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FUEL INJECTION MEANS

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Fig. 1

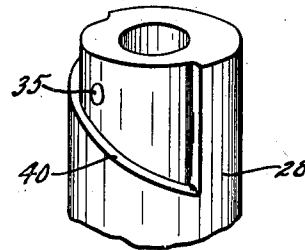
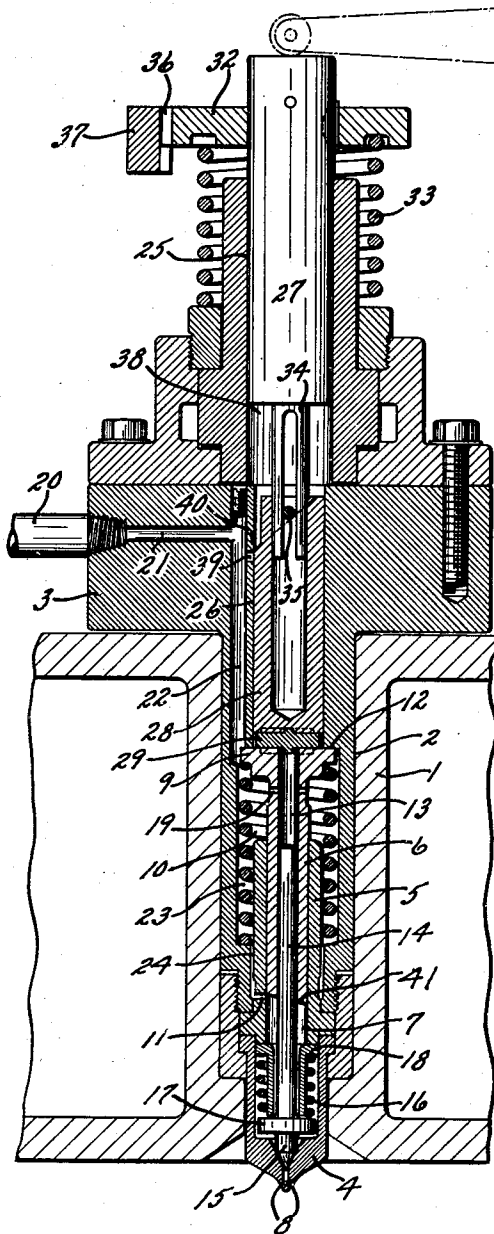


Fig. 2

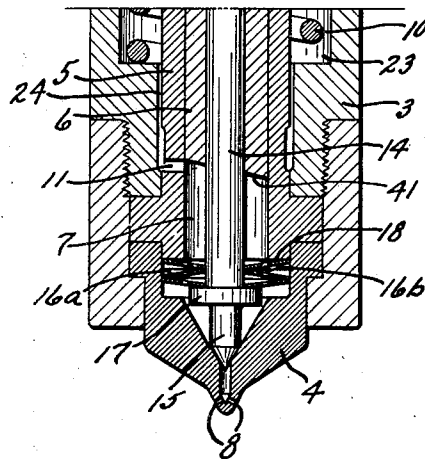


Fig. 3

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FUEL INJECTION MEANS

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This invention relates to fuel injection means for engines operable on the Diesel or a similar cycle wherein combustion is had by injection of liquid fuel into a combustion chamber when the latter contains air so highly compressed that combustion will occur as injection is had.

For each cylinder of such an engine the injection apparatus will include an injection pump having a plunger to be actuated through a working stroke each time injection is to be had to that cylinder. Particularly when the engine is to operate at a high speed, as is the modern trend, the injection period must be exceedingly brief, in fact almost instantaneous; so that the period extends over only a very few degrees of movement of the engine crank. Consequently the rise on the usual cam by which the injection gear is actuated must be very steep. As will be appreciated, there is a limit to the steepness of a cam rise, and the fuel injection art has advanced to about the maximum in this.

An object of this invention is to increase the action of the injection plunger over that of the follower of the actuating cam, so that injection may be more rapid than heretofore, yet without the attendant difficulties above described.

More particularly it is an object to accomplish this by hydraulic transmission means interposed between a timed actuating member of the mechanical gear which receives motion, and the injection pump plunger, by which transmission means the working stroke of the injection plunger may be effected by lesser motion of said actuating gear member. By hydraulic transmission means is meant one wherein a substantially noncompressible liquid is employed, and still another object of the invention is to employ the fuel itself as such liquid.

To control the engine output the successive fuel charges must be varied, and as will be appreciated such variation should be by way of cutoff of injection, that is, the decrement should be at the end rather than the commencement of the injection period, so that injection may always commence at the beginning of the working stroke of the pis-

ton but may continue through variable portions of said stroke. Further objects of the invention are to effect cutoff by relief of pressure in my described hydraulic system, and also to vary the time of such relief to vary the cutoff.

Briefly, the transmission means comprises a pair of communicating cylinders, one of larger diameter than the other, with pistons therefor, the larger piston being associated with the cam-actuated gear and the smaller piston with the injection plunger; so that cutoff may be effected by variably terminating the stroke of the injection plunger, this in turn accomplished merely by relief of pressure between the pistons, and this in turn nicely accomplished by arranging a port to be uncovered by the smaller or following piston. The manner of varying the time of uncovering this port, which is a further object of the invention, is by the simple expedient of providing on the port-controlling piston a port-controlling shoulder advancing along the piston as it advances thereabout, so that adjusting the piston about its axis will vary the time of port opening.

Although generally speaking it is true that commencement of injection should take place at the beginning of the working stroke of the piston, yet where the speed range or flexibility of the engine is great, it is desirable that the time of commencement of injection be slightly advanced as the throttle is opened, that is, as the injection charge is increased. It is still a further object of this invention to provide for such advance automatically and in lesser degree than the retard of injection cutoff.

As another object this control of commencement of injection is made dependent upon variation in cutoff in that both will coincidentally follow adjustment of a single control member. Briefly this again is accomplished by providing a port to be controlled by the injection plunger, providing adjustment for closing of this port by adjustment of the plunger on its axis, and finally by connecting the plunger for such adjustment with the follower piston of the hydraulic transmission means.

Finally an object of the invention is to provide in such described injection apparatus an injection valve which will be unseated inwardly of its nozzle under predetermined injection pressure, and which will otherwise maintain the nozzle closed.

The exact nature of the invention together with further objects and advantages thereof will be apparent from the following description taken in connection with the accompanying drawing, in which Fig. 1 is an assembly view in section of an embodiment of my invention, wherein the mechanical actuating gear is indicated conventionally, the parts appearing in throttle closed position; Fig. 2 is a perspective detail of the port-controlling portion of the following hydraulic piston; and Fig. 3 is an enlarged detail of the nozzle end of the apparatus wherein an alternate form of injection valve control appears.

With reference now to the drawing, 1 is a portion of the combustion chamber wall of one of the engine cylinders. The wall is a double wall to provide the usual water jacket for the cylinder, and a through opening 2 is provided therein to receive the injection apparatus to be described.

The larger part of this injection apparatus is a body 3 including at the inner face of the wall a nozzle 4. Actually, for convenience of manufacture and assembly the body is made up of a number of separate parts, but these parts are secured together in assembly to provide a stationary body unit in which the moving parts are enclosed or mounted; so that for the present purpose the term "body" is used to include all of the fixed or stationary parts of the injection apparatus which appear in Fig. 1.

The cylinder 5, then, is a part of the body in which the injection plunger 6 moves, these parts including the fuel injection pump providing the expansible chamber 7 adjacent the nozzle 4 by which fuel may be forced through the minute nozzle orifices 8 into the combustion chamber of the engine. The plunger 6 has a head 9 against which bears one end of a compression spring 10, the opposite end of which bears in the body 3; whereby the plunger is yieldably urged outwardly. A port 11 is provided in the cylinder 5 to connect the chamber 7 with the space about the spring 10, and so located as to be controlled by the plunger 6. Thus assuming the plunger at the outer end of its stroke as shown, with its head 9 bearing upon the shoulder 12 of the body, the port 11 is uncovered by the plunger so that fuel may enter and fill the chamber 7. Upon a downward stroke of the plunger to contract the chamber 7, fuel will leave the chamber by way of the port 11 until the port is covered by the plunger. Thereafter, the fuel will be trapped in the chamber and can find escape

therefrom only by way of the nozzle orifices 8, so that injection into the combustion chamber will be had.

The plunger 6 has a central opening 13 in which fits the stem portion 14 of the injection valve 15, which seats within the nozzle 4. The injection valve is yieldably maintained in seated position by a compression spring 16, seating between a flange 17 on the valve and a shoulder 18 of the body of the apparatus. The opening 13 of the plunger is vented to the space 23 about the spring 10 by a transverse opening 19.

The sectional area of the stem 14 of the injection valve being greater than the injection opening controlled by the valve 15, when sufficient pressure is built up in the chamber 7 to overbalance the effect of the spring 16, the injection valve 15 will be unseated by the liquid pressure thereupon. At all other times the valve 15 will remain seated to prevent drip into the combustion chamber.

A connection 20 with a source of fuel supply provides delivery of fuel to the pump chamber 7 by way of the leads 21, 22, the chamber 23 in which the spring 10 is located, the annular passage 24 and the port 11, all of these parts being of the body as will be understood.

The body 3 has a pair of communicating cylinders 25, 26, aligned with the cylinder 5 of the injection pump. The diameter of the cylinder 25 is greater than that of the cylinder 26, and pistons 27 and 28 are provided for the cylinders. The smaller piston 28 has bearing against the head 9 of the injection pump plunger through the member 29 which has rectangularly disposed ribs seating in transverse grooves in the parts to rigidly associate the parts against relative angular movement about their common axis, yet make allowance for misalignment. The arrangement will be recognized as that of the Oldham coupling.

The larger piston 27 is arranged to receive motion from the cam 30 acting through a rocker 31. A collar 32 rigidly secured with the piston 27 outside the body 3 extends thereabout to provide a seat for a compression spring 33, the opposite end of which bears against the body 3 so that the piston 27 is caused to follow the motion of the rocker 31 and hence of the cam 30.

It will be apparent that, presuming the cylinder space 38 between the pistons 27 and 28 filled with a liquid, a downward stroke of the larger or leading piston 27 will cause a corresponding stroke of the smaller or following piston 28, but amplified inversely to the ratio of the two piston areas. Since the piston 27 follows motion of the mechanical actuating gear, and the injection pump plunger 6 follows the piston 28, the plunger is caused to follow said gear but, by virtue of

the described hydraulic transmission means, with a stroke greater than the motion of the gear.

That the pistons 27 and 28 may not have relative angular movement, although relative longitudinal movement may be allowed, the piston 28 is hollowed as indicated to receive an extension 34 on the piston 27, and the extension 34 is slotted as shown to receive a pin 35 extending across the hollow of the piston 28.

That axial adjustment of the piston 27 may be had, so that the piston 28 and the plunger 6 may be correspondingly adjusted, the collar 32 is provided on one side with gear teeth 36, and a rack 37 is arranged to intermesh therewith so that endwise rack movement will rotate the collar. The face of the rack is of sufficient width that the rack position will control that of the collar during operation of the apparatus.

A port 39 is arranged between the lead 22 and the cylinder 26 to provide a connection for liquid supply to the chamber 38, the liquid here employed being the fuel itself. That the stroke of the piston 28 may terminate at varying times before the end of the stroke of the piston 27, I provide for variably timed opening of the port 39. To this end I trim the upper end of the piston 28 as indicated Fig. 2 to provide a shoulder 40 of helical characteristic extending along the piston as it extends thereabout. Obviously when the shoulder 40 passes the port 39, when the piston 28 is moving downwardly to impart a working stroke to the plunger 6, the port 39 will be opened and relieve pressure in the chamber 38 between the pistons 27 and 28. Thereafter, the strength of the spring 10 being sufficient for the purpose, the piston 27 will continue to the end of its stroke but the piston 28 will stop. Instantly the working stroke of the plunger 6 is terminated, injection stops. And by adjustment of the piston 28 about its axis, as by longitudinal adjustment of the bracket 34, a different portion of the shoulder 40 may be brought to registry with the port 39 so that the latter will be opened at a correspondingly different instant in the stroke of the piston 28. Thus the time of injection cutoff is dependent upon the adjustment of the piston 28 about its axis.

That the time of commencement of injection may be varied, the end face of the pump plunger 6 is provided with a shoulder 41 co-operable with the port 11 as the shoulder 40 was co-operable with its port 39. A helical characteristic is here given to the shoulder, as by facing off the plunger upon an oblique plane. Then, since by the coupling 29 angular adjustment of the plunger will follow that of the two pistons 27 and 28, the time of closing of the port 11 will be varied when the time of opening of the port 39 is varied, so that the time of commencement of injection

will be varied when the time of cutoff of injection is varied. But the pitch or slope of the shoulder 41 is less than that of the shoulder 40 so that for a given change in time of cutoff of injection there will be less change in the time of commencement of injection.

In Figs. 1 and 3 the parts are shown in throttle-closed or off position wherein cutoff is advanced to a maximum and commencement of injection is delayed or retarded to its maximum. Here it will be observed that the port 39 will be opened as the port 11 is closed so that substantially no injection will take place and the engine will not run. As, however, the collar 32 is turned left-hand, Fig. 1, that portion of the shoulder 40 in line with the port 39 will be raised, and that portion of the plunger shoulder 41 in line with the port 11 will be lowered so that commencement of injection will be slightly advanced and cutoff retarded. The engine will then be in condition to run dependent upon the exact setting of the control.

In the drawing the cam 30 is not in position to affect the rocker 31 so that the springs 10 of the pump plunger and 33 of the piston 27 have both moved their actuated parts to their extreme positions in sprung direction.

It will be apparent that the described hydraulic transmission means operative between the rocker 31 and the injection pump, has an amplifying effect as to motion so that pump plunger movement initiated by the cam 30 may be greater than the rise of the cam lobe and, therefore, this rise need not be as steep as heretofore, for the same effect; or a greater effect may be obtained from a rise as steep as heretofore. It will further be observed that the stroke of the pump plunger is not only greater than the constant motion of the mechanical actuating gear but is also variable although the mechanical motion is constant.

In the detail, Fig. 3, a number of spring disks 16a having perforations 16b are employed to perform the functions of the spring 16 of Fig. 1, whereby the volume of the pump chamber 7 may be decreased. Otherwise the parts and their functioning are as before.

What I claim is:

1. In fuel injection apparatus of the class described and including an injection pump plunger and a timed actuating member therefor, hydraulic transmission means effective between said parts to receive motion from said actuating member and impart said motion with amplified effect to said plunger, said transmission means including communicating cylinders of different diameters and pistons for said cylinders, and control means for terminating the working stroke of said plunger to correspondingly effect cutoff of injection, and comprising valve means arranged to relieve pressure between said pistons.

2. In fuel injection apparatus of the class described and including an injection pump plunger and a timed actuating member therefor, hydraulic transmission means effective
 5 between said parts to receive motion from said actuating member and impart said motion with amplified effect to said plunger, said transmission means including communi-
 10 cating cylinders of different diameters and pistons for said cylinders, one of said cylinders having a port and its piston being arranged to control said port to relieve pressure between said pistons upon predetermined piston movement.

15 3. In fuel injection apparatus of the class described and including an injection pump plunger and a timed actuating member therefor, hydraulic transmission means effective between said parts to receive motion from
 20 said actuating member and impart said motion with amplified effect to said plunger, said transmission means including communicating cylinders of different diameters and pistons for said cylinders, the smaller cylinder
 25 having a port and its piston being arranged to control said port to relieve pressure between said pistons upon predetermined piston movement.

4. In fuel injection apparatus of the class
 30 described and including an injection pump plunger and a timed actuating member therefor, hydraulic transmission means effective between said parts to receive motion from said actuating member and impart said motion
 35 with amplified effect to said plunger, said transmission means including communicating cylinders of different diameters and pistons for said cylinders, control means for terminating the working stroke of said
 40 plunger to correspondingly effect cutoff of injection, and comprising valve means arranged to relieve pressure between said pistons, and means for controlling the time of opening of said valve means.

45 5. In fuel injection apparatus of the class described and including an injection pump plunger and a timed actuating member therefor, hydraulic transmission means effective between said parts to receive motion from
 50 said actuating member and impart said motion with amplified effect to said plunger, said transmission means including communicating cylinders of different diameters and pistons for said cylinders, the smaller cylinder
 55 having a port in its side wall, and its piston having a shoulder of helical characteristic on a corresponding wall portion, and means for adjusting said piston about its axis whereby the time of opening said port may
 60 be varied.

6. In fuel injection apparatus of the class described and including an injection pump plunger and a timed actuating member therefor hydraulic transmission means effective
 65 between said parts to receive motion from

said actuating member and impart said motion with amplified effect to said plunger, said transmission means including communicating cylinders and pistons for said cylinders, one of said cylinders having a port in its side wall and its piston having a shoulder on a corresponding wall portion and of helical characteristic, means interassociating said pistons to allow relative longitudinal movement therebetween but prevent relative angular movement therebetween, and means associated with the other piston to adjust the same about its axis.

7. Fuel injection apparatus of the class described, a body having a cylinder, an injection pump plunger therefor, means for actuating said plunger, said body having a fuel passage opening in the wall of said cylinder to be controlled by the plunger, said plunger having a corresponding shoulder portion of helical characteristic, and means for adjusting said plunger about its axis whereby the time of closing said opening may be varied, to vary the commencement of injection.

8. In fuel injection apparatus of the class described and including a body having an injection pump plunger movable in a cylinder thereof, a timed actuating member, hydraulic transmission means effective between said parts to receive motion from said actuating member and impart the same to said plunger, said transmission means including communicating cylinders and piston for said cylinders, one of the cylinders having a port in its side wall and its piston having a shoulder on a corresponding wall portion and of helical characteristic, means for adjusting said piston about its axis whereby the time of opening said port may be varied to vary cutoff of injection, said plunger cylinder having a fuel passage opening in the wall thereof to be controlled by said plunger, and the plunger having a corresponding helical shoulder portion whereby adjustment of the plunger about its axis will vary the time of commencement of injection, and means associating said plunger with said adjustable piston to cause plunger adjustment with piston adjustment.

9. In fuel injection apparatus of the class described and including a body having an injection pump plunger movable in a cylinder thereof, a timed actuating member, hydraulic transmission means effective between said parts to receive motion from said actuating member and impart the same to said plunger, said transmission means including communicating cylinders and pistons for said cylinders, one of the cylinders having a port in its side wall and its piston having a shoulder on a corresponding wall portion and of helical characteristic, means for adjusting said piston about its axis whereby the time of opening said port may be varied to vary cutoff of injection, said plunger cylinder having a fuel passage opening in the wall thereof

to be controlled by said plunger, and the plunger having a corresponding helical shoulder portion whereby adjustment of the plunger about its axis will vary the time of commencement of injection, and means associating said plunger with said adjustable piston to cause plunger adjustment with piston adjustment, the parts being so proportioned and arranged that as cutoff is advanced, commencement of injection will be retarded.

10. In fuel injection apparatus of the class described and including a body having an injection pump plunger movable in a cylinder thereof, a timed actuating member, hydraulic transmission means effective between said parts to receive motion from said actuating member and impart the same to said plunger, said transmission means including communicating cylinders and pistons for said cylinders, one of the cylinders having a port in its side wall and its piston having a shoulder on a corresponding wall portion and of helical characteristic, means for adjusting said piston about its axis whereby the time of opening said port may be varied to vary cutoff of injection, said plunger cylinder having a fuel passage opening in the wall thereof to be controlled by said plunger, and the plunger having a corresponding helical shoulder portion whereby adjustment of the plunger about its axis will vary the time of commencement of injection, and means associating said plunger with said adjustable piston to cause plunger adjustment with piston adjustment, the parts being so proportioned and arranged that as cutoff is advanced, commencement of injection will be retarded but in lesser degree.

In testimony whereof I hereby affix my signature.

CARL D. SALISBURY.