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FUEL INJECTION PUMP

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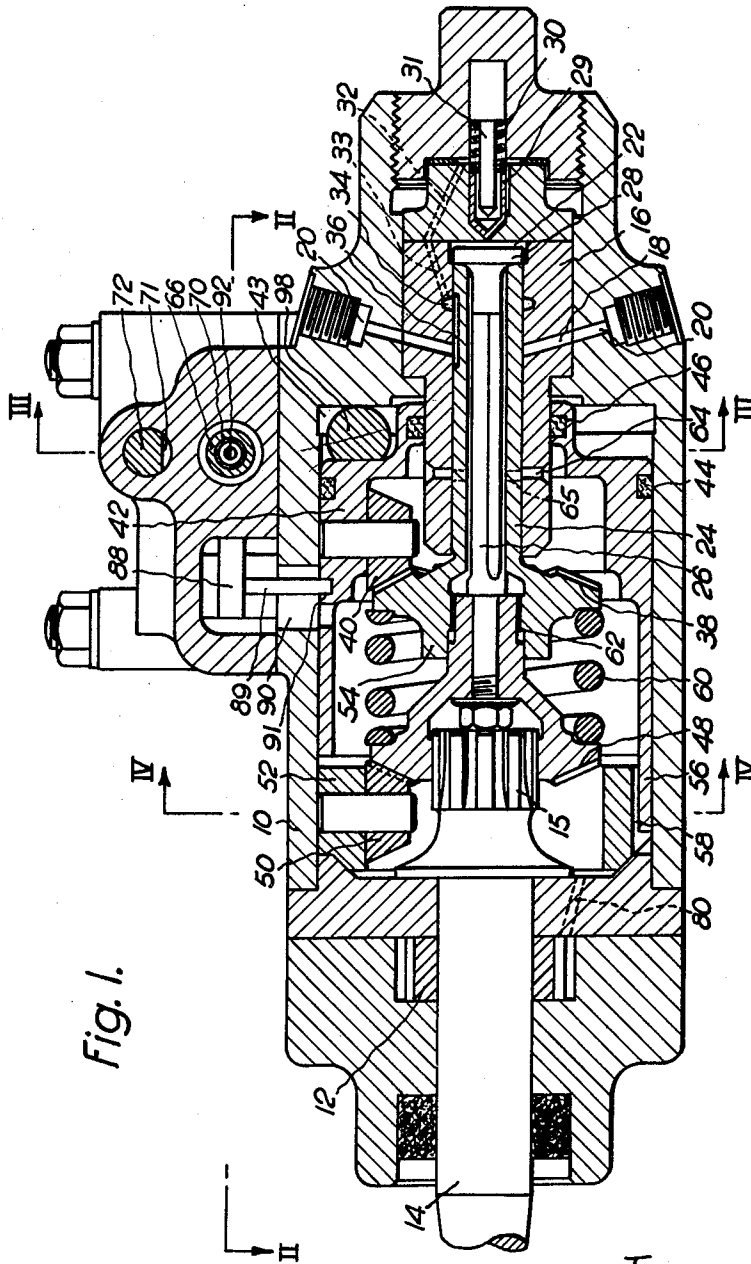


Fig. 1.

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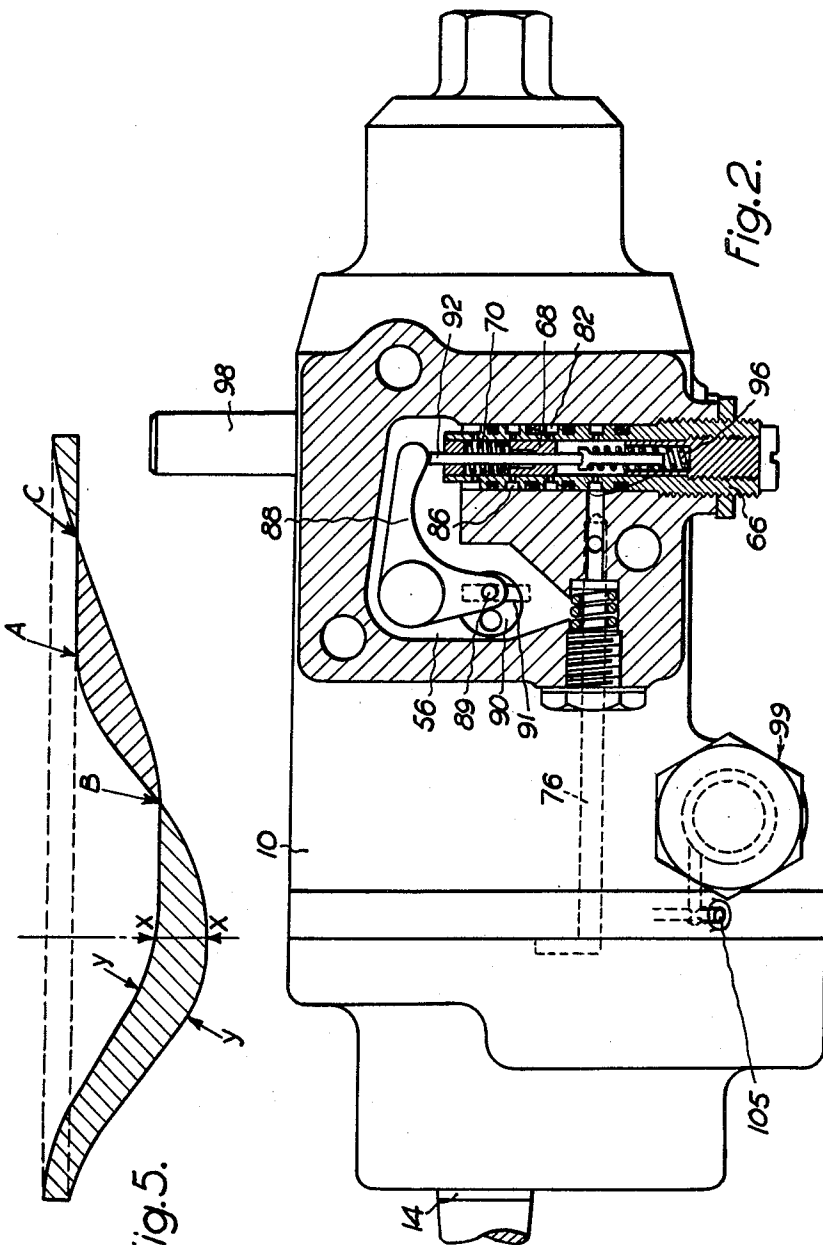
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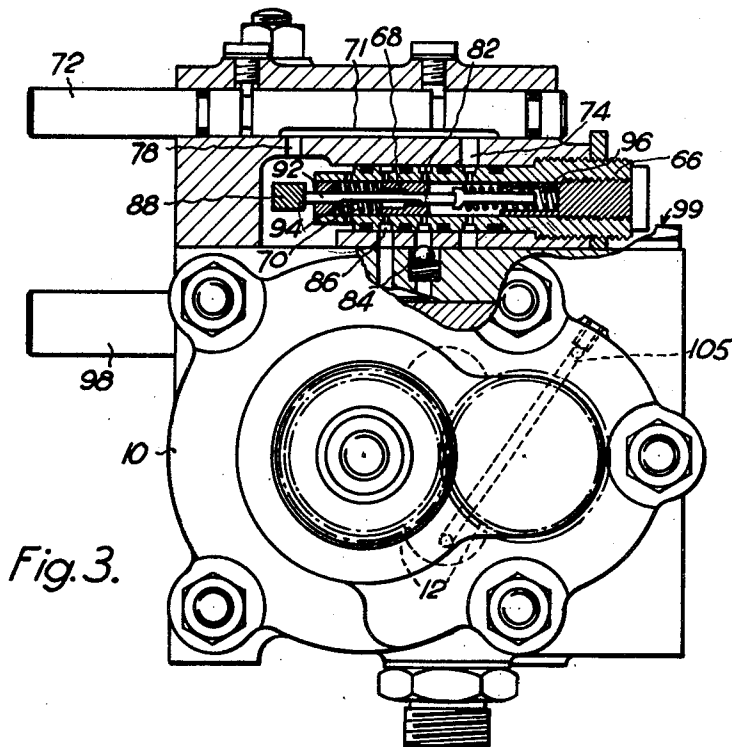
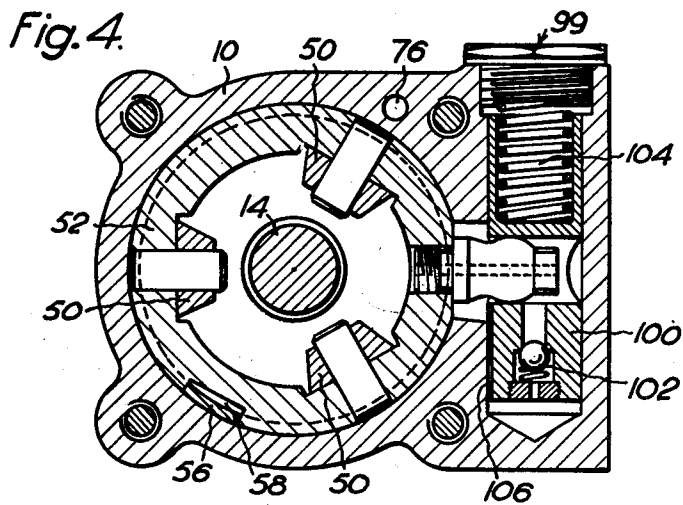


Fig. 3.



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FUEL INJECTION PUMP

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10 Claims. (Cl. 123—139)

The invention relates to pumps for injecting fuel into the cylinders of internal combustion engines.

With a view to obtaining a rapid start and an abrupt ending of injection a pumping head is made to seat on the end of a tubular plunger to form a controllable valve. Both pumping head and plunger are reciprocated by cam means so that they move together with the valve closed during the pumping stroke separating at the end of it and coming together before the beginning of it. The pumping stroke is only a part of the stroke in the pumping direction, it should terminate while the pumping head is still moving quickly.

Conveniently, the pumping head forms part of a poppet valve of which the spindle extends through the bore of the plunger leaving space around the spindle through which fuel is supplied, and a spring interposed between the spindle and the plunger tends to close the valve formed between them. They are rotated together and each carries a cam or cam follower co-operating with a cam follower or cam normally fixed in the pump casing.

For use with a multi-cylinder engine the rotation of the plunger, besides bringing about its reciprocation, enables it to serve also as a distributor, by bringing a slot in its surface, to which fuel passes from the pumping space by way of a delivery valve, into register successively with ports communicating with the injection nozzles of several cylinders.

Control of the fuel supply is effected by relative adjustment of the cam mechanisms of the plunger and pumping head, either axially or in the circumferential direction, and may be effected automatically.

An example of construction of the invention is illustrated by the accompanying drawings, in which:

FIGURE 1 is an axial section through a pump;

FIGURE 2 is a plan view showing a section through the governor on the line II—II of FIGURE 1;

FIGURE 3 is a vertical part-section through the governor and control spindle on the line III—III of FIGURE 1;

FIGURE 4 is a section on the line IV—IV of FIGURE 1, showing the automatic advance unit; and

FIGURE 5 shows the relative motions of the cam rings during one cycle of operation.

FIGURE 1 shows a pump contained within a casing 10 which is kept filled with fuel supplied from a feed pump 12 situated in the end of the casing 10 containing the driving spindle 14. There is inset in the casing a pump cylinder 16 having passages 18 registering with passages 20 in the casing wall connected to the several injectors of a multi-cylinder engine (not shown). The pumping end 22 of the cylinder bore is slightly increased in diameter.

The plunger-rotor 24 is in the form of a sleeve, carried in the bore of which is a spindle 26 having a head 28 at the pumping end. The spindle 26 and its head 28 form a poppet valve. The head 28 of the spindle 26 carries the hydraulic pumping load. The backface of the pumping head 28 seats on the end of the plunger-rotor 24 to form a controllable valve. To permit passage of fuel to this point, there is space between the spindle 26 and the bore of the rotor 24, in this case in the form of three flats on the spindle.

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Fuel pumped by the head 28 lifts a hollow delivery valve 29 forcing it back against the pressure of a spring 30 into engagement with an internal stop 31, to allow the fuel to pass by passages 32, 33 (shown in broken lines in FIGURE 1) to an annular groove 34 in the bore of the cylinder 16. This annular groove is always in communication with a groove 36 cut in the face of the plunger-rotor 24. As the rotor rotates it communicates successively with the passages 18. The inner end of the plunger-rotor carries a ring of cams 38, six in number, for a six-cylinder engine. The cams are formed upon a generally conical surface of the ring 38, and this surface can abut upon a conical roller 40 carried in a movable sleeve 42 which is a close fit in the casing 10. The sleeve 42 carries two sealing rings 44 and 46 which make a fuel tight seal within the bore of the body and between the sleeve and the cylinder 16. The axial position of the sleeve 42 is controlled by the flow of fuel into, or from, the space 43 between it and the casing 10.

The end of the central spindle 26 remote from the pumping head 28 carries a similar ring of cams 48 engaging with rollers 50, in this case three equally spaced and carried in a roller carrier 52 (see FIGURE 4). The cam ring 38 has projections 54 which engage with flats on the cam ring 48. This forms a dog drive between the two cam rings 38 and 48.

A tongue 56 on the sleeve 42 engages with slot 58 in the ring 52 allowing relative axial, but not circumferential, movement.

The cam ring 48 is splined in its bore to engage with splines 15 on the driving spindle 14. Relative axial movement between the cam ring 48 and the driving splines 15 takes place as the assembly rotates. Between the two cam rings is situated a spring 60 which is compressed to load the contact between the pumping head 28 and the end of the rotor 24.

The pumping cam ring 48 is spigotted into the return cam ring 38 and a small leakage is allowed, as at 62, from the space between the spindle 26 and the rotor 24. A further set of holes 64 allows communication from the inside of the casing 10 to the feed passages on the spindle 26 as regulated by corresponding holes 65 in the plunger-rotor 24.

There are various methods of adjusting the position of the roller 40 to control the amount of fuel delivered at each stroke. The roller may be moved axially or circumferentially but in the example shown in the drawings, it is moved axially under the influence of a hydraulic governor. This governor consists principally of a governor barrel 66 in which moves a governor piston 68 working against a governor spring 70.

Fuel is supplied from the gear type feed pump 12 to a flat 71 on a control spindle 72, through a passage 74 (FIGURE 3) by way of passages 76 (shown in broken lines in FIGURE 2) drilled in the pump casing and end cover. The other end of the flat on the spindle 72 can communicate with a hole 78 through which fuel can pass back to the body of the pump, and there is a restricted passage 80 (shown in broken lines in FIGURE 1) between the body of the pump and the inlet to the feed pump 12 so that there is always a positive pressure of fuel in the body of the pump to charge the pumping space.

As the control spindle 72 is rotated, as for example under the control of the accelerator pedal of a vehicle, to reduce the passage area between the holes 74 and 78, the supply pressure from the feed pump 12 is caused to build up and communicate to the space behind the governor piston 68, forcing it to move against the governor spring 70 and expose a set of ports 82 which communicate through a non-return valve 84 to the sealed space 43 behind the sleeve 42. This movement of the sleeve 42

(to the left of FIGURE 1) is in the direction which reduces the period in each reciprocation of the plunger-rotor 24 for which the valve formed by the back space of the pumping head 28 seating on the end of the motor 24, remains closed, and hence reduces the fuel delivery. Movement of the piston 68 in the opposite direction will open a series of ports 86 to allow fuel to leak out of the space behind the control sleeve 42 back into the body of the pump.

In order to avoid a deadbeat governing characteristic, that is, to give the engine a positive run-out of say 200 r.p.m., a sensing device is employed. This consists of a bell crank lever 88 pivotally mounted in the governor body, one arm of which carries a spigot 89 which passes through an opening 90 and engages with a groove 91 in the control sleeve 42, and the other arm of which rests against a spindle 92 co-axial with the governor body. This spindle has a flute 94 in such a position that excessive movement of the control sleeve 42 will cause fuel to by-pass the governor valve 68 and halt, temporarily, further governing action. A spring 96 serves to hold the spindle 92 in contact with the bell crank lever 88.

A cross shaft 98 has a flat or curved portion which bears against the end of the sleeve 42 in the sealed space 43. Rotation of this shaft will vary the maximum amount of fuel which can be pumped. The shaft 98 can also be used as a stop control, by reducing the fuel delivery to zero.

A means 99 for automatically advancing the start of injection by rotating the ring 52 carrying the three rollers 50 within the casing 10 is shown in FIGURE 4. A tangential plunger 100 rotates the ring in an anti-clockwise direction in FIGURE 4 with rising pressure within the casing 10. The pressure is communicated to the underside of the plunger 100 through a non-return valve 102 and opposes a spring 104 above the plunger. The space in which the spring 104 is situated communicates through a passage 105 (shown in broken lines in FIGURES 2 and 3) with the inlet to the feed pump 12. By this means the point of injection is advanced some 6° as the engine speed rises to a maximum. A leakage groove 106 in the side of the plunger allows it to return to the retard position when the pressure in the body falls.

The action of the pump is as follows:

In the position shown in FIGURE 1, three of the six cams on the ring 48 are about to contact the three rollers 50 and cause movement of the pumping head 28 to form the beginning of the stroke. This corresponds with position A on the phasing diagram, FIGURE 5. At this point, the roller 40 is not in contact with the cam ring 38, and the seal behind the pumping head is held tight by the spring 60. Fuel is pumped past the delivery valve 30 to the distributor slot 36 which, at this stage, is in communication with one of the outlets 18 passing to an injector on the engine (not shown). At the end of delivery predetermined by the axial position of the sleeve 42, the roller 40 contacts the return cam ring 38 thereby prohibiting further axial movement of the plunger-rotor 24 (position B in FIGURE 5). The central spindle 26 however, still continues to move to the end of its travel thereby breaking the seal between the pumping head 28 and the plunger-rotor 24. The pressure in the pumping space is suddenly released and the delivery valve 30 is forced back onto its seat by the residual pressure in the fuel line, thereby unloading an appropriate volume of fuel from the line.

As the valve seal is broken a pressure wave escapes down the flutes of the poppet valve spindle 26 and would be inclined to cavitate the spaces of the flutes unless it were restrained from so doing. To this end, the radial holes 64 are so arranged that they do not at this stage communicate with the radial hole 65 in the rotor 24 and the dissipation of the pressure in the flutes is regulated by the size chosen for the leakage path 62. The radial holes in the rotor and in the barrel begin to overlap only

after the pressure wave has been dissipated and the pumping head is close to the end of its stroke. The spaces in the flutes of the spindle 26 can then again be supplied with fuel from the body.

During the whole of the return stroke of the pumping head 28 and the rotor-plunger, the seat between the two is maintained open by the relative shapes of the two sets of cams 38 and 48, as will be seen in the phasing diagram of FIGURE 5. This allows the pumping space to be recharged with fuel ready for the next injection. The return cam 38 comes free from the roller 40 at position C in FIGURE 5 before the next set of cams on the ring 48 reach the rollers 50 to start the next injection at position A. In the phasing diagram of FIGURE 5 the extent and instant of maximum lift of the valve formed by the pumping head 28 and the end of the rotor 24 is indicated by the arrows X—X and that at an arbitrary point by the arrows Y—Y.

Any increase in speed of engine and pump will result in an increase of pressure delivered by the feed pump 12, and the sleeve 42 will move in the direction which reduces the fuel delivery and the engine speed will likewise be reduced.

In opposite fashion, a reduction of engine speed will result in a fall in pressure from the feed pump 12 and the governor spring 70 will move the governor piston 68 in the direction which will open the series of ports 86 and allow a small quantity of fuel to leak out of the space behind the control sleeve 42 back into the body of the pump. Consequently the sleeve 42 will move in the direction (to the right of FIGURE 1) which increases fuel delivery and therefore engine speed.

As explained above the spindle 92 of the sensing device has a flute 94 which is in such a position that excessive movement of the control sleeve 42 will cause fuel to by-pass the governor valve 68 and halt, temporarily, further governing action, thus avoiding an undesirable deadbeat governing characteristic.

Although FIGURE 1 shows a preferred method for actuating the sleeve 42 hydraulically, this can be done by other means such as through a mechanical linkage using a screwed ring actuated by a rack either manually or controlled by governing means.

I claim:

1. A liquid fuel injection pump comprising a pump cylinder; a tubular plunger; a poppet valve having a stem extending through the bore of said plunger leaving free space for the passage of fuel and having a head adapted to carry the hydraulic pumping load and arranged to seat on the end of the said plunger to form a controllable valve; a spring interposed between said stem and said plunger tending to close the valve formed between the pumping head and the plunger; co-operating cam and cam follower, the one carried by said plunger and the other held within a casing of the pump; co-operating cam and cam follower, the one carried by said poppet valve spindle and the other by said pump casing; and means for rotating said pumping head spindle and said plunger together, said cams and cam followers being so arranged that the pumping head and the plunger move together during the pumping stroke and separate at the end of it while the pumping head is still moving in the pumping direction.

2. A liquid fuel injection pump according to claim 1, in which the cams have a plurality of operative portions, the plunger being slotted and a plurality of outlet ports being provided in said pump cylinder equal in number to said operative cam portions, in such manner that rotation of the plunger permits fuel to pass from the pumping space of the pump to said ports successively.

3. A liquid fuel injection pump according to claim 1, in which the cams have a plurality of operative portions, the plunger being slotted and a plurality of outlet ports being provided in said pump cylinder equal in number to said operative cam portions, in such manner that rotation

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of the plunger permits fuel to pass from the pumping space of the pump to said ports successively, and a ring normally fixed within the pump casing and three cam followers carried on said ring and positioned to engage cams carried by the pumping head spindle.

4. A liquid fuel injection pump according to claim 1, in which the cams have a plurality of operative portions, the plunger being slotted and a plurality of outlet ports being provided in said pump cylinder equal in number to said operative cam portions, in such manner that rotation of the plunger permits fuel to pass from the pumping space of the pump to said ports successively, and a ring normally fixed within the pump casing and three cam followers carried on said ring and positioned to engage cams carried by the pumping head spindle, said ring being mounted in said casing so as to be circumferentially adjustable thereby to vary the timing of the beginning of the pumping stroke of said pumping head.

5. A liquid fuel injection pump according to claim 1, in which the cams have a plurality of operative portions, the plunger being slotted and a plurality of outlet ports being provided in said pump cylinder equal in number to said operative cam portions, in such manner that rotation of the plunger permits fuel to pass from the pumping space of the pump to said ports successively, and the cam means carried by the pumping head spindle and the cam means connected to the plunger being connected by a dog drive, being thereby caused to rotate together but allowed relative axial movement, and in which a drive shaft is provided coupled to said spindle by an axially slidable coupling.

6. A liquid fuel injection pump comprising a pump cylinder, a pumping head and a tubular plunger, the said head being arranged to seat on the end of the said plunger to form a controllable valve, and means for reciprocating both the pumping head and the plunger within the cylinder to move said head and said plunger together in the pumping direction during a pumping stroke, to separate the head and plunger at the end of the pumping stroke while the pumping head is still moving in the pumping direction, and to bring said head and plunger together again to close said controllable valve before the pumping head again moves in the pumping direction.

7. A liquid fuel injection pump according to claim 1, in which the parts of said cooperating cams and cam followers held within said pump casing are arranged to be capable of relative axial adjustment, thereby to vary the fuel delivery.

8. A liquid fuel injection pump comprising a pump cylinder; a tubular plunger; a poppet valve having a stem extending through the bore of said plunger leaving free space for the passage of fuel and having a head adapted to carry the hydraulic pumping load and arranged to seat on the end of the said plunger to form a controllable valve; a spring interposed between said stem and said plunger tending to close the valve formed between the

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pumping head and the plunger; a piston closing one end of a sealed space within a casing of the pump; cooperating cam and cam follower, the one carried by said plunger and the other held on said piston within said pump casing; cooperating cam and cam follower, the one carried by said poppet spindle and the other by said pump casing; valve means in communication with a fuel inlet to said pump and with said space within said pump casing and adapted and arranged to admit fuel to said space in dependence upon the pressure of fuel at said inlet; and means for rotating said pumping head spindle and plunger together, said cams and cam followers being so arranged that the pumping head and the plunger move together during the pumping strokes and separate at the end thereof while the pumping head is still moving in the pumping direction at a point determined by the position of said piston in said pump casing, the said relative axial movement reducing the fuel delivery with increase in fuel pressure at said inlet.

9. A liquid fuel injection pump according to claim 1, in which the cams have a plurality of operative portions, the plunger being slotted and a plurality of outlet ports being provided in said pump cylinder equal in number to said operative cam portions, in such manner that rotation of the plunger permits fuel to pass from an outlet of said pumping space to said ports successively, and having an outlet valve provided in said outlet from said pumping space, said outlet valve comprising a hollow valve member, a pressure spring and an internal stop, delivery of fuel past said valve member forcing said member back against the pressure of said spring into engagement with said stop.

10. A fuel injection pump for an internal combustion engine, comprising a cylinder, a tubular plunger adapted to move in said cylinder, a pumping head adapted to sit upon said plunger and forming therewith a valve which by-passes said pump, a stem of said pumping head passing through said plunger leaving free space around it, a first cam and cam follower with one held in a casing of said pump and the other carried by said plunger, a second cam and cam follower with one held in said pump casing and the other carried by said pumping head, said cams and cam followers comprising cam assemblies adapted to be driven by said internal combustion engine and to control respectively said pumping head and said plunger, the one throughout its cycle of reciprocation and the other during such time the valve is required to be open, said cam assemblies being relatively adjustable to vary the extent of travel of pumping head and plunger with said valve closed.

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