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FUEL INJECTION PUMP FOR INTERNAL-COMBUSTION ENGINES

Filed May 12, 1948 2 Sheets-Sheet 1

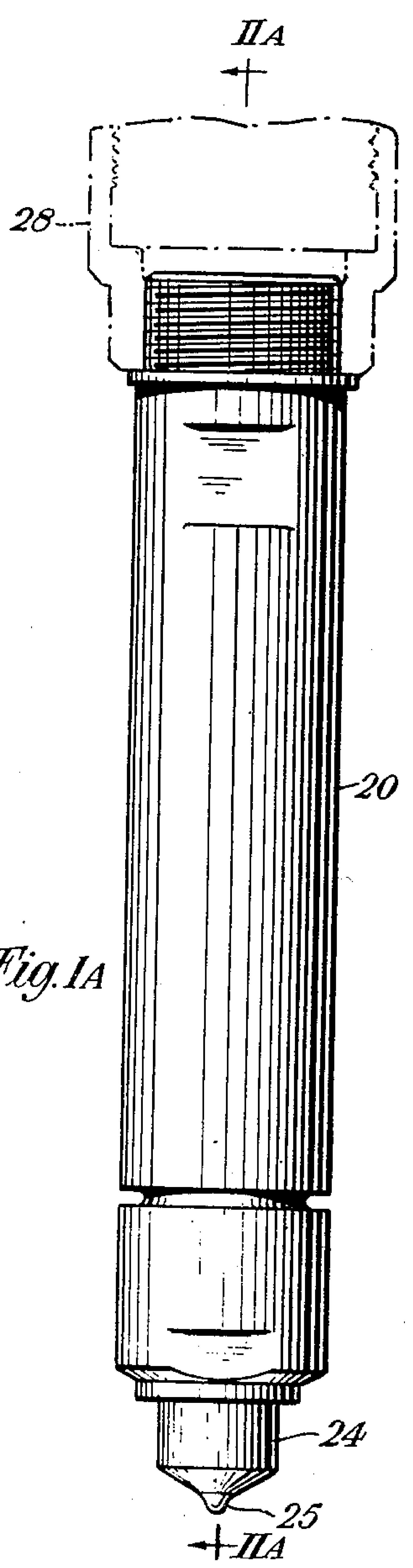

Fig. 1A

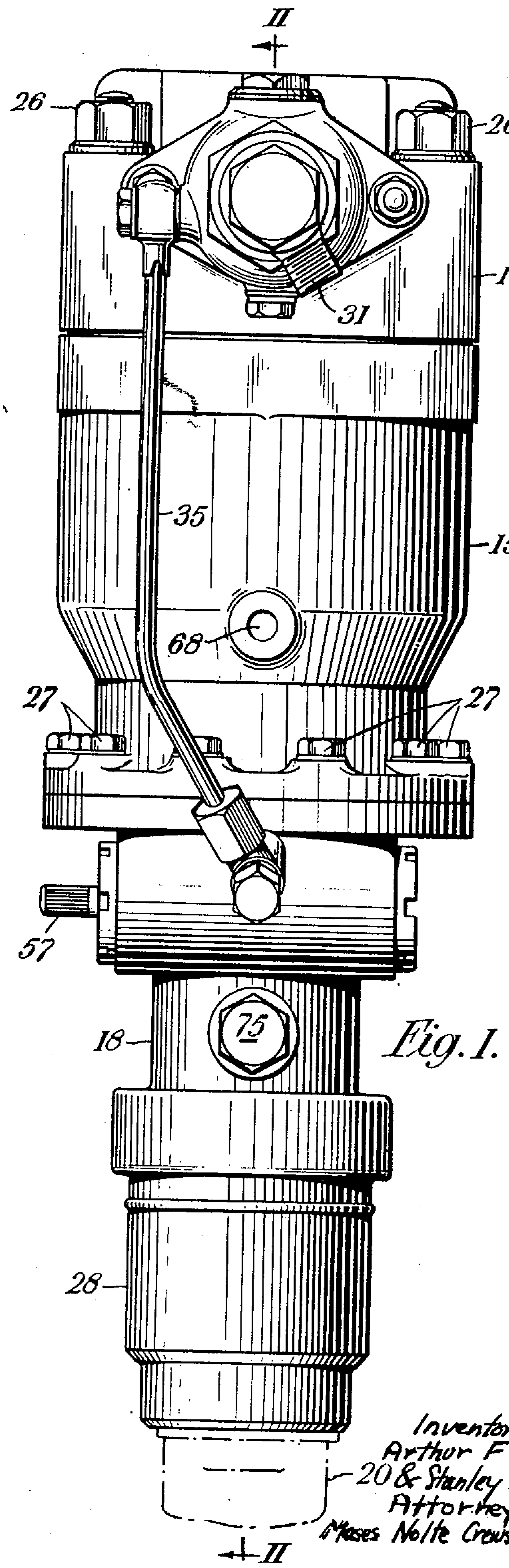

Fig. 1.

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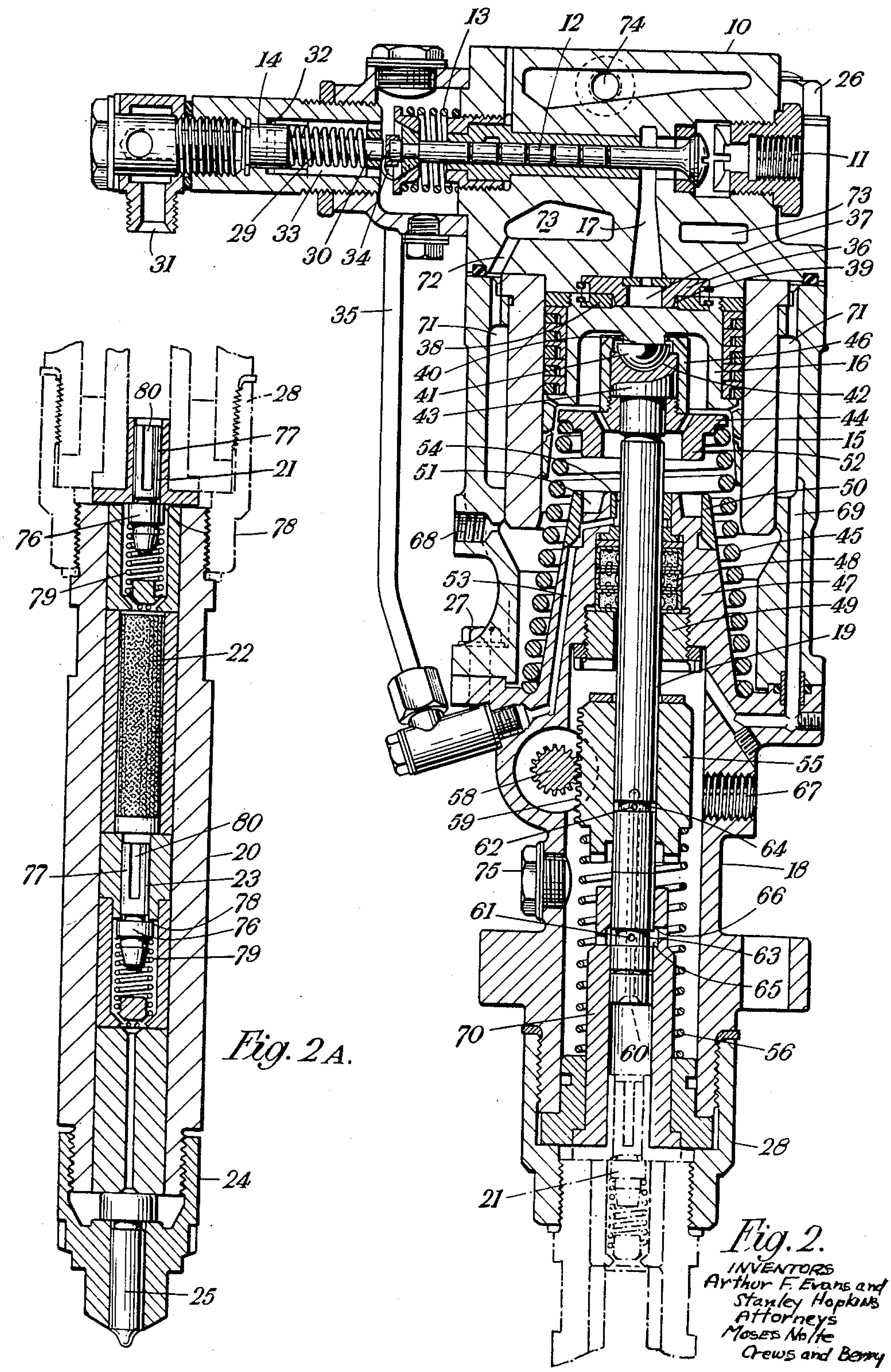

Fig. 2A.

Fig. 2.

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FUEL INJECTION PUMP FOR INTERNAL-COMBUSTION ENGINES

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4 Claims. (Cl. 103—50)

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This invention relates to a fuel injection pump for injecting fuel into the cylinder of an internal combustion engine of the type comprising an injection plunger operated, through the agency of a servo piston connected to the injection plunger, by air pressure derived from the engine cylinder, the servo piston executing a forward stroke, to cause the injection plunger to deliver fuel to the engine, under the action of the air pressure and being returned by a return spring.

According to the invention the face of the servo piston exposed to the air pressure and the cooperating end wall of the servo cylinder are formed with complementary stepped parts so arranged that, at the start of the forward stroke of the servo piston the air pressure acts on part only of the area of the servo piston, so that initial movement of the servo piston is slow, the air pressure acting on the full area of the servo piston only after the latter has moved forward a distance determined by the configuration of the stepped faces of the piston and cylinder.

The provision of these complementary stepped parts serves to delay the injection of the fuel and, in the case where the servo piston is permanently exposed to the air pressure, they will act as the timing device for determining the point in the engine stroke at which injection will commence. In the case of larger engines, where an air timing valve is provided for exposing the servo piston to the air pressure in the cylinder at an appropriate point in the engine stroke, the complementary stepped parts will act as a safety device to prevent serious premature injection in case the air timing valve should stick in the open position.

The complementary stepped portions serve to trap air during the return stroke of the servo piston, and thus constitute a dashpot on the return stroke as well as a safety device on the forward stroke.

Further features of novelty, to be described in detail below, are:

(*a*) the provision of a dashpot or dashpots for retarding the injection plunger towards the end of its delivery stroke,

(*b*) the provision of articulation between the servo piston and injection plunger,

(*c*) a hydraulic timing gear for operating an air timing valve, which timing gear also serves to lubricate the servo piston,

(*d*) a fuel oil circuit which serves to cool the working parts.

In the pump about to be described in detail, the injection plunger is a solid plunger operating

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in a sleeve drilled with holes for the admission of fuel to the space in front of the plunger. It is to be understood, however, that in suitable cases the injection plunger may be of annular form and mounted to slide on a fixed piston.

One form of fuel injection pump according to the invention will now be described in detail, by way of example, with reference to the accompanying drawings, in which:

Figs. 1 and 1A, taken together, constitute a front elevation of the injection pump, the injector shown in Fig. 1A fitting beneath the part of the apparatus shown in Fig. 1 as indicated in chain-dotted lines at the bottom of Fig. 1 and at the top of Fig. 1A, and

Figs. 2 and 2A are respectively longitudinal sections taken on the line II—II in Fig. 1, and on the line IIA—IIA in Fig. 1A.

The injection pump is constituted by a unit arranged to fit in a hole in the top of the engine cylinder. The unit (see in particular Figs. 2 and 2A) comprises the following main parts, which adjoin one another, in the order recited, starting from the top:

(i) A valve casing 10 with an air inlet 11 for connection to the engine cylinder and containing a horizontally movable air timing valve 12 normally held closed by a spring 13 but associated with a servo plunger 14 for opening it.

(ii) A vertical servo cylinder 15 containing a main servo piston 16 and communicating with the valve casing 10 by a passage 17 controlled by the air timing valve 12.

(iii) A vertical pump chamber 18 containing the injection plunger 19, and the fuel inlet and fuel delivery control means, the injection plunger projecting at its upper end into the servo cylinder 15 and being connected to the main servo piston 16.

(iv) A vertical injector body 20, connected to the pump chamber 18 and containing a delivery valve 21, a filter 22 and a check valve 23.

(v) A cap 24, containing the jet 25, and screwed to the lower end of the injector body 20.

The valve casing 10 is secured to the servo cylinder 15 by nut and bolt connections 26 (Fig. 1), and the servo cylinder 15 is connected to the pump chamber 18 by bolts 27. The injector body 20 is connected to the pump chamber 18 by a thimble 28 having an internal screw thread engaging a screw thread on the lower end of the pump chamber 18 and an external screw thread engaging a screw thread at the top of the injector body 20.

The function of the air timing valve 12 is to admit to the main servo piston compressed air from the engine cylinder, at pressures from four to five hundred pounds per sq. in., as and when required. The first condition is that the valve 12 should open rapidly in order that full pressure should be available when the piston moves. The timing of this valve 12 relatively to the engine stroke must be correct and this timing should be adjustable.

The air timing valve 12 could be operated mechanically, but in the pump under description it is operated hydraulically, by means of the servo plunger 14, which is in alignment with the valve stem and at the end thereof remote from its head. A spring 29 normally maintains the end 30 of the servo plunger clear of the stem of valve 12.

On the engine cam shaft is arranged a cam with a suitable phase adjustment and this operates a spring loaded plunger which delivers oil to a delivery pipe. A tappet lever and roller are interposed between the cam and the plunger and this lever has an adjustable fulcrum that enables fine phase adjustment to be accomplished. This "displacer," as it may be considered, is supplied with lubricating oil from the engine circuit via a filter. The displacer is arranged with a considerable delivery excess beyond the actual bore and stroke requirements of the servo plunger associated with the air timing valve.

The displacer is not illustrated, but the delivery line communicates with an inlet 31 in the valve chamber 10, and the displacer plunger periodically develops a pressure wave in the oil in the delivery line, and thereby effects movement of the servo plunger 14 to open the air timing valve 14. The required lift of the air timing valve 12 will be accomplished some time before the pump plunger 19 has finished its delivery stroke but at a designed point, where sufficient lift has been given to the air timing valve 12, the servo plunger 14 uncovers a spill port by reason of its left hand end (Fig. 2) passing to the right of the flange 32 of the chamber 33, and the remainder of the delivery enters the servo plunger chamber 33. It will be realised that while the motion of the servo plunger has been arrested, it cannot retract because of the oil pressure acting on its left hand end face. Therefore this arrangement assures a constant motion to the air timing valve.

The excess oil entering the servo plunger chamber 33 accumulates until its normal level makes contact with the air timing valve spring 13 and by this means is splashed on to the stem of the valve 12 and thereby provides adequate lubrication for this valve which is never at a very high temperature.

As the oil enters this chamber the pressure will rise and the surplus oil, plus any air that may leak through the air valve stem, will pass, via a port 34, to a connection 35 that leads to the vicinity of the main dashpot described later.

When the air timing valve 12 opens, compressed air from the cylinder is admitted from the inlet 11 to the passage 17 which leads to, and is in axial alignment with, the servo cylinder 15. On the upper end wall of the servo cylinder is fixed a spigot 36, having a central bore 37 registering with the air passage 17. On the adjoining upper face of the servo piston 16 is mounted a socket 38 which, when the servo piston has completed its return stroke, fits over the spigot 36. Initially therefore the air pressure is applied only to an area of the servo piston equal to the area of the bore 37 in the spigot 36. As soon however as the servo piston has moved forward sufficiently to

clear the socket 38 from the spigot 36, the air pressure is applied to the full area of the servo piston and rapidly accelerates it. On the return stroke of the servo piston, air is trapped as the socket 38 moves over the spigot 36 to act as a dash-pot and cushion the return stroke. The outer wall 39 of the spigot 36 is given a slight taper, converging in a downward direction, to enable the air compressed in the space surrounding the spigot to escape gradually, through the space between the socket 38 and spigot 36, into the bore 37 of the spigot. The moment in the forward stroke of the servo piston at which it will receive full air pressure is influenced by the amount of taper of the spigot, as the provision of a taper will allow air pressure to leak past on the forward stroke and gradually build up behind the parts of the servo piston outside the socket. If therefore the taper is sufficient, full air pressure will develop over the servo piston before the socket is entirely clear of the spigot.

The lower face of the servo piston has a central projection 40 having a flat end which rests on the flat surface of a hemispherical ball member 41, the curved face of which rests in a correspondingly shaped socket 42 in the upper end of the injection plunger 19. This upper end has an enlarged shoulder 43, against the lower face of which fits a spring plate 44 by which the pressure of a return spring 45 is applied to the injection plunger 19 and servo piston 16. A cap nut 46 is screwed to the spring plate 44, and a small clearance is left between the head of the cap nut and the flat upper surface of the ball member 41.

This connection provides a small degree of articulation between the servo piston 16 and injection plunger 19, which accommodates for any small inaccuracies in alignment between them, since the servo piston 16 can float on the plunger 19, while the flat face of the ball member 41 ensures axial loading and a surface contact with the projection 40 on the servo piston.

Into the lower end of the servo cylinder projects a gland housing 47, which is constituted by an upward extension of the pump chamber 18 and forms the lower abutment for the return spring 45. Inside the gland housing 47 are a gland 48 and a steady bush 49 for the injection plunger. The upper end of the gland housing 47 is of reduced external diameter, and surrounding this reduced portion is a steel ring 50, the space between the ring and the reduced portion forming an annular groove 51 into which an annular piston 52, provided on the undersurface of the spring plate 44, moves on the forward stroke of the injection plunger 19. These cooperate to form a dashpot for decelerating the injection plunger 19 at the conclusion of its forward stroke. This is necessary because, at conditions below full throttle, a spill port is opened, as later described, to terminate the injection. Without the dashpot, the servo piston and injection plunger would be accelerated to a dangerous degree by the continued application of air pressure after the spill port has opened. A secondary dashpot may, also as described later, be provided at the lower end of the injection plunger. The main dashpot is preferably arranged to give a progressively increasing resistance to movement of the parts during the injection stroke by making the annular groove 51 of tapering form so that its width decreases gradually from top to bottom.

The excess lubricating oil, fed as already described from the servo plunger 14 of the air timing valve through the connection 35 to the vicinity of the main dashpot, passes up through a passage 53 in the gland housing 47, lubricates the gland 48 and passes thence through a passage 54 into the annular groove 51 of the dashpot. From here it is splashed into the servo cylinder and distributed by the return spring over the skirt of the servo piston. The lubricating oil leaves the system through an outlet 68.

The pump chamber carries at its lower end a pump sleeve 70 within which the injection plunger 19 fits, the sleeve being held in position by the thimble 28. Slidably mounted on the injection plunger 19 at the upper end of the pump body 18 is a delivery control muff 55, which is urged upwards by a spring 56 mounted in compression with the pump chamber, but which can be moved downwardly against the action of the spring by rotation, by means of a finger grip 57 (Fig. 1), of a toothed throttle control wheel 58 (Fig. 2) which engages rack teeth 59 on the control muff 55.

The injection plunger has, in its lower end, an axial bore 60 open to the forward or lower end of the plunger and communicating, via radial throughgoing holes 61, 62 with a pair of annular grooves 63, 64 in the outer surface of the plunger. In the retracted position of the plunger, the front groove 63 is in register with an internal groove 65 in the sleeve 70, which communicates by a port 66 with the interior of the pump body 18. Fuel oil is fed under pressure to a pump body as later described, through an inlet 67, so that the axial bore 60 and the portion of the sleeve 70 in advance of the plunger 19 are filled with oil.

After a short initial forward movement of the plunger, the front radial hole 61 is brought out of register with the groove 65 in the sleeve 70, so preventing oil displaced from in front of the plunger from flowing through the bore. At this point injection commences, the oil pressure in front of the plunger causing the injector valves 21, 23 to open. During this initial movement of the plunger, the rear annular groove 64 in the plunger is blanked off by the control muff 55 and injection will continue until the rear radial hole 62 clears the forward end of the control muff 55, whereupon oil can flow through the bore 60 in the plunger and back to the pump body through the rear radial hole 62, which acts as a spill port. Injection thus terminates at a point in the forward stroke of the plunger determined by the position of the control muff 55, the remainder of the forward stroke of the plunger being idle since the injector valves 21, 23 close immediately the rear radial hole 62 is opened. It is during this idle portion of the stroke that the above-mentioned dashpot is effective. The initial idle portion of the stroke, i. e. that portion preceding the closing of the front radial hole 61, allows the plunger to attain a high momentum prior to opening of the injector valves, thus ensuring that the charge of fuel will be injected into the cylinder at high speed and under high pressure.

The fuel oil should be delivered to the pump from a priming circuit. Oil is taken from the day running tank by means of a small motor-driven low pressure oil pump (a suds pump), passed through a suitable fine filter and delivered to a common line serving all the cylinders of the engine and connected to the inlets 67 of all the injection pumps. At the terminal of the line is a spring loaded escape valve loaded to about 10 lb. sq. in. so as to ensure that this pressure is maintained in the system. Each pump has its tapping from this main and the oil enters the pump at the inlet 67 in the pump chamber and therefore quite high up. Any solid matter that might be suspended in the oil will fall to the bottom out of the way and any free air that may be contained or which may be liberated will immediately rise to the top of the chamber out of the way of the inlet ports to the pump itself. This oil is at a pressure of ten pounds and therefore its velocity will be high and the surplus fuel oil and any free air will be carried over through a passage 69 into a jacket 71 surrounding the servo cylinder and then through a passage 72 into an annular cavity 73 in the head of the servo cylinder to an outlet 74 whence it is collected and delivered back to the day tank. This circulation of the oil serves to cool the working parts of the pump.

It will be understood that the capacity of the priming pump will be at least three times the actual fuel requirements of the engine.

The pump chamber is provided with an inspection plug 75.

The injector body 20 contains, as already mentioned, the injection valve 21, filter 22 and delivery valve 23, these being mounted in tandem in the body in that order, injection valve 21 uppermost. The two valves 21, 23 are of identical construction each comprising a valve head 76, and a valve thimble 77 projecting into the bore of a valve seating 78 against which the head 76 is normally held closed by a spring 79. The valve thimble 77 is in the form of a cylinder open at its upper end and having grooves 80 milled in its outer surface, these groves 80 extending from the upper end of the thimble 77 to near the point where it terminates in the valve head 76.

The grooves 80 in the valve thimbles are initially full of oil and as soon as the oil pressure on the delivery stroke of the plunger 19 has lifted either valve sufficiently to bring the ends of the grooves 80 in the thimble beyond the seating 78 oil will flow through the valve. As soon as the spill port 62 opens, the springs 79 of the valves 21, 23 will return them to their seatings, the cut-off being effected immediately the grooves 80 in the valve thimbles are again masked by their seatings 78.

The above-mentioned secondary dashpot, if provided, is constituted by a spigot (not shown) on the lower end of the injection plunger 19 which passes into the thimble 77 of the injection valve 21 towards the end of the delivery stroke of the plunger. This arrangement will allow a certain amount of oil to be trapped, after the injection valve 21 has closed, in the annulus formed between the spigot and the bore in the thimble, an escape being arranged by making the thimble slightly taper in bore. The oil that escapes through this annulus will pass up the central bore 60 of the plunger to the spill port 62.

What we claim as our invention and desire to secure by Letters Patent is:

1. A fuel injection pump, comprising an injection plunger, a servo piston connected to the injection plunger, a servo cylinder housing the servo piston, a reciprocable air timing valve for periodically admitting to the servo cylinder air pressure to cause forward movement of the servo piston to effect a delivery stroke of the injection plunger, a responsive piston aligned with the air timing valve, a chamber housing the responsive piston and having an inlet for pressure oil and a spill port, a spring for normally holding said

air timing valve closed, said responsive piston being movable under oil pressure supplied thereto through said inlet to open said air timing valve and, on continued movement under said oil pressure to open said spill port, a gland housing surrounding said injection plunger and having therein an annular groove, an annular piston fitted to the injection plunger and arranged, near the end of the delivery stroke thereof to enter said annular groove to decelerate the injection plunger, a return spring, mounted in compression between said gland housing and said annular piston for returning the injection plunger after the conclusion of the delivery stroke and a conduit for conveying oil from said spill port to a passage in said gland housing communicating with the annular groove therein, the oil fed to said annular groove from said spill port serving to lubricate the servo piston.

2. A fuel injection pump comprising an injection plunger, a servo piston connected to the injection plunger, a servo cylinder housing the servo piston, a jacket surrounding the servo cylinder, an air timing valve mounted to reciprocate in the head of said servo cylinder in a direction transverse to the direction of movement of said servo piston and thereby to periodically admit air under pressure to the servo cylinder to cause forward movement of the servo piston to effect a delivery stroke of the injection plunger, an annular cavity in the head of said servo cylinder surrounding said air timing valve, a fuel chamber surrounding said injection plunger, an inlet for supplying fuel under pressure to said fuel chamber, a variable cut-off gear for determining the quantity of fuel which will be delivered by the injection plunger from said fuel chamber at each delivery stroke of said plunger, conduits for conducting fuel oil from said fuel chamber to said jacket and thence to said cavity to cool said servo-piston and said air timing valve, and a return spring for returning the injection plunger and servo piston after the conclusion of the delivery stroke.

3. A fuel injection pump, comprising an injection plunger, a servo piston connected to the injection plunger, a servo cylinder housing the servo piston, an air-timing valve mounted to reciprocate from an open to a closed position and adapted, when open, to admit pressure air to the servo cylinder to cause forward movement of the servo piston to effect a delivery stroke of

the injection plunger, a return spring for returning said injection plunger and servo piston at the conclusion of the delivery stroke, a further spring for normally holding said air-timing valve in closed position, a responsive piston aligned with said air timing valve, a chamber housing said responsive piston and having an inlet for pressure oil and a spill port, said responsive piston being movable under oil pressure supplied thereto through said inlet to open said air timing valve, and, on continued movement under said oil pressure, to open said spill port, and a conduit communicating with said spill port for conveying excess oil to the servo piston to lubricate the same.

4. A fuel injection pump, comprising an injection plunger, a servo piston connected to the injection plunger, a servo cylinder housing the servo piston, an air timing valve mounted to reciprocate from an open to a closed position and adapted, when open, to admit pressure air to the servo cylinder to cause forward movement of the servo piston to effect a delivery stroke of the injection plunger, a return spring for returning said injection plunger and servo piston at the conclusion of the delivery stroke, a further spring for normally holding said air timing valve in closed position, a responsive piston aligned with said air timing valve, and a chamber housing said responsive piston and having an inlet for pressure oil and a spill port, said responsive piston being movable under oil pressure supplied thereto through said inlet to open said air timing valve, and, on continued movement under said oil pressure, to open said spill port.

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