Aug. 4, 1942. G. AMERY 2,291,939

PUMP AND FUEL INJECTION CONTROL DEVICE

Filed Aug. 15, 1938 5 Sheets-Sheet 1

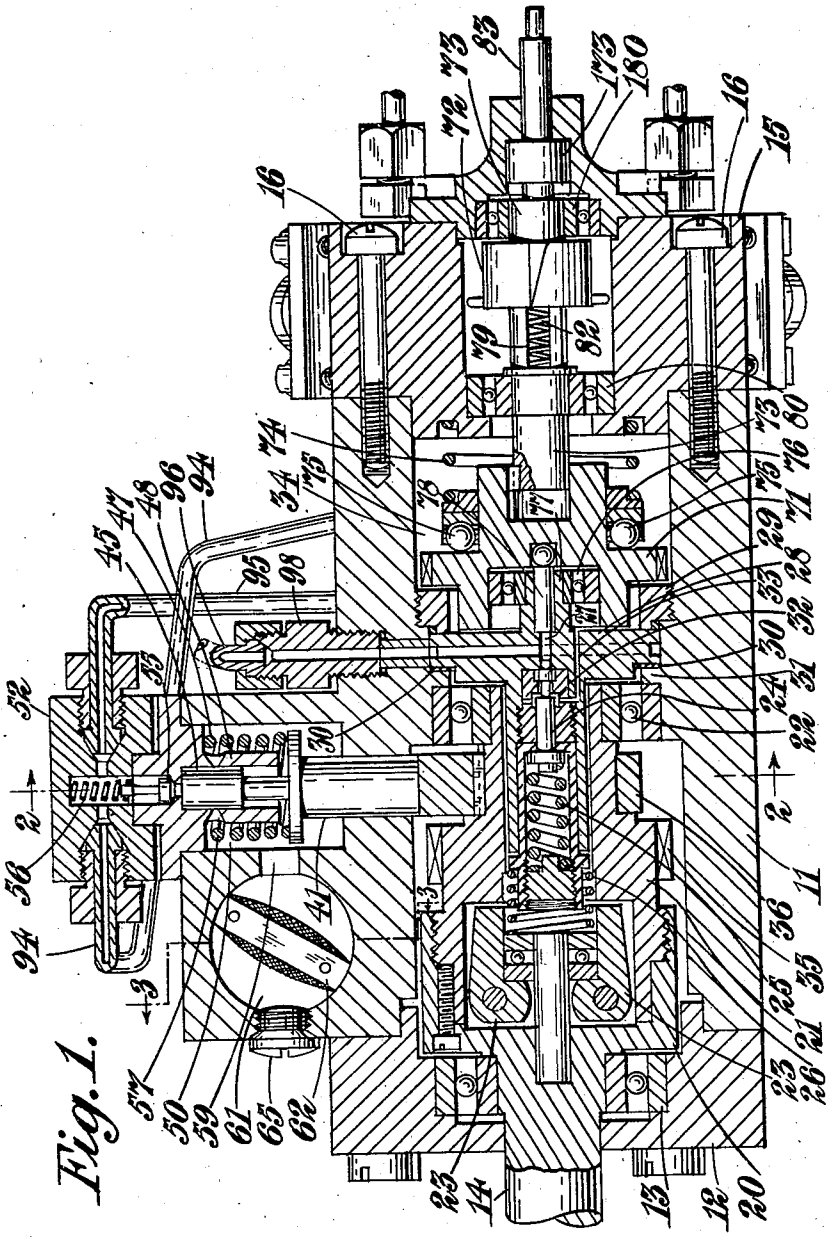


Fig. 1.

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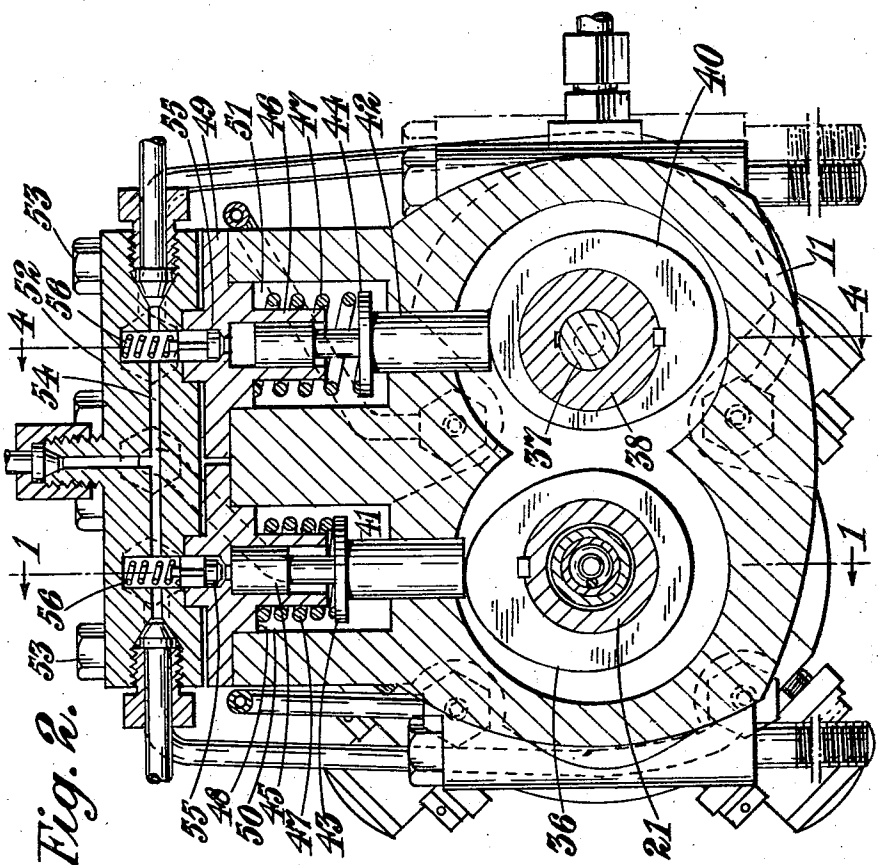


Fig. 2.

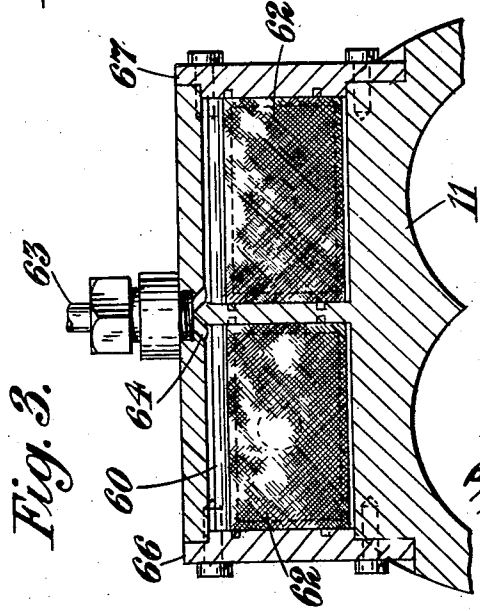


Fig. 3.

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PUMP AND FUEL INJECTION CONTROL DEVICE

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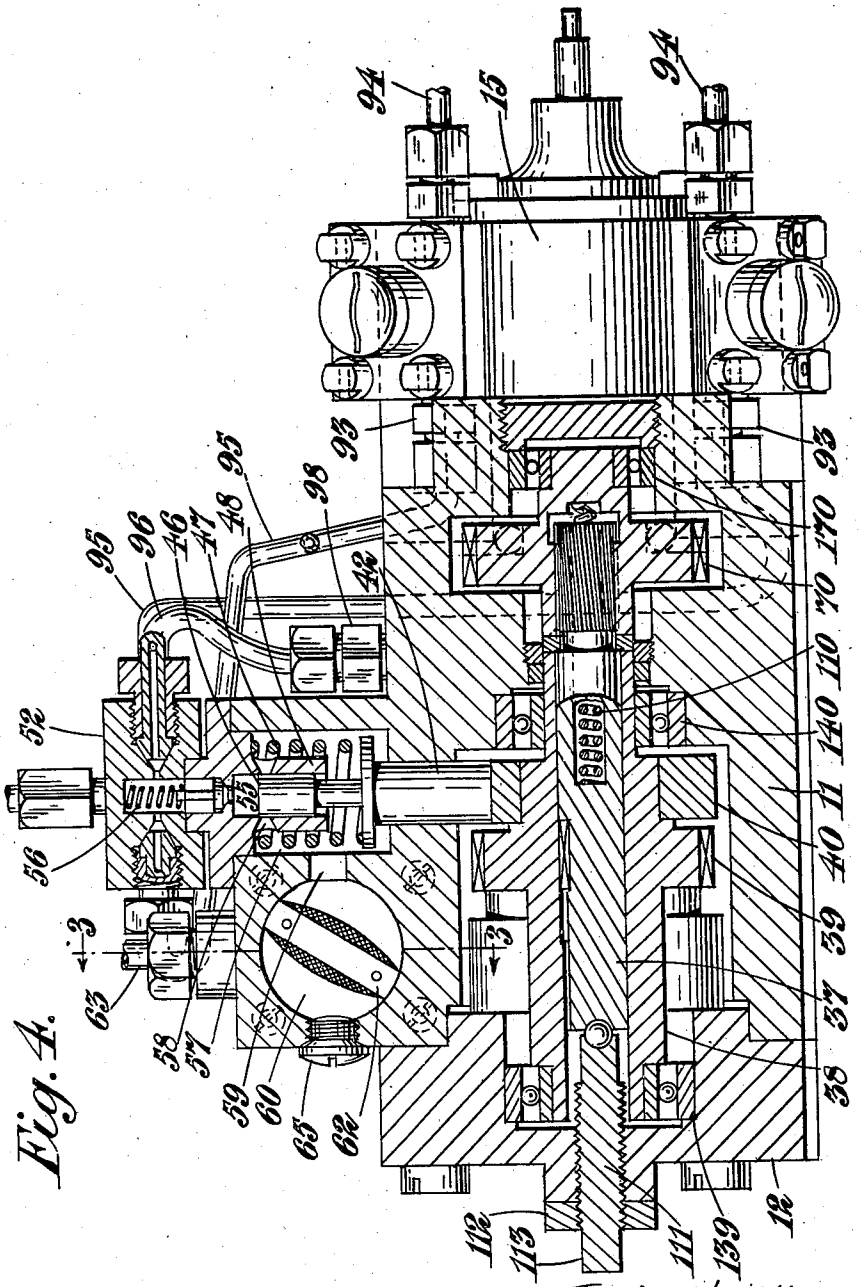


Fig. 4.

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PUMP AND FUEL INJECTION CONTROL DEVICE

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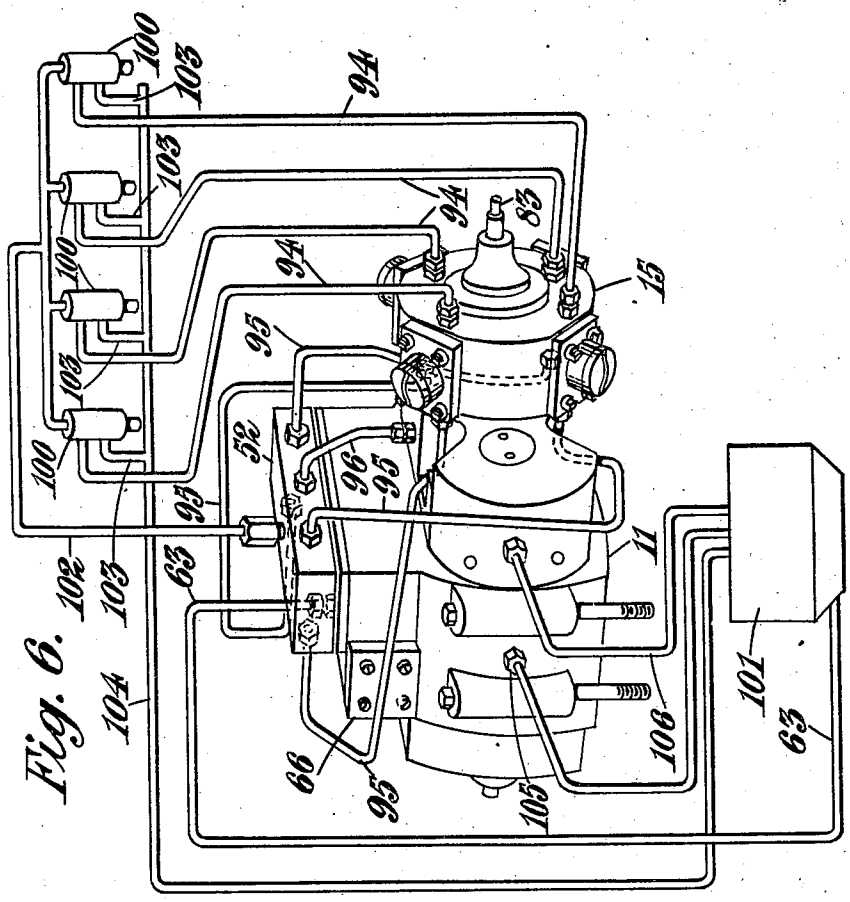


Fig. 6.

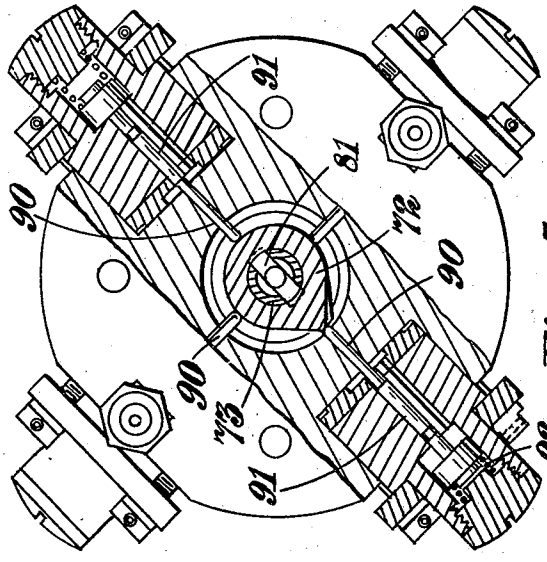


Fig. 5.

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PUMP AND FUEL INJECTION CONTROL DEVICE

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Fig. 7.

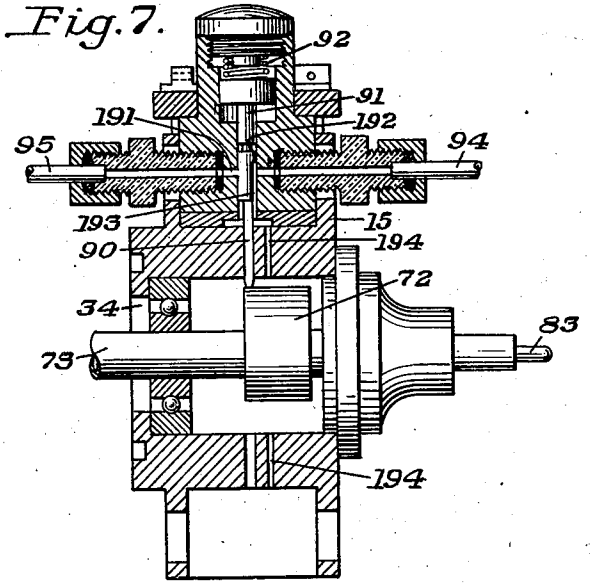
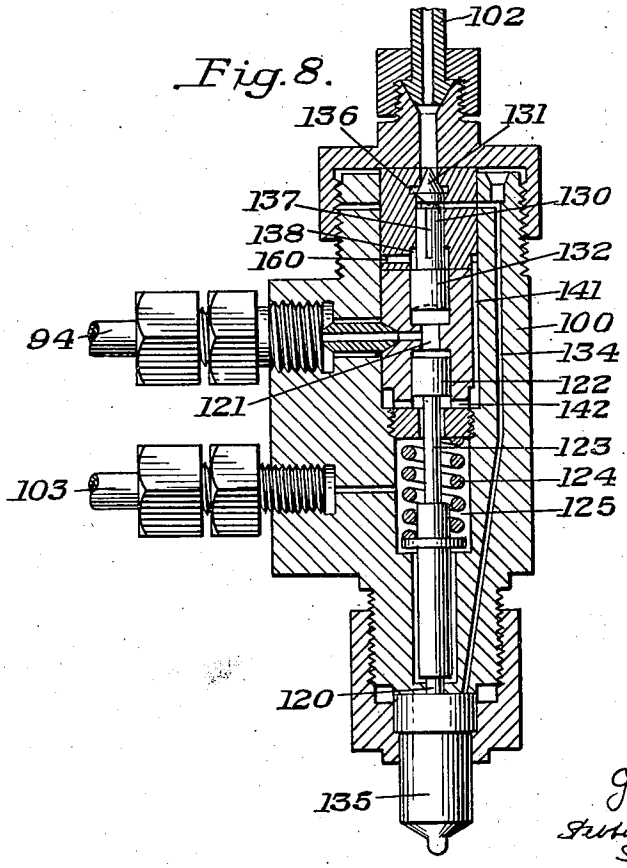


Fig. 8.



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UNITED STATES PATENT OFFICE

2,291,939

PUMP AND FUEL INJECTION CONTROL DEVICE

George Amery, London, England

Application August 15, 1938, Serial No. 225,025
In Great Britain August 25, 1937

10 Claims. (Cl. 123—139)

This invention comprises improvements in or relating to fuel-injection controlling devices for internal-combustion engines.

The present invention relates to a fuel-injection apparatus which in the construction described embodies in a single unit a fuel pump, governor mechanism for controlling the fuel pressure and distributing means for determining the delivery of fuel oil to injector devices upon the engine cylinders.

The present invention comprises (in fuel-injection apparatus for an internal-combustion compression-ignition engine comprising a pump for pumping fuel oil under pressure and a distributor for distributing said fuel oil to injector devices, the arrangement being such that the pressure of the fuel oil increases with increasing engine speed) the provision of automatic means operated by the fuel-oil pressure for advancing the timing of the distributor under increased fuel-oil pressure.

The distributor may comprise mechanically actuated distributor valves, a rotatable axially-slidable intermediate driving member through which the means for actuating the valves is driven, and a piston subject to the pressure of the fuel oil, which piston acts to determine the position of the intermediate driving member, the construction being such that the axial sliding movement of the said driving member serves to advance or retard the position of the actuating means. The actuating means is preferably a cam.

A control chamber may be provided in which the piston for advancing and retarding the distributor operates, together with a relief-valve, for controlling the fuel pressure, which is located in the wall of the control-chamber.

The relief-valve may be governed by a centifugal governor arranged in one unit with the distributor and the driving means therefor. The governor and the distributor may be interconnected by a lay shaft geared to both of them. Moreover, the axially-slidable intermediate driving member for advancing and retarding the distributor may be constituted by one of the gears in the train between the governor and the cam, which gear has helical driving teeth so that the teeth alter the timing upon the aforesaid axial movement.

In a preferred arrangement the governor, the control chamber and the distributor-cam are co-axial with one another, the lay shaft is parallel to them and the axially-slidable intermediate driving member and its piston are co-axial with the distributor-cam.

A fuel pump may be incorporated in the unit and connected directly to the control chamber and distributor to deliver fuel oil under pressure thereto.

The invention further relates to features of the pump which are not in themselves limited to their use in a fuel pump as herein described. To this end the invention comprises in a pump the provision of an inlet passage to the pump, a filter spanning said inlet passage and means whereby part of the liquid drawn into said inlet passage through the filter is displaced backwardly through the filter at each working stroke of the pump for the purpose of keeping the filter clean.

While it would be possible to arrange for the pump plunger itself to effect the said partial return displacement of the fluid being pumped through the filter by holding up the closing of the inlet port of the pump during a part of the return stroke of the pump plunger, it is preferable to use separate means for producing the return flow through the filter. To this end, in one construction of fuel pump according to the invention the pump comprises in combination a pump plunger, an inlet passage thereto, a filter spanning said inlet passage and a plunger-operating ram, of greater diameter than the pump plunger, working in said inlet passage, the arrangement being such that the plunger-operating ram displaces a portion of the fuel in the inlet passage back through the filter during the delivery stroke of the pump plunger.

The following is a description by way of example of one form of fuel-injection apparatus in accordance with the invention, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal section through a fuel supply and distribution unit;

Figure 2 is a transverse section upon the line 2—2 of Figure 1, looking in the direction of the arrows;

Figure 3 is a detail transverse section upon the line 3—3 of Figure 1, looking in the direction of the arrows;

Figure 4 is another longitudinal section in a different plane from Figure 1 as indicated by the line 4—4 in Figure 2;

Figure 5 is an end view of the distributor with the central portion broken away to show the internal construction;

Figure 6 is a diagram of the pipe connections;

Figure 7 is a section through one of the dis-

tributor valves in a plan at right angles to that of Figure 5; and

Figure 8 is a section through one of the injector nozzles.

Like reference characters indicate like parts throughout the drawings.

Referring to Figure 1, the apparatus comprises a casing 11 to which is screwed at one end a cap 12 which forms a housing for a ball bearing 13 supporting a driving shaft 14. At the other end of the casing 11 there is secured by means of screws 16 a distributor casing 15.

The driving shaft 14 has a head 20 which is screwed on to a rotatable casing 21 supported at the end remote from the driving shaft 14 in a ball bearing 22 in the casing 11. Within the casing 21 and rotating therewith are centrifugal governor weights 23 which act on a relief-valve 24 through interposed springs 25, 26 in the same manner as the governor which is more fully described in prior United States patent application Serial No. 117,964, filed December 28, 1936. The head of the relief-valve 22 is subjected to oil pressure in a control-chamber 27 formed in a diaphragm 28 which is co-axial with the governor casing 21 and is held in the casing 11 by a screwed plug 29 which holds the diaphragm against a packing member 30 resting on a shoulder 31 in the casing 11. When the oil pressure in the chamber 27 forces the relief-valve back, against the springs and the action of the governor, past the port 32, the fuel finds an outlet through the drain passage 33 into the chamber 34 in the casing 11 which lies on the right of the diaphragm 28.

Upon the outside of the casing 21 there are cut gear teeth 35 for driving a lay shaft 37 and there is mounted a pump-operating cam 36. The lay shaft 37 is seen in Figure 4 and its relationship to the governor casing 21 is shown in Figure 2.

Referring to Figure 4, the lay shaft 37 is splined within a sleeve 38 which is mounted on ball bearings 139, 140 in the casing 11. The sleeve 38 carries gear teeth 39 which mesh with the gear teeth 35 on the governor casing 21 and thus the sleeve is driven by the governor casing and the lay shaft 37 by the splines on the sleeve. The sleeve 38 also carries a second pump-operating cam 40 and as the sleeve necessarily always rotates with the lay shaft 37, it may be regarded from the point of view of operating the pump as part of the lay shaft.

Referring to Figure 2, the two pump-operating cams 36, 40 each act upon a plunger-operating ram 41, 42 respectively. The rams are made a close fit in guide-bores in the casing 11 and bear upon flanges 43, 44 carried by plungers 45, 46. Two return springs 47 serve to press the plungers and the rams downwardly and maintain contact between the rams and the cams 36, 40.

The plungers 45, 46 work in pump barrels 48, 49 and the pump barrels serve to close the upper ends of inlet chambers 50, 51 which surround the barrels 48, 49 and the upper ends of the rams 41, 42. It will be observed that the plunger-operating rams 41, 42 are larger in diameter than the pump plungers 45, 46. The pump barrels 48, 49 are held down on the casing 11 by a delivery box 52 which is secured in place by set-screws 53. The delivery box 52 contains a pump delivery chamber 54 into which both the pump plungers 45, 46 deliver fuel oil under pressure and from which the oil is taken by various pipe connections hereinafter referred to. In the upper end of each pump barrel is a delivery valve 55 held on its seat by a spring 56.

In Figures 1 and 4 can be seen inlet ports 57, 58 to the pump barrels 48, 49. These ports are uncovered when the pump plungers are in their lowermost position, so as to admit fuel oil to the interior of the pump barrels and are closed by the plungers during their ascent under the influence of the cams 36, 40. The inlet passage for fuel oil to the fuel pump is constituted in part by two filter chambers 60, 61 (Figures 1, 3 and 4) which are connected to the inlet chambers 51 and 50 respectively by ports 59. Each of the filter chambers is spanned by a filter element 62 which is set at an inclination to the horizontal such that the inlet for fuel to the top of the filter chamber, 60 or 61 as the case may be, is above the filter element 62, while the port 59 is below it. Fuel enters through an inlet pipe 63 which has a divided delivery opening 64 into the upper portion of the two filter chambers (Figure 3). Drain plugs 65 are provided for the removal of any accumulated dirt and the filter elements themselves can be removed endwise from the chambers upon the removal of end plates 66, 67 (Figure 3). Before describing the rest of the apparatus it will be convenient to refer to the operation of the pump. It will be observed from Figure 2 that the shape of the cams 36, 40 is such that the delivery stroke takes longer than the suction stroke and by properly shaping the cams it is possible for an almost uniform flow of oil to be secured without any "dead point," as the deliveries of the two barrels overlap.

Owing to the fact that the plunger-operating rams 41, 42 are larger in diameter than the pump plungers 45, 46 and work in the closed inlet chambers 50, 51, a larger quantity of fuel oil is drawn through the filters 62 on each inlet stroke than is required to fill the pump barrels 48, 49. On the delivery stroke of the pump the rams 41, 42 displace this excess fuel oil backwards through the filters 62 and this temporary backward surge of oil tends to displace any dirt which may have collected on the surface of the filter and to allow it to fall into the lower portion of the space above the filter elements, thus preventing the filter elements from becoming clogged. Inspection on removal of the screws 65 can readily be effected to ascertain if any material quantity of sediment has collected, and if so it can either be washed out through the apertures for the screws, or if necessary, the filter elements can be removed afer taking off the end plates 66, 67.

The lay shaft 37 is employed for operating the distributor 15 and to this end it is splined within a gear wheel 70 supported on a ball bearing 170 (Figure 4) which meshes with a gear wheel 71 (Figure 1) which drives the distributor cam 72 through an intermediate shaft 73. The gear wheels 70, 71 are made with helical teeth and the gear wheel 71 is axially movable so that the timing of the distributor-cam 72 can be advanced or retarded by axial movement of the gear wheel 71.

The lay shaft 37 is pressed yieldingly to the left, as viewed in Figure 4, by a spring 110 and is capable of hand-adjustment against the action of the spring by a screwed spindle 111 passing through the end cap 12 and secured by a lock nut 112. The spindle 111 is provided with a square 113 so that it can be set by a key. The splined connection between the lay shaft 37 and the gear wheel 70 is made with helical splines

and therefore endwise movement of the lay shaft 37 will advance or retard the gear wheel 70 relatively to the lay shaft. This provides a limited hand-adjustment for the distributor timing.

Referring to Figure 1, this shows the gear wheel 71 at the extreme left-hand end of its travel where it is held by a spring 74 bearing a ball thrust race 75. The gear wheel 71 is supported so as to be concentric with the distributor and governor axis by means of an internal ball race 76 carried on a cylindrical stem 77 projecting from the diaphragm 28. The gear wheel 71 is made a sliding fit on the outside of this ball race. The stem 77 is bored out to constitute a cylinder within which works a control piston 78 and the cylinder opens directly out of the control chamber 27. The pressure of the fuel oil therefore acts on the piston 78 and if the fuel pressure is sufficient the gear wheel 71 will be forced to the right against the action of the spring 74. It will be recollected that the action of the governor weights 23 is to cause the fuel pressure to increase as the engine speed increases, as more fully described in the aforesaid United States patent application Serial No. 117,964, filed December 28, 1936. Consequently, if the strength of the spring 74 is properly proportioned relatively to the fuel pressure and the size of the piston 78, the gear wheel 71 will occupy various positions under the differing fuel pressures at various engine speeds and the distributor-cam 72 will be advanced as the engine speed increases, owing to the twisting movement imparted to the gear wheel 71, when axial movement occurs, by the helical teeth with which it is provided.

The relief valve 24, as more fully set forth in the said application Serial No. 117,964, ensures a high injection pressure for the first few strokes when starting. This has the effect of advancing the ignition in the present construction, but as it only applies to the first few engine strokes until the engine reaches idling speed, it is in many cases immaterial, if the adjusting screw 111 is not set too far in the direction of advance. If the engine is such as to require an ignition timing which would be too advanced for easy starting in this way, a hand adjustment lever may be provided for temporarily retarding the ignition when starting. This can operate, by suitable controls, the screw 111 which could be provided with a quick thread for the purpose.

The gear wheel 71 is splined to the intermediate shaft 73 so that its angular movements under the influence of the piston 78 are transmitted to the shaft 73 and the shaft 73 has a longitudinal slot 79 which passes right through the shaft from side to side and is traversed by a key on the cam 72 so that angular movements of the shaft 73 are transmitted to the cam 72. The shaft 73 is supported in the distributor casing 15 by ball bearings 80, 180. It will therefore be seen that the gear wheel 71 constitutes an axially-slidable intermediate driving member through which the cam 72 is driven and the position of which is determined by the piston 78.

The shaft 73 can be seen in Figure 5 within the cam 72 and this figure shows the position of the key 81 within the cam which traverses the slot 79 in the shaft 73. A spring 82 (Figure 1) within the shaft 73 bears on the transverse key 81 and tends to force the cam 72 as far as possible to the right, as viewed in Figure 1. A plunger 83 which projects beyond the end of the distributor casing 15 and is co-axial with the shaft 73, enters the casing 15 through a seal 173 and is extended into the end of the shaft 73 and secured to the transverse key 81. By pressure upon the plunger 83 it is therefore possible to move the distributor-cam axially along the shaft 73, the cam being returned, if the pressure is relieved, by the spring 82. The cam is formed so that it can vary the period of injection of fuel oil and the plunger 83 is therefore connected to a hand-control for regulating the power delivered by the engine with which the distributor is intended to be employed.

As shown in Figure 5, the distributor-cam 72 actuates a number of plungers 90 disposed radially around it, which plungers operate piston valves 91 and are forced radially inwards so that the plungers bear against the cam by means of return springs 92. The piston valves 91 serve to open or shut, according to their position, oil passages which run across the distributor parallel with its axis from inlet connections 93 (Figure 4) to outlet connections 94. When a piston valve is lifted by cam 72, its passage is closed and when the valve falls, it opens the passage. This can be best seen in Figure 7 where the passage 191 is shown closed by reason of the fact that the valve is lifted by cam 72 and the groove 192 in the valve 91 is out of register with the passage. One such valve, with inlet and outlet, is appropriated to each of the engine fuel nozzles which is to be controlled. Each of the inlets 93 receives fuel under pressure from the delivery box 52 of the fuel pump by means of appropriate pipe connections, some of which can be seen at 94, 95 in Figures 1 and 4. In these figures can also be seen a pipe connection 96 which leads from the delivery box 52 to the top of the casing 11 through a union 98 to the control-chamber 27.

Referring to Figure 6, this shows in diagrammatic form, the casing 11, distributor 15 and associated parts together with the pipework by which they are connected to a number of fuel-injection nozzles 100 on engine cylinders. The fuel inlet pipe 63 draws from a fuel tank 101. The distributor delivery pipes 94 are connected one to each of the fuel nozzles and a further delivery pipe 102 is connected from the delivery box 52 of the pump directly to each of the fuel nozzles 100. A drain 103 from each of the fuel nozzles is connected to a return pipe 104 which returns any leaking fuel oil back to the tank 101. A drain 106 returns fuel oil from the chamber 34. The oil from the chamber 34 is that which has been allowed to pass by the relief-valve 24. Preferably the drain 106 is provided with a spring-loaded non-return valve of such strength as to retain oil in the chamber 34 at a low pressure of approximately fifty pounds per square inch. The distributor 15, in the position of the piston valves 91 where they are lifted by cam 72, returns fuel oil from the pipes 94 into the chamber 34 by way of the passage formed by the flat 193 on the side of the valve 91 and the passage 194 in the body 15 of the distributor, thus allowing the nozzles 100 to open, whereas when the valves are in their normal position, that is, not lifted by the cam 72, fuel pressure is admitted to pipes 94 and this keeps the nozzles 100 closed. By maintaining a residual pressure, such as is referred to, in this chamber, complete release of pressure from the pipes 94 is prevented and the closing of the injector nozzles 100 is thereby rendered somewhat prompter. A drain 105 carries fuel oil, if any, should such leak into the chamber which contains the gov-

ernor casing 21, back to the fuel tank. It will be understood that the fuel tank 101 can be placed at any desired level and is only illustrated below the other parts in the figure for the sake of convenience in preparing the diagram.

The construction and operation of the fuel nozzles themselves are described in my co-pending patent application No. 225,024 of even date herewith.

Briefly stated, the nozzle comprises in the casing 100 a needle-valve 120 which is connected by a stem 123 to a needle-valve closing-piston 122 working in a valve-closing pressure-chamber 121. Closing pressure on the needle-valve is further exerted by means of a spring 124. Drain pipe 103 is connected to the space 125 in which the spring 124 works. The needle-valve 120 has a seating in a detachable nozzle section 135 which contains the actual nozzle opening through which fuel is injected into the engine cylinder.

The fuel pipe 102 from the pump 52 is connected to the back end of the fuel nozzle and thence by a passage 134 controlled by an auxiliary cut-off valve 130 to the seating of the valve 120. The auxiliary cut-off valve has a head 132 which constitutes a piston and works in the before-mentioned valve-closing pressure-chamber 121. Pressure through the pipe 102 is continuous. When pressure is applied by the distributor through pipe 94, which is whenever the distributor valve 91 are not lifted by the cam 72, this pressure holds the needle-valve 120 on its seat owing to the pressure exerted in the chamber 121 on the piston 122 and also holds the auxiliary cut-off valve 132 on its seat 131, thus cutting off fuel pressure from the passage 134. At the same time the valve 130 opens a drain passage by way of the grooves 136, 137, chamber 138, channel 160, drain passage 141 and apertures 142 to the drain 103.

Immediately the valve 91 is lifted by the cam 72 the pipe 94 is connected by the flat 193 to the chamber 134 as already described, pressure in the valve-closing pressure-chamber 121 is released, the auxiliary cut-off valve 130 is forced open by the pressure in pipe 102, thus closing the drain connection and opening the passage 134 to fuel pressure, and the fuel pressure forces open the valve 120 against the spring 124 thereby commencing injection. When the cam 72 gets past the stem 90 of the valve 91 in the distributor, fuel pressure is restored in the pipe 94 and the valve 120 and auxiliary cut-off valve 130 are forcibly and immediately shut, thus sharply terminating injection.

Instead of using a multiple cylinder pump a single cylinder pump could be used in the apparatus described herein in conjunction with an accumulator device connected to the delivery of the pump for maintaining the pressure between successive strokes of the pump.

Owing to the operation of the plunger-operating rams 41, 42 the volume of free space in the chamber which contains the cams 36, 40 varies during rotation of the cams. If desired this cyclic variation of volume can be used for delivering fuel to the fuel tank 101. For this purpose a suction pipe would be connected to the casing 11, such pipe containing a non-return valve, the suction pipe being connected to a main fuel tank, not shown in the drawings. The pipe 105 would be provided with a non-return valve at the outlet of the casing 11 and would then deliver the fuel oil to the tank 101.

It is also possible to take a connection from the delivery box 52 to a control tap provided with a return connection to the tank 101. If the tap is opened the pump is prevented from building up a pressure in the delivery box 52 and the engine is thereby stopped. When mounted on a motor vehicle, such a tap can be installed on the dashboard of the vehicle. It constitutes an equivalent to the ignition key which is ordinarily provided on an automobile.

I claim:

1. Fuel-injection apparatus for an internal combustion compression-ignition engine, comprising in combination fuel injectors on the engine cylinders, a pump for supplying fuel oil at injection pressure to the injectors, a distributor connected to the pump and the injectors for timing the operation of the injectors, said distributor having valves for controlling the flow of fluid under pressure to open and close the injectors and rotatable mechanical means for actuating said valves, a rotatable driving element, adjustable operative connections therefrom to the said mechanical means which actuate the distribution valves such that the angular relationship between the driving element and the said means may be adjusted, a control cylinder, and a yieldingly supported piston therein subject to fuel-pump pressure operatively connected to the said adjustable operative connections to vary the said angular relationship and so determine the timing of the distributor.

2. Fuel-injection apparatus as claimed in claim 1, wherein a relief valve for controlling the fuel pressure is located in the wall of the control cylinder.

3. Fuel-injection apparatus as claimed in claim 1, wherein a relief valve for controlling the fuel pressure is located in the wall of the control cylinder and a centrifugal governor, driven by the same driving means as the mechanical means for actuating the distribution valves, supports the relief valve against the fuel pressure, so that the fuel pressure is proportional to the square of the engine speed.

4. Fuel-injection apparatus as claimed in claim 1, wherein a relief valve for controlling the fuel pressure is located in the wall of the control cylinder, a centrifugal governor resists opening of the relief valve and the governor and distributor are interconnected by a lay shaft and gears thereon meshing with gears on the governor and distributor shafts.

5. Fuel-injection apparatus as claimed in claim 1, wherein a relief valve for controlling the fuel pressure is located in the wall of the control cylinder, a centrifugal governor resists opening of the relief valve, the governor and distributor are interconnected by a lay shaft having gears thereon meshing with gears on the governor and distributor shafts, said gears including helical toothed gears, one of which is axially slidable, connected to said yieldingly supported piston and constituting the adjustable part of the operative connections from the driving element by which the angular relationship of the distributor thereto is adjusted.

6. Fuel-injection apparatus comprising in combination a centrifugal governor, an operating shaft therefor, a lay shaft, gears connecting the lay shaft with the operating shaft, a distributor casing, an actuating cam therein coaxial with the governor gears connecting said lay shaft with the cam, mechanically actuated valves in said distributor casing actuated by said cam, a control cylinder located between the governor

and the distributor, a fuel pump delivering to said control cylinder, a relief valve in said control cylinder, the opening of which is resisted by said governor, and a piston in said control cylinder coaxial with said distributor cam and so operatively connected thereto as to move the gear connecting the cam with the lay shaft axially under the influence of fuel pressure in the control cylinder, said gear having inclined sliding engagement with one of the members through which rotation is transmitted so as to advance said cam during said axial movement as fuel pressure increases.

7. Fuel injection apparatus as claimed in claim 6, wherein a pump-operating cam is provided upon the governor shaft and the pump is located so as to be actuated thereby.

8. Fuel injection apparatus as claimed in claim 6, wherein a pump-operating cam is provided upon the lay shaft and the pump is located so as to be actuated thereby.

9. Fuel injection apparatus as claimed in claim 6, wherein pump-operating cams are provided, one upon the governor shaft and one upon the lay shaft and the pump is a dual barrel pump operated as to one barrel by the cam upon the governor shaft and as to the other barrel by the cam upon the lay shaft.

10. Fuel-injection apparatus as claimed in claim 6, wherein hand-operated means are provided connected to the lay shaft for additionally advancing and retarding the distributor relatively to the operating shaft.

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