

Aug. 20, 1946.

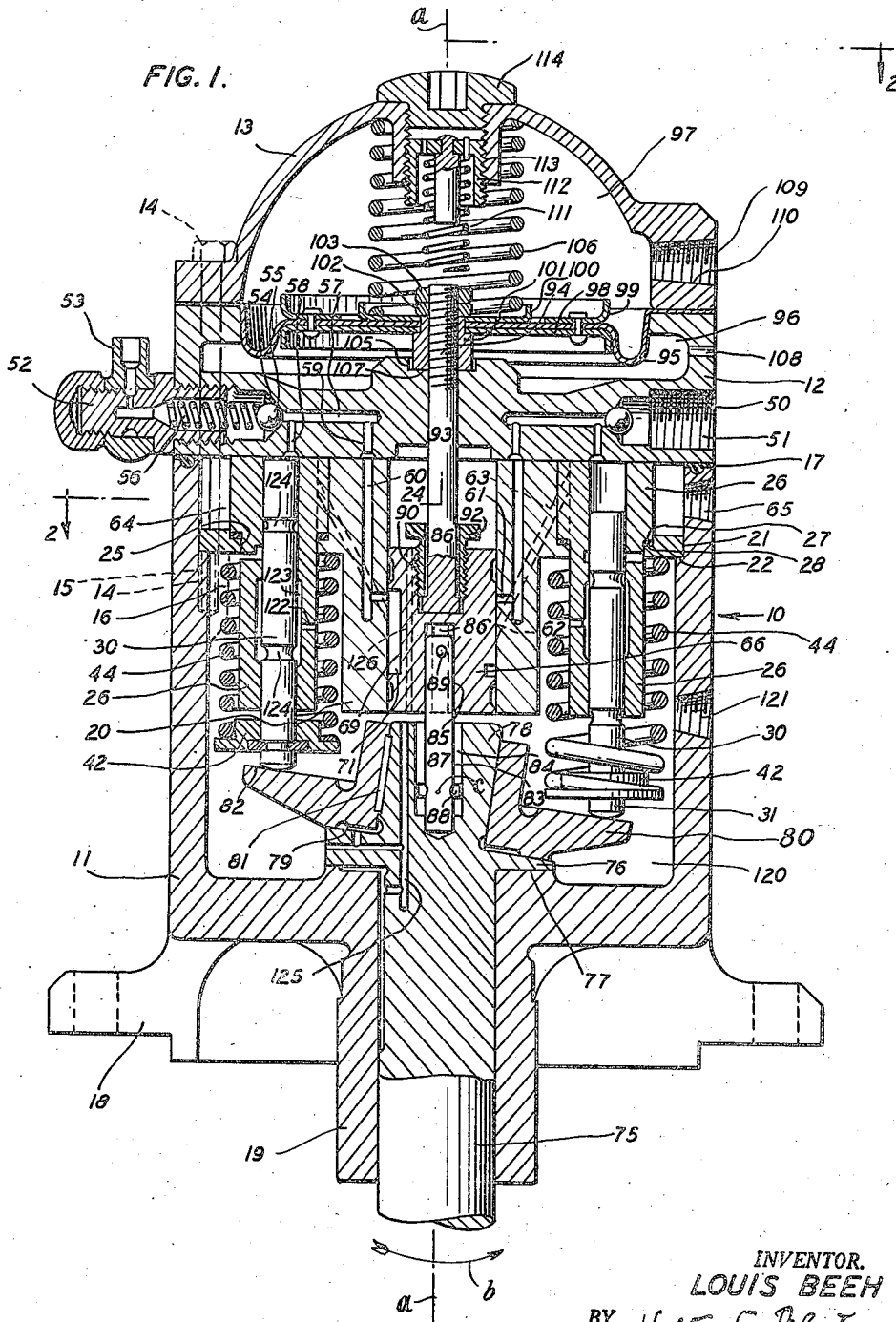
L. BEEH

2,405,938

MULTIPLE INJECTION PUMP

Filed July 18, 1944

2 Sheets--Sheet 1



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FIG. 2.

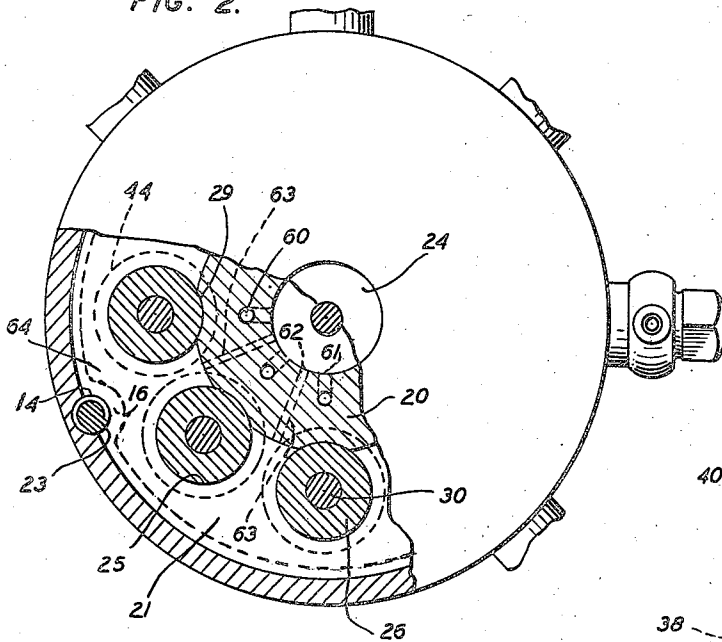


FIG. 3.

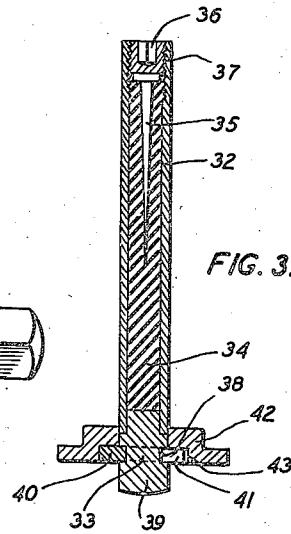


FIG. 4.

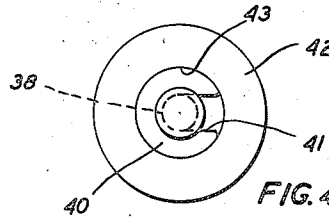
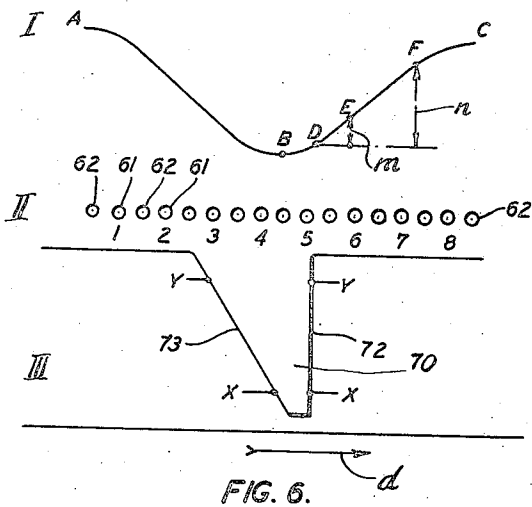
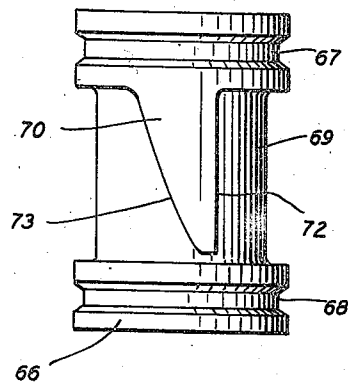


FIG. 5.



INVENTOR.
LOUIS BEEH
BY *Walter S. Pleston*

ATTORNEY

UNITED STATES PATENT OFFICE

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MULTIPLE INJECTION PUMP

Louis Beeh, Long Meadow, Mass.

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7 Claims. (Cl. 103—173)

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The invention relates to an injection pump for charging the cylinders of an internal combustion engine, and aims to provide a relatively simple and low cost pump useful for engines of the spark ignition type as well as for those with compression ignition. In multiple cylinder engines for which the pump according to the invention is destined, it frequently happens that the cylinders are not uniform as to their fuel consumption so that the one or the other cylinder should be charged more or less than the remainder of the cylinders in order to attain highest or most economical output of the engine. The conventional injection pumps cannot or not readily be adapted to such differences. Furthermore, if in such a pump, parts such as pump, barrel or plunger are worn or become defective for other reasons, the entire pump is frequently beyond repair; also, any failures of the conventional pump will put the whole engine to be charged by the pump out of operation. The invention contemplates to overcome the indicated drawbacks by providing a pump comprising in one housing a plurality of pump units, i. e. as many as there are engine cylinders to be charged by the multiple pump which further comprises a timing and/or metering organ common to all the pump units and controlling their output as to time and quantity. The invention also provides a structure whereby the pump cylinders and plungers may be separately removed and exchanged. In this manner it is possible not only to replace defective parts individually but also to have pump cylinder and plunger units of slightly different diameter combined in one pump as the differences in the engine cylinders may require. The common control organ, on the other hand, insures uniformity in timing and metering. Moreover, if during the operation of an engine charged by the pump, one of the units should become defective so that one of the cylinders of the engine cannot properly function, it will be necessary only, if at all, to disconnect the particular unit from the cylinder. The other units may then still operate as required to charge their coordinate cylinders in the same manner as before. The fact that the pump cylinders are not integral with the housing presents another advantage which will be particularly noticeable in the production of large series of such pumps. Correct metering of the fuel to be injected per each charging stroke of an engine cylinder requires utmost accuracy with practically no tolerances in the manufacturing of the parts of the pump. With the pump according to the inven-

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tion it is possible first to sort the pump cylinders and plungers as they are produced, according to their sizes, in order to fit together sets of a cylinder and plunger of exact size, other sets of a cylinder and plunger, both oversized within admissible limits, and still other sets of undersized cylinder and plunger. Then pumps may be assembled having only correct sized pump units, or only oversized or only undersized ones, except in the event that one or the other unit of different size is desired in a pump for the reasons mentioned hereinbefore. The difference in the output of pumps assembled of correct sized units in comparison to those of undersize or oversize may then be equalized by an initial setting of the control organ. In order to facilitate the correct fitting together of a pump cylinder and a plunger, the latter may be provided with interior means, also according to the invention whereby it may be adjustably expanded to a slight extent.

Further objects and details of the invention will be apparent from the description given hereinafter and the accompanying drawings illustrating an embodiment thereof by way of example.

In the drawings,

Fig. 1 is a longitudinal cross-section of a pump according to the invention;

Fig. 2 is a cross-section along line 2—2 of Fig. 1;

Fig. 3 is a longitudinal cross-section of one of the plungers with a foot flange attached thereto;

Fig. 4 is a bottom plan view of the plunger and flange;

Fig. 5 is a side elevation of the control organ of the pump; and

Fig. 6 is a diagram illustrating the operation of the control organ.

Referring now to the drawings, the illustrated pump comprises a housing 10 formed of a main body 11, a cover 12 and a top 13. The three parts are held together by means such as bolts 14 engaging with their threaded lower ends 15 interior brackets 16 of the body 11. Gaskets such as indicated at 17 may be applied to insure fluid-tightness where required. The body 11 has a foot 18 and a lower extension 19 shaped as a bearing with its axis coinciding with the central axis *a*—*a* of the substantially cylindrical housing. Interiorly of the body 11 and coaxially therewith, a barrel 20 bears with a flange 21 on an interior shoulder 22 of the body wall, and the bolts 14 passed fittingly through recesses 23 prevent the

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barrel from turning. The barrel having a central bore 24 throughout its length extends from the top of body 11 downward, and its flange 21 is provided with a number of holes 25 according to the number of individual pump units. These holes are equidistant from the axis $a-a$ and equally spaced as to each two neighbored holes. Each pump unit comprises a cylinder 26 fitted into one of the holes 25 with its axis parallel to the central axis $a-a$ and bearing with a shoulder 27 on flange 21. A gasket 28 is interpositioned between the shoulder and the flange. The arrangement may be such that a portion of the upper part of the cylinder 26 is in close contact with an outer wall portion of the barrel 20 which for this purpose is of a larger diameter above than below the flange 21 and is provided with arcuate recesses 29. Each pump unit further comprises a plunger 30 reciprocable in cylinder 26 and projecting therefrom with its lower or foot end 31 so shaped as to engage a cooperating driving element to be described herein after. In view of the abovementioned requirements of an injection pump plunger as to the accuracy of its dimensions, the plunger may be of a structure shown in Fig. 3, and which is also part of the present invention. This plunger has a body consisting of a tube 32 closed at its lower end by a member 33 fitted into and secured to the tube which, at its top end, is provided with an interior threading 37. The tube is filled with a preferably elastic material 34 such as rubber and a tapered pin 35 is driven from the top into the filler. A nut 36 is screwed into the mentioned threading 37 of the top of the tube so as to bear on the pin 35. Thus, by turning the nut the depth can be adjusted to which the pin is forced into the filler 34, and more or less pressure can be exerted by the filler on the tube from the interior to expand the tube diameter to the very slight extent which may be required in order to fit the plunger to its cylinder. The foot member 33 has a peripheral groove 38 and its lower end face 39 is preferably curved or ball-shaped. A washer 40 with a radial recess 41 engages the groove 38, and a second washer 42 provided in its bottom face with a circular recess 43 according to the size of the washer 40 is slipped on the plunger in axial direction, so that both washers hold each other in position. The plunger 30 with the washers 40 and 42 thereon is inserted into its cylinder 26 from below and a compression spring 44 is interpositioned between the flange 21 and washer 42 so as to bias the plunger in a downward direction.

The pump units are secured in the housing by the cover 12 the lower face of which bears not only on the top rim of the body 11 but also on the top faces of the cylinders 26 and of the barrel 20. In the same radial planes as the cylinders 26 are arranged, the cover 12 is provided with chambers 50 opening towards the outside and having an interior threading 51 into which a connecting member 52 is screwed for the attachment of a pipe line 53 to an engine cylinder not shown. The chamber bottom 54 forms a seat for a valve such as ball 55 urged against its seat by a spring 56 bearing on the connecting member 52. Each valve 55 controls communication of a radial conduit 57 with its coordinate chamber 59. Conduit 57 has two branches 58 and 59 of which the former communicates with the interior of cylinder 26 whereas branch 59 is continued by a conduit 60 in the wall of barrel 20. Each conduit 60 ends in a port 61 of the barrel, all the ports 61 being on the same level and equally

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spaced in the peripheral direction. Other ports 62 are provided in the barrel. In the illustrated embodiment, they are arranged intermediate the ports 61, but their location may be selected differently as it will be clear from description hereinafter. The ports 62 are connected by conduits 63 to the space 64 constituting a fuel chamber between the wall of body 11, the cover 12, flange 21, and the upper portions of the cylinders 26 and the barrel 20. Chamber 64 has an opening 65 in the side wall of body 11 to which a pipe line (not shown) from a fuel source may be connected to charge the chamber.

The ports 61 are controlled by the common control valve 66 rotatably and axially movable in the barrel space 24. The valve 66, as clearly shown in Fig. 5, has two peripheral grooves 67 and 68 near the top and bottom thereof to serve as lubricating grooves. Intermediate its grooved portions the valve body is circumferentially recessed at 69 and within that recess a land 70 is provided which increases in width from its top towards the bottom end. The outer surface of the land 70 constitutes a part of a cylinder with the same diameter as the inner diameter of the barrel. In consequence, if the land covers one of the ports 61 or 62 such port will be closed, whereas the other ports are free to communicate with the space 71 formed by the inner barrel wall and the walls of the recess 69. However, it should be noticed that closing of a particular port 62 does not interrupt, between chamber 64 and space 71, the communication which is maintained through the other ports 62 and their connecting conduits 63. Hence, for proper operation of the pump it is immaterial how many ports 62 there are in the barrel and where they are located in relation to the ports 61, provided the recess space 71 is in permanent communication with the low pressure fuel chamber 64. For this reason, it will be necessary to consider hereinafter the effect of the movement of land 70 on the ports 61 only as far as the operation of the pump is concerned.

Furthermore, it will be clear that during the rotation of the valve 66 a port 61 will be closed the longer, the wider the portion of the land 70 is, which covers such port. Thus, the lower the position of the valve 66 (shown in Fig. 1 in its lowermost position) in barrel 20 is, the longer the ports will be closed, one after the other. In the illustrated embodiment, the flank 72 is parallel to the axis, and flank 73 is so helically curved that the developments of both flanks are straight-lined in which event the increase or decrease of the closing time of a port will be at the same ratio as a corresponding axial movement of the valve. If, however, some other ratio is desired, this can be attained by curving the flanks according to the law to be followed in controlling the ports. Presuming now that a certain port 61 is open, communication exists between chamber 64 with the interior of the coordinate cylinder 26 through at least a number of the conduits 63, valve recess space 71, port 61 and conduits 60, 59, 57, 58. If, however, land 70 covers such port 61 the just described connection will be interrupted. In order to operate the movable parts of the pump units and the common valve, a drive is provided which comprises a shaft 75 which is rotatable in bearing 19 and has a collar 76 bearing on a surface 77 of the bottom wall of housing body 11. The top end 78 of shaft 75 is cylindrical, however with an axis at an angle to the central axis of the housing and the shaft 75. The

top surface 79 of collar 76 is in a plane at right angles to the inclined shaft head 78. A wobble or swash plate 80 is splined at 81 to shaft head 78 and the arrangement is such that the feet 31 of the plunger 30 bear on the plane top surface 82 of the plate 80, and the point of intersection c of the axis of the top end 78 with the axis *a-a* is preferably located in the plane of said top surface 82. Now it will be clear that during a rotation of the shaft 75 each plunger 30 will be lifted against the restraint of its spring 44 to its topmost position shown in the left hand side of Fig. 1 and will be lowered by spring 44 to the position of the plunger 30 on the righthand side according to the inclination of the face 82. Thus, each plunger will complete one reciprocation during each revolution of the shaft 75; however, the phases of such plunger movement will be displaced according to the number of pump units in the housing. In other words, if there are for instance eight units, as shown in the present embodiment, that means if the pump is destined for an eight-cylinder engine, then the phase displacement between two subsequent plungers will be 45°. A connection between shaft 75 and valve 66 is provided so that both will rotate in synchronism, however, in such a manner that the valve may be axially shifted in relation to the shaft during rotation. For this purpose, shaft head 78 is provided with a bore 83 in line with the central axis *a-a* and also with spline grooves 84 parallel to that axis. Similarly, valve 66 has a bore 85 with spline grooves 86. A connecting rod 87 engages in both said bores 83 and 85 and cross pins 88 and 89 are passed through rod 87 so as to engage the grooves 84 and 86 respectively. If now, the lower end of shaft 75 projecting from the bearing 19 is connected to a driving means (not shown), rotation of shaft 75 will cause reciprocation of the plungers 30 and simultaneous rotation of the valve 66. Connected to a four-cycle engine, the pump shaft 75 should rotate with half the R. P. M. of the engine crank shaft.

The control valve 66 may be moved in axial direction by any suitable and conventional means and according to any law desirable according to the engine to which the pump is applied. In the present embodiment, the valve may be actuated in axial direction by and according to the vacuum prevailing in the manifold of the engine for which the pump is destined. For this purpose the valve is provided with an upper threaded bore 90 into which a nut 92 is screwed. The nut has an axial bore through which a headed rod 93 is passed so as to bear against the lower surface of the nut 92 and the bottom of bore 90 without being clamped so that the valve 66 with nut 92 can freely rotate about the rod. Rod 93 extends upward through cover 12 and has a threaded upper end 94. A diaphragm 95 is clamped between the cover 12 and the dome-shaped housing top 13 so that it forms a partition between a lower chamber 96 and an upper chamber 97. The diaphragm is reinforced in its central part by a lower disc 98 and two upper concentric discs 99 and 100, and a bushing 101 is secured to the center of the diaphragm and the discs 98 and 100. Rod 93 is screwed through bushing 101, and two nuts 102 and 103 are provided to hold the rod adjusted relatively to the diaphragm. The central portion of the housing cover is recessed at 105 so that the bushing 101 may rest on the recess bottom 107. Between the reinforcing disc 100 and the housing top part 13, a spring 106 is interpositioned, tending to urge valve 66 downward into its lowermost position

which is reached when bushing 101 bears on the said surface 107. Chamber 96 opens at 108 into the atmosphere while the chamber 97 may be connected to the mentioned engine manifold by means of a pipe (not shown), which may be screwed into the threading 109 of a bore 110 provided in the wall of the housing top 13. Thus, if a vacuum prevails in chamber 97 the diaphragm 95 will bend upward against the restraint of spring 106 and thus lift the valve 66 in axial direction. The rotary movement of the valve will not be transmitted to the diaphragm because valve 66 with nut 92 is free to rotate about the rod 93 as stated hereinbefore. Upward movement of the valve may be limited by an adjustable stop which may have resilient qualities. For this purpose, a buffer spring 111 is mounted interiorly of a cap nut 112 screwed into an axial threading 113 in the top portion of the housing part 13. Thus, when valve 66 is lifted sufficiently high, nut 103 will engage the end face of the downwardly projecting spring 111, whereby the axial valve movement will be stopped by the force of that spring. A headed nut 114 may be provided to close the opening into which nut 112 is screwed. In order to lubricate the movable parts of the pump, the free space in body 11 underneath the barrel flange 21 may be used as an oil chamber 120 which may be charged through an opening 121 in the side wall of the body. From this chamber oil conduits may lead to the movable parts as for instance conduit 122, leading to longitudinal grooves or recesses 123 in the wall of the cylinder 26. Also the plungers 26 may be provided with peripheral grooves 124 (not shown in Fig. 3) for this purpose, if the wall of the plunger tube 32 is sufficiently thick. Similarly, a conduit 125 may carry oil to the bearings 79 of the wobble plate and 19 of the shaft 75. Furthermore, a conduit 126 may be provided through the length of valve 66 so that oil may pass from chamber 24 to chamber 123 when the valve moves in axial direction.

The pump according to the invention operates in the following manner. When shaft 75 is rotated the wobble or swash plate 80 will also turn and will thereby enforce axial reciprocation of the plungers in cooperation with their springs 44. The plunger on the lefthand side of Fig. 1 is in its topmost position, that means the compression stroke of this plunger has just been completed and with shaft 75 rotating in the direction of the arrow *b*, the plunger will have been shifted into the lowermost position after 180°, i. e., into the position of the plunger in the righthand side of Fig. 1, in which its suction stroke is completed. As stated hereinbefore, the valve recess space 71 is in permanent communication with the low pressure chamber 64, and as furthermore, the relative position of the valve is such that, during the suction stroke of the plunger, the coordinate port 61 is uncovered, fuel will enter and fill the free cylinder space of the contemplated pump unit. When now, during further rotation of the plate 80, that means during the compression stroke or part of the compression stroke of the plunger, the land 70 of valve 66 covers the coordinate port 61, communication between the recess and the cylinder space will be interrupted and the fuel pressure in the cylinder will act on the connected check valve 55 to open it so that fuel will be ejected through the valve chamber 50 into the pipe line 53. If then, during a later portion of the compression stroke land 70 has passed the port 61 the remainder of the fuel in the cylinder will be

returned to the space 71 and the low pressure chamber 64.

If now during the operation of the pump the vacuum of the engine manifold increases, the higher difference of pressure between chambers 96 and 97 will cause the diaphragm 95 to bend upward and thereby to raise the valve. In consequence, a narrower portion of the land will pass the ports 61, with the result that each port 61 will be closed for a shorter portion of a revolution of swash plate 80 and that fuel will be ejected through a smaller portion of the compression strokes of the plungers. It is of course necessary to position valve 66 so from the start that the leading edge 72 of land 70 just has completed or nearly completed covering a certain portion 61 when the coordinate plunger is in that position in which it is intended to start ejection of fuel. This is diagrammatically shown in Fig. 6, where curve I indicates the plunger movement during one complete revolution of the swash plate 80 or what amounts to the same during one revolution of the valve 66. For sake of illustration, the plunger to which curve I relates may be denoted as the fifth of the number of eight unit plungers in the pump. Thus the point A is identified as the upper dead center of the fifth plunger, B is the lower dead center, and C the upper dead center reached after one plunger reciprocation. Underneath this curve the ports 61 and 62 are shown on the line II, and the ports 61 are further distinguished by the reference numerals 1 to 8 according to the number of the pump units or plungers to which they are coordinated. At III the land 70 is shown as a development of the surface of valve 66, and it is assumed that rotation occurs or that the land advances in relation to the ports 61 and 62 in the direction of the arrow *d*. If it is further assumed that ejection of fuel from the fifth pump unit is intended to start at the point D of the plunger compression stroke BC, then, the relative position of the parts should be as shown, that means the leading edge 72 of the land 70 is in a position in which the land just covers the port 61—5 shown on top of it. This port will stay covered until the trailing edge 73 of the advancing land begins to clear it. If during the time of the land passing port 61—5 the level *x*—*x* of the land was in registry with the level of the ports, the plunger will have risen in the meantime to point E so that the quantity of ejected fuel will correspond to a piston movement according to the length of the line *m*. Similarly if valve 66 has been so lowered that its level *y*—*y* is in registry with the ports, the land will cover the port 61—5 to cause fuel ejection during the plunger stroke portion from D to F or according to the length of line *n*. It will be clear that the operation of the other pump units is similar to that just described, with the difference, however, that the stroke of each subsequent plunger is delayed in phase according to 360° divided by the number of units in the pump. Thus, the quantity of ejected fuel can be metered by the shape of the land and by the law according to which the valve 66 will be shifted in axial direction. However, it is also possible to attain an adjustment of the timing of the start of each ejection period. It will be noticed that in the illustrated embodiment the leading edge 72 is shown at right angles to the direction *d* of the advancing valve. In consequence, closing of port 61—5 will occur always when the plunger is at point D. On the other hand, owing to the inclination of the trailing edge 73, closing of the port will last as long as

the piston requires to move from D to F when the valve is lowered from *x* to *y*. Similarly, a delayed or advanced opening of the ports 61 can be attained if the leading edge is inclined with its lower end backward or forward respectively. Thus, the valve may serve for timing as well as for metering the quantity of the ejected fuel.

It will be apparent to those skilled in the art that many alterations and modifications of the mechanism illustrated and described are possible without departing from the spirit and essence of my invention which for this reason shall be limited only by the scope of the appended claims.

I claim:

1. In a fuel injection pump comprising a plurality of pump units, each including a cylinder with reciprocable plunger therein, the combination of a common fuel supply chamber, as many discharge valves as there are pump units and coordinated to the latter respectively, first conduits from said supply chamber to said discharge valves respectively, a rotatable valve in controlling relationship to said conduits so as to cyclically close said conduits each during a portion of the pressure stroke of the coordinate pump unit plunger, and second conduits connecting the cylinders respectively with the coordinate first conduits at points between the rotatable valve and the discharge valves.
2. A fuel injection pump comprising a plurality of parallel pump units arranged on a circle, each unit including a cylinder barrel with a reciprocable plunger therein, a cover for the cylinder barrels, said cover being provided with ports opening into said cylinders respectively, as many discharge valves as there are pump units and coordinated to the latter respectively, a common fuel supply chamber, first conduits from said supply chamber to said discharge valves respectively, a rotatable valve in controlling relationship to said conduits, a common drive for cyclically reciprocating the plungers and for rotating said rotatable valve so as to cause the latter to close said first conduits each during a portion of the pressure stroke of the coordinate pump unit plunger, and second conduits connecting said ports respectively with the coordinate first conduits at points between said rotatable valve and said discharge valves.
3. A fuel injection pump comprising a substantially cylindrical housing, a plurality of parallel pump units including each a cylinder with a reciprocable plunger therein, and arranged on a circle within the housing so as to form a peripheral fuel supply chamber substantially between said cylinders and said housing, a centrally located barrel constituting an inner chamber, said inner chamber having ports, one for each pump unit, on the same level in the wall of said barrel, a permanently open connection between said two chambers, as many discharge valves as there are pump units and coordinated to the latter respectively, first conduits each connecting one of the discharge valves with one of said ports, a rotatable valve in said barrel, a common drive for cyclically reciprocating said plungers and for rotating said valve so as to cause the latter to close said ports each during a portion of the pressure stroke of the coordinate pump unit plunger, and second conduits connecting said first conduits with the coordinate cylinders respectively.
4. A fuel pump as claimed in claim 3 further comprising a common cover for said housing and said cylinders, said discharge valves, portions of

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said first conduits, and said second conduits being arranged in said cover.

5. A pump as claimed in claim 3 wherein said housing includes an inner shoulder and said barrel includes a flange bearing on said shoulder and provided with holes in which said cylinders are inserted, said flange constituting a partition of said housing so as to form said peripheral fuel supply chamber on the one side and an oil chamber on the other side thereof.

6. A fuel injection pump comprising a substantially cylindrical housing, a plurality of parallel pump units including each a cylinder with a reciprocable plunger therein and arranged on a circle within said housing, a plurality of discharge valves, one for each unit, a centrally located barrel constituting an inner chamber and forming on its outside together with said housing and said cylinders a peripheral fuel supply cham-

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ber, said barrel being provided with two sets of ports each set comprising as many ports as there are pump units, first conduits connecting the ports of the first set with said peripheral chamber, second conduits, each connecting one of the ports of the second set with one of said discharge valves, third conduits each connecting one of said second conduits to one of said cylinders, a rotatable valve within said barrel in controlling relationship to the ports of said second set, and a drive for said valve so as to cause the latter to cyclically close the ports of said second set, each during a portion of the pressure stroke of the coordinate plunger.

7. A pump as claimed in claim 6 wherein said first conduits are arranged each between two adjacent cylinders, and each port of the one set is located intermediate two ports of the other set.

LOUIS BEEH.