United States Patent

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[54] **FLUID PRESSURE ACTUATED MOTOR**
3 Claims, 10 Drawing Figs.

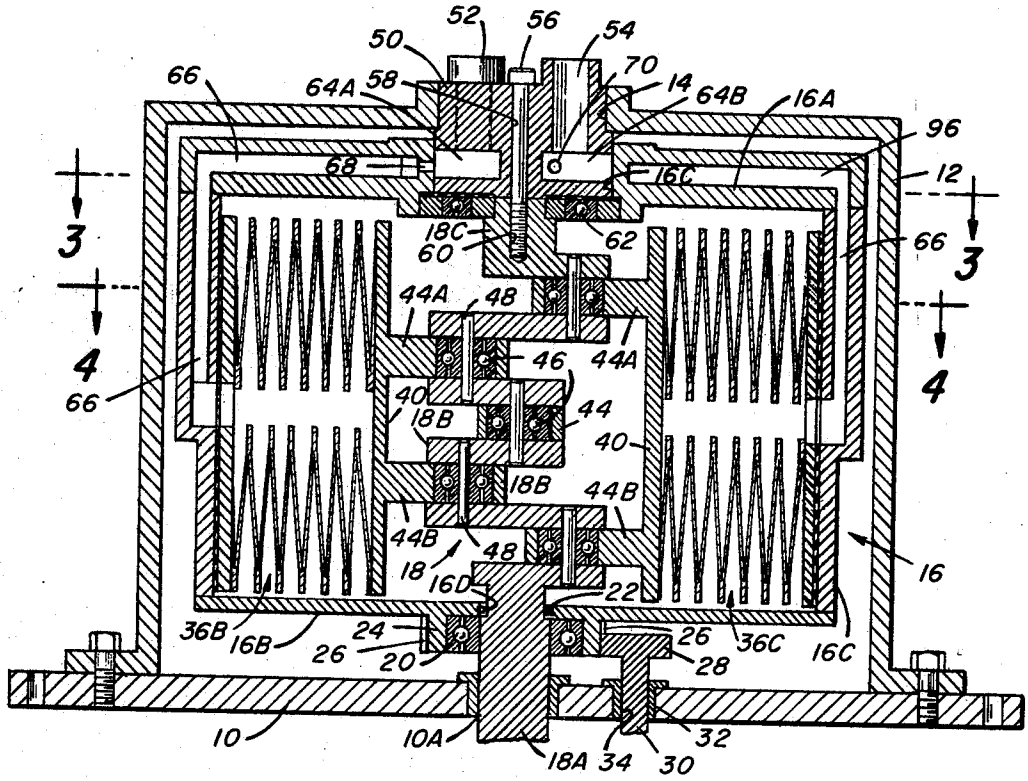
[52] **U.S. Cl.** **91/496,**
91/180, 91/202, 92/37, 92/72, 91/176
[51] **Int. Cl.** **F01l 33/02,**
F01b 13/06, F10j 3/00
[50] **Field of Search** 91/176,
180, (Inquired), 202, 204, 205; 92/72, 58;
107/161, 161A

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ABSTRACT: This invention relates to a fluid pressure actuated motor. More particularly, the invention relates to a fluid pressure actuated motor having a crankshaft within a closed housing and a plurality of bellows, each of the bellows having a connecting rod extending therefrom and connected to the crankshaft, including valve means communicating fluid pressure to the interior of the bellows and exhausting fluid pressure from the exterior of the bellows during one-half of a cycle and communicating fluid pressure to the exterior of the bellows and exhausting the bellows, during the other half of the cycle.



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SHEET 1 OF 3

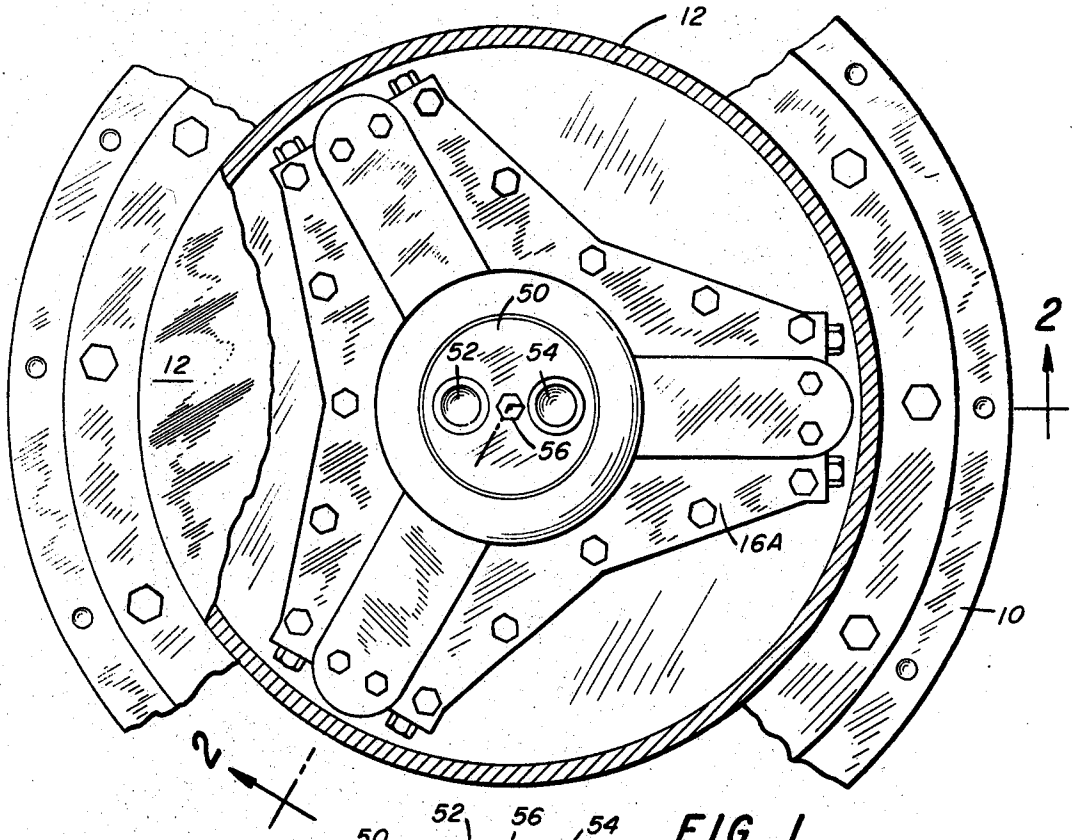


FIG. 1

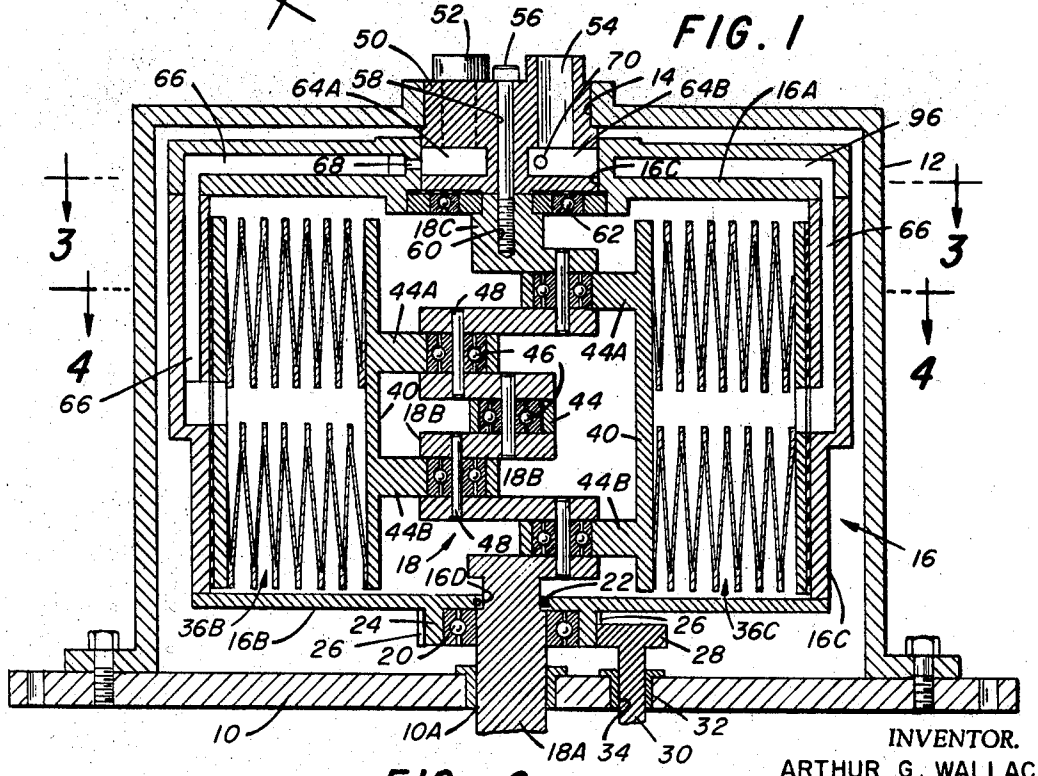


FIG. 2

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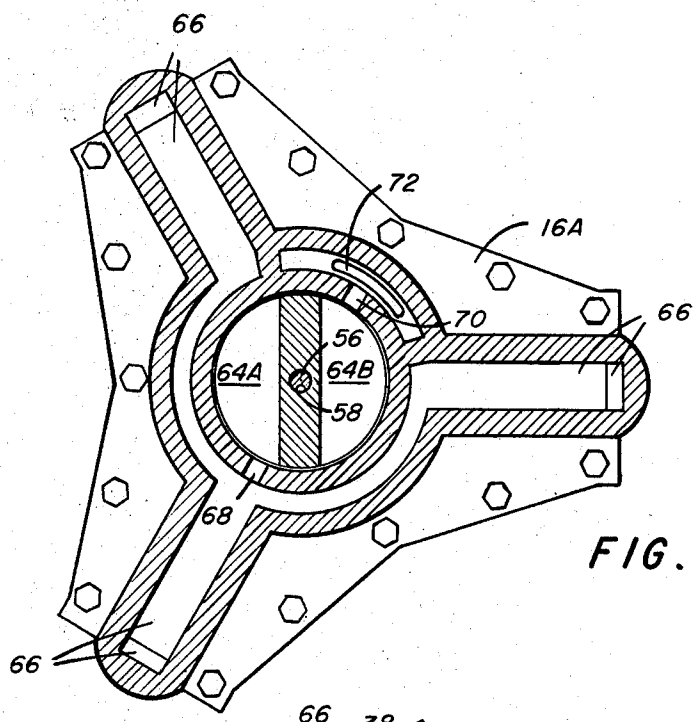


FIG. 3

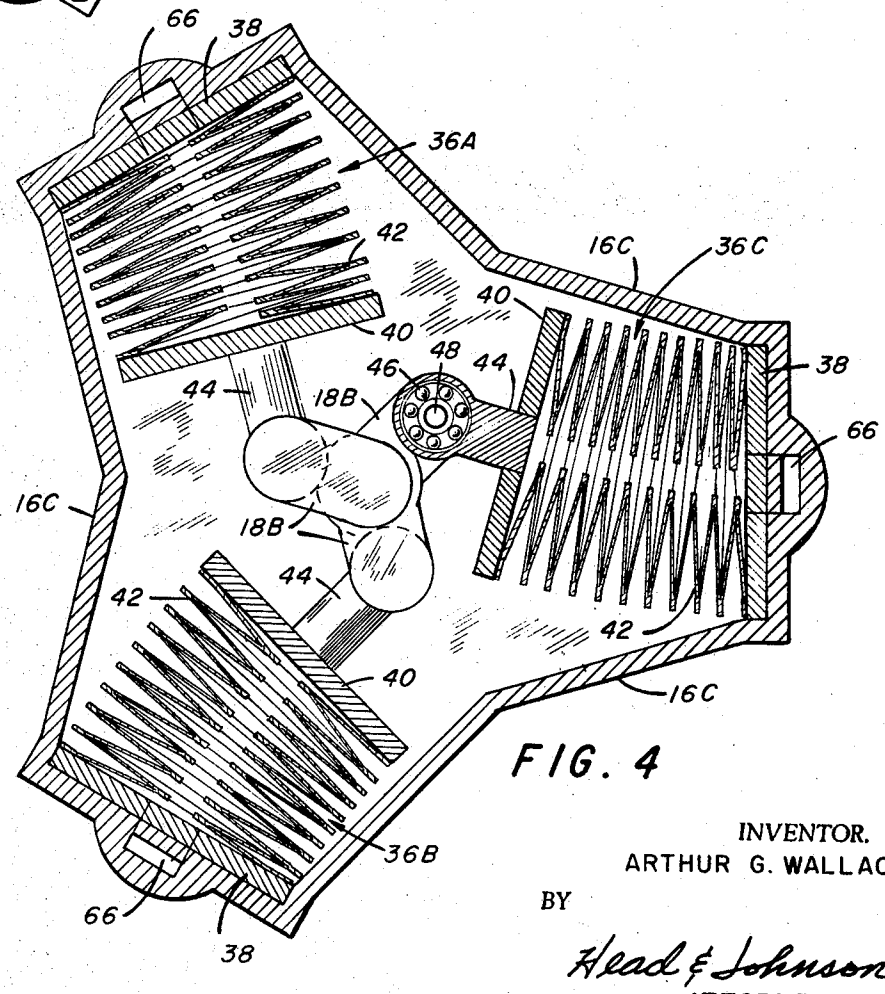


FIG. 4

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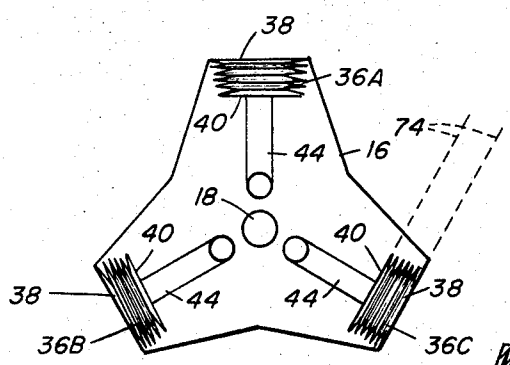


FIG. 5

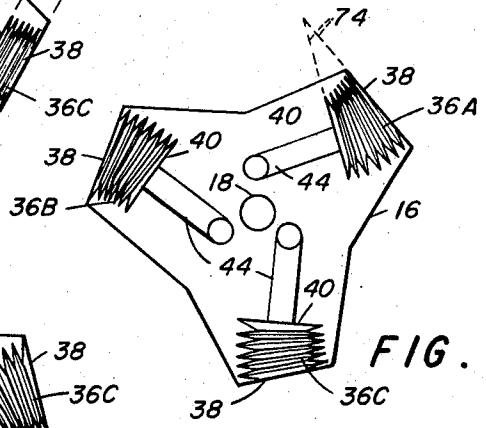


FIG. 10

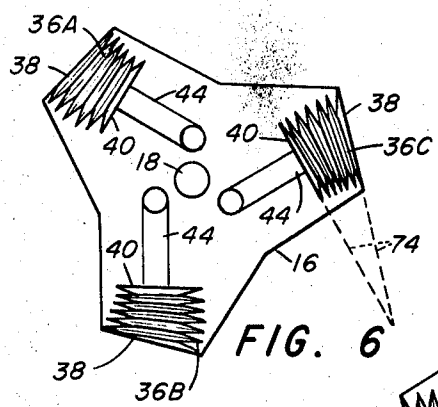


FIG. 6

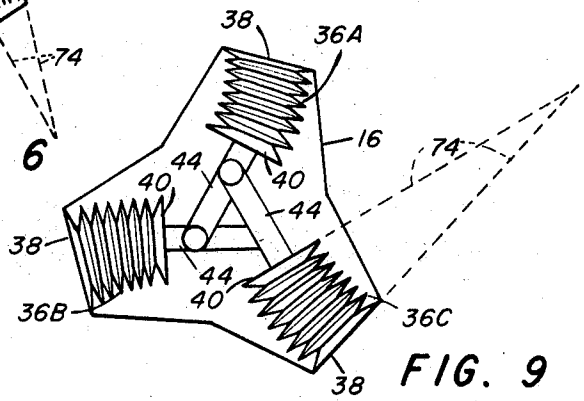


FIG. 9

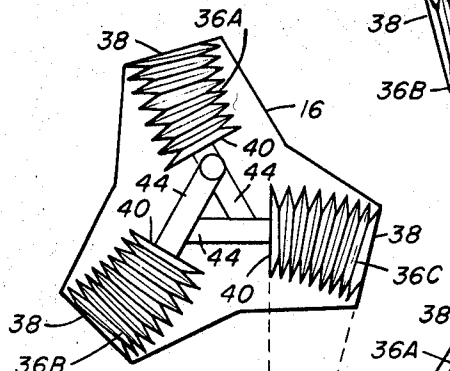


FIG. 7

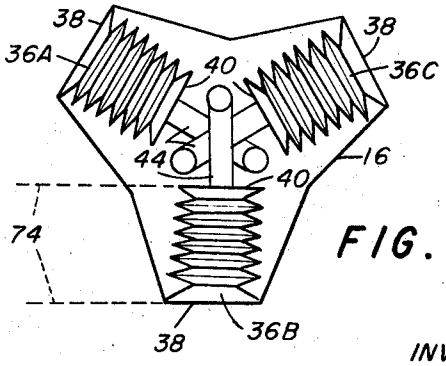


FIG. 8

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FLUID PRESSURE ACTUATED MOTOR

CROSS-REFERENCE

This disclosure is not related to any pending U.S. or foreign patent application.

BACKGROUND, SUMMARY, AND OBJECTS OF THE INVENTION

The use of bellows arrangements for converting pressure or vacuum into mechanical motion is well-known. This invention utilizes this well-known principal in a new and unique arrangement having several advantages over existing types of fluid actuated motors or pumps.

In this invention a plurality of bellows are sequentially communicated with a pressure source and then evacuated to transmit reciprocal motion to a crankshaft which converts such reciprocal motion into rotary motion. Among the unusual and unique features of the invention are the manner in which the torque is produced by fluid pressure on unequal surfaces within the bellows and the application of external as well as internal pressure on the bellows during a complete rotation cycle.

Other features of the invention which distinguish it over typical internal combustion engines and reciprocating pumps are the absence of frictional surfaces and particularly the absence of sealed frictional surfaces. In addition, unlike the typical reciprocating engine each bellows unit in this invention provides torque throughout the complete revolution thus providing a design having a favorable weight-power ratio.

One additional advantage of the invention over other types of engines is that it provides energy in the form of rotary motion without the use of electricity or combustion of gases and therefore the fluid motor of this invention is highly adaptable to hazardous locations.

The fluid pressure actuated motor of this invention has a unique application as a power source for driving implements from energy supplied from a typical hydraulic system. A specific application includes driving implements and tools, such as commonly utilized by a farmer, from fluid pressure derived from the hydraulic system commonly available on modern tractors.

The invention can equally as well be utilized as a motor or a pump. When utilized as a pump it includes several advantages, such as the provision of substantially constant fluid flow rather than pulsating flow as typically produced by a piston acting in a cylinder. In addition, the absence of frictional surfaces and sealing ring affords improved efficiency.

It is therefore an object of this invention to provide an improved pressure-actuated motor.

A more particular object of this invention is to provide an improved pressure-actuated motor utilizing bellows arranged in a closed housing wherein pressure is applied to the interior of the bellows on one half of a cycle and to the exterior of the bellows on the following half of the cycle to provide substantially uniform torque throughout a complete cycle.

Another object of the invention is to provide a fluid-actuating motor utilizing bellows in an arrangement where torque is produced by pressurized fluid on unequal surface areas within the bellows.

Another object of the invention is to provide an improved fluid pressure actuated device useful for operating tools and implements from any hydraulic pressure source.

Another object of the invention is to provide a pump for pumping fluids in an arrangement eliminating sealed frictional surfaces as typically encountered in reciprocating piston pumps.

These general objects as well as more specific objects of the invention will be understood by reference to the drawings and to the description as hereinafter set forth.

DESCRIPTION OF THE VIEWS

FIG. 1 is an end view of an embodiment of the motor of this invention with a portion of the supporting structure cut away to disclose the motor-closed housing.

FIG. 2 is a cross-sectional view of the fluid pressure actuated motor of this invention taken along the line 2–2 of FIG. 1.

FIG. 3 is a cross-sectional view taken along the line 3–3 of FIG. 2.

FIG. 4 is a cross-sectional view taken along the line 4–4 of FIG. 2.

FIGS. 5 through 10 are diagrammatic illustrations of the relationship of forward and rearward bellows plate during a complete cycle.

DETAILED DESCRIPTION

Referring to FIGS. 1, 2, 3 and 4 am embodiment exemplifying the invention is shown. Supported to a base plate 10 is a structural enclosure 12 having a valve block opening 14 therein. The structural enclosure 12 is more or less a superstructure for the motor elements. Rotatably positioned within structural enclosure 12 is a closed housing 16 including a valve plate 16A, a bearing plate 16B parallel to and spaced from the valve plate, and a circumferential housing portion 16C which extends from plate 16A and 16B to provide a fully enclosed housing.

Rotatably received within the closed housing 16 is a crankshaft, generally indicated by the numeral 18, having one end 18A extending through an opening 10A in base plate 10. The crankshaft portion 18A also extends through an opening 16D in closed housing 16 and the housing is rotatably supported relative to the crankshaft 18 by means of bearing 20. A seal 22 in opening 16D sealably closes the opening. Bearing 20 is retained by a tubular bearing housing 24, extending from bearing plate 16B. On the exterior circumferential surface of the bearing housing 24 are gear teeth 26 which mesh with a pinion gear 28 affixed to gear shaft 30. Shaft 30 is rotatably supported by a sleeve bearing 32 received in opening 34 in base plate 10.

Positioned within housing 16 is a plurality of bellows 36, there being three of such bellows in the illustrated embodiment, designated as 36A, 36B, and 36C (best seen in FIG. 4). Each of the bellows includes an outer bellows plate 38 and an inner bellows plate 40. Each of the bellows is completed by a foldable bellows portion 42 which is secured at the outer end to outer bellows plate 38 and at the inner end to inner bellows plate 40. Affixed to each of the inner bellows plate 40 is a rigidly extending connecting rod 44 (see FIG. 4). In the preferred arrangement, in order to provide balanced transmittal of reciprocating force from the inner bellows plates 40 to crankshaft 18, all but one of the inner bellows plates 40 have connecting rods in parallel pairs, as best seen in FIG. 2, designated by the letters 44A and 44B. Since one of the inner bellows plate 40 may have a connecting rod 44 extending from the center of the plate symmetry may be preserved when this connecting rod is single, that is, it does not need to be in the form of a pair. Thus, comparing FIG. 2 and FIG. 4, bellows 36B and 36C each have a pair of connecting rods 44A and 44B, while bellows 36A has only a single connecting rod 44.

Crankshaft 18 is a typical crankshaft as utilized in a multicylinder internal combustion engine, that is, it includes a plurality of crank arms 18B each of which rotatably receives a bearing 46 by means of a wrist pin 48. With each of the bellows except one having pairs of connecting rods 44A and 44B the crankshaft 18 includes spaced pairs of crank arms 18B as illustrated in FIG. 2.

Received in opening 14 in the structural enclosure 12 and in opening 16C in enclosed housing 16 is a cylindrical valve block 50. The valve block includes a pressure inlet opening 52 and an exhaust opening 54. In the preferred embodiment the valve block 50 is secured to the end of crankshaft 18 opposite the extending portion 18A, such as by means of a blot 56 extending through opening 58 in the valve block, the bolt 56 being threadably secured to a threaded opening 60 in the end 18C of crankshaft 18. A bearing 62 rotatably supports the crankshaft end 18C and bearing block 50 relative to closed housing 16.

The bearing block 50 includes opposed semicircular port recesses 64A and 64B therein, recess 64A communicating with pressure inlet 52 and recess 64B communicating with the exhaust opening 54.

Formed in the circumferential housing portion 16C are manifold passageways 66 which, as shown in FIG. 3, communicate with a port 68 terminating in the same plane as the port recesses 64A and 64B in valve block 50. According to the position of the valve block 50 relative to housing 16, during approximately one-half of a revolution of housing 16 relative to crankshaft 18, manifold passageways 66 communicate through port 68 and port recess 64A with pressure inlet 52, while in the other half of the revolution of the housing 16 relative to crankshaft 18 port 68 communicates with port recess 64B and exhaust opening 54.

A second port 70 is formed in a portion of the housing valve plate 16A, the second port being shown best in FIG. 3. Second port 70 communicates with a housing valve port 72 providing direct communication to the interior of the closed housing 16. Thus during one-half of a revolution of the housing 16 relative to crankshaft 18 the interior of the closed housing communicated by way of housing valve port 72, second port 70 and port recess 64B to the exhaust opening 54, and during the other half of the revolution the interior of the housing 16 communicates through housing port 72, second port 70, port recess 64A, to pressure inlet 52.

OPERATION

The apparatus of this invention can be used as a motor or as a pump. When used as a motor, fluid pressure is fed into pressure inlet 52. When the bellows 36 is fully withdrawn the port recess 64A in valve block 50 is aligned with first port 68. Thus the pressurized fluid is fed through manifold passageways 66 into the interior of each of the bellows 36A, 36B, and 36C. This pressure forces the bellows outwardly causing the housing and the crankshaft 18 to begin to rotate relative to each other. Pressure internally of housing 16, and externally of bellows 36, is exhausted by way of housing port 72, second port 70, port recess 64B, and exhaust opening 54. This condition exists until the housing 16 and shaft 18 have rotated approximately 180° relative to each other, at which time first port 68 aligns with port recess 64B and second port 70 aligns with port recess 64A. When this alignment takes place pressurized fluid passes through the pressure inlet 52, through port recess 64A, second port 70, and housing port 72 into the interior of housing 16. Thus pressure is applied to the exterior of the bellows. At the same time manifold passageways 66 now communicate by way of first port 68 to port recess 64B and thereby to exhaust opening 54. During this portion of the cycle pressure exterior of the bellows 36 forces fluid to flow out of the bellows, retracting the outer bellows plate 40 and connecting rod 44. Thus, during each one-half cycle pressure is forced into the bellows and exhausted out of the housing while during the other half of the cycle pressure is forced into the housing and exhausted out of the bellows.

The invention is uniquely arranged such that the crankshaft 18 may be held stationary while housing 16 rotates around it upon the application of fluid pressure to inlet 52 or, the housing 16 may be held stationary and crankshaft 18 rotated. When the crankshaft 18 is held stationary, such as by means of a brake (not shown) affixed to crankshaft extending portion 18A, the housing 16 is caused to rotate upon the application of fluid pressure. In this mode gear 26 on the exterior of bearing housing 24 rotates pinion gear 28 and shaft 30 to provide rotary power output in response to fluid pressure at inlet 52. If, instead, shaft 30 is held in a fixed position, such as by means of a brake, (not shown), then fluid pressure applied at opening 52 will cause crankshaft 18 to rotate while housing 16 remains stationary, thus providing rotary power out at the crankshaft extending portion 18A. When the second mode is utilized some form of a slip arrangement for transmitting fluid pressure to pressure inlet 52 and receiving discharge fluid at exhaust opening 54 would be needed (not shown).

Each of the bellows 36 inside closed housing 16 applies force to crankshaft 18 throughout the complete cycle of rotation of the housing and crankshaft relative to each other except for a small increment when ports 68 and 70 are passing between valve block port recesses 64A and 64B. Thus, unlike many reciprocal piston arrangements torque is delivered throughout substantially the complete cycle of rotation of the motor.

The provision of bellows in the motor of this invention eliminates frictional surfaces encountered in the typical cylinder piston type motor, thus reducing friction and wear, and preventing leakage or blow by which incurs in the piston-cylinder arrangement.

It can be seen that the apparatus of this invention can function equally as well as a pump. In this arrangement crankshaft 18 may be held stationary and rotary energy supplied to crankshaft 30 which rotates pinion gear 28 and thus rotates the housing 16 relative to the crankshaft 18. During one-half of a revolution, when the device functions as a pump, fluid is drawn into the interior of the bellows and forced out of the interior of the housing, and during the other half of the cycle fluid is drawn into the interior of the housing and forced out of the interior of the bellows. Thus, when used as a pump the invention provides substantially continuous flow.

A unique feature of the invention is the arrangement wherein force is applied on unequal surface areas during different portions of each cycle. This is best illustrated in FIGS. 5 through 8 which diagrammatically show three bellows within housing 16 rotating around a stationary crankshaft 18. FIG. 5 shows the bellows fully compressed at the beginning of a cycle. By dotted lines 74 it can be seen that the inner and outer plates 38 and 40 are parallel to each other and pressure internally of the bellows 36 causes a maximum force to be transmitted to the crankshaft 18. At this point opposing sides within the bellows units are equal in surface area and the torque is zero. As the cycle progresses as shown in FIGS. 6 and 7, the bellows are caused to expand and the surface area relationships within the bellows are progressingly altered. Through the first 180° of the cycle the inner bellows plate 40 becomes inclined at an angle relative to outer bellows plate 38 as illustrated by the dotted lines 74 which converge. This has the effect of reducing the effective surface area on the convergent side relative to the effective surface area on the divergent side. A resultant torque is thereby produced which rotates the bellows and bellows housing through 180° to a position of maximum expansion as shown in FIG. 8. At the completion of one-half cycle the inner and outer bellows plates 40 and 38 are again parallel, as shown by the nonconverging lines 74 in FIG. 8. At this point all opposing surfaces within the bellows are equal and the resultant forces desired from internal pressure create a torque of zero.

As the motor passes through the final 180° of a cycle it passes through positions as shown in FIGS. 9 and 10 wherein the inner bellows plate 40 is inclined relative to the outer bellows plate 38 resulting in a differential in effective surface area on each bellows unit. During the final 180° it will be noted that the convergent lines 74 in FIGS. 9 and 10 converge on a point which is 180° opposed to the point of convergence during the first 180° of the cycle. This in effect reverses the relative effective surface area relationship noted in the first one-half cycle. Pressure is applied to the external surface of the bellows during the final 180° of the cycle while the bellows interior is evacuated. This thereby develops a torque which acts in the same direction as the torque developed during the first one-half cycle.

Another unique feature of this invention lies in the manner of construction of the bellows which is best seen in FIG. 4. The flexible bellows leaves are so arranged that when the bellows is collapsed the adjacent leaves closely approximate. This arrangement reduces the volume within the bellows to a minimum when in the compressed position, best illustrated in FIG. 5. This allows for greater displacement than afforded by bellows mechanisms of different design which have relatively larger residual volume when compressed. This is of particular

advantage when the activating fluid is gaseous since the residual volume must be filled with pressurized fluid before effective force is developed.

The number of flexible bellows leaves herein illustrated in each bellows unit has been reduced to aid in graphic illustration. The number of such leaves in the invention can be materially increased to minimize the degree of flexion required of each leaf during operation, the magnitude of flexion being inversely proportional to the number of leaves comprising a bellows unit.

Fluid, as the term is used herein, means either gas or liquid which, under pressure, can be used to power the motor of this invention. It can be seen that the motor does not utilize any electricity nor does it depend upon combustion and therefore it can be utilized in explosive environments.

The valving arrangement illustrated herein is merely exemplary. Many other types of valving arrangements may be utilized within the concepts of the invention. Particularly, the valving mechanisms illustrated may be replaced by cam-operated valves, hydraulically operated valves, or even electrically operated valves, if desired. The use of a cam-operated valve system would be particularly applicable where variable pressure inlet injection time is desired.

The pressure-actuated motor illustrated normally will require a flywheel arrangement for smooth operation. In addition, the illustrated embodiment must be positioned off dead center to initiate operation. This latter requirement can be overcome by compounding the motor in a serial arrangement with sections in phase relationship so that at any time one section is on dead center one or more sections will be off center. Compounding the motor arrangement would, in addition, provide smoother torque output or more constant fluid flow when the device is used as a pump.

All of these various alternate arrangements are known adaptations of motor or pump systems and the utilization in these and other similar arrangements is within the scope of this invention.

While the invention has been described with a certain degree of particularity it is manifest that many changes may be made in the details of construction and arrangement of components without departing from the spirit and scope of this disclosure.

I claim:

1. A fluid pressure actuated motor comprising:

a closed housing having a fluid port therein;

a crankshaft positioned within said housing having a plurality of crank arms, said housing and crankshaft arranged for rotation relative to each other;

a plurality of bellow members positioned within said housing, each of said bellow members having an inner end and an outer end, the outer end being affixed to said housing;

a bellows plate member affixed to the inner end of each of said bellows member;

a connecting rod rigidly extending from each of said bellows plate members and each being rotatably received by a crank arm of said crankshaft;

valve means having an inlet port and an exhaust port, the inlet port being connected to a fluid pressure source and the exhaust being connected to a fluid discharge; and

manifold means connecting said valve means to the interior of said bellows, said valve means connecting said inlet port with said manifold means and said exhaust port with said port in said housing during 180° of rotation of said crankshaft and housing relative to each other and connecting said exhaust port with said manifold means and said inlet port with said port in said housing during the subsequent 180° of rotation of said crankshaft and housing relative to each other.

2. A fluid pressure actuated motor according to claim 1 wherein said housing includes a cylindrical opening therein concentric with said crankshaft and wherein said valve means includes a cylindrical valve block rotatably received in said opening in said housing, said valve block having opposed semicircular port recesses therein in a plane perpendicular the cylindrical axis, said valve means exhaust port communicating with one of said port recesses and said inlet port communicating with the other, said housing fluid port communicating with valve block semicircular port recesses alternately as said valve block and said housing rotate relative to each other and said manifold means communicating with said valve block semicircular port recesses alternately as said valve block and said housing rotate relative to each other, said housing fluid port and said manifold communicating at all times with opposite semicircular port recesses.

3. A fluid pressure actuated motor according to claim 1 wherein said connecting rod rigidly extending from all except one of said bellows plates is in the form of a pair of spaced-apart paralleled connecting rods, each connecting rod of each pair being equally spaced from the midpoint of its respective bellows plate, and each connecting rod of each pair rotatably receiving a crank arm portion of said crankshaft.