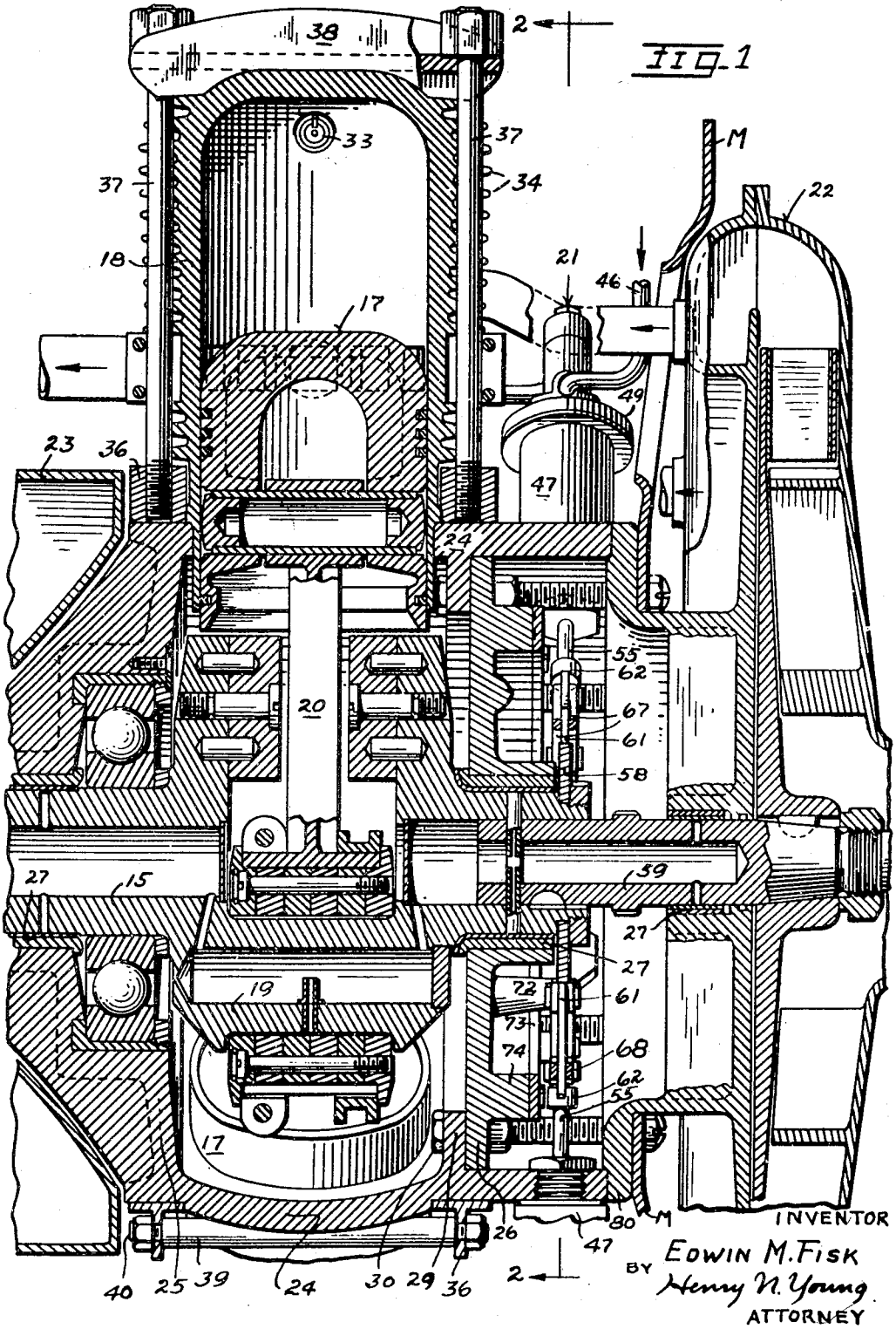
June 1, 1948. E. M. FISK 2,442,488

FUEL INJECTION PUMP

Original Filed May 19, 1941 3 Sheets-Sheet 1

FIG. 1



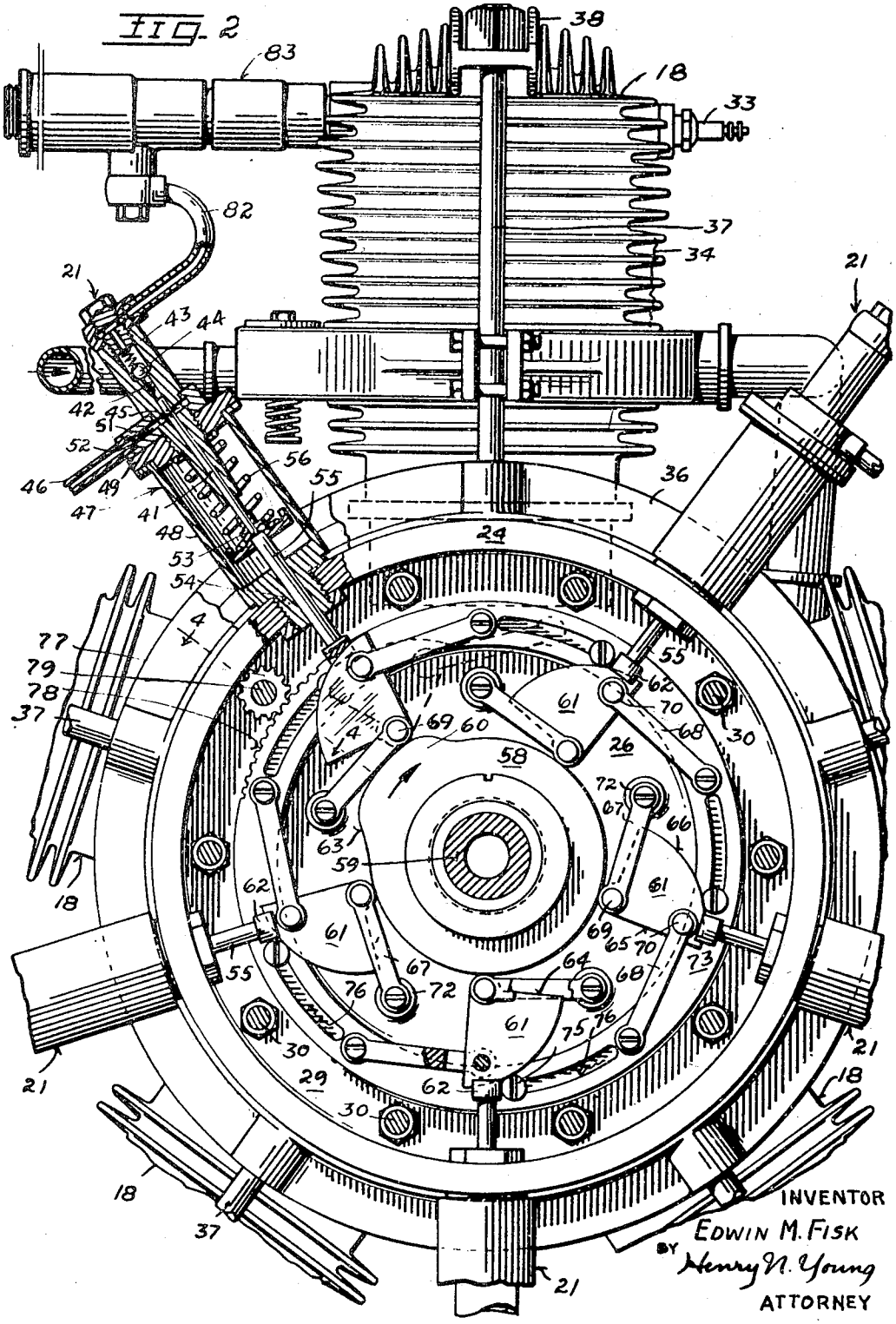
INVENTOR
BY EDWIN M. FISK
Henry N. Young
ATTORNEY

June 1, 1948. E. M. FISK 2,442,488

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FIG. 2



INVENTOR
EDWIN M. FISK
BY Henry M. Young
ATTORNEY

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FIG. 3

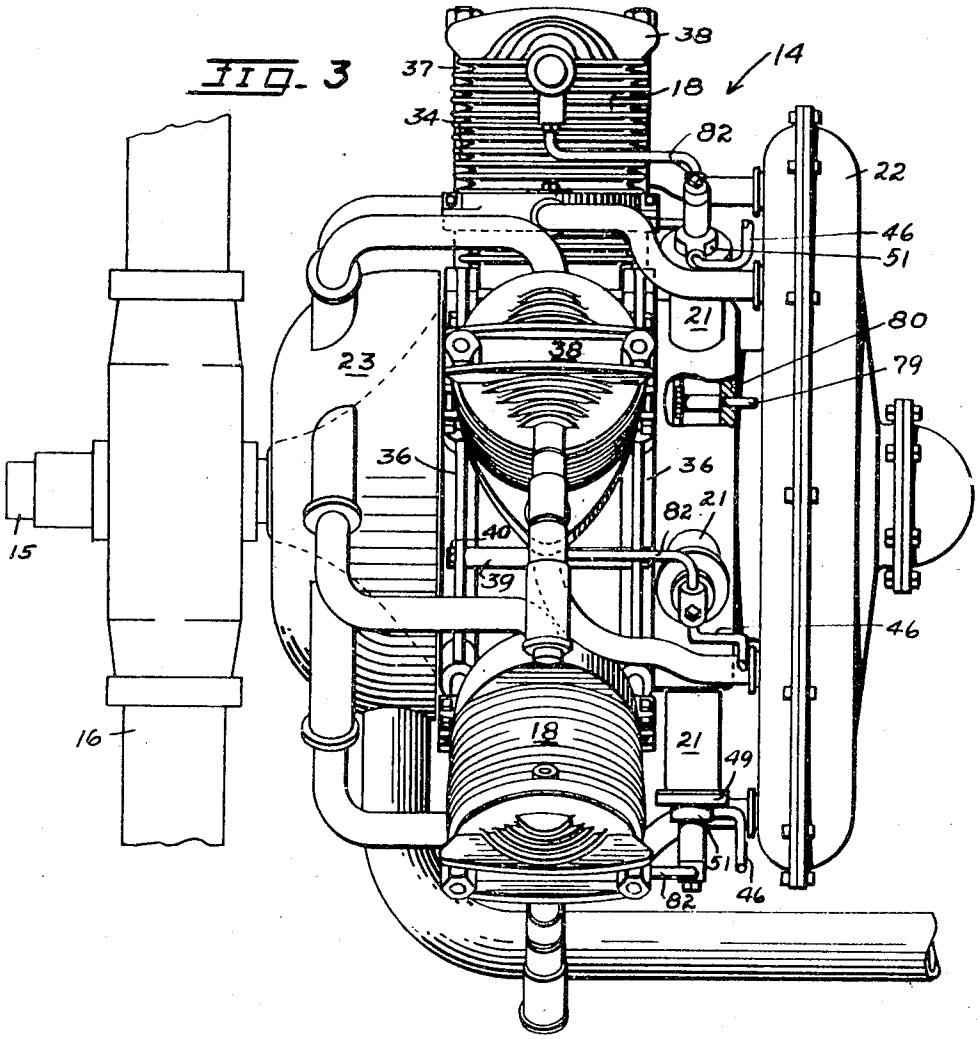
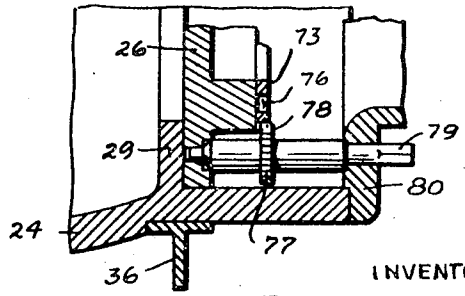


FIG. 4



INVENTOR
EDWIN. M. FISK
BY Henry N. Young
ATTORNEY

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UNITED STATES PATENT OFFICE

2,442,488

FUEL INJECTION PUMP

Edwin M. Fisk, Mission San Jose, Calif.

Original application May 19, 1941, Serial No. 394,097. Divided and this application November 15, 1943, Serial No. 510,354

5 Claims. (Cl. 103—38)

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The invention relates to a fuel injection pump for internal combustion engines of the Diesel-cycle type, and this application comprises a division of my application Serial No. 394,097, filed May 19, 1941 which issued into Patent No. 2,334,185 on November 16, 1943.

A general object of the invention is to provide a fuel injection pump which is particularly positive and dependable in its action.

A further object is to provide a fuel injection pump of the reciprocating piston type in which the volume of delivered charges may be adjustably varied without changing the length of the piston stroke.

A more specific object is to provide an improved operating and control means for an injector pump of the type described supplying fuel oil to the cylinders of a multi-cylinder radial engine.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be set forth or be apparent in the following description of a typical embodiment thereof, and in the accompanying drawings, in which,

Figure 1 is a fragmentary longitudinal section taken through a Diesel-cycle engine embodying the present features of invention.

Figure 2 is a fragmentary transverse sectional view of the engine taken at the line 2—2 in Figure 1.

Figure 3 is a side elevation of the engine at a reduced scale.

Figure 4 is a fragmentary section taken radially and axially of the engine structure at the line 4—4 in Figure 2.

For purposes of illustration, the features of present invention are incorporated in the structure of a radial Diesel engine 14 which is particularly arranged for use in the propulsion of an aeronautic vehicle. A crankshaft 15 carries a propeller 16 and is arranged to be driven by pistons 17 operative in cylinders 18 which radiate from the crankshaft axis and are connected to the same throw offset or crankpin 19 of the shaft by connecting rods 20, the cylinders being disposed in a common plane perpendicular to the crankshaft axis. The crankpin 19 may be counter-balanced by weighted shaft extensions extending radially from the opposite side of the shaft and spaced axially of the shaft to permit the operation of the connecting rods 20 between them. The present engine assembly, being particularly a Diesel-type engine, includes individual fuel pumps 21 and an air compressor 22 for respectively supplying fuel and air to the cylinders,

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these elements being provided at the opposite end of the engine from the propeller 16. An exhaust manifold 23 is provided at the forward end of the engine and behind the propeller 16.

The crankcase assembly comprises a generally drum-shaped structure including a tubular peripheral wall 24 coaxial with the shaft axis, and forward and rear end walls 25 and 26 which mount the shaft in suitable antifriction bearings 27 provided at axial openings therethrough. In the present structure, the wall 25 is integral with the peripheral wall 24 of the crankcase, and these walls are cooperative with the wall 26 to define the crankcase space in which the crankpin 19 of the shaft is operative. As particularly illustrated, a flange 29 extends radially inwardly from an intermediate point of the bore of the wall 24, and the wall 26 is fixed to said flange by means of bolts 30. At spaced points thereabout laterally of the zone of action of the crankpin, the peripheral crankcase wall 24 is provided with cylinder-receiving openings having their axes radial to the shaft axis, mutually co-planar, and equally spaced in their line, said openings being arranged to slidably and closely receive inner end portions of the cylinders 18.

It will now be noted that the cylinders 18 are alike, comprise separate and replaceable elements of the engine assembly, and are so mounted and secured at the cylinder-receiving openings that the firing of fuel charges therein does not produce tensional strains radially of the engine on either the cylinder or crankcase structures. As particularly shown, the cylinders 18 comprise like one-piece structures provided with bores having more or less convex closed outer end portions. Electric ignition plugs 33 may be provided at said outer portions of the cylinder bores, this providing for the necessary ignition for the starting of the engine while cold. The head end of each piston 17 is appropriately shaped for cooperation with the opposed head end of the cylinder cavity to provide the required head clearance, to facilitate the scavenging of combustion products, and to effect a desirable turbulence of the supplied aid to intimately mix it with the injected fuel. Externally thereof, each cylinder 18 provided at its sides and head end with heat-radiating ribs or fins 34, the cylinders thereby being arranged for air cooling.

At a point thereof spaced from its inner end, each cylinder 18 is provided with a radial flange which is operative to limit the distance of insertion of the cylinder within a cylinder-receiving opening in the crankcase wall 24. The inner faces

of each said cylinder flange and the opposed outer face portion of the wall 24 are mutually complementary to permit a sealing seating of the flange against the wall 24; as shown, said bearing faces are flat.

Ring members 36 are mounted on the crankcase wall 24 at opposite sides of the openings 28 and provide suitably positioned threaded radial bores for receiving the inner extremities of bolts 37 which are arranged to secure the cylinders to the rings while the inner cylinder portions extend through the cylinder-receiving crankcase openings; the present rings 36 are of T section. As particularly illustrated, a yoke member 38 spans and bears against each cylinder at its head end, extends parallel to the engine axis, and receives a bolt 37 through each of its extremities whereby said bolts freely receive the cylinder between them; this arrangement facilitates a balanced tightening of the bolts which are operative as tension elements between the cylinder head and the rings 36 to seat and secure the cylinder at the cylinder-receiving openings with an adjustable degree of pressure. Since the rings 36 receive the crankcase wall 24 within their bores, a tightening of a pair of bolts 37 for a cylinder urges the cylinder inwardly to effect a sealed seating of its flange against the opposed seat on the wall 24 while tending to pull the opposite sides of the rings against said wall. The mounted rings 36 may be tied together in fixed spaced relation; as shown, spreader sleeves 39 engaged between the rings and passing between adjacent cylinders and axially of the engine receive tie bolts 40 which are engaged with and between the flange portions of the rings.

With all the cylinders fixed on the crankcase in the described manner, it is preferable that the bores of the rings snugly engage the crankcase whereby the inward bearing and sealing pressure of the cylinder flanges against the crankcase may be assured. Under operating conditions, the reaction to a working stroke of a piston will tend to move its cylinder outwardly in the receiving casing opening to thereby, through the bolts 37, urge a pulling away of the rings from the wall 24 at the cylinder base while pulling the rings toward the wall at its diametrically opposite side to provide a positive bearing pressure of the rings thereat. Since each cylinder 18 is held against the crankcase only through the rings 36 and bolts 37 between the rings and other cylinders, their side walls are not subjected to any longitudinal tension by reason of a firing reaction, and the cylindrical crankcase is simultaneously subjected only to compressive forces, with the result that the present crankcase and cylinder structures do not receive the repeated tensile shocks which the crankcase and cylinders of an engine having its cylinders fixedly related to the crankcase must experience.

In the present five-cylinder Diesel-type engine, individual fuel pumps 21 are provided and operated for effecting the delivery of vaporized fuel to the different cylinders, said pumps being mounted on the portion of the crankcase wall 24 which extends rearwardly beyond the wall 26. By particular reference to Figure 2, it will be noted that each pump 21 comprises a piston or plunger 41 operative in a uniform bore 42 provided in a pump body or barrel 43. A spring-pressed check valve 44 is provided at the discharge end of the bore 42, and an input duct 45 extends radially to an intermediate point of the bore 42 through the body 43 for connection with a suitable source (not shown) of liquid fuel through a connecting tube 46.

Intermediately thereof, and at the opposite side of the duct 45 from the valve 44, the pump body 43 is externally threaded for mounting it on a base assembly 47 which is in turn mounted on the crankcase wall 24. As shown, the pump base assembly 47 comprises a cup-like member 48 of cylindrical outline and mounting a closure cap 49 which threadedly receives the threaded portion of the pump body 43. A ring member 51 comprising a connection for the tube 46 provides a duct 52 terminating in an annular groove in its bore for registration with the input duct 45 of the body. As particularly shown, the body 43 is stepped to provide a reduced cylindrical portion adjacent its threaded portion for extension through the bore of the member 41 whereby said member may be clamped between the cap 49 and the shoulder at the opposite end of the reduced body portion from the threaded portion by reason of the threaded engagement of the body in the cap, the duct 52 then being disposed in the plane of the duct 45.

The mounted pump body 43 extends into the cavity of the pump base member 48, and its piston-receiving bore 42 is long enough to insure a liquid seal of the plunger 41 which is relatively small and rod-like. The piston is arranged to constantly extend beyond the body extremity and its extending end carries a contact disc 53. The base portion 54 of the member 48 opposite the cap 49 is provided with an axial bore which slidably receives a push rod 55 for actuation against the contact head 53 of the pump piston 41, said bore being long enough to insure a solely rectilinear movement of the push rod. Also, the portion 54 of the member 48 has its extremity reduced and threaded for threaded engagement in a complementary and radially threaded opening in the portion of the crankcase wall 24 rearwardly of the crankcase and wall 26. In this manner, the axially aligned push rod 55 and piston 41 extend radially of the engine axis, and the piston 41 is movable outwardly in a working stroke thereof against the resistance of a compression spring 56 which encircles the pump body portion and piston 41 within the cavity of the base member 48 and reacts between the inner face of the cap 49 and the disc 53 to urge a constant disposal of the pump piston 41 in a limiting withdrawn position inwardly of the duct 45.

Understanding that the amount of liquid discharged from the pump is determined by the distance of working projection of the pump piston 41 beyond the discharge point of the input duct 45, and that the size of a charge must be variable to meet varying load and speed conditions for the engine, means are provided for varying the charge delivered through the check valve 44 at the will of an operator and while the engine is operating. The present piston actuating means is so operative that the piston stroke is the same for all of the different fuel charges to be provided by the pump, the position of the stroke range in the bore 42 being varied rather than the actual length of piston stroke.

For producing the two-stroke cycle for which the present engine is designed, a plate cam 58 fixed on a rear end extension 59 of the shaft 15 has its cam projection 60 operative in the general plane of the push rods 55 to successively actuate the pump pistons 41. Members 61 are constantly engaged between the cam profile 63 and shoes

62 provided on the inner ends of the push rods 55, said members being shaped and disposable to vary the distances between the shoes 62 and the cam profile 63 against which the shoes are held by the action of the spring 56 to determine the position and range of action of the head end of the plunger 41. As particularly shown, each member 61 is generally sector-shaped, and has radial edges 64 and 65 substantially perpendicular to each other and connected by a curved edge 66.

Links 67 and 68 respectively extend from pivotal connections with the members 61 provided by corresponding pivot pins 69 and 70, with the pin 69 adjacent the intersection point of the edges 64 and 65 while the pin 70 is adjacent the intersection point of the edges 65 and 66. The edge 66 of each member 61 is curved in the arc of a circle having its center at the opposite side of the pin 69 from the point of the juncture of the edge 64 with the edge 66; in this manner, the distance from the pin 69 to the said member point is less than the distances from the pin 69 to the point of the member at the juncture of the edges 65 and 66. With such an arrangement, it will be understood that the push rod shoe 62 is furthest from the pin 69 when the line of the pins 69 and 70 intersects the engine axis, and is nearest to the pivot point 69 when said line of pivot points is perpendicular to a line through the pivot point and the engine axis.

Each link 67 extends from a pivotal connection with a post 72 projecting transversely from the casing and wall 26, while each link 68 extends from a pivotal connection with an annular ring 73 which is rotatably mounted on an annular boss 74 on the wall 26. As particularly shown, the links 67 comprise pairs of transversely spaced like members which receive the members 61 between them adjacent the pivot pins 69, while the links 68 comprise pairs of transversely spaced like members which receive the members 61 between them and are pivoted to the same side of the ring 73. Header screws 75 are engaged through arcuate slots 76 provided in the ring 73 for mounting said ring on the boss 74 for a limited circumferential shifting thereof. By shifting the ring 73, the pivot points 70 may be variably disposed with respect to the plane of the axes of the pivot pin 69 and the engine for varying the radial spacing of the push rod shoe 62 from the pivot 69, it being noted that the members 61 provide cylindrical bearing edge portions which are concentric with the pivot pins 69, while the shoes 62 are slotted on their bearing faces to receive the edges 66.

Means are preferably provided for circumferentially adjusting the position of the ring 73, and said means is shown as comprising a gear 77 engaging a complementary gear portion 78 of the ring 73. The gear 77 is mounted on a stem 79 rotatably mounted on and extending transversely through a plate 80 which is fixed against the rear extremity of the crankcase wall 24. As brought out in Figure 4, the outer stem end is of polygonal cross-section for engagement by a lever or the end of a flexible shaft (not shown) to rotate the gear 77 and so adjust the positioning of the members 61 and the working stroke of the piston 41 in the bore 42; this comprises the throttle control for the engine.

An annular-plate 80 closes the rear end of the crankcase wall 24, comprises the attaching means or base of the rotary air compressor 22, and is secured to the crankcase by the bolts 30. As indicated in Figure 1, the bolts 30 may also secure

the engine to a mounting frame M for the engine. The shaft extension 59 mounts the rotor for the compressor 22, and its forward end is splined and pinned within the axial bore of the shaft 15 which is tubular for minimizing the weight of the engine.

A charge of liquid fuel discharged by a pump 21 is delivered to an engine cylinder 18 through a tube 82 to an injector nozzle 83 which discharges through an atomizing tip member 84 fixedly (threadedly) mounted in a fuel injection port of the cylinder for delivering an atomized spray of the liquid fuel to the head end of the cylinder. The injector nozzle 83 may be of any suitable structure for injecting a fuel charge into the cylinder. A particularly effective atomizing nozzle structure is disclosed in my copending application, Serial No. 510,356, filed November 15, 1943, which application also comprises a division of the aforesaid application Serial No. 394,097. It will be understood that certain features of the present injector pump 21 are adaptable for use in liquid-charge devices generally, and that the present disclosures are therefore not to be considered as limited to a Diesel-cycle radial type engine.

From the foregoing description taken in connection with the accompanying drawings, the advantages of the construction and operation of the present device will be readily understood by those skilled in the art to which this invention appertains. While I have described the features and principles of operation of an assembly which I now consider to comprise a preferred embodiment of my invention, I desire to have it understood that the showing is primarily illustrative, and that such changes may be made, when desired, as fall within the scope of the following claims.

I claim:

1. In an injector pump, a barrel providing a piston bore, a plunger operative as a piston in said bore, a liquid inlet port at an intermediate point of the bore, a cam shaft providing a cam, a single actuator member constantly and directly engaged with and between the plunger and cam for the driving of the plunger from the cam and disposable to variably space the plunger and the cam profile, and means adjustable to adjust the operative disposition of said actuator member between the plunger and cam whereby to adjustably vary the range of the plunger stroke in the bore without changing the length of the plunger stroke imposed by the cam.

2. In an injector pump, a barrel providing a piston bore, a liquid inlet port at an intermediate point of the bore, a plunger operative as a piston in said bore to deliver a liquid charge to the nozzle at each actuation thereof and in accordance with the distance of its projection beyond the inlet port, a shaft fixedly related to said barrel and providing a plate cam, a single member directly engaged between the plunger and cam for actuating the plunger from the cam and movable therewith, means constantly operative upon the plunger to maintain its engagement with the members and the engagement of the member with the cam profile, said member being adjustably rockable in its plane and shaped to differently space its points of engagement with the plunger and cam in its different adjusted positions, links cooperatively and pivotally securing the member in its operative position between the plunger and cam and between fixed and movable elements whereby a movement of the movable element is arranged to rock the member in

its plane to change the mutual spacing of the rod and cam for changing the range of operation of the plunger in the bore without changing the working stroke of the plunger produced by the cam, and means adjustable to adjust the setting of the movable element for varying the fuel charge delivered by the pump at each actuation thereof.

3. In an injector pump, a barrel providing a piston bore, a liquid inlet port at an intermediate point of the bore, a plunger operative as a piston in said bore to deliver a fuel charge to the nozzle at each actuation thereof and in accordance with the distance of its projection beyond the inlet port, a shaft fixedly related to said barrel and providing a plate cam, an actuator member of general sector form having radial side edges connected by an arcuate edge and interposed between the cam and the plunger with its apical point slidably engaging the cam edge and its arcuate edge portion slidably engaging the plunger at points in the axial line of the plunger, a link pivotally connecting the apical point of the member with a fixed point and extending transversely of said line, a ring member mounted for circumferential adjustment about the axis of the cam shaft, and a link pivotally connecting a point of the member spaced radially of said apical point with said ring member whereby a circumferential adjustment of the ring is arranged to change the spacing of the engaged plunger point and the cam profile, and means adjustable to adjust the positioning of the ring element circumferentially thereof.

4. In an injection pump, a barrel providing a piston bore having a liquid inlet port at an intermediate point thereof, a plunger operative as a piston in said bore, a drive shaft in constantly fixed relation to said barrel and providing a cam, means providing a driving connection of variable effective length constantly engaged with and between the plunger and cam for the driving of the plunger from the cam in a working stroke, and means adjustable to adjust the effective length of said strut connection without change of the length of piston stroke.

5. A structure in accordance with claim 4 such that an adjustment of the effective length of the drive connection by the last means is arranged to simultaneously adjust the timing of the plunger actuation with respect to the rotative cycle of the cam.

EDWIN M. FISK.

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