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FUEL INJECTION PUMPS FOR INTERNAL COMBUSTION ENGINES

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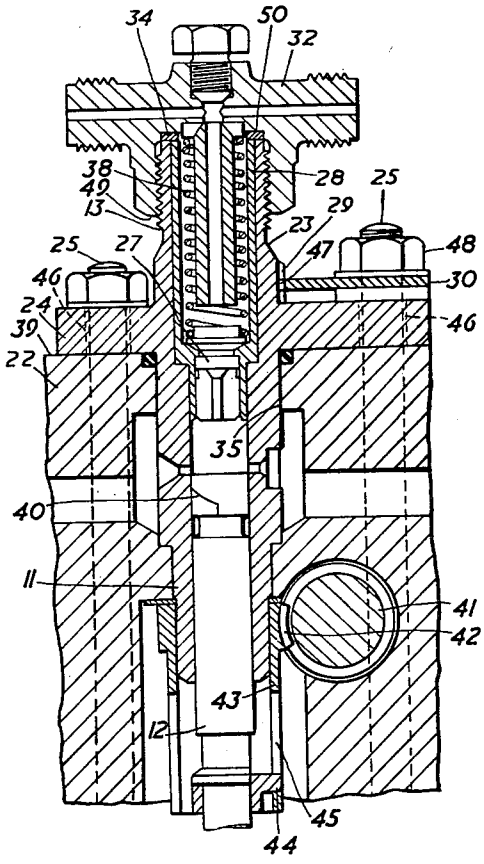



FIG. 1.

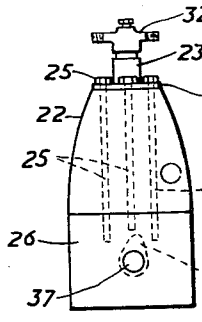



FIG. 2.

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# FUEL INJECTION PUMPS FOR INTERNAL COMBUSTION ENGINES

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1 Claim. (Cl. 103—41)

This invention relates to fuel injection pumps for internal combustion engines, of the kind comprising a barrel in which slides a plunger, the fuel being forced by the plunger out of the barrel at high pressure through a delivery valve and into a fuel delivery pipe or pipes leading to one or more injectors which spray the fuel into a cylinder of the engine.

For certain types of engine there is a demand for what may be termed an ultra high pressure pump i.e. a fuel injection pump which will deliver fuel at a considerably higher pressure than is obtainable with fuel injection pumps of conventional design. One factor which is essential with an ultra high pressure fuel pump is that the plunger shall be an extremely close and accurate fit in the barrel, to avoid leakage of fuel between the plunger and the barrel during the pressure stroke of the pump. To provide such accuracy it is necessary that the interior of the barrel in which the plunger slides shall be finished by means of a lapping operation using a hone, and that the hone shall be capable of being passed right through the barrel. It is not practicable to obtain the desired accuracy of finish if the hone has to be stopped in the barrel and withdrawn in the opposite direction. This precludes the provision, as a part of the barrel, of a delivery valve seating of smaller diameter than the bore of the barrel in which the plunger slides. On the other hand, it is sometimes desirable for proper operation of the delivery valve of the pump that the seating for this valve should be of smaller diameter than the bore of the barrel in which the plunger slides. Another problem which is encountered in an ultra high pressure pump is to seal the joints of the pump which are subjected to the very high pressure. Indeed, failure of a high pressure seal must be expected from time to time, and it is generally important for operation of the engine, particularly a multi-cylinder engine, that such failure shall not go undetected, since this may lead to over-fuelling of the other cylinders either by automatic or manual control in an attempt to maintain the power output.

It is an object of this invention to provide a fuel injection pump suitable for ultra high pressure operation which meets the above-mentioned requirements.

This and other objects of the invention will be explained more fully in connection with a specific embodiment which will be described with reference to the accompanying drawings, in which:

FIGURE 1 is a sectional side elevation of the upper part of one form of ultra high pressure pump embodying the invention; and

FIGURE 2 is an end view on a smaller scale of the pump shown in FIGURE 1.

The fuel pump of the present invention embodies, in combination, a number of different features which all contribute essentially to fulfilling the said objects. Although certain of these features are known in themselves, they have not hitherto been employed in this combination, and it is only by this novel combination and correlation of the several features that the desired objects of the invention are achieved.

One of these features is that the barrel and delivery valve housing of the pump are made as a one-piece unit. Although it is known to make the delivery valve housing



and the barrel as a one-piece unit, this is not conventional. In the conventional construction of a fuel pump the barrel is made as a separate part from the delivery valve housing, the mating faces of these parts being accurately finished, and the two parts being held tightly together with a strong clamping force to prevent leakage of fuel. In the usual conventional construction, the pump barrel has an external shoulder which engages a seating formed in a recess in the pump body, which is an aluminium or aluminium alloy casting, and the delivery valve housing has an external shoulder engaged by a ring nut which screws into this recess. The force with which the delivery valve housing and the pump barrel are clamped together is determined by the force applied by the ring nut, the reaction of this force being transmitted through the pump body. The pump body not only has to sustain this constant clamping force, but also the reaction of the pumping force applied by the plunger. Such conventional designs are not satisfactory when pumping pressures substantially higher than conventional pumping pressures are required, since at ultra high pressures both the clamping force and the reaction of the pumping force are very large and may be so high as to distort the pump body. Moreover, if the mating faces of the barrel and the separate delivery valve housing are not extremely accurate, or these parts are not clamped sufficiently tightly together, leakage may occur between these faces, and since these faces are clamped together within the pump body the leaking fuel will not be visible to the operator.

By providing a one-piece barrel and delivery valve housing unit, this problem is overcome. Thus, the risk of leakage between the pump barrel and the delivery valve housing is completely eliminated, and, moreover, it is no longer necessary to provide a clamping force. Consequently, the pump body is relieved of the stresses which would otherwise be created due to the clamping force.

A further feature of the invention is that the said one-piece barrel and delivery valve housing unit has a stepped bore extending throughout its length, the plunger being slidable in a lower part of the stepped bore which has the smallest diameter of any part of the bore, a larger diameter upper part of the bore containing the delivery valve of the pump and the delivery valve spring. Since the lower part of the bore in which the plunger slides has the smallest diameter of any part of the bore, that is to say, there is no smaller diameter valve seating or similar obstruction forming an integral part of the said unit, a lapping hone can be passed right through the bore during the finishing operation, whereby the bore can be given the extremely accurate finish necessary for ultra high pressure operation.

A further feature of the invention is that a detachable sleeve is provided within said delivery valve housing portion of said unit, a lower part of said sleeve providing guide means and seating means for said delivery valve. It is thus possible to provide a seating for the delivery valve which is of smaller diameter than the part of the bore in which the plunger slides, while yet enabling a hone to be passed right through the bore as above described. It may in some instances be found that the wear on the parts of the said sleeve forming the valve seating and the valve guide is greater than the wear caused by the plunger in the pump barrel. The detachable sleeve avoids the need for having to replace the costly barrel and delivery valve housing unit in the event of wear of the valve seating and valve guide while the barrel itself is still serviceable, since wear caused by the delivery valve will take place in the detachable sleeve and not in the said unit. The sleeve is a relatively in-

expensive item and can readily be withdrawn and replaced.

A further feature of the invention is that the upper end of the detachable sleeve is flush with the upper end of the delivery valve housing portion of said one-piece unit, a fuel delivery pipe connector is screwed on to the projecting part of the said unit externally of the pump body, and a common sealing washer is compressed between, on the one hand, the upper ends of said housing and said sleeve and, on the other hand, a seating in said fuel delivery pipe connector. In this way, a common seal is provided against leakage of high pressure fuel from the interior of said sleeve, and against leakage of high pressure fuel between the sleeve and the delivery valve housing portion of the said unit, so that there is, in effect, only one high pressure seal. Moreover, since this seal is disposed externally of the pump body, leakage of fuel in the event of failure of this seal will be visible to the operator.

Referring now to the accompanying drawings, in which only those parts are shown in detail which are necessary for a proper understanding of the invention since the detailed construction of the remaining parts will be apparent to those skilled in the art, there is shown a fuel pump suitable for delivering fuel at ultra high pressures. The pump comprises a cast body **22** made of aluminium or aluminium alloy, having a recess **35** therein which accommodates a one-piece pump barrel and delivery valve housing unit **11**. In the barrel there reciprocates a pump plunger **12**. This plunger is reciprocated by means of a cam **36** mounted on a cam shaft **37** and contained in a cam box **26** on which pump body **22** is mounted.

The delivery valve housing portion **13** of said unit **11** accommodates a delivery valve **27** and a detachable sleeve **28** which serves as a guide and seating for delivery valve **27**. Sleeve **28** is a loose fit in housing portion **13** to permit easy insertion and withdrawal and to avoid distorting unit **11**. Delivery valve **27** is urged towards its seating by a compression spring **38**. As will be readily apparent, wear caused by movements of delivery valve **27** will occur only in sleeve **28** which can readily be withdrawn and replaced.

Screwed on to the upper end of housing portion **13** is a T-connector **32** to which can be attached two fuel delivery pipes (not shown) leading to two fuel injectors. The top of sleeve **28** is flush with the top of housing portion **13** and both these parts are sealed against the escape of high pressure oil by means of a common sealing washer **34** which is squeezed between, on the one hand, the tops of both sleeve **28** and housing portion **13**, and on the other hand, a flat seating **50** in T-connector **32**.

Unit **11** is provided with an external flange **24** which is held against a flat top surface **39** of pump body **22** by through-bolts or studs **25** passing through arcuate slots **46** in flange **24** and extending right through pump body **22** and screwing into threaded holes in cam box **26**. These through-bolts or studs transmit the reaction of the pumping force from unit **11** directly to cam box **26** so that body **22** is relieved of stresses due to said reaction.

Plunger **12** is provided with a conventional control helix **40** and is adapted for rotation to control the fuel delivery by means of a control rack **41**, toothed quadrant **42**, a slotted sleeve **43** and a lug **44**. Lug **44** is non-rotatable on plunger **12** and is slidable in a vertical slot **45** in sleeve **43** to permit relative reciprocating movements of plunger **12** in relation to sleeve **43** but preventing relative rotation between these parts. Thus, on rotation of quadrant **42** and sleeve **43** by actuation of rack **41**, plunger **12** is correspondingly rotated. Since control of the fuel supply is dependent on the relative angular positions of unit **11** and plunger **12**, it is necessary for the rotational position of unit **11** in relation to pump body **22** to be accurately set. For this purpose, positive locking means are provided for securing unit **11** in a desired angular or rotational position in relation to body **22**.



The aforementioned arcuate slots **46** through which pass the through-bolts **25** permit limited rotational movement of unit **11** in body **22** for purposes of adjustment. The locking means comprise serrations **29** on the exposed exterior **23** of housing portion **13** engaged by corresponding serrations **47** in a plate **30** secured by one of the through-bolts **25**. To adjust the rotational position of unit **11**, nut **48** is slackened, plate **30** is lifted until serrations **47** clear serrations **29**, the rotational position of unit **11** is adjusted, and plate **30** is replaced with serrations **29** and **47** in the corresponding relative positions. With this arrangement the angular increments of adjustment are equal to the angle subtended by adjacent serrations, but alternative plates corresponding to plate **30** but having serrations disposed in different angular relationships to the bolt hole in the plate may be provided if desired so that finer adjustments can be made.

Since said barrel and delivery valve housing are made in one piece, no clamping force has to be provided to prevent leakage between these parts as would be necessary if they were formed separately in the conventional manner. Consequently, no clamping force has to be resisted by pump body **22**. Moreover, as hereinabove explained, the provision of through-bolts **25** means that pump body **22** does not have to provide the reaction to the pumping force. Also, there is no high pressure seal at a lower level than sealing washer **34**, and since the lower end **49** of T-connector **32** terminates substantially above top surface **39** of body **22**, there is no risk of fuel which may leak past the seal **34** in the event of failure thereof entering the interior of pump body **22** without first being visible on the exposed outer surface **23** of unit **11**.

This application is a continuation-in-part of application Serial No. 635,658, filed January 23, 1957, now abandoned.

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

A fuel injection pump for an internal combustion engine comprising a pump body having a recess therein, a one-piece barrel and delivery valve housing unit comprising a lower barrel portion and an upper delivery valve housing portion mounted in said recess with at least a part of said delivery valve housing portion projecting out of said recess externally of said body, said delivery valve housing portion having an upper end, said unit having a stepped bore extending throughout its length, a plunger slidable in a lower part of said stepped bore which part has the smallest diameter of any part of said bore, a delivery valve contained in an upper part of said bore in said delivery valve housing portion, said upper part of said bore being of larger diameter than said lower part, a delivery valve spring contained within said delivery valve housing portion above said valve, a detachable sleeve within said delivery valve housing portion and having a lower part and an upper end, said lower part of said sleeve providing guide means and seating means for said valve and said upper end thereof being flush with said upper end of said delivery valve housing portion, a fuel delivery pipe connector screwed on to said projecting part of said unit externally of said body, and a common sealing washer compressed between on the one hand said upper ends of said housing and said sleeve and on the other hand said fuel delivery pipe connector, said body having an upper seating surface and including a cam box, cam means in said box for reciprocating said plunger, a mounting flange on said unit contacting said upper seating surface of said body, and through-bolts extending from said mounting flange to said cam box through said body and serving to transmit pumping reaction forces from said unit to said cam box.

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