MECHANISM FOR CONVERTING ROTARY MOVEMENT INTO RECIPROCATORY MOVEMENT

Fig.4.

Fig.8.

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The present invention relates to mechanisms for converting a rotary movement into a reciprocating movement and although the mechanism is primarily intended for actuating a reciprocating plunger of a pump, more especially, although not essentially, a fuel injection pump for internal combustion engines, it may advantageously be used for any other purpose where it is necessary to drive a reciprocating member from a source of rotary motion. One suitable alternative use to which the mechanism can be put is for actuating a vibratory apparatus such as is used for carrying out metal fatigue tests in workshops in which a supporting platform is subjected to vibration by one or more reciprocating members. Another use to which the mechanism of this invention may be put is for actuating a pawl for turning a ratchet wheel effecting feed movement of tool slides, machine tables and so on.

The main object of the invention is to provide a mechanism for the purpose referred to which permits the stroke of the reciprocating member to be varied infinitely between zero and a predetermined maximum.

A further object of the invention is to provide a mechanism in which the variation of the stroke of the reciprocating member can be effected automatically by means which is responsive to changes in the speed of the rotary member. Thus, in the case where the reciprocating member is a plunger of a fuel pump, then the mechanism can be driven from a suitable part of the engine and the stroke of the plunger varied to suit different working conditions of the engine.

Another object of the invention, as applied to a liquid fuel injector pump, is to provide an arrangement in which the pump is self-priming whereby vapour lock in the pump, due to temperature rise during an idle period after use, is eliminated.

A still further object of the invention is to provide a mechanism for the purpose referred to which is simple and inexpensive to make and which lends itself readily to mass production methods.

Still another object of the invention is to provide a mechanism for the purpose referred to which is capable of being adjusted either manually or automatically while the parts are in operation.

Broadly, according to the present invention, there is provided a mechanism for the purpose referred to which comprises a rocker arm or cross head pivoted between its ends to a member to be reciprocated, an eccentric, crank, cam or the equivalent connected to or adapted to engage said rocker arm on each side of its pivot, the eccentrics being arranged to act respectively on opposite sides of the rocker arm so as to move the latter bodily to reciprocate the said member when the eccentrics are wholly or partly in phase, means being provided for driving said eccentrics or the like and means for infinitely adjusting the eccentrics relatively to one another, or one relatively to the other, through a range of partly out-of-phase positions to vary the bodily displacement of the pivotal axis of the rocker arm and therefore the stroke of the reciprocating member.

To enable the invention to be clearly understood an embodiment thereof will now be described by way of example with reference to the accompanying drawings, as applied to a fuel injection pump, wherein:

Figure 1 is a vertical section through the pump taken on the line I—I of Figure 2.

Figure 2 is a fragmentary sectional view drawn to a larger scale of the lower end of one of the pump pistons.

Figure 3 is a vertical section of the pump taken in a plane at right angles to Figure 1 and on the line III—III of Figure 4.

Figure 4 is a projected section taken on the line IV—IV of Figure 1.

Figures 5 to 7 are purely diagrammatic views illustrating the setting of the eccentrics when (a) are wholly out of phase and impart no stroke to the piston or plunger, (b) are only partly out of phase and set to produce approximately a half stroke of the piston, and (c) are completely in phase to produce full stroke of the piston, and

Figure 8 is an explanatory diagram illustrating the relation between the parts for obtaining the settings shown in Figures 5 to 7.

The pump illustrated in the drawings is intended for use with a four cylinder engine and for this reason comprises four pistons which pump fuel to four injectors associated one with each of the engine cylinders. The pump may of course comprise only one piston or more or less than four pistons to suit requirements.

Referring to the drawings, the pump comprises four elongated tubular pistons or plungers 1 each arranged with its axis disposed vertically and with its upper and lower ends slidably supported in bores in spaced apart portions 2 and 3 of a main body part 4 so as to leave an intermediate part of the tubular plunger free for engagement by means described in detail hereinafter for imparting a reciprocating movement to the plunger 1 in such a manner that the lengths of stroke can be varied infinitely between zero and a predetermined maximum.

The internal diameter of the lower end of each plunger 1 is enlarged as indicated at 5 (Figure 2) and accommodates a non-return valve which may be a ball valve 6 which may be loaded by a spring 6a although obviously any other suitable form of non-return valve may be employed. The space below the lower end of each plunger 1 is connected by way of a chamber 7 to a fuel inlet 8 and, during downward movement of the plunger 1, the fuel enters the enlarged diameter lower end 5 thereof by way of the ball valve 6 which lifts off its seating 6b, the valve 6 being forced against its seating 6b so as to close the lower end of the plunger 1 when the latter rises during its fuel injection stroke when fuel is discharged through the upper end 1a to a pipe (not shown) connected to an outlet 9 and thence to a fuel injector nozzle associated with a cylinder of the engine.

The enlarged diameter lower end 5 of the plunger 1 constitutes a pumping chamber and also a priming chamber which renders the pump self-priming and also acts to eliminate vapour lock due to temperature rise during an idle period after use.

If desired, a suitable non-return valve may be inserted adjacent to the upper end of the plunger in the fuel line leading to the fuel injector nozzle of the cylinder supplied by the particular plunger.

The guiding of the ends of each tubular plunger 1 in co-axial bores in the portions 2 and 3 of the main body part ensures alignment and, if necessary, these ends of the plunger may slide through any suitable glands (not illustrated).

The means for imparting an infinitely variable recipro-
catory movement to each plunger 1 comprises a rocker member 10 or the equivalent pivoted between its ends at 11 to the plunger 1 and which is pivotally engaged at each side of its pivot at 12a by the straps 12 of eccentrics or cams 13 and 13a disposed at opposite sides of the rocker member, i.e., one above and one below and which are carried by shafts 14 and 14a in such a manner that the eccentrics 13 and 13a act on the rocker member 10 (when the eccentrics are wholly or partly in phase) to move the latter bodily to displace the plunger 1 axially to effect a pumping stroke. The said eccentrics are inter-connected by means for turning one or both thereof so that they may be infinitely adjusted relatively to one another, or one relatively to the other, through a range of partly out-of-phase positions to vary the movement or stroke of the rocker member 10 at the point 11 where it is pivotally connected to the plunger 1. In the specific embodiment being described, the shaft 14 is driven by the engine of which the pump forms a part and due to the resistance of the driving connection thereto can be regarded as non-adjustable for the purpose of setting the eccentric 13 carried thereby and for this reason the eccentric 13a on the shaft 14a is the one which is adjusted to vary the relative setting of the two eccentrics and therefore the stroke of the plunger 1, the setting of the eccentric 13 remaining constant.

The two shafts 14 and 14a are interconnected by a train of five or any other suitable number of gears 15 which are constantly driven by the engine through the shaft 14 carrying the eccentric 13 so that the gear on the shaft 14a always drives the larger and therefore the eccentric 13a carried thereby. The arrangement is substantially the same when both shafts 14 and 14a are free to be turned for adjustment of the eccentrics in which case the eccentrics 13 and 13a are turned simultaneously in opposite directions and are advanced and retarded relatively to one another. The eccentrics are preferably circular as shown but may be cam-shaped if desired.

The two end gears 15 of the train of gears are fixedly secured to their respective shafts 14 and 14a and the remaining three intermediate gears are supported by a bodily displaceable link 16 (see particularly Figures 4 and 7) which is pivoted at its ends to arms 17 and 18 which are mounted loosely on the shafts 14 and 14a respectively. Thus, by swinging the arm 18 by turning a squared portion 19 extending from this arm (see Figure 4) the arms 16, 17 and 18 can be caused to assume an infinite number of different angular positions (three of which are illustrated in Figures 5, 6 and 7); it is emphasised that Figures 5 to 7 are purely diagrammatic and that the shafts 14 and 14a have been purposely extended to space the linkage away from the first set of eccentrics and their rocker member, to which they are normally closely disposed as shown in Figures 3 and 4, so that the action of the linkage and gears can be clearly illustrated. When adjusting said arms the gears 15 are caused to turn as they are always in mesh and drive back on to the gear which is fitted to the shaft 14a so as to advance or retard this shaft and the eccentric 13a carried thereby. This adjustment can be made when the gears 15 are in motion with both shafts 14 and 14a rotating to drive their respective eccentrics 13 and 13a.

In Figure 5 the eccentrics 13 and 13a are 180° out of phase and cause the rocker arm 10 simply to rock about its pivot 11 without displacing the rocker member 10 that with the result that no stroke is imparted to the piston 1. In Figure 6 the eccentric 13a has been moved 90° out of phase with the other eccentric 13 with the result that the rocker member is displaced bodily as indicated in chain-dotted outline so that the plunger is moved approximately half its stroke.

Welded eccentrics 13 and 13a in phase is shown in Figure 7 and the eccentrics act to displace both ends of the rocker member in the same direction by a distance equal to the full throw of each eccentric, and a full stroke is imparted to the plunger 1 and the rocker arm is disposed at right angles to the axis of the plunger and moves between the full line and chain-dotted line positions. When the eccentrics are only partly out of phase and set to intermediate positions the rocker member 10 becomes inclined relatively to its right-angular position (as illustrated by Figure 6) and oscillates about its pivot 11 as shown in chain-dotted outline as the eccentrics rise and fall so that the eccentrics can be said to follow one another with one eccentric subtracting from the movement imparted to the rocker 10 by the other. In other words in intermediate positions the movement of one eccentric subtracts from the movement imparted to the other eccentric by the linear displacement of the pivotal connection 11 of the arm 10 with the plunger 1 is less than when the eccentrics are in phase so that the stroke of the plunger is correspondingly reduced.

In Figures 5 to 7 three main positions of the eccentrics are illustrated which correspond to no stroke (eccentrics 180° out of phase), approximately half stroke (eccentrics 90° out of phase), and full stroke (eccentrics in phase) but it will be appreciated that the eccentrics can be set to an infinite number of in-between positions so that the eccentric fuel pumped by each plunger can be varied to suit requirements.

Figure 8 which, as already stated is an explanatory diagram, indicates the length of the plunger stroke which is dependent upon (a) the angular movement of the setting arm 16 and the number of degrees to which the eccentrics 13 and 13a are rotated out of phase. The table of readings indicated in Figure 8 correspond to the different positions of the eccentrics shown in Figures 5 to 7. In this figure the movement of the arm 18 through the arc A to C at the right hand side of this figure results in the angular displacement of the arm 17 through the arc A' to C' at the left hand side of this figure. As tabulated, the reading when the outer end of the arms 18 and 17 are in the A and A' positions respectively indicates that the eccentrics are 180° out of phase (Figure 5 position) and no stroke of the piston as indicated in column three. When the arms 18 and 17 have been swung to their B and B' positions the arm 18 has been swung through 22.7° and the eccentric 13a are 90° out of phase and a piston stroke of 180° is obtained (Figure 6). When the arms 18 and 17 are moved to their C and C' positions and the arm 18 has been swung through 76° the eccentrics are in phase (Figure 7), i.e., 0° giving a piston stroke of 252°. This piston stroke of the opposite sense, 56 and 72°, for both eccentrics and the readings given are purely examples.

The amount of fuel pumped by each plunger can be adjusted so infinitesimally that the fuel supply to an engine can be regulated with complete accuracy to suit changes in running conditions of the engine.

The setting or adjusting arm 16 can be actuated automatically by the throttle control of an engine, by an engine driven governor or by means which are responsive to engine temperature or by any combination thereof.

To ensure that a constant and sufficient supply of fuel is maintained in the chamber 7, a priming piston 20 (Figures 1 and 3) may be provided in conjunction with each plunger 1, or one which is common to all the plungers, which feeds fuel from the inlet 8 way of a valve 21 to said chamber 7, excess fuel being discharged back to the fuel supply through an outlet 22. The or each priming piston 20 can be driven by an extension 22b of the strap of an eccentric.

I claim:
1. A phase shifting mechanism for controlling the stroke of a reciprocating element, comprising a driving shaft and a driven shaft mounted in spaced relation, and means for variably regulating the stroke of said element, said means comprising a rocking element axially pivoted to said reciprocating element, an eccentric on the driving shaft, an eccentric on the driven shaft, straps
pivoted to the opposite ends of said rocker member, and respectively surrounding the periphery of the eccentrics, a first arm loosely mounted on the driving shaft, a second arm loosely mounted on the driven shaft, a link pivoted at the opposite ends thereof to the free ends of said arms, a train of gearing having the end gears of said train connected with the driving shaft and the driven shaft, the gears intermediate the end gears of the train mounted on said link, and adjusting means for changing the angular position of the rocker member relative to the axis of the reciprocating element, said means having a manually controlled operating portion connected with said first and second arms, whereby, the turning of said operating portion will swing one arm to tilt the link and simultaneously turn the other arm on the drive shaft to cause the rocker member to assume an infinite number of different angular positions.

2. A phase shifting mechanism for a reciprocating piston, comprising, a rocker member pivoted between its ends to said reciprocating member, first and second eccentrics pivotally connected to the ends of said rocker member, said eccentrics acting on opposite ends of the rocker member to move the latter bodily with said reciprocating member when the eccentrics are wholly or partly in phase, a driving shaft, a driven shaft, a gear train whose end gears are mounted on said shafts, a displaceable link supporting the intermediate gears of the train, arms free on said driving and driven shafts and pivotally connected to the ends of said link, a manually manipulatable member mounted co-axially with the driven shaft and angularly adjustable to swing said arms whereby, the turning of said operating member will cause one of said arms to tilt the link and simultaneously turn the other arm on the drive shaft to cause the rocker member to assume an infinite number of different angular positions and to move the reciprocating member accordingly.

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