

[54] **APPARATUS CAPABLE OF USE AS A PUMP OR A MOTOR**

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[22] Filed: **May 26, 1970**

[21] Appl. No.: **40,543**

[30] **Foreign Application Priority Data**

May 31, 1969 Great Britain.....27,685/69
June 27, 1969 Great Britain.....32,556/69

[52] U.S. Cl.....**418/45**, 417/477

[51] Int. Cl.**F01c 5/00**, F04b 43/08, F04b 43/12

[58] Field of Search 418/45; 417/476, 477; 92/132

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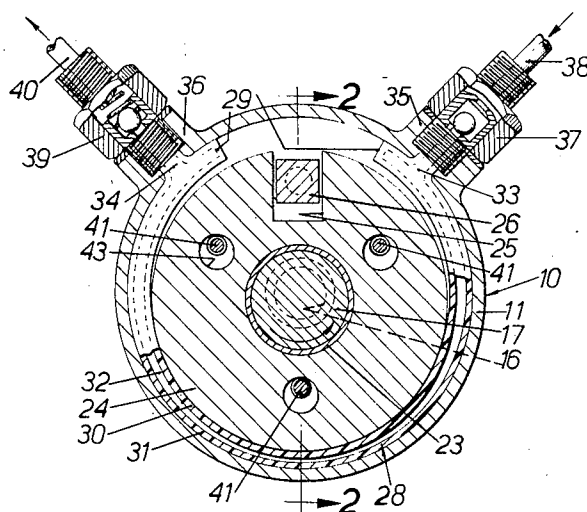
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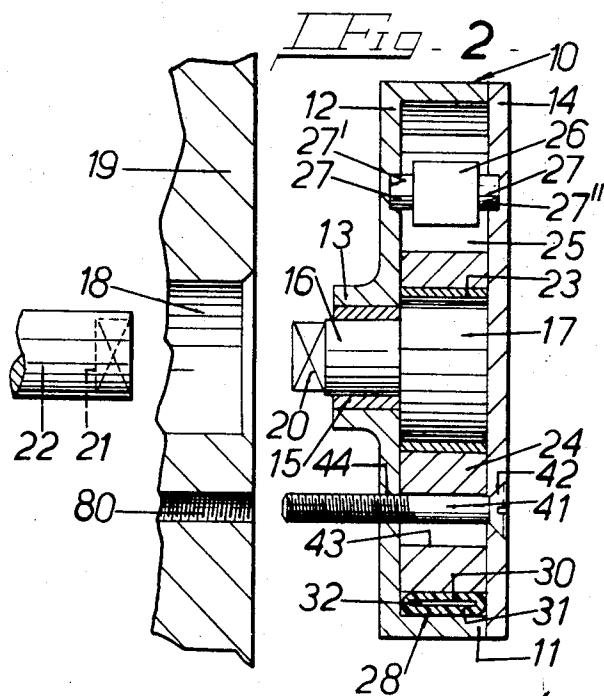
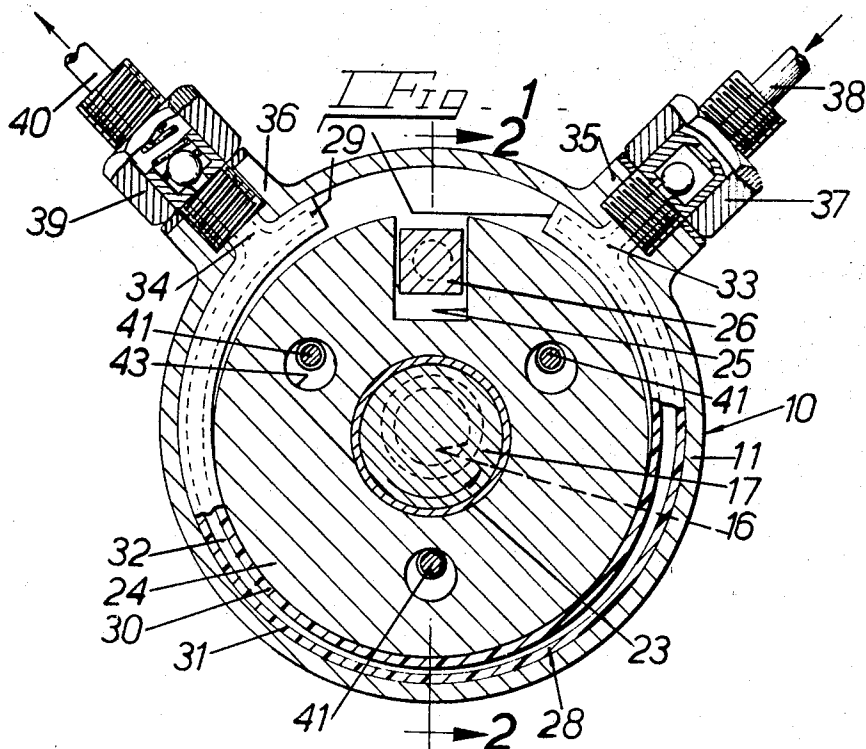
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[57] **ABSTRACT**

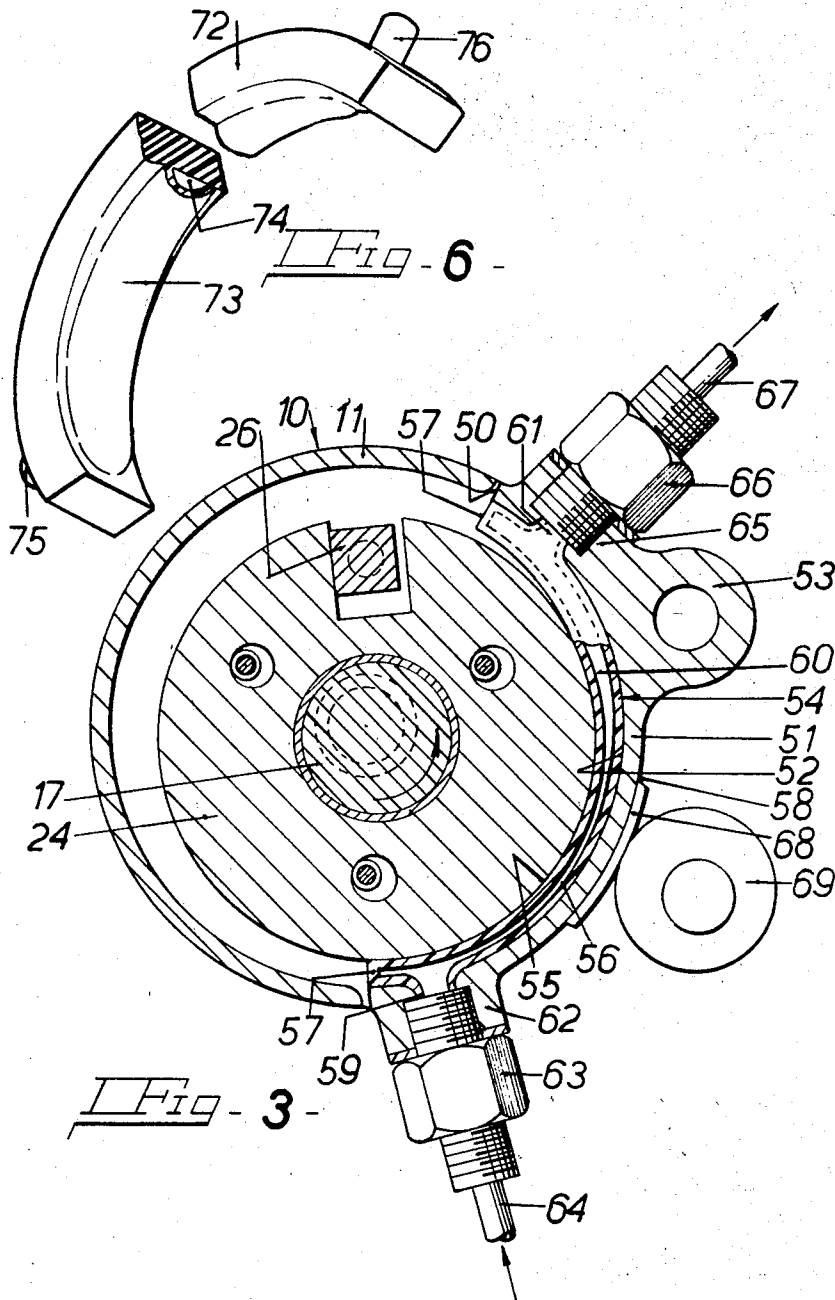
There is disclosed hereinafter an apparatus which may be used as a pump, particularly suitable for fuel injection, or as a fluid driven motor. The apparatus comprises at least one flexible diaphragm which defines with a supporting part thereof a chamber for receiving fluid, and a compression element which is operatively connected to a rotary shaft and moves with an oscillatory action normal to the diaphragm, and bears on the diaphragm, to compress the chamber intermittently so that fluid in the chamber is pressurized and leaves the chamber with a pulse-like action.

9 Claims, 8 Drawing Figures





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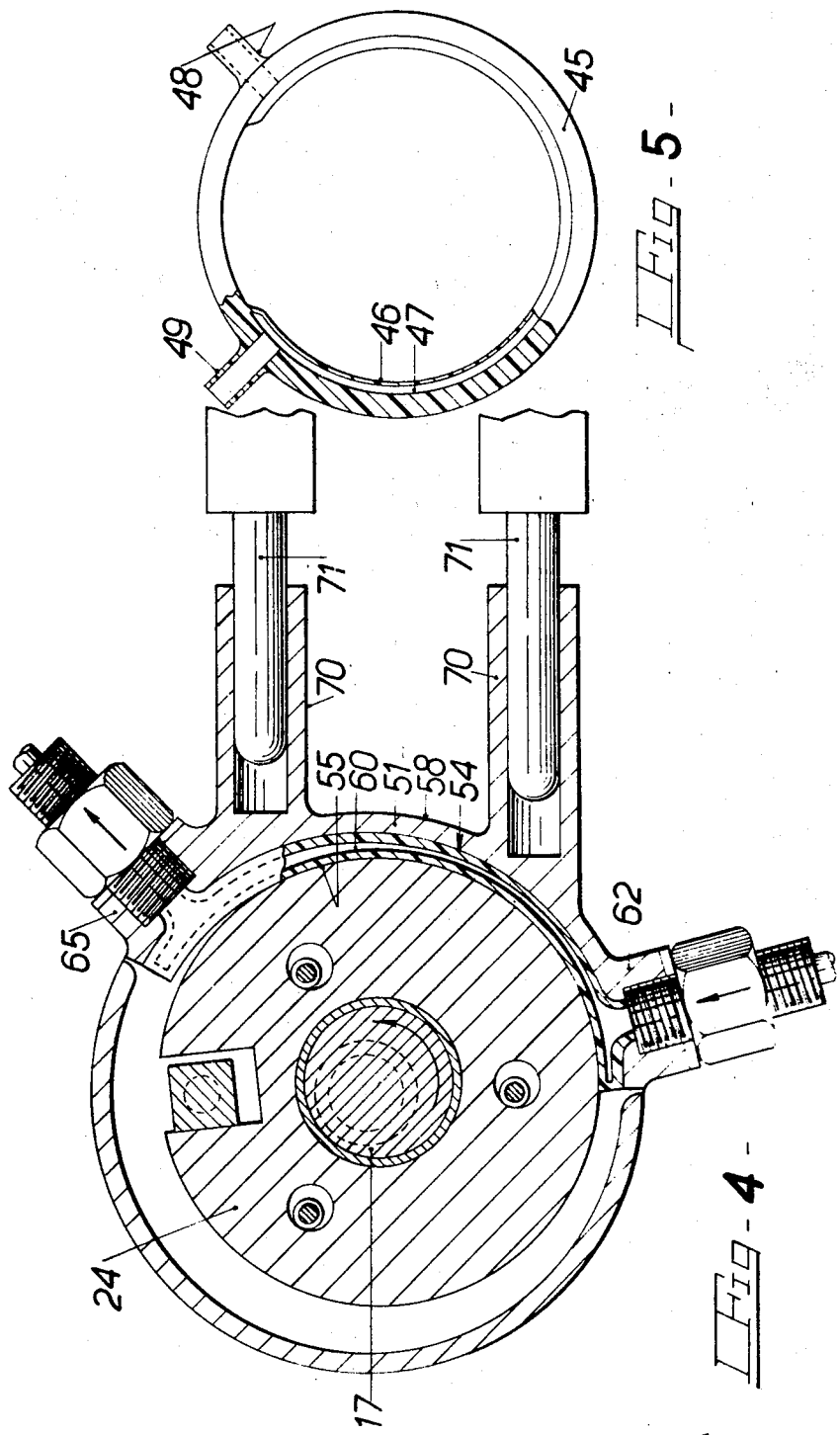


FIG - 5 -

FIG - 4 -

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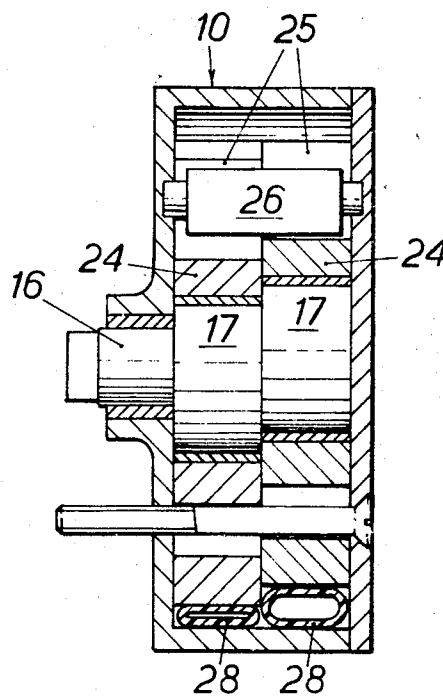
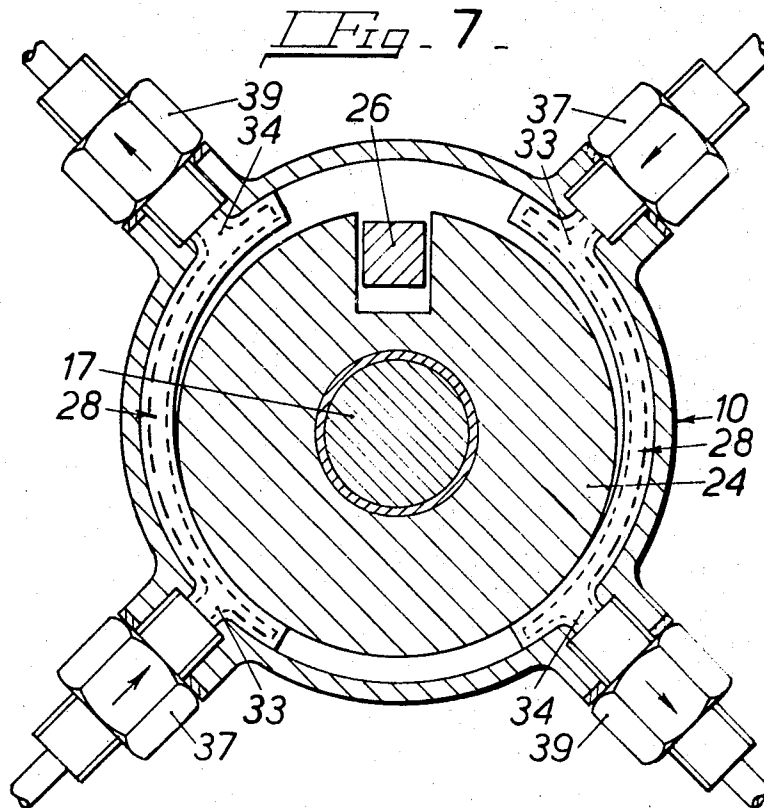


Fig. 8

APPARATUS CAPABLE OF USE AS A PUMP OR A MOTOR

This invention relates to apparatus capable of use as a pump for imparting energy to fluids, or as a fluid-driven motor.

An object of the present invention is to provide apparatus capable of use as a pump or a motor comprising at least one flexible diaphragm which defines with a diaphragm-supporting part a chamber for receiving fluid, and compressing means operable connected to a rotary shaft and movable with substantially oscillatory action normal to the diaphragm so as to bear on the diaphragm to compress the chamber intermittently and thereby cause fluid supplied to the chamber in use to be pressurized in the chamber.

The apparatus may be used with gaseous and liquid fluids. Where the apparatus is used as a pump fluid will normally be supplied continually to the chamber at a predetermined pressure. The intermittent compressing of the chamber by the compression means causes the fluid to be pressurized in the chamber and to be propelled out of the chamber under pressure with a pulse-like action. There may be just one diaphragm, and hence just one chamber, or there may be a plurality of diaphragms. When the apparatus is used as a pump, the rotary shaft operates the compressing means. Where the apparatus is used as a motor it will usually be necessary to have at least two diaphragms and hence two chambers, which are successively operated upon by the compression means, in order to avoid dead spots in the operation of the motor. Fluid is supplied continually to each chamber under pressure and the build up of pressure in the chamber due to compression of the chamber by the compression means causes movement of the compression means which is transferred to the rotary shaft to rotate the shaft. The fluid again leaves the chamber with a pulse-like action.

Normally the chamber defined by the diaphragm and supporting part will be elongated, with fluid being supplied to the chamber near one end, and leaving the chamber at or near its opposite end. The chamber thus defined extends arcuately about, and usually substantially concentrically with, the axis of the rotary shaft. The chamber may taper towards one end.

The diaphragm may be a separate flexible membrane member secured and sealed to the supporting part. In such an arrangement the diaphragm may be of suitable rubber, synthetic rubber, plastics material or even possibly of metal having the required flexibility. It is preferred, however, because sealing problems are then avoided, that the diaphragm is formed integrally with the supporting part. It may for example be formed by a wall, or part of a wall, of a flexible tubular member, the remainder of which member constitutes the supporting part for the diaphragm. A tubular member may be provided in which the diaphragm is formed by a thin-walled, hollow, elongated, protruberance on one surface of a pad of flexible material which forms the supporting part, the interior of the protruberance forming the chamber for the fluid. A flexible, preferably strong, wear-resistant plastics material is suitable for the tubular member, although rubber and synthetic rubber may possibly be used as alternative materials, provided that they have sufficient strength and resistance to wear. The diaphragm-forming part of the tubular member is

on the inner circumferential side of the tubular member. Fluid inlet and outlet passages leading respectively to and from the chamber open to the outer circumferential side of the tubular member through the supporting part where connection is made to fluid supply and discharge pipes. The tubular member has sealed ends, and the inlet and outlet passages are provided near the ends.

It is preferred that the supporting part, whether it is formed integrally with the diaphragm or not, is flexible in order that it will absorb some of the shock loads resulting from the compressing engagements of the compression means with the diaphragm, which might otherwise cause choking of fluid in the chamber.

It is an essential requirement of the apparatus in accordance with the present invention that the compression means bears on the diaphragm to compress the chamber by movement of the compression means normal to the diaphragm. Hence there is no rolling or sliding contact between the compression means and the diaphragm, and therefore there is little or no friction between them so that wear on the diaphragm is minimized.

The compression means may comprise a disc or annulus which is mounted on but restrained from rotation with an eccentric rotatable with the rotary shaft, so that, because of the eccentric, the disc or annulus moves relative to the axis of the shaft with an oscillatory action and its periphery progressively describes a circle of larger diameter than that of the disc or annulus, and as it does so it bears on the diaphragm causing the chamber to be progressively compressed from its inlet end to its outlet end, with the result that fluid in the chamber is forced to flow along the chamber to the outlet. In the case of the apparatus being used as a pump the pressure of the fluid increases as it is forced to flow along the chamber. It will be appreciated that although the chamber is progressively compressed from its inlet end to its outlet end, this is effected by the disc's bearing on the diaphragm to apply pressure only in a direction substantially normal to the surface of the diaphragm, and not by a rolling action. Where there is more than one diaphragm they may be disposed at angularly spaced intervals around a single disc or annulus which bears on the diaphragms in turn to compress their associated chambers, or alternatively there may be two or more discs or annuli each of which is arranged to co-operate with one or more diaphragms.

If desired, means may be provided for varying the extent by which fluid in the chamber will be pressurized.

There are various uses to which the apparatus may be put. One application for which the apparatus when used as a pump is particularly suitable is for fuel injection in motor vehicles. It may be applied to single and multi-cylinder engines.

Embodiments of apparatus in accordance with the invention which take the form of fuel injection pumps for single cylinder internal combustion engines, will now be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a cross-section through one form of fuel injection pump,

FIG. 2 is a partly exploded axial section through the pump taken on line 2—2 of FIG. 1,

FIG. 3 is a cross-section through a further form of fuel injection pump which is adjustable,

FIG. 4 is a cross-section through another adjustable form of fuel injection pump,

FIG. 5 is a small partly sectioned front view of a modified form of integral diaphragm and support part which may be used in the pump shown in FIGS. 1 and 2,

FIG. 6 is a partly sectioned perspective view of a modified form of integral diaphragm and support part which may be used in the pump shown in FIG. 3 or FIG. 4,

FIG. 7 is a cross-section through a modified form of the fuel injection pump shown in FIGS. 1 and 2 of the accompanying drawings, and

FIG. 8 is a further modified form of the pump shown in FIGS. 1 and 2.

The fuel injection pump shown in FIGS. 1 and 2 of the accompanying drawings has a cylindrical housing 10 having a peripheral wall 11 and an annular back wall 12 formed with a central, rearwardly-directed, axial sleeve portion 13. A circular cover plate 14, which seats at its periphery on the forward edge of the peripheral wall 11, closes the front of the housing 10.

In the sleeve 13 is a bearing 15 in which is journaled a shaft portion 16 of an eccentric 17 disposed in the housing 10. In this instance the sleeve 13 is arranged to be received into a socket 18 of complementary diameter formed in a casing 19, FIG. 2, of an internal combustion engine. When the sleeve 13 is received into the socket 18 the rear face of the back wall 12 of the housing 10 lies flush against the engine casing 19. At its outer end 20 the shaft 16 of the eccentric 17 is squared and engages in a complementary socket 21 in the end of a drive shaft 22 which may for example be driven by the cam-shaft drive of the engine, or by the crank shaft drive, or any other suitable part of the engine.

Fitted to the eccentric 17 within the housing 10 is a bearing 23 on which is centrally mounted a metal disc 24 of somewhat smaller diameter than the internal diameter of the peripheral wall 11 of the housing. In the periphery of the disc 24 there is a notch 25 of elongated rectangular shape which extends radially of the disc. Engaged in this notch 25 is a square-section block 26 having co-axial journals 27 at its opposite ends which are received into bearing sockets 27' and 27'' in the back wall 12 of the housing 10 and the inner plate 14 respectively. The block 26 and its journals 27 may be formed as a moulding in a suitable plastics material having self-lubricating qualities. The width of the notch 25 is only slightly larger than that of the block 26 but the depth of the notch 25, that is the dimension of the notch measured radially of the disc 24, is appreciably greater than the dimension of the block 26 measured in the same direction. The engagement of the block 26 in the notch 25 restrains the disc 24 from rotating with the eccentric 17, and hence with the drive shaft 22, but allows the disc to move relative to the axis of the shaft under the action of the eccentric so that the periphery of the disc progressively describes a circle of larger diameter than that of the disc.

Inside the housing 10 a tubular member 28 is secured against the internal surface of the peripheral wall 11. The tubular member 28 extends arcuately through approximately 300° along the peripheral wall 11 and the radially innermost surface of the tubular member lies on a circle of diameter approximately equal to the diameter of the disc. The tubular member 28 is of regu-

lar oval cross-section with sealed ends 29, and it forms a composite diaphragm 30 and support 31 for the diaphragm; the diaphragm 30 being formed by the radially innermost wall portion of the tubular member, and the support 31 being formed by the radially outermost wall portion, the opposite side walls portions defining the rounded ends of the oval cross-section of the tubular member, and the sealed ends 29 of the tubular member. The tubular member 28 is formed from flexible, strong, wear-resistant synthetic plastics material, such as for example VITON (Trade Mark), which is moulded to shape. The interior of the tubular member 28 forms a closed chamber 32. The sealed ends 29 of the tubular member 28 are disposed at the side of the housing 10 nearest to the block 26 and they lie on opposite sides of, at equal distances from, a notional line extending radially of the disc 24 through the axis of the journals 27 of the block. Formed integrally with the radially outermost wall portion of the tubular member 28 near to each of the sealed ends 29 is a tubular spigot portion 33, 34 the bore of which opens into the chamber 32. The one spigot portion 33 provides an inlet to the chamber 32 and the other spigot portion 34 provides an outlet from the chamber. The spigot portions 33 and 34 respectively communicate with the bores of internally screw-threaded bosses 35 and 36 formed on the exterior of the peripheral wall 11 of the housing 10. Connected to that boss 35 with the bore of which the inlet spigot 33 communicates is a non-return valve 37 of known type and connected in turn to the non-return valve 37 is a fuel supply pipe 38. Connected to the other boss 36, with the bore of which the outlet spigot 34 communicates, is a normally closed pulse-valve 39, also of known type, to which is connected a fuel discharge pipe 40 leading to a fuel control and injector, not shown.

The cover plate 14 is secured in place by means of screws 41 the shanks of which extend through plain, countersunk holes 42 in the cover plate, through holes 43 in the disc 24 and through plain holes 44 in the back wall 12 of the housing 10, and are screwed into tapped holes 80 in the engine casing 19. The holes 43 in the disc 24 are sufficiently larger in diameter than the shanks of the screws 41 to allow for the movement of the disc with the eccentric 17 without interference from the screws.

In use fuel is continually supplied at a constant predetermined pressure to the chamber 32 by way of the fuel supply pipe 38, non-return valve 37 and inlet spigot 33. Because of the action of the eccentric 17 rotating with the drive shaft 22, the periphery of the disc 24 engages with the diaphragm part 30 of the tubular member 28 and causes the chamber 32 to be progressively compressed from its inlet end to its outlet end, with the result that fluid in the chamber is forced to flow along the chamber to the outlet spigot 34. The pressure of the fluid in the chamber increases as it is forced to flow along the chamber. The pressure of the fluid opens the pulse-valve 39 so that the fluid can pass out of the chamber, with a pulse-like action, by way of the outlet spigot 34 and to the discharge pipe 40. When the disc moves out of engagement with the diaphragm, and hence the chamber 32 is uncompressed and the fuel in the chamber returns to its normal, pre-determined, pressure, the pulse-valve 39 closes.

The resilience of the tubular member absorbs some of the shock load resulting from the compressing engagement of the disc 24 with the diaphragm part 30, and thereby avoids the possibility of fuel choking in the chamber 32.

Instead of the tubular member 28 described and illustrated in FIGS. 1 and 2, an annular pad 45 may be provided, as shown in FIG. 5, which is moulded from flexible, strong, wear-resistant plastics material. Formed on the inner circumferential surface of the pad 45 is a thin-walled, hollow, protruberance 46 which extends along a substantial part of the circumferential length of the inner surface of the pad. This protruberance 46 constitutes a diaphragm and the pad constitutes an integral support for the diaphragm. The interior of the protruberance 46 forms a chamber 47. A fuel inlet 48 and a fuel outlet 49 opening respectively into and from opposite ends of the chamber 47, extend from the outer circumferential surface of the pad 45 for connection to fuel supply and discharge pipes respectively. The pad 45 need not necessarily be a complete annulus.

In the embodiment shown in FIG. 3, the fuel injection pump again has a housing 10 which is of basically similar form to the housing 10 of the last described embodiment except that part of the peripheral wall 11 is removed leaving an opening 50 at one side of the housing. Fitted in this opening 50 is an arcuate shoe 51 an inner surface 52 of which forms in effect a continuation of the inner surface of the peripheral wall of the housing 10. The shoe 51 has an integral lug 53 near one end by which it is arranged to be pivoted to a suitable fixed mounting so that the shoe can be swung angularly about the pivot towards and away from the axis of the housing 10.

Secured on the inner surface 52 of the shoe 51 is an oblong, similarly arcuately curved, moulded tubular member 54 which is generally similar to the tubular member 28 of the first described embodiment except that it is shorter; the innermost wall portion of the tubular member forming a diaphragm 55 and the remainder of the member forming in effect a support 56 for the diaphragm. This tubular member 54 also has sealed ends 57, and, on its outer surface 58, a tubular inlet spigot 59 the bore of which opens to one end of a chamber 60 defined by the interior of the tubular member 54, and a tubular outlet spigot 61 the bore of which opens to the opposite end of the chamber 60. The inlet spigot 59 communicates with the bore of an internally threaded boss 62 on the outer surface 58 of the shoe 51 at the end of the shoe remote from the lug 53, to which boss 62 on a non-return valve 63 is connected, to which in turn a fuel supply pipe 64 is connected. The outlet spigot 61 communicates with the bore of an internally threaded boss 65 at the opposite end of the shoe 51 to which boss a normally closed pulse-valve 66 is connected. A fuel discharge pipe 67 is connected to the pulse-valve 66.

On the outer surface 58 of the shoe intermediate the lug 53 and the boss 62 is a raised bearing surface 68 which is engaged by a cam 69 pivoted to a suitable fixed mounting, not shown, and which is conveniently controlled by an accelerator of the vehicle to which the pump is fitted in use. Actuation of the cam 69 causes the shoe to swing towards the axis of the housing 10.

The shoe may normally be urged in the direction away from the axis of the housing by spring loading, not shown.

The rest of the pump shown in FIG. 3 is similar to the pump of the first described embodiment and the eccentric, disc and block are identified by the same reference numerals as those used in the previous embodiment for these parts. The disc 24 is operated as before.

Under the action of the eccentric 17 a portion of the periphery of the disc 24 is caused to move into contact with the diaphragm 55 once in every revolution of the eccentric. At low idling speeds of the engine the peripheral portion of the disc 24 engages and presses on the diaphragm 55 only near the inlet end of the chamber 60 and causes just that end portion of the chamber to be compressed. As the chamber 60 is compressed fuel is forced from that end portion of the chamber into the remaining un-compressed portion of the chamber, with the result that the pressure of the fuel in the chamber is increased and the fuel is urged to leave the chamber by way of the outlet spigot 61. The increased pressure of the fuel opens the pulse valve 66 so that the fuel can pass to the discharge pipe 67. When the disc 24 moves out of compressing engagement with the diaphragm 55 and the chamber returns to its normal state so that the fuel return to its normal, pre-determined pressure, the pulse valve 66 closes. Upon turning the cam 69 so that the shoe 51 is swung towards the disc the area of the diaphragm 55 which the disc engages is increased, and therefore more of the chamber is caused to be compressed. This of course increases the pressure of the fuel in the un-compressed portion of the chamber and increases the velocity of the flow of the fuel out of the chamber.

In FIG. 4 an alternative arrangement is shown for varying the extent by which fuel in the chamber is pressurized. The fuel injection pump is generally similar to that illustrated by FIG. 3 of the drawings, and the corresponding parts of the pump are identified by the same reference numerals as those used in FIG. 3. The difference between the two forms of pump lies in the fact that in the arrangement of FIG. 4 the shoe 63 is not pivotally movable but instead is linearly movable towards and away from the disc 24. In this instance there are formed integrally on the outer surface 58 of the shoe 63 two parallel, tubular bosses 70, one being positioned near to the inlet boss 62, and the other being positioned near to the outlet boss 65. These tubular bosses 70 are engaged by fixing pegs 71. The bosses 70 are slidable along the pegs 71. A cam, not shown, such as the cam 69 in the last described embodiment, may act on the outer surface 58 to cause the shoe, and hence the diaphragm part 55 of the tubular member 54, to be moved linearly of the pegs 71 towards and away from the disc 24 to vary the area of the diaphragm which is engaged by the disc and thereby vary the extent by which the chamber 60 is compressed so as to alter the pressure of the fuel as required. The movement of the shoe 63 relative to the pegs 71 may be effected in other convenient ways, as will be appreciated. Again, the shoe 63 may normally be spring-loaded away from the disc 24.

Instead of the tubular member 54 provided in the pumps illustrated by FIGS. 3 and 4, an arcuate pad 72, as shown in FIG. 6, may be used. The pad 72 is

moulded from flexible, strong, wear-resistant plastics material, such as for example VITON (Trade Mark). It has formed on its inner surface a thin-walled, hollow, protruberance 73 which extends almost the full length of the pad 72. This protruberance 73 constitutes a diaphragm and the pad 72 constitutes an integral support for the diaphragm. The interior of the protruberance 73 forms a chamber 74. As illustrated the protruberance 73, and thus the chamber 74, tapers towards one end. A fuel inlet 75 opens into the larger end of the chamber 74 and a fuel outlet 76 opens from the narrower end of the chamber. The inlet 75 and outlet 76 extend from the outer surface of the pad 72 for connection to the inlet boss 62 and outlet boss 65 respectively. The protruberance 73 may be untapered if desired. In some circumstances it may be better for the protruberance 73, and thus the chamber 74, to taper from the fuel outlet end to the fuel inlet end of the pad, or to be un-tapered.

The pumps described are for use with single cylinder engines. They are primarily intended for use on motor-cycles, but they could possibly be used on other motor vehicles as well.

It will be understood that the pumps described may be adapted readily for use with multicylinder engines. For example for a two cylinder engine the first described pump illustrated by FIGS. 1 and 2 of the accompanying drawings may be modified as shown in FIG. 7, so as to include two tubular members 28, instead of one, which are secured at angularly spaced positions adjacent the internal surface of the peripheral wall 11 of the housing 10 so that as the disc oscillates when the eccentric 17 is rotated its periphery bears in turn on the tubular members 28 to compress their associated chambers. As before each tubular member 28 has an inlet spigot 33 and an outlet spigot 34 connected respectively to a non-return valve 37 and a normally-closed pulse valve 39. Alternatively the pump may be modified as shown in FIG. 8. In this further modified form there are again two tubular members 28 but they are secured side-by-side to the internal surface of the peripheral wall 11 of the housing 10, and there are two similar discs 24 which are mounted on separate eccentrics 17 carried by the shaft portion 16 and are restrained, as before, from rotation with the eccentrics 17 by a common block 26. There is one tubular member 28 positioned opposite the periphery of each disc 24 so that as the disc oscillates it bears on the tubular member to compress the associated chamber. The discs are so arranged that when the chamber of one tubular member 28 is being compressed the chamber of the other tubular member is uncompressed.

It has been found that numerous advantages may be obtained from apparatus in accordance with the present invention when used as a pump for fuel injection. For example extremely accurate metering of fuel is possible with resultant consistency in output and efficiency. Also efficient air/fuel mixing can be achieved with consequent economical advantages, and high performance can be obtained from engines with which the pump is used, and high torque with low r.p.m. Furthermore, engines with which such a pump has been used have been found to give a very clean exhaust.

It will be understood that apparatus of the form described above and illustrated in the accompanying

drawings could be readily modified to convert them for use as motors.

What is claimed is:

1. Apparatus capable of use as a pump or as a motor comprising:
 - a housing having a cylindrical inner surface;
 - a rotary shaft journaled in said housing axially of said inner surface;
 - eccentric means rotatable with said shaft;
 - a cylindrical compression member mounted on said eccentric means within said housing;
 - restraining means secured to said housing and engaged with said compression member to prevent said member from rotating with said eccentric means but to allow said compression member, by the rotary action of said eccentric means, to oscillate relative to the rotational axis of said shaft;
 - a closed-ended tubular member having a flexible supporting part and a flexible diaphragm of thinner section than said supporting part, which said supporting part and diaphragm together define an arcuate closed fluid-receiving chamber which extends through an arc of substantially less than 360°, said supporting part having a fluid entry therein which opens into said chamber radially through said supporting part at one end thereof and a fluid outlet which opens into said chamber radially through said supporting part at the opposite end thereof, and said tubular member being mounted by said supporting part on said inner surface circumferentially thereof and directly opposite the periphery of said compression member with said chamber extending arcuately adjacent part of the periphery of said compression member and said diaphragm being towards, and lying on a circle centered on, the rotational axis of said rotary shaft, said circle being of a diameter substantially equal to the diameter of said compression member;
 - and a normally closed pulse valve at said fluid outlet adapted to open when subjected to fluid pressure above a predetermined value,
- the construction and arrangement being such that in use as said compression member oscillates its periphery bears intermittently on said diaphragm and urges said diaphragm resiliently towards said supporting part to cause said chamber to be compressed progressively from said fluid entry to said fluid outlet, and thereby to cause the pressure of fluid in said chamber to be increased to a level which opens said pulse valve and the fluid flows under pressure out of said chamber, and such that during each cycle of oscillating motion of said compression member there is a phase in which said chamber is not compressed by said member and said pulse valve is closed, the flow of fluid out of said chamber in consequence being intermittent and pulse-like.
2. Apparatus according to claim 1 wherein said tubular member comprises an arcuate pad of flexible material which forms said supporting part and is provided with said fluid entry inlet and outlet, and on an inner circumferential surface of said pad a thin-walled, hollow protruberance which extends along a substantial part of the length of said inner circumferential sur-

face and which forms said diaphragm, the interior of said protruberance forming said chamber.

3. Apparatus according to claim 11 wherein said tubular member comprises an annular pad of flexible material which forms said supporting part and is provided with said fluid entry inlet and outlet, and on an inner circumferential surface of said pad a thin-walled, hollow protruberance which extends along said inner circumferential surface and which forms said diaphragm, the interior of said protruberance forming said chamber.

4. Apparatus according to claim 1 wherein said diaphragm, and hence said chamber, tapers towards one end.

5. Apparatus according to claim 1 wherein there is a plurality of said diaphragms, and hence a plurality of said chambers, disposed at angularly spaced intervals around said compression member which as it oscillates bears in turn on said diaphragms to compress their associated chambers.

6. Apparatus according to claim 1 wherein there is a plurality of said diaphragms, and hence a plurality of said chambers, and a plurality of said compression members, there being at least one of said diaphragms positioned adjacent the periphery of each said compression member.

7. Apparatus capable of use as a pump or as a motor comprising:

- a housing having a cylindrical inner surface;
- a rotary shaft journaled in said housing axially of said inner surface;
- eccentric means rotatable with said shaft;
- a cylindrical compression member mounted on said eccentric means within said housing;
- restraining means secured to said housing and engaged with said compression member to prevent said member from rotating with said eccentric means but to allow said compression member, by the rotary action of said eccentric means, to oscillate relative to the rotational axis of said shaft;
- a closed-ended tubular member having a flexible supporting part and a flexible diaphragm of thinner section than said supporting part, which said supporting part and diaphragm together define an arcuate, closed fluid-receiving chamber which extends through an arc of substantially less than 360°, said supporting part having a fluid entry therein which opens into said chamber radially through said supporting part at one end thereof and a fluid outlet which opens into said chamber radially through said supporting part at the opposite end thereof;
- a normally closed pulse valve at said fluid outlet adapted to open when subjected to fluid pressure

above a predetermined value;

a movable member mounted in said housing opposite the periphery of said compression member for movement towards and away from the rotational axis of said rotary shaft, which said movable member forms part of said inner surface and on which said movable member said tubular member is mounted by said supporting part directly opposite the periphery of said compression member, with said chamber extending arcuately adjacent part of the periphery of said compression member and said diaphragm being towards, and lying on a circle centred on, the rotational axis of said rotary shaft, said circle being of a diameter substantially equal to the diameter of said compression member,

and means for moving said movable member towards and away from the rotational axis of said rotary shaft thereby to cause said tubular member to be moved towards and away from said compression member, the construction and arrangement being such that in use as said compression member oscillates its periphery bears intermittently on said diaphragm and urges said diaphragm resiliently towards said supporting part to cause said chamber to be compressed progressively from said fluid entry to said fluid outlet, and thereby to cause the pressure of fluid in said chamber to be increased to a level which opens said pulse valve and the fluid flows under pressure out of said chamber, and such that during each cycle of oscillatory motion of said compression member there is a phase in which said chamber is not compressed by said member and said pulse valve is closed, the flow of liquid out of said chamber in consequence being intermittent and pulse-like, the extent by which said chamber is compressed being adjustable by varying the position of said movable member, and thus of said tubular member, relative to the rotational axis of said rotary shaft.

8. Apparatus according to claim 7 wherein said movable member is an arcuate shoe pivoted to said housing adjacent one end of said shoe for angular movement towards and away from said rotational axis of said rotary shaft, and said means for moving said movable member comprising a cam engageable with said movable member.

9. Apparatus according to claim 7 wherein said movable member is an arcuate shoe having integral therewith parallel tubular bosses, and wherein fixed parallel pegs are engaged in said bosses, and said bosses are slidable along said pegs such that said movable member can be moved linearly towards and away from said rotational axis of said rotary shaft.

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