

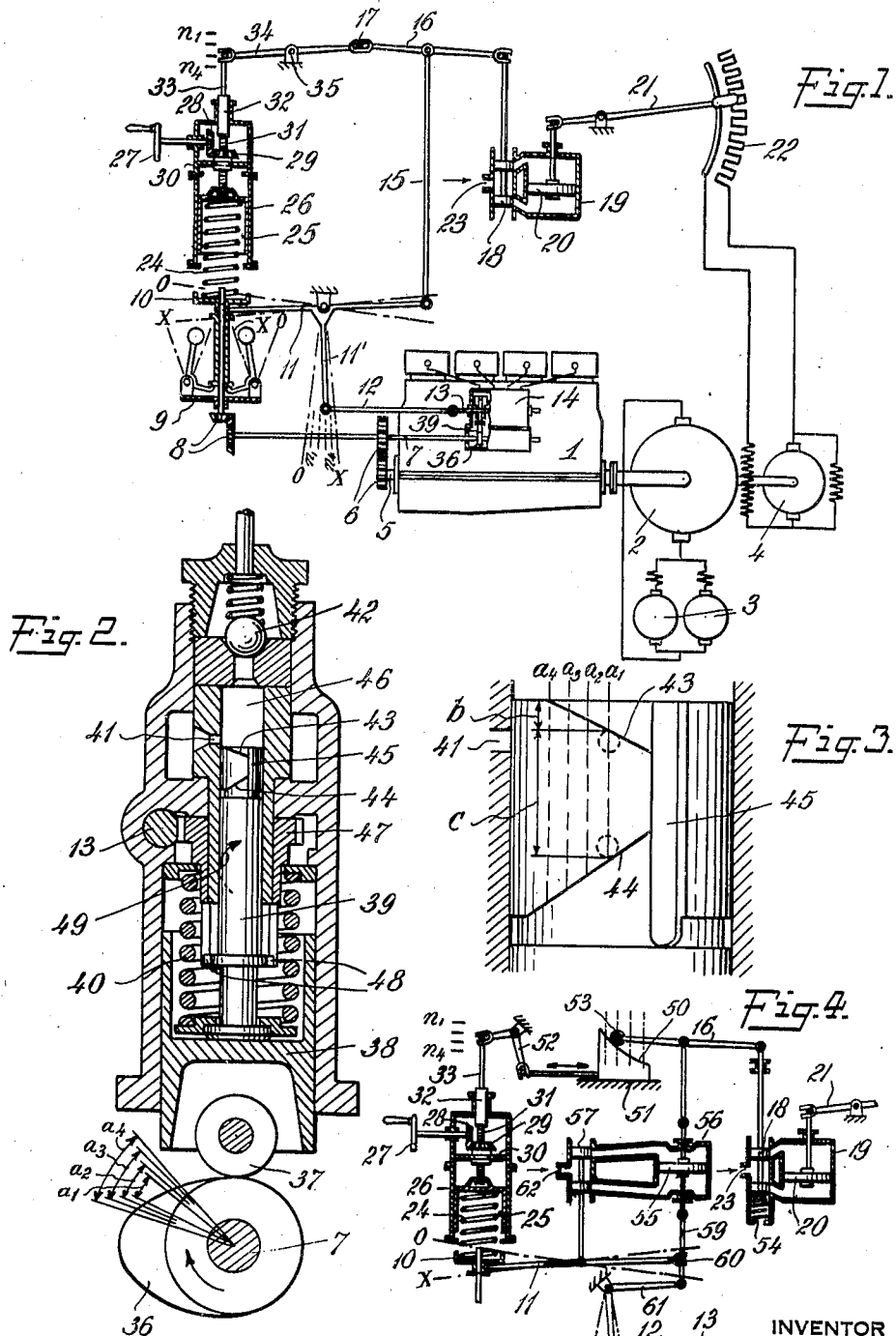
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INTERNAL COMBUSTION ENGINE-ELECTRIC POWER UNIT

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INTERNAL COMBUSTION ENGINE-ELECTRIC
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This invention relates to internal combustion engine-electric power units and has for its object the provision of certain improvements in apparatus of this type. The invention relates particularly to apparatus for controlling the engine speed, for maintaining the engine torque constant for a given engine speed and for controlling the quantity of fuel supplied to the engine in accordance with the engine speed. It is an object of this invention to provide means in combination with such apparatus for controlling the quantity of fuel injected into the engine which also controls the timing of the commencement of the fuel injection.

In accordance with the invention the combination or arrangement of apparatus may be such that when the quantity of fuel injected during each injection period is reduced, the commencement of the injection period is retarded. It is a further object of the invention to provide a combination or arrangement of apparatus which operates in such way that when the quantity of fuel injected during each injection period is reduced, the commencement of the said period is advanced.

These and other features of the invention will be better understood, if reference is made to the accompanying drawing, taken in conjunction with the following description, in which:

Figure 1 shows diagrammatically one arrangement according to the invention;

Figure 2 is a vertical section on an enlarged scale of one of the fuel pump cylinders included in Figure 1;

Figure 3 illustrates, on yet a larger scale, the relative positions of the control edges on the pump plunger and the associated suction port; and

Figure 4 is a diagrammatic representation of a modified arrangement, also according to the invention.

In the arrangement of apparatus shown in Figure 1, the internal combustion engine 1 drives a main current generator 2 which supplies current to the traction motors 3 of a Diesel-electric vehicle (not shown), the engine 1 driving also an auxiliary current generator 4 which supplies the excitation current for the main generator 2.

The crankshaft 5 of the engine 1 drives, through gear wheels 6, a shaft 7 which in turn transmits the drive through bevel wheels 8 to a governor 9. The sleeve 10 of the governor 9 is connected to a lever 11 pivoted at an intermediate point to a fixed pivot and has secured thereto an arm 11' pivotally connected at its lower end

to a rod 12 through which movement is imparted to a rack 13 for controlling the several fuel pumps 14 as hereinafter described. The lever 11 is also connected through a link 15 to a lever 16 having one end pivotally connected at 17 to a lever hereinafter described, and the other end connected to a piston valve 18. The valve 18 controls the supply of pressure medium to a servomotor cylinder 19 containing a piston 20 whose rod is connected to a contact arm 21 of a rheostat 22 whereby the excitation current for the main generator is regulated. The pressure medium for actuating the servo piston 20 is supplied through an inlet conduit 23.

The sleeve 10 of the governor 9 is opposed by a spring 24 acted upon from above by a hollow piston 25 movable within a cylinder 26. The initial tension of the spring 24 can be set as desired, for example, by means of a hand wheel 27 having a bevel wheel 28 which drives a bevel wheel 29 rotatable in a fixed bearing plate 30 and internally threaded to cooperate with a threaded shaft 31. The shaft 31 acts at its lower end on the piston 25 and has at its upper end a part 32 of square-cross-section which cooperates with a corresponding guide at the upper end of the cylinder 26. The upper end of the rod 31 is connected, as shown at 33, to one end of a lever 34 carried on a fixed pivot 35 and carrying at its other end the pivot 17.

Instead of a single spring 24, the governor may be opposed by several springs which can be successively rendered operative or inoperative as illustrated in the patent to O. Simmen No. 1,941,500.

Each of the fuel pumps is driven by a cam 36 secured to the shaft 7, as shown in Figure 2, the cam 36 acting, during the delivery stroke of the pump, on a roller 37 carried at the lower end of a cylindrical guide member 38 so that the pump plunger 39 is moved upwards against the action of a spring 40. During the suction stroke of the pump, the spring 40 moves the guide member 38 and plunger 39 downwardly so as to draw fuel through a suction port 41 into the pump chamber, this fuel being delivered to a corresponding engine cylinder through a non-return valve 42 by the next upward or delivery stroke of the plunger 39.

The plunger 39 has two control edges 43 and 44 so that when, during the delivery stroke of the plunger 39, the control edge 43 passes over the suction port 41, delivery of fuel past the non-return valve 42 and injection into the corresponding engine cylinder commences. When,

towards the end of the delivery stroke, the control edge 44 passes over the suction port 41, fuel can flow through a groove 45 in the plunger 39 from the pump chamber or cylinder 46 and back through the suction port 41, the injection period being thus terminated.

The relative positions of the control edges 43, 44 and the suction port 41 are indicated in Figure 3. When the rotational position of the plunger 39 is such that the port 41 lies on the line a_1 , the control edge 43 will close the suction port 41 late in the delivery stroke of the plunger and the control edge 44 will uncover the port 41 early in the delivery stroke of the plunger. This position of the plunger 39 enables the minimum fuel to be discharged. Points on the control edges 43 and 44 are marked by a series of vertical lines a_1, a_2, a_3 , and a_4 . These points (Fig. 3) represent positions of the plunger 39 when the edges 43 and 44 intersect the opening 41. In Fig. 2, the cam 36 is marked with the characters a_1, a_2, a_3 and a_4 , to indicate the relative positions of the cam corresponding to the positions of the edges 43 and 44 as indicated by the vertical lines a_1, a_2, a_3 and a_4 in Fig. 3. As shown in Fig. 3, the plunger 39 is set for maximum fuel delivery and as it is rotated so that the lines a_2, a_3 and a_4 are successively coincident with the port 41 the quantity of fuel delivered is successively increased. The difference between the distance b as measured along one of the vertical lines from the control edge 43 to a line at right angle thereto which intersects the top of the port 41, say line a_4 , and the corresponding distance on the next line, for example the line a_3 , represents the alteration in the timing of the commencement of injection by a rotation of the plunger 39. The distance c between the points of intersection of any one of the lines a_1, a_2, a_3 or a_4 and the control edges 43 and 44, represents the quantity of fuel injected when the plunger is in the rotational position with the said line in alignment with the port 41.

Each plunger 39 has associated therewith a sleeve-like member 47 having a toothed rim which is engaged by the rack 13, each member 47 being slotted at its lower end to cooperate with lugs 48 formed on the cooperating plunger 39. Thus, though each plunger can be rotated about its longitudinal axis by longitudinal movement of the rack 13, the plunger is free to reciprocate within the member 47. When the rack is moved so as to turn the pump plunger 39 in the direction of the arrow 49 say from the position a_1 to the position a_2 the control edge 43 on each plunger passes over and closes the suction port 41 earlier in the delivery stroke and the control edge 44 uncovers the said suction port later in the delivery stroke so that the effective distance c , i. e., the quantity of fuel injected, is increased. Conversely, when the rack is moved so as to turn the pump plungers in the direction opposite to the arrow 49, say from the position corresponding to the line a_4 , to that corresponding to the line a_3 , the quantity of fuel injected into each engine cylinder will be reduced.

In Figure 1 the parts are shown in the position which they occupy when equilibrium has been established between the load on the internal combustion engine 1 and the corresponding quantity of fuel injected for a given engine speed as set by the hand wheel 27. If now the current conditions of the main generator 2 are changed, for example, if the current absorbed by the motors 3 changes so that the load is increased, the corre-

sponding reduction in engine speed will cause the sleeve 10 to turn the lever 11 in the counter-clockwise direction towards the position X. The lever 16 will thus be turned in the counter-clockwise direction about the pivot 17 so that the valve 18 will be raised and pressure medium will be delivered from the conduit 23 into the cylinder 19 above the piston 20, pressure medium being discharged from beneath the piston 20 through the lower end of the cylinder containing the valve 18. The piston 20 will thus move downwards so that the contact arm 21 is moved to increase the effective value of the resistance 22, thereby decreasing the excitation current for the main generator 2 and decreasing the load on the internal combustion engine. The speed of the engine will thus tend to rise again so that the sleeve 10 will turn the lever 11 in the clockwise direction, i. e., towards the position 0, and thus restore the valve 18 to its central position shown in Figure 1. When the valve 18 is in the central position shown, the piston 20 comes to rest in a new position so that the new setting of the rheostat 22 is maintained. Since, therefore, the desired engine speed is restored and the engine can now carry the load at the torque imposed, a state of equilibrium is again reached. If this is not the case, the valve 18 will again automatically be adjusted and further adjustment of the rheostat 22 effected until the valve 18 is restored to the position shown.

When the load on the internal combustion engine 1 is reduced, the engine speed rises and the valve 18 is moved downwardly so that the effective value of the rheostat 22 is reduced and the excitation current of the main generator is increased. In the event of a rapid and considerable increase or decrease in the load on the engine, the governor 9 may tend to hunt but the sleeve 10 will eventually reach the position of equilibrium in accordance with the engine speed setting.

With a view to enabling different torque requirements and fuel charges to be set when the engine speed is to be changed, the effective length of the link system between the sleeve 10 and the valve 18 is adjusted by bodily altering the position of the pivot 17, though this may, if desired, be effected by altering the effective length of the link 15. Thus, with a view to increasing the speed at which the engine is to operate, the hand wheel 27 is turned so as to lower the rod 31, towards the high speed setting indicated at n_4 and thus increase the initial tension of the spring 24. The lever 34 thus will be turned in the counter-clockwise direction about the pivot 35 so that the pivot 17 will be raised. In this way the valve 18 will be lowered so as to reduce the effective value of the resistance 22 and increase the excitation current of the main generator 2. Increase in the initial tension of the spring 24 will result in temporary inward movement of the mass of the governor 9 since the engine speed will not have changed. The resulting counter-clockwise movement of the lever 11 will cause the rack 13 to be moved to the right as shown in Figure 1, so as to increase the quantity of fuel injected into each internal combustion engine cylinder. At the same time, the downward movement of the valve 18 due to raising of the pivot 17 will be, in part, counteracted by the resulting upward movement of the link 15 unless, at the same time, the current conditions in the armature circuit of the main generator 2 are changed so that such conditions already correspond to the new excitation

current required for the higher engine speed. The alternation in the excitation current of the main generator 2 relieves the internal combustion engine 1 so that its speed can increase to the new higher value which will then be maintained substantially constant.

When the desired engine speed has been obtained, the valve 18 will have been restored to the normal or central position shown in Figure 1. Since, however, the pivot 17 is now in a new position, the position of equilibrium of the governor sleeve 10 will be altered in accordance with the new speed. As a result, the position of equilibrium of the arm 11' will be moved, towards the position n_4 , within its range of adjustment O, X, the adjustment of the arm 11' turning the plungers 39 of the fuel pumps in the direction of the arrow 49. In this way not only will the commencement of fuel injection into each engine cylinder be advanced but the termination of each injection period will be retarded, that is to say the quantity of fuel injected during each injection period will be increased, say, from the value c on the line a_2 to the value c on the line a_3 . Each injection period is thus increased and the quantity of fuel injected is also increased.

Though in the construction described with reference to Figure 1 the ratio of the quantity of fuel to be injected to the engine speed is governed by the position of the pivot 17, i. e., the effective length of the link 15, in the modified arrangement shown in Figure 4 this ratio is adjusted, in accordance with a predetermined requirement, with alteration in the setting for the commencement of each fuel injection. To this end a cam track 50 is provided which can be moved along a fixed support or base 51 by means of a bell-crank lever 52 connected to the rod 31. A roller 53 at one end of the lever 16 is maintained in contact with the cam track 50 by means of a spring 54.

If, for each engine speed which is to be set by the hand wheel 27, a given engine torque is to be obtained, the end of each injection period for any given speed being determined by the control edge 44 on the pump plunger, the shape of the control edge 43 for determining the commencement of each fuel injection and also the ratio of the torque to the speed must be influenced in such a manner that for each engine speed set by the hand wheel 27 the torque set shall correspond to the setting of the quantity of fuel injected by the pump. The cam track 50, which is adjusted by the hand wheel 27 in accordance with the engine speed set thereby, is advantageous in that the above ratio will be automatically maintained but can be readily altered.

The lever 16 is connected to a piston 55 which can reciprocate within a servocylinder 56, the supply of pressure medium to which is controlled by a piston valve 57 connected to the lever 11. The piston 55 is also connected through a rod 59 to the end 60 of the lever 11, the rod 59 being connected to one arm of a bell-crank lever 61, the other arm of which is connected to the rod 12 and rack 13. The pressure medium is supplied to the servomotor 56 through an inlet conduit 62.

The invention is advantageous in that since the torque is controlled in accordance with the engine speed while the commencement of fuel injection and the quantity of fuel injected are simultaneously controlled to suit the speed, an internal combustion engine-electric power unit embodying the invention can be controlled in a manner analogous to that available by regulation of combustion engines in ships, driving the propeller

mechanically, the load of such engines being dependent on the speed of the engine.

The timing of ignition in accordance with the engine speed is thus ensured without the necessity for providing additional control means for transmitting adjustments from the speed setting apparatus to the fuel pumps. This is particularly advantageous in vehicles where, owing to limitation of space, the change-speed apparatus and the fuel pumps are arranged to opposite ends respectively of the internal combustion engine, since in view of the compact construction of internal combustion engines for driving vehicles, the number of rods or the like extending along the engine has necessarily to be limited for reasons of accessibility.

I claim:

1. Power apparatus which comprises in combination an internal combustion engine, fuel injectors for said engine, a main generator driven by the engine, governor means responsive to the engine speed for varying the commencement of fuel injection during each stroke of the injectors and for regulating the quantity of fuel injected into the engine during each period of injection, and means connected to the governor means for varying the load on said generator, whereby at each speed set for the engine the engine torque is maintained constant.

2. An internal combustion engine electric power unit which comprises in combination an internal combustion engine which is operable at various speeds, an electric generator driven by the engine, means for exciting the generator, a fuel injection pump for the engine, governor means responsive to engine speed, said governor means controlling the means for exciting the generator, whereby for each speed set for the engine the torque of the engine is automatically maintained constant in accordance with the engine speed, means for varying the timing of fuel injection in the engine, means for varying the quantity of fuel delivered by said injection pump and means operatively coupling the means for varying the quantity of fuel delivered by the pump and the means for timing the fuel injection, said governor means controlling the means for varying the quantity of fuel delivered by the pump.

3. An internal combustion engine electric power unit which comprises in combination an internal combustion engine, an electric generator driven by the engine, means for the excitation of said generator, a fuel injection pump for the engine, a governor responsive to the engine speed, means for setting the governor at various engine speeds, means controlled by the governor for varying the excitation means, said last mentioned means being operatively connected to said setting means, whereby for each speed set for the engine the torque of the engine is automatically maintained constant in accordance with the engine speed, means for varying the timing of fuel injection in the engine, and means for varying the quantity of fuel delivered by the injection pump controlled by the governor and coupled to the means for varying the timing of fuel injection.

4. Power apparatus which comprises in combination an internal combustion engine which is operable at various speeds, a fuel injector for the engine, a main electrical generator driven by the engine, an auxiliary current generator for supplying the excitation current for the main generator, governor means responsive to the engine speed for regulating the quantity of fuel in-

jected into the engine and for adjusting the timing of commencement of injection of fuel during each injection stroke of the injector, and means operatively coupled to the governor means for varying the excitation current, whereby for
5 each speed set for the engine the torque of the engine is automatically maintained constant in accordance with engine speed.

5. Power apparatus which comprises in combination an internal combustion engine which
10 is operable at various speeds, a fuel injector for the engine the plungers of which are driven by the engine, a main electric generator driven by the engine, an auxiliary current generator for
15 the excitation of said main generator, a governor driven by the engine, said plungers being adjusted by the governor and having control edges for regulating the quantity of the fuel injected and the timing of commencement of fuel injection
20 by the injector, and means operatively con-

nected with and responsive to the governor for varying said excitation, whereby for each speed set for the engine the torque of the engine is automatically maintained constant in accordance with engine speed.

6. A power unit in accordance with claim 2 in which the fuel injector comprises a cylinder, a plunger reciprocable in the cylinder, an inlet port in said cylinder, means operatively associated with the plunger for adjusting the period during the plunger stroke when fuel is admitted through the inlet port, and means for by-passing fuel from the cylinder.

7. A power unit according to claim 3 in which the fuel pump comprises a cylinder, a plunger reciprocable and rotatable in the cylinder, and the means for controlling the timing of commencement of fuel injection during each stroke of the pump is effected by rotation of the plunger.

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