ABSTRACT: A low speed, high-torque fluid pressure apparatus adapted for use as a reversible motor or a pump, which includes a rotor having an axis which is fixed relative to the supporting housing and containing external gear teeth which mesh with internal gear teeth on an oscillator mounted for orbital motion relative to the housing. The oscillator contains radially spaced piston cavities which receive reciprocating pistons having the outer ends thereof in limited sliding engagement with the housing. Each piston cavity has an eccentric valving assembly associated therewith for controlling the flow of fluid among the piston cavity and the housing fluid inlet and fluid outlet.
FLUID PRESSURE APPARATUS WITH ORBITING OSCILLATOR

BACKGROUND OF THE INVENTION

The present invention relates generally to fluid pressure apparatus, and more particularly to a novel low speed, high-torque radial piston fluid pressure apparatus with an orbiting oscillator, which is adapted for use as a reversible motor or a reversible pump.

In the same general field of fluid pressure apparatus, there are various devices which can operate as a low speed, high-torque motor or pump, and which include any internally-toothed cylindrical member which meshes with and has rotational movement relative to an externally-toothed member containing an unlike number of complimentary teeth. However, most of such devices are large and cumbersome, have problems with fluid seals and valving arrangements, and usually require a wobble shaft between the driven member and the power take off, with its attendant bearing problems.

SUMMARY OF THE INVENTION

With the aforementioned limitations and deficiencies of presently known apparatus in mind, it is an object of the present invention to provide a novel, low speed, high-torque fluid pressure apparatus which can be used as a reversible fluid motor or a reversible fluid pump, and which is compact in size and of relatively light weight as compared with its output.

A further object is to provide such a fluid pressure apparatus which is generally of disclike or flat cylindrical configuration with a through-shaft construction, whereby a plurality of such units can be conveniently stacked side-by-side and connected in tandem to increase the power output in proportion to the number of units so interconnected.

Yet another object is to provide such a fluid pressure apparatus having an orbiting component which directly drives or is driven by a rotor or shaft, the axis of which remains stationary relative to the housing. More particularly, it is an object to provide such a fluid pressure apparatus which can be used as a motor or a pump and in which the rotor or shaft is supported in spaced-apart fixed bearings. Specifically, it is an object to provide such a low speed, high-torque fluid pressure apparatus with an orbiting component, which when used as a motor contains a rotor or driven shaft supported in spaced-apart fixed bearings to facilitate supporting overhung shaft loads such as occur with winches, wheel drives and chain or belt drives.

An additional object, which is related to the immediately preceding object, is to provide such a low speed, high-torque fluid motor containing an orbiting component, in which the driven shaft has an axis which is fixed relative to the supporting housing, whereby the driven member can take the form of a large diameter, hollow rotor for use as a drill rig rotary table, or to receive a conventional drill bar of an auger.

A further object is to provide such a novel low speed, high-torque fluid pressure apparatus with an orbiting component, in which the valve assembly is actuated by the orbiting component. More particularly, it is an object to provide a valving assembly for such an apparatus, which contains relatively few parts and which permits the use of relatively high fluid pressures, i.e., about 5,000 lb. per sq. inch.

Yet another object of the present invention is to provide a novel fluid motor which has generally universal application for installations which require a low speed, high-torque prime mover, as for example with augers, drill rigs, winches, tunneling machinery, and off-road graders... to name a few.

I have discovered that the aforementioned objects and advantages are fulfilled by a fluid pressure apparatus constructed in accordance with the teachings of the present invention, which includes a housing having a fluid inlet and a fluid outlet; a shaft or rotor with external teeth mounted in the housing for rotation about a fixed axis; an annular oscillator member with internal teeth mounted for orbiting movement (without rotation) about the shaft with the teeth in engagement; a plurality of circumferentially spaced fluid pistons between the housing and the oscillator member for radial movement relative to the latter member; and fluid flow control means associated with the pistons and responsive to the orbiting of the oscillator member.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a vertical sectional view of a fluid pressure apparatus with orbiting oscillator embodying the teachings of the present invention, the sectional view being taken on a plane transverse to the axis of the rotor shaft;

FIG. 2 is a longitudinal vertical sectional view taken on the line 2—2 in FIG. 1 with some of the parts being shown in elevation and with the bearings being shown schematically;

FIGS. 3a—3e are enlarged fragmentary transverse sectional views of one of the eccentric assemblies shown in FIG. 1, illustrating in a step-by-step sequence the manner in which the eccentric members rotate relative to its associated journal shaft as the oscillator member orbits relative to the housing; and

FIG. 4 is a transverse sectional view taken on the line 4—4 in FIG. 3e, and rotated 90°.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings more particularly by reference numerals, the number 10 indicates generally a fluid pressure apparatus with orbiting oscillator constructed in accordance with the teachings in the present invention, which for convenience of description, will be described as a fluid motor insofar as concerns the direction of the flow of fluid therewith, and the description of the driving and the driven members.

The fluid pressure apparatus 10 includes a housing 12 (FIG. 2) which is generally cuplike in shape with an endwall portion 14 having an inlet face 15 and containing a rotor aperture 16 and a sidewall or peripheral wall portion 18. The interior of the housing is provided with a circular oscillator cavity 20 and a counterbored bearing cavity 21, both of which are concentric with the rotor aperture 16.

A plurality of circumferentially spaced fluid inlet passageways 22 extend from the inlet face 15 through the end wall 14, and intersect and are in fluid communication with an annular fluid distribution passageway 23 also formed in said end wall 14. All except one of the inlet passageways are closed with conventional pipe plugs (not shown).

The end of the housing opposite from the rotor aperture 16 is fitted with a removable end plate 24 having an outlet face 25 with a rotor aperture 26 adjacent the center thereof and containing a bearing cavity 27 therein. The end plate 24 is mounted on the housing with alternately positioned, spaced-apart machine screws 28 and tapered dowel pins 29, said pins facilitating the mounting of the end plate on the housing prior to the use of the machine screws for holding purposes.

A plurality of circumferentially spaced fluid outlet passageways 30 (FIG. 2) extend from the outlet face 25 through the end plate 24 in axial alignment with the inlet passageways 22, said outlet passageways intersecting and being in fluid communication with an annular fluid collecting passageway 31 formed in the end plate 24. As with the inlet passageways, all but one of the fluid outlet passageways are closed with conventional pipe plugs (not shown).

Bearing cones 32 and 33 are positioned in the bearing cavities 21 and 27, respectively, to rotatably support a tubular rotor member 34 having ends which extend through the rotor apertures 16 and 26. The outer surface of the rotor member 34 contains a set of external gear teeth 35 adjacent the center portion thereof, and the interior of the tubular rotor member contains a longitudinally extending key slot 36 (FIG. 1).

As shown in FIG. 2, a cylindrical shaft 38 with a corresponding key slot 49 (FIG. 1) extends into the tubular rotor member from the housing side of the assembly, and the rotor
and shaft are removably held together by a key member 42 of conventional construction. It is to be noted that the shaft 38 could extend completely through the rotor members 34 or that a second shaft (not shown) could be inserted into the rotor members from the end plate side of the assembly.

Mounted within the oscillator cavity 20 (FIG. 1) for orbital movement (without rotation) relative to the housing 12, is a generally annular platelike oscillator member 44 with (in this particular embodiment) five outer peripheral faces 46 and internal gear teeth 48 which mesh with the teeth 35 on the rotor member 34 in a manner which will be described more fully hereinafter. As indicated in FIG. 1, the gear teeth 48 are greater in number than the number of gear teeth 35. Although gear teeth are shown and described, it will be understood that other types of meshing elements or lobes can be used.

Formed centrally in the outer peripheral faces 46 of the oscillator member 44 are radially extending, circumferentially spaced cylindrical piston cavities 50A–50E which slidably receive cylindrical pistons 52A–52E, respectively, each piston having an inner face or end 53. The outer end of each piston is recessed to provide an outer end cavity 54 surrounded by an annular wall having a sealing face 56, each cavity being in fluid communication with its main piston cavity by means of one or more longitudinally extending channels 58. As appears in FIG. 1, the inner face 53 of each piston has a greater surface area than the outer face of the end cavity, whereby the fluid pressure is greater on the inner face than on the outer face, for a purpose to appear.

Positioned within the oscillator cavity 20 and mounted on the inner face of the sidewall 18 are five platelike piston seat blocks 60 (FIG. 1), each of which has a flat inner face 62 to slidably receive the annular bearing face 56 of its associated piston 52. The bearing face 56 and the block face 62 are ground flat and lapped to provide a fluid seal therebetween.

Formed in the oscillator member 44 intermediate the piston cavities, are transversely extending, generally cylindrical eccentric or fluid flow control cavities 64 (FIG. 2), each of which is provided with an inner shoulder 66 and an outer shoulder 68 for the purpose of providing fluid seals, as will appear.

Received in the eccentric cavities are cylindrical eccentric members 70A–70E, the outer surfaces of which are spaced from the inner walls of the eccentric cavities 64 to provide annular eccentric fluid passages 72A–72E between spaced-apart bearings 74 and 76 which provide for the rotation of the eccentric members in the eccentric cavities.

One such eccentric member 70 is positioned against the shoulder 66 in each eccentric cavity adjacent the bearing 76, and a second sealing ring 80 is positioned adjacent the bearing 74, the ring 80 being held in position by a threaded retainer ring 82.

Piston inlet and exhaust passages 84A–84E (FIG. 1) extend between each annular eccentric passage 72A–72E and its associated piston cavity 50A–50E, respectively, to provide for reverse fluid flow therebetween.

The eccentric members 70A–70E contain offcenter transversely extending journal shaft cavities 86A–86E which are in axial alignment with the fluid inlet passages 22 in the housing 12 and with the outlet passages 30 in the end plate 24, (FIG. 2).

Elongated, cylindrical journal shafts 88A–88E are rotatably received in the journal shaft cavities 86A–86E (FIG. 2) and project into the inlet passages 22 and the outlet passages 30, each journal shaft being maintained in a selected, fixed position relative to the housing 12 (and the end plate 24) by means of a set screw 90.

Each journal shaft 88 (FIG. 4) contains diametrically opposed oval, dish-shaped ports 92A–92E and 94A–94E adjacent the center thereof with a partition 95 (A–E) therebetween, each port 92A–92E being in communication with an axially extending inlet passage 96A–96E in one end of the journal shaft, and each port 94A–94E being in communication with a like outlet passage 98A–98E in the other end of said shaft. The tolerance between each journal shaft 88 and its associated eccentric member 70 is such that there is a fluid seal between the two members, even though there is also relative rotational movement therebetween.

As shown in FIG. 1, each of the eccentric members 76A–76E is provided with a radial passage 100A–100E which extends from the eccentric annular passage 72A–72E surrounding the eccentric, to adjacent the outlet port 92A–92E or outlet port 94A–94E.

As will be described more fully hereinafter, depending upon the rotated position of each eccentric relative to its associated journal shaft, the eccentric radial passageway 100 can be blocked by the partition 95, or the eccentric radial passageway 100A can be in fluid communication (to a great or a lesser degree) with either the inlet port 92 and the outlet passage 96 or with the outlet port 94 and the outlet passage 98.

Referring to FIG. 2 and assuming that the apparatus is to function as a fluid motor, high-pressure fluid will enter the inlet passageway 22 and fill the high-pressure fluid distributing passageway 23, from where it will flow into the journal shaft inlet passageways 96A–96E and to adjacent the inlet ports 92A–93E. If an inlet port 92A–92E is in communication with an eccentric radial passageway 100 (FIG. 1), fluid pressure will flow through the port and the radial passageway to the associated eccentric annular passage 72A–72E, through the associated piston inlet and exhaust passageway 84A–84E, and into the associated piston cavity 50A–50E.

If, on the other hand, the oval outlet port 94A–94E in a particular journal shaft 88A–88E is in communication with the eccentric radial passageway 100A–100E, the flow will be away from the piston cavity. Thus, the exhaust or outlet flow will be from the piston cavity 50A–50E, through the inlet and exhaust passageway 84A–84E, into the eccentric annular passage 72A–72E through the eccentric channel 96A–96E, into the oval outlet port 94A–94E, through the journal shaft outlet passage 98A–98E, and into the annular low-pressure fluid collecting passageway 31, from where it can be exhausted through the fluid outlet passageway 30.

As previously described, each journal shaft 88 is maintained in a predetermined rotated position relative to the housing 12 and the end plate 24 by the set screw 90.

Referring to FIG. 1, and assuming that the apparatus is to be utilized as a fluid motor with the shaft 38 rotating in the clockwise direction, the oscillator member 44 will orbit in the counterclockwise direction because of the sequential action of the pistons 52A–52E. Thus, it will be noted that piston cavity 50A is almost filled with fluid under pressure with the inlet port 92A being in communication with the eccentric radial passageway 100A, that piston cavity 50B is starting to fill, and that piston cavity 50C is at an inoperative or at rest position because its eccentric radial passageway is blocked and is not in communication with either the inlet port 92C or the outlet 94C. However, both piston cavities 50D and 50E are in communication with their respective outlet ports 94D and 94E, whereby fluid is flowing from these piston cavities.

Accordingly, as the piston cavities fill under pressure in the counterclockwise direction (or more accurately, as fluid under pressure is forced into the piston cavity so as to force the piston out of the cavity and thereby move the oscillator member 44 away from the piston seat block), the oscillator member 44 will orbit in the same counterclockwise direction, and, in turn, will cause each eccentric member 70 to rotate about its journal shaft 88 in the counterclockwise direction to cause the inlet and outlet ports to be brought into communication with the eccentric radial passageway in sequence to continue the orbiting of the oscillator member so long as there is fluid pressure in the fluid distributing passageway 23.

Torque produced in the rotor member 34 by forces acting between the gear teeth 35 and the gear teeth 48 will ultimately be transmitted to the housing 12. Thus, assuming high pressure in the cavity 23, rotor member 34 (FIG. 1) will rotate in the clockwise direction. The force applied to the teeth 48 by the teeth 35 results in a counterclockwise torque component applied to the oscillator member 44, which, in turn, is trans-
mitted through the bearings 74 and 76 (FIG. 2) and through the eccentric members 70(A-E) to the journal shafts 88(A-E) which are fixed relative to the housing 12. This counter-clockwise load or torque component is resisted by high pressure fluid in each inlet port 92(A-E), with each of said ports facing the clockwise direction against the aforementioned load. This is a form of hydraulic balancing, similar to the fluid balancing of pistons 52(A-E) as will be described hereinafter. Pressure balancing by the journal shaft inlet and outlet ports 92(A-E) and 94(A-E) is effective for either direction of rotation by the rotor member 34 and reduces the unit journal shaft loading to a minimum.

FIG. 3 illustrates the manner in which each eccentric member and its radial passageway 100 rotates about the journal shaft and its outlet and inlet ports. Thus, FIG. 3a is actually an enlarged fragmentary view of eccentric member 70A which appears adjacent the top in FIG. 1, and in which the eccentric radial passageway 100A is moving in a counterclockwise direction past the inlet port 92A, and toward the partition 95A. In the next position shown, FIG. 3b, the eccentric member 70A has been rotated (because of the orbiting of the oscillator member 44) to a position in which the eccentric radial passageway 100A is in alignment with the partition 95A which occurs when each piston 52 is at its fully extended position, and there is no fluid flow relative to the piston cavity 50A. In FIG. 3c, the eccentric radial passageway 100A is in communication with the outlet port 94A, and therefore piston cavity 50A is exhausting to the low pressure fluid collecting passageway 31, in the manner previously described. FIG. 3d shows the exhausting or venting of the piston cavity 50A as continuing, the FIG. 3e shows the partition 95A in alignment with the eccentric radial passageway 100A... which relationship occurs when each piston 52 is at its fully exhausted position (as illustrated by the position of piston 52C in FIG. 1). Lastly, FIG. 3f illustrates the position of the eccentric radial passageway 100A when it again is in communication with the inlet port 92A. Further rotation of the eccentric member about its journal shaft, brings the eccentric radial passageway 100A to the position first described with reference to FIG. 3a, thereby completing the cycle.

Thus, it will be apparent that there has been provided a very simple but effective working arrangement utilizing the orbiting of the oscillator member to rotate the eccentric members about the journal shafts, whereby each eccentric radial passageway 100 is alternately in communication with its inlet port or its outlet port, with the transition from one such port to the other port being interrupted by the partition 95 blocking the radial passageway.

To reverse the direction of rotation of the shaft 38, it is only necessary to reverse the flow of fluid through the apparatus, i.e. to connect the inlet or high-pressure line to passageway 30, and to connect the outlet or low-pressure line to passageway 22. The oscillator member 44 will orbit and the eccentric members will rotate in the clockwise direction. This will cause the shaft 38 to rotate in the counterclockwise direction.

As previously described, the annular sealing face 56 of each piston 52 is in sliding sealing engagement with the face 62 of the associated piston seat block 60, and will move back and forth across said face as the oscillator member 44 orbits about the shaft 38. Inasmuch as the channel 58 interconnects the piston cavity 50 with the cavity 54 adjacent the outer end of the piston, the fluid pressures in the cavities at the opposite ends of each piston are substantially equal. However, because the surface area at the inner face 53 is greater than the surface area at the outer end, the force on the inner face is greater than the force on the outer end of the piston, whereby the annular bearing faces 56 are maintained in fluid sealing relationship with the block faces 62. However, because the pressures are nearly balanced, there is a minimum amount of friction between the block face 62 and the annular bearing face 56 of the associated piston.

To use the apparatus as a reversible fluid pump, the shaft 38 would be rotated in either direction, which in turn will cause the oscillator member 44 to orbit about the shaft and move the pistons within the piston cavities so as to create a vacuum in the piston cavities which will draw in and, and thereby force, the fluid from such cavities when the piston moves inwardly relative to the oscillator member. One minor change is necessary when the apparatus is to be used as a pump, and that is that it is necessary to use coiled springs (not shown) in the piston cavities in order to maintain the sealing faces 56 at the outer ends of the pistons in engagement with the faces 62 of the seat blocks.

The oscillator member 44, the pistons 52(A-E) and the eccentric members 70(A-E) form an orbiting group of elements which function to provide automatic fluid valving, a load path between the rotor member 34 and the housing 12, and proper positioning of the major components so as to maintain the gear teeth in proper meshing relationship.

As mentioned hereinafore, the particular embodiment which has been shown and described is the preferred construction. An alternative construction would eliminate the piston seat blocks 60 and replace the cylindrical pistons 52(A-E) with spherical pistons (not shown) which would have limited rolling travel on the inner surface of the wall 18 (FIG. 1).

Thus, it is apparent that there has been provided a low speed, high-torque fluid pressure apparatus which can be used as either a reversible motor or a reversible pump and which fulfills all of the objects and advantages sought therefor. The axis of the rotor is fixed relative to the housing so as to obviate the use of a "wobble" connector, the apparatus is relatively small in size for its power output and of a configuration to facilitate connecting multiple units in tandem, there are relatively few parts, and the relationship of the parts is such as to permit the use of relatively high-fluid pressures without leakage.

What is claimed is:
1. A fluid motor, comprising: a housing having a fluid inlet and a fluid outlet; a shaft with external teeth mounted in the housing for rotation about a fixed axis; an annular oscillator member with an outer peripheral portion and internal teeth mounted in the housing about said shaft; the number of external teeth on the shaft being less that the number of internal teeth on the oscillator member, and the teeth on the oscillator member being adapted to mesh with the teeth on the shaft; and fluid pressure responsive means between the oscillator member and the housing in selective communication with the fluid inlet and fluid outlet through fluid flow control means for causing the oscillator member to orbit without rotation about the shaft with the teeth on the oscillator member in driving engagement with the teeth on the shaft.
2. The fluid motor described in claim 1 in which the fluid pressure means comprises a plurality of pistons slidably mounted in piston cavities formed in the outer peripheral portion of the oscillator member.
3. The fluid motor described in claim 1 in which the fluid pressure means comprises a plurality of pistons circumferentially spaced about the oscillator member and slidably mounted in piston cavities formed radially in the outer peripheral portion of said member, the outer end of each piston being in sliding engagement with a piston seat block in fixed position relative to the housing.
4. The fluid motor described in claim 3 in which:
   a. each piston has an inner end face;
   b. the outer end of each piston contains an annular ridge defining an end cavity with an outer end face, said outer end face being of less area than the inner end face of the piston; and fluid communication means are provided between the piston cavity and the end cavity.
5. A fluid motor, comprising:
a housing having a fluid inlet and a fluid outlet;
a shaft with external teeth mounted in the housing for rotation about a fixed axis;
an annular oscillator member with an outer peripheral portion and internal teeth mounted in the housing about said shaft;
the number of external teeth on the shaft being less than the number of internal teeth on the oscillator member, and the teeth on the oscillator member being adapted to mesh with the teeth on the shaft;
a plurality of fluid pressure responsive units between the oscillator member and the housing; and
fluid flow control means associated with the oscillator member and responsive to the movement thereof for controlling the flow of fluid among said pressure responsive units and the fluid inlet and the fluid outlet to cause said oscillator member to rotate without rotation about the shaft with the teeth on the oscillator member in driving engagement with the teeth on the shaft.

6. The fluid motor described in claim 5 in which the fluid flow control means includes:
a plurality of spaced apart, transversely extending eccentric cavities in the outer peripheral portion of the oscillator member;
a journal shaft with outlet and inlet ports extending through each eccentric cavity, each journal shaft being in a fixed position relative to the housing; and
an eccentric member in each eccentric cavity mounted for rotation within the cavity and about the journal shaft, each eccentric member containing a radially extending fluid passageway which is adapted to alternately communicate with said outlet and inlet ports as the eccentric member rotates around the journal shaft.

7. The fluid motor described in claim 5 in which the fluid flow control means includes:
a plurality of circumferentially spaced, radially extending eccentric cavities in the outer peripheral portion of the oscillator member;
a journal shaft parallel with and offset from the axis thereof; and
means are provided for adjusting the angular position of each journal shaft relative to the housing.

8. The fluid motor described in claim 7 in which each journal shaft is of cylindrical configuration and contains diametrically opposed inlet and outlet ports at the surface thereof; and means are provided for adjusting the angular position of each journal shaft relative to the housing.

9. The fluid motor described in claim 5 in which the fluid flow control means includes:
a plurality of circumferentially spaced, transversely extending eccentric cavities in the outer peripheral portion of the oscillator member;
a cylindrical member mounted in each eccentric cavity for rotation about the axis of the eccentric member;
a journal shaft cavity extending through each eccentric member parallel with and offset from the axis thereof;
a radially extending passage in each eccentric member in fluid communication with its journal shaft cavity; and
a cylindrical journal shaft which is fixed relative to the housing extending through each journal shaft cavity, each journal shaft containing diametrically opposed inlet and outlet ports for selective communication with the radial passageway as the eccentric member rotates in the eccentric cavity relative to the journal shaft.

10. Fluid pressure apparatus, comprising:
a housing having a fluid inlet and a fluid outlet;
a shaft with external gear teeth mounted in the housing for rotation about a fixed axis;
an annular oscillator member with an outer peripheral portion and internal teeth mounted in the housing about said shaft for orbital movement without rotation relative to the shaft and the housing;
the number of internal teeth on the oscillator member being greater than the number of teeth of the shaft, and the teeth on the oscillator member being adapted to mesh with the teeth on the shaft;
a plurality of circumferentially spaced, radially extending piston cavities in the outer peripheral portion of the oscillator member;
a piston with inner and outer ends slidable mounted in each piston cavity, the outer end of each piston being in sliding engagement with a piston seat block which is fixed relative to the housing;
a plurality of fluid flow control cavities in the outer peripheral portion of the oscillator member intermediate the piston cavities, there being one control cavity for each associated piston cavity;
an inlet-exhaust fluid passageway between each fluid flow control cavity and its associated piston cavity;
a flow control assembly in each fluid flow control cavity in communication with the housing outlet for controlling the flow of fluid among the inlet-exhaust passageway and said housing inlet and housing outlet during the orbital movement of the oscillator member, whereby each piston cavity will receive and discharge fluid in sequence.

11. Fluid pressure apparatus as described in claim 10 wherein each flow control cavity is of cylindrical shape and each flow control assembly includes:
a cylindrical journal shaft extending through the flow control cavity offset from the axis of said cavity and containing spaced-apart inlet and outlet ports in fluid communication with the housing inlet and the housing outlet, respectively; and
a cylindrical eccentric member mounted in the flow control cavity for rotation about the journal shaft as the oscillator member orbits, and including a radial passageway in communication with the flow control cavity and in selective communication with said inlet and outlet ports of the journal shaft during rotation.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,613,510 Dated October 19, 1971

Inventor(s) Henry B. Chambers

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 21, "92A-93E" should read -- 92A-92E --.
Column 8, line 35, "housing outlet for controlling" should read -- housing inlet and housing outlet for controlling --.

Signed and sealed this 29th day of August 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCALK
Commissioner of Patents