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2 Sheets-Sheet 1

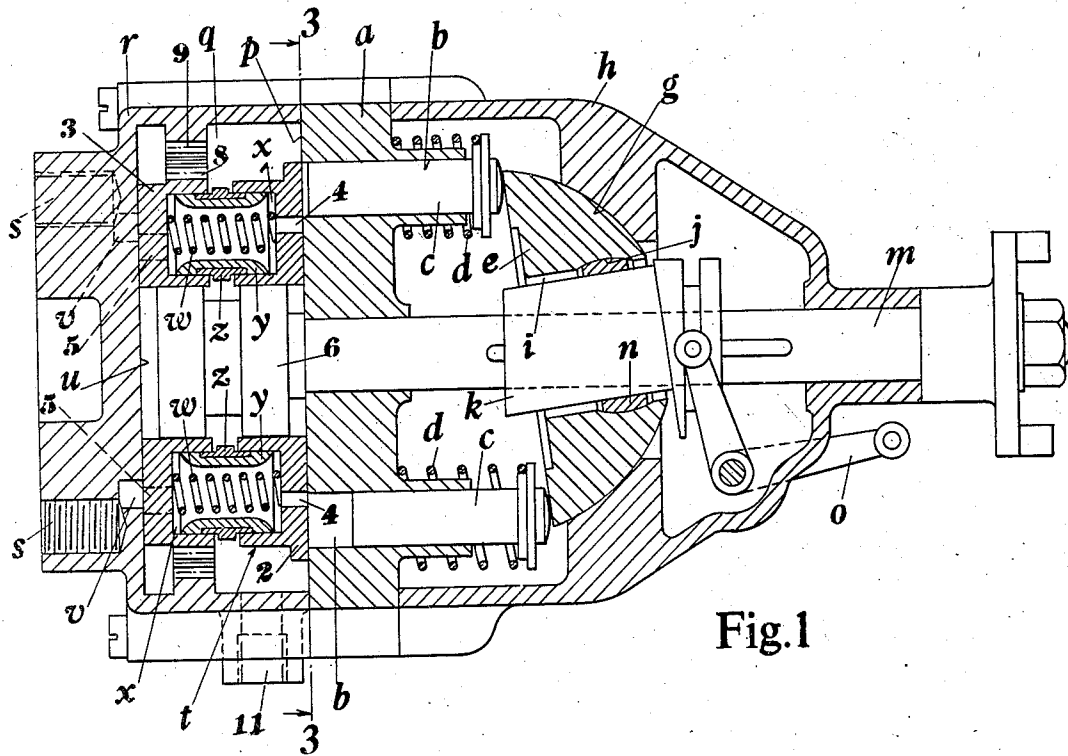


Fig. 1

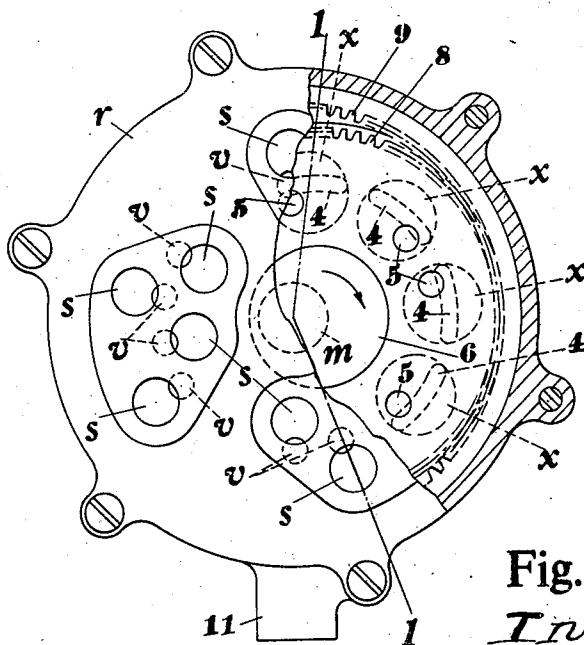


Fig. 2

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2 Sheets-Sheet 2

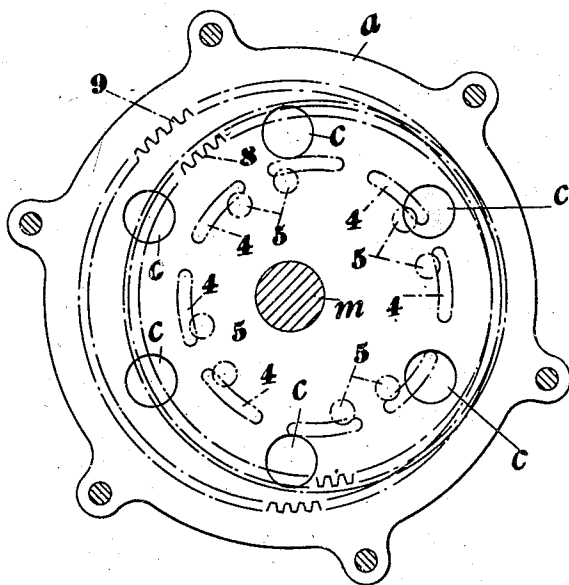


Fig.3

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4 Claims. (Cl. 103—173)

This invention relates to pumps of the reciprocatory type, and more particularly to injection pumps for supplying liquid fuel to multi-cylinder internal combustion engines. The object of the invention is to provide improved valve means adapted to serve both for controlling the suction and delivery phases of the pump action and for distributing the liquid among a number of different discharge passages.

The invention comprises the combination of a plurality of stationary cylindrical pump chambers arranged around a common axis and each having one end open to a valve seating surface, a reciprocatory plunger in each chamber, a plurality of discharge passages, greater in number than the pump chambers, an eccentrically mounted valve abutting on the said surface, and means for imparting epicyclic motion to the valve, the valve being adapted to control the admission of liquid to the pump chambers and to convey the liquid from the chambers to the discharge passages in the desired sequence.

In the accompanying sheets of explanatory drawings:

Figures 1 and 2 are respectively a sectional side view and a part sectional end view illustrating the invention applied to a liquid fuel injection pump for a multi-cylinder internal combustion engine, the left hand part of Figure 1 being taken on the line 1—1 of Figure 2.

Figure 3 is a section on the line 3—3 of Figure 1 looking in the direction of the arrows.

As shown in the drawings, we employ a stationary cylinder block *a* in which are formed or arranged a plurality of cylindrical pump chambers *b*, the latter being disposed with their axes equidistantly around a common central axis. Each chamber *b* contains a reciprocatory plunger *c*, which is movable in the outward direction by a spring *d*. Movement of the plungers *c* in the opposite direction is effected by a wobble plate *e* acting on the outer ends of all the plungers. The wobble plate *e* has the form of a part of a sphere and is supported in an oscillatory manner on a complementary concave surface *g* in a hollow stationary end cover *h* enclosing the outer ends of the plungers *c* and the adjacent end of the cylinder block *a*. In the wobble plate *e* is formed an axial bore *i*, and this is provided at or near one end with an annular recess *j*, the surface of the recess being of spherical form, and having its geometrical centre situated at any convenient distance from that of the spherical surface of the wobble plate. Extending through the bore *i* in the wobble plate *e* is an oblique

sleeve *k* on a rotary driving shaft *m*, the sleeve being rotatable with and capable of sliding movement on the shaft. Freely supported in the recess *j* is a complementary ring *n* which closely surrounds the sleeve *k*. When the driving shaft *m* rotates the axis of the sleeve *k* generates a conical surface. By moving the sleeve *k* axially to vary the distance between the centre of the ring *n* and the apex of the conical surface generated by the axis of the sleeve, the amplitude of motion of the wobble plate *e* can be adjusted, and this causes the strokes of the plungers *c* to be varied. Axial movement of the sleeve *k* is effected by a lever *o* pivoted to the end cover *h*. The ends of the pump chambers *b* remote from the wobble plate *e* open into a plane surface *p* on the cylinder block *a* at right angles to the common axis around which the chambers are arranged, and this surface forms one of the boundaries of a chamber *q* in a stationary end cover *r* enclosing the adjacent end of the cylinder block.

It is desirable that the pump above described shall be operated at engine speed, and therefore the number of pump chambers *b* provided in the cylinder block *a* is one half the number of cylinders in the engine, it being assumed that the latter operates on the usual four-stroke cycle. That is to say, in the case of a pump required to supply a twelve-cylinder engine, six pump chambers *b* and plungers *c* are provided for supplying liquid fuel through twelve delivery pipe connections or passages as *s* to the corresponding engine cylinders. It follows from this condition that the contents of each pump chamber *b* must be discharged to each in turn of two delivery pipe connections or passages *s*.

For controlling the supply and discharge of liquid to and from the pump chambers *b*, we employ a rotary disc valve *t* which is situated in the above-mentioned chamber *q*, and which constitutes the essential feature of the present invention. Preferably and as shown the delivery pipe connections *s* are provided in the end cover *r* at the end of the valve chamber *q* remote from the flat surface *p* of the cylinder block *a*, and the opposite flat faces of the valve *t* respectively abut against the said surface of the cylinder block and a flat face *u* in the said end of the valve chamber, the said flat face being formed with blind holes *v* leading to the pipe connections *s*.

To enable both faces of the valve *t* to maintain proper contact with their seating surfaces *p*, *u* in the valve chamber *q*, the valve is made from

two coaxially arranged annular parts 2, 3, and springs *w* are located between these parts to press them against the seating surfaces. The springs *w* are located in recesses *x* formed in the adjacent sides of the valve parts 2, 3, and in the same recesses are arranged sealing bushes *y* which surround the springs. The recesses *x* serve to establish communication between ports 4, 5, in the valve parts 2, 3, and the sealing bushes *y* serve to prevent escape of liquid from between the valve parts. Preferably and as shown the bushes *y* are provided with rubber or like sealing rings *z* which extend into the recesses *x* and between the valve parts 2, 3.

The valve *t* is actuated by an eccentric 6 formed or secured on the driving shaft *m* which passes coaxially through the cylinder block *a*, the eccentric (which may conveniently consist of a pair of spaced parts as shown) being situated within and adapted to fit the inner peripheries of the annular valve parts 2, 3. Moreover, the outer periphery of the valve *t*, or of one of its two parts 2, 3, is formed with a ring of gear teeth 8 adapted to engage an internally toothed annulus 9 in the valve chamber *q*, so that rotation of the driving shaft *m* produces an eccentric and epicyclic rotation of the valve.

The valve chamber *q* in the example shown serves also as a chamber to which liquid fuel is supplied through a pipe connection 11 from a storage tank (not shown), and from which the liquid fuel can pass into the adjacent ends of the pump chambers *b*. The diameter of the valve *t* is made such that its outer periphery can control the flow of liquid from the valve chamber *q* to each of the pump chambers *b*, the eccentric motion of the valve causing the latter to open and close the ends of the pump chambers in sequence.

Assuming the cylinder block *a* to be provided with six pump chambers *b*, the outer face of the valve part 2 (which is contiguous with the surface *p* of the cylinder block *a*) is formed with eight of the above-mentioned ports 4, these being of arcuate or kidney-shaped form, and being situated around a circle concentric with the centre of the valve *t* with their adjacent ends suitably spaced apart. Also the outer face of the other valve part 3 (which is contiguous with the surface *u* of the valve chamber *q*) is formed with eight of the ports 5, these being of circular form in cross section, and being situated around a circle concentric with the centre of the valve. Moreover the ports 5 are disposed in pairs, the ports of each pair being respectively situated opposite or nearly opposite to the adjacent ends of the corresponding arcuate or kidney-shaped ports 4, and the pairs of ports being separated by considerable distances as shown in Figure 2. In other words the valve part 3 is provided with four pairs of ports 5, the ports in each pair being close together, and the spacing between each pair being relatively large. The ports 4 and 5 serve with the recesses *x* to effect communication between the pump chambers *b* and the holes *v* in the valve chamber *q* leading to the delivery pipe connections *s*. The holes *v* are appropriately arranged in three groups of four, and the delivery pipe connections *s* are conveniently arranged in staggered formation as shown in Figure 2.

To elucidate the mode of action of the valve *t*, attention will be confined to the sequence of operations associated with one only of the pump chambers *b*. In one position of the valve *t* the outer periphery of its part 2 exposes an ample area of the adjacent end of the pump chamber *b*,

and liquid flows into that chamber from the valve chamber *q* while the corresponding plunger *c* is performing its suction stroke. Meanwhile the adjacent kidney-shaped ports 4 are closed. By the rotation of the valve *t* the end of the pump chamber *b* is gradually closed, and when the plunger *c* is about to commence its delivery stroke the pump chamber is fully closed. Continued rotation of the valve *t* now causes one of the kidney-shaped ports 4 to move into position over the end of the pump chamber *b*, thus putting the latter into communication with one of the ports 5, and simultaneously or just previously this latter port has been brought into alignment with one of the holes *v* leading to one of an adjacent pair of the delivery connections *s*. Later in the rotation of the valve *t* the kidney-shaped port 4 moves out of its position over the end of the pump chamber *b* which simultaneously is again opened by the outer periphery of the valve part 2 to the valve chamber *q*. Simultaneously with, or shortly after, these events the port 5 moves out of coincidence with the hole *v*. This takes place during one rotation of the valve *t*. During the next rotation, the cycle is repeated, but in this cycle the next of the kidney-shaped ports 4 comes into action and during the delivery stroke causes the liquid from the chamber *b* to be discharged to the other of the said pair of delivery pipe connections *s*. Consequently this particular pump chamber *b* supplies fuel alternately to each of one pair of the engine cylinders. It will be understood, however, that during each rotation of the valve *t* it opens and closes each pump chamber *b* in turn and causes liquid to be supplied to six of the twelve engine cylinders in the proper sequence, the other six cylinders being supplied in the next rotation.

By our present invention we are able to effect the required control of the pump and distribution of the liquid among the different cylinders of the engine in a very simple and convenient manner. The invention is not, however, limited to the example above described, as the number of pump chambers employed can be varied to suit the number of cylinders in the engine to be supplied, and moreover subordinate details of construction may be varied to suit different requirements. Also instead of arranging the delivery passages at the side of the valve chamber remote from the cylinder block, they may be arranged in or adjacent to the said block, in which case the valve ports are all disposed in the one side of the valve and the latter is made in one piece, being held on its seating by a spring situated behind the valve. Also the invention is not limited to the particular kind of pump above described as it may be applied to other kinds of reciprocatory pumps, and moreover, whilst the invention is primarily intended for use in liquid fuel injection pumps it may advantageously be applied to pumps required for other analogous uses.

Having thus described our invention what we claim as new and desire to secure by Letters Patent is:

1. A reciprocatory pump having in combination a plurality of stationary cylindrical pump chambers arranged around a common axis and each having one end open to a valve seating surface, a reciprocatory plunger in each chamber, a plurality of discharge passages, greater in number than the pump chambers, an eccentrically mounted valve abutting on the said surface, and means for imparting epicyclic motion to the

valve, the valve being adapted to control the admission of liquid to the pump chambers and to convey the liquid from the chambers to the discharge passages in the desired sequence.

2. A reciprocatory pump as claimed in claim 1 and having in combination an eccentric adapted to actuate the valve, a ring of gear teeth on the valve, and a stationary toothed annulus adapted for engagement by the said gear teeth, the arrangement being such that motion of the eccentric produces an eccentric and epicyclic rotation of the valve.

3. A reciprocatory pump as claimed in claim 1, in which the valve comprises in combination a pair of coaxial parts arranged between a pair of seating surfaces, and resilient means holding the outer faces of the said parts in contact with

the said seating surfaces, one of the said faces being formed with arcuate ports through which liquid can enter the valve from the pump chambers, and the other of the said faces being formed with ports through which the said liquid can flow to the discharge passages.

4. A reciprocatory pump as claimed in claim 1, in which the valve comprises in combination a pair of coaxial parts arranged between a pair of seating surfaces and provided with ported outer faces and intermediate recesses, springs arranged between the said parts, and sealing bushes surrounding the said springs and arranged in the said recesses.

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