should be a circuit break between the sensing circuit 10 and the actuator 14, then the mechanical governor 26 can take over to prevent runaway of the engine.

The actuator 14 may be utilized for remote adjustable speed control, as distinguished from the governor operation above described, by providing an appropriate adjustable electrical signal to the coils 16 and by utilizing a reference spring 72 having appropriate tension-elongation characteristics such that the armature 18 will assume a predetermined position relative to the coils 16 for a given signal magnitude.

It is noteworthy that speed control of an internal combustion engine is thus achieved by means of a small compact electromagnetic device which has but a single moving part directly connected to the existing fuel control system, and without having to use any hydraulic systems or complex mechanical linkages. The unit is believed to have substantially no maintenance problems. The only places where wear might occur is at the engagement between the edges 118 and the actuator portions 122 and the engagement between the elements 134 and 146. It is believed that the life of these parts is unlimited, but even if some defect in the actuator should develop, the actuator may be removed and replaced in a matter of minutes. It may be incorporated into existing engines without any material modifications thereof. The safety factor inherent in the use of a mechanical governor can still be employed, and will protect the system on loss of voltage, short circuits or any other electrical malfunction. The structure of the actuator is such that it may readily be manufactured on a production basis without having to utilize excessively close tolerances. It nevertheless functions in an exceptionally rapid and accurate manner. If emergency shutdown is desired, overriding the action of the electrical actuator, this can be accomplished without any change in existing design, manual movement of the shutdown arm 92 and cam 90 being effective to that end independently of the operation of the electrical actuator.

While but a single embodiment of the present invention is here specifically disclosed, it will be apparent that many variations may be made therein, in actuator structure, method of control, and type of engine equipment in connection with which it is used, all within the spirit of the invention as defined in the following claims.

We claim:

1. In combination, an engine, power control means including an element operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, means for producing an electrical signal corresponding to a desired speed of operation of said engine, and an electromagnetic means comprising a coil operatively connected to said signal means and

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energized thereby, an armature attracted by said coil, and reference means biasing said armature relative to said coil, said armature being movable by attraction of said coil against the action of said reference means, in accordance with the energization of said coil by said signal, from one position through a series of intermediate positions to another position, said armature being mechanically connected to said power control means element to position the latter in that one of its positions corresponding to the position of said armature, and a mechanical governor operatively connected to said power control means element independently of said armature and effective to prevent the speed higher than said desired speed of rotation of said engine from exceeding a predetermined speed irrespective of said signal means and said electromagnetic means.

2. The combination of claim 1, in which the operative connection between said mechanical governor and said power control means is structurally independent of said armature, whereby the action of said mechanical governor does not affect said armature.

3. In combination, an engine, a generator driven by said engine and having an electrical output, power control means operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, and electromagnetic means operatively connected to said electrical output to be energized thereby and operatively connected to said power control means by direct mechanical connection to position the latter in that one of its positions corresponding to said energization, said electromagnetic means comprising a support, a winding thereon operatively connected to said electrical output so as to be energized thereby, an edge structure on said support, an armature operatively connected to said power control means and mounted on said support in operative relation to said winding so as to be attracted thereby in accordance with the energization thereof, said armature being positioned on said edge structure so as to be pivotable thereon between positions close to and remote from said winding, and resilient means biasing said armature against said edge structure.

4. In the combination of claim 3, biasing means active on said power control means to bias it to one of its extreme positions, said armature being biased by said biasing means, via said power control means, to a pivoted position remote from said winding.

5. In combination, an engine, a generator driven by said engine and having an electrical output, power control means operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, and electromagnetic means operatively connected to said electrical output to be energized thereby and operatively connected to said power control means by direct mechanical connection to position the latter in that one of its positions corresponding to said energization, said electromagnetic means comprising a support, a winding thereon operatively connected to said electrical output so as to be energized thereby, an edge structure on said support, an armature operatively connected to said power control means and mounted on said support in operative relation to said winding so as to be attracted thereby in accordance with the energization thereof, said armature being positioned on said edge structure so as to be pivotable thereon between positions close to and remote from said winding, resilient means biasing said armature against said edge structure, and stop means closely overlying that portion of said armature positioned on said edge structure, thereby defining

a stop restraining movement of said armature away from said edge structure.

6. In the combination of claim 5, biasing means active on said power control means to bias it to one of its extreme positions, said armature being biased by said biasing means, via said power control means, to a pivoted position remote from said winding.

7. In combination, an engine, a generator driven by said engine and having an electrical output, power control means operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, and electromagnetic means operatively connected to said electrical output to be energized thereby and operatively connected to said power control means by direct mechanical connection to position the latter in that one of its positions corresponding to said energization, said electromagnetic means comprising a support, a winding thereon operatively connected to said electrical output so as to be energized thereby, a pair of separated edge portions on said support located above and to one side of said winding, an armature operatively connected to said power control means and positioned over said winding so as to be attracted thereby in accordance with the energization thereof and having elements connected thereto and extending over and in engagement with said edge portions, said armature being pivotal about said edge portions between positions close to and remote from said winding, and a leaf spring connected between said armature and a portion of said support on the other side of said edge portions from said winding.

8. In the combination of claim 7, biasing means active on said power control means to bias it to one of its extreme positions, said armature being biased by said biasing means, via said power control means, to a pivoted position remote from said winding.

9. In combination, an engine, a generator driven by said engine and having an electrical output, power control means operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, and electromagnetic means operatively connected to said electrical output to be energized thereby and operatively connected to said power control means by direct mechanical connection to position the latter in that one of its positions corresponding to said energization, said electromagnetic means comprising a support, a winding thereon operatively connected to said electrical output so as to be energized thereby, a pair of separated edge portions on said support located above and to one side of said winding, an armature operatively connected to said power control means and positioned over said winding so as to be attracted thereby in accordance with the energization thereof and having elements connected thereto and extending over and in engagement with said edge portions, said armature being pivotal about said edge portions between positions close to and remote from said winding, a leaf spring connected between said armature and a portion of said support on the other side of said edge portions from said winding, and resilient stop means fixed to said support and closely overlying said armature elements, thereby restraining said armature from moving away from said edge portions.

10. In the combination of claim 9, biasing means active on said power control means to bias it to one of its extreme positions, said armature being biased by said biasing means, via said power control means, to a pivoted position remote from said winding.

11. In combination, an engine, a generator driven by said engine and having an electrical output, power control means operatively connected to said engine and mov-

able between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, biasing means active on said power control means to bias it to one of its extreme positions, and electromagnetic means comprising a winding energized by said electrical output and a movable armature operatively connected to said power control means and magnetically attracted by said winding in accordance with the energization thereof in opposition to said biasing means, said electromagnetic means comprising a support, a winding thereon operatively connected to said electrical output so as to be energized thereby, an edge structure on said support, an armature operatively connected to said power control means and mounted on said support in operative relation to said winding so as to be attracted thereby in accordance with the energization thereof, said armature being positioned on said edge structure so as to be pivotable thereon between positions close to and remote from said winding, and resilient means biasing said armature against said edge structure.

12. In combination, an engine, a generator driven by said engine and having an electrical output, power control means operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate positions corresponding to intermediate values of engine power to another position corresponding to a minimum value of engine power, biasing means active on said power control means to bias it to one of its extreme positions, and electromagnetic means comprising a winding energized by said electrical output and a movable armature operatively connected to said power control means and magnetically attracted by said winding in accordance with the energization thereof in opposition to said biasing means, said electromagnetic means comprising a support, a winding thereon operatively connected to said electrical output so as to be energized thereby, an edge structure on said support, an armature operatively connected to said power control means and mounted on said support in operative relation to said winding so as to be attracted thereby in accordance with the energization thereof, said armature being positioned on said edge structure so as to be pivotable thereon between positions close to and remote from said winding, resilient means biasing said armature against said edge structure, and stop means closely overlying that portion of said armature positioned on said edge

structure, thereby defining a stop restraining movement of said armature away from said edge structure.

13. In combination, an engine, a generator drivingly connected to said engine and adapted to be driven thereby at a first predetermined speed, said generator having an electrical output, power control means including an element operatively connected to said engine and movable between one position corresponding to high engine power through a series of intermediate values of engine power to another position corresponding to a minimum value of engine power, electromagnetic means including an armature operatively connected to said electrical output to be energized thereby, said armature being movable in accordance with the energization of said electromagnetic means from one position through a series of intermediate positions to another position, said armature being operatively connected to said power control means element to position the latter in that one of its positions corresponding to said energization, and a governor operatively connected to said power control means element structurally independently of said electromagnetic means and effective to reduce the power to said engine without affecting said electromagnetic means when the speed thereof exceeds a second predetermined speed greater than said first predetermined speed.

14. In the combination of claim 13, biasing means active on said power control means to bias it to one of its extreme positions, said electromagnetic means comprising a winding energized by said electrical output and said armature, the latter being operatively connected to said power control means and magnetically attracted by said winding in accordance with the energization thereof in opposition to said biasing means, said governor being operatively connected to said power control means independently of said armature.

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