



Europäisches Patentamt
European Patent Office
Office européen des brevets



(11) **EP 1 158 165 A2**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
28.11.2001 Bulletin 2001/48

(51) Int Cl.7: **F04C 2/10**

(21) Application number: **01112161.3**

(22) Date of filing: **17.05.2001**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE TR**
Designated Extension States:
AL LT LV MK RO SI

- **Kassen, Gary R.**
Chanhassen, MN 55317 (US)
- **Millar, Jarett D.**
Minneapolis, MN 55404-3201 (US)
- **Bernstrom, Marvin L.**
Eden Prairie, MN 55347 (US)

(30) Priority: **25.05.2000 US 579164**

(71) Applicant: **EATON CORPORATION**
Cleveland, Ohio 44114-2584 (US)

(74) Representative: **Schwan - Schwan - Schorer**
Patentanwälte
European Patent Attorneys
Elfenstrasse 32
81739 München (DE)

(72) Inventors:
• **Haarstad, Donald M.**
Chaska, MN 55318 (US)

(54) **Gyrotor hydraulic motor**

(57) A multi-speed gerotor motor of the type including a fluid displacement mechanism (21) defining expanding (33E) and contracting (33C) fluid volume chambers, a stationary valve member (19), defining a plurality N of stationary valve passages, and a movable valve member (43). The upstream end of each valve passage communicates with the movable valve member (43), and the downstream end of each valve passage com-

municates with one of the volume chambers. In a plurality M of the stationary valve passages (79A through 79E) the upstream (81) and downstream (83) passage portions are blocked from direct communication, and for each there is a control valve member (103) which can, selectively, permit fluid communication for normal, low-speed, high-torque operation, or can block such communication, and recirculate the associated volume chambers for highspeed, low torque operation.

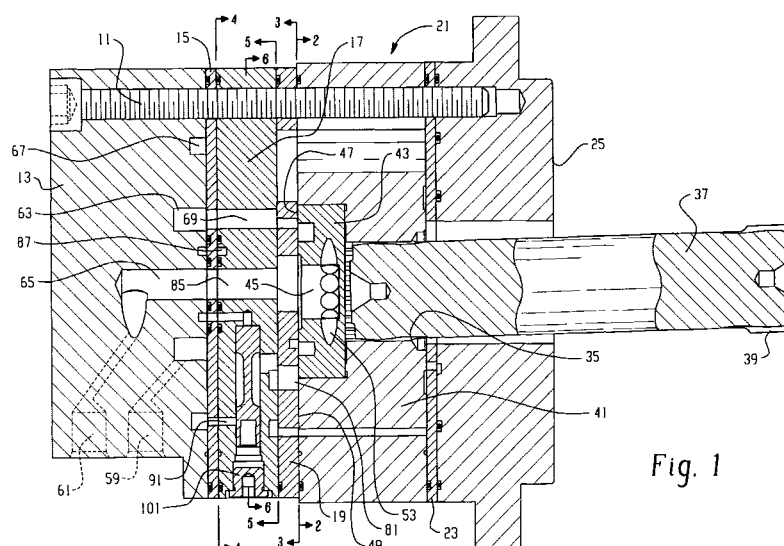


Fig. 1

EP 1 158 165 A2

Description

BACKGROUND OF THE DISCLOSURE

[0001] The present invention relates to rotary fluid pressure devices of the type in which a gerotor gear set serves as the fluid displacement mechanism, and more particularly, to such devices which are provided with multiple speed ratio capability.

[0002] Although the teachings of the present invention can be applied to devices having fluid displacement mechanisms other than gerotors, such as cam lobe type devices, the invention is especially adapted to gerotor devices and will be described in connection therewith.

[0003] Devices utilizing gerotor gear sets can be used in a variety of applications, one of the most common being to use the device as a low-speed, high-torque (LSHT) motor. One common application for low-speed, high-torque gerotor motors is vehicle propulsion, wherein the vehicle includes an engine driven pump which provides pressurized fluid to a pair of gerotor motors, with each motor being associated with one of the drive wheels. Those skilled in the art will be aware that many gerotor motors utilize a roller gerotor, especially on larger, higher torque motors of the type used in propel applications, and subsequent references hereinafter to "gerotors" will be understood to mean and include both conventional gerotors, as well as roller gerotors.

[0004] In recent years, there has been a desire on the part of the vehicle manufacturers to be able to provide both the low-speed, high-torque (LSHT) mode of operation, such as when the vehicle is at the work site, and also a high-speed, low-torque (HSLT) mode of operation, for when the vehicle is traveling ("roading") between work sites. One possible solution has been to provide a gerotor motor having a two-speed capability.

[0005] Two-speed gerotor motors are known from U. S. Patent No. 4,480,971, assigned to the assignee of the present invention and incorporated herein by reference. The device of the cited patent has been in widespread commercial use and has performed in a generally satisfactory manner. As is well known to those skilled in the art, a gerotor motor may be operated as a two speed ratio device by providing valving which can effectively "recirculate" fluid between expanding and contracting fluid volume chambers of the gerotor gear set. In other words, if the inlet port communicates with all of the expanding chambers, and all of the contracting chambers communicate with the outlet port, the motor operates in the normal low-speed, high-torque mode. If some of the fluid from the contracting chambers is recirculated back to some of the expanding chambers, the result will be operation in the high-speed, low-torque mode, which is the same result as if the displacement of the gerotor were decreased, but with the same flow rate through the gerotor.

[0006] In the two-speed gerotor motors which are in use commercially, and as shown in the above-cited pat-

ent, each volume chamber within the gerotor gear set has the opportunity to be a "recirculating" volume chamber, both as the volume chamber expands and as it contracts, while the motor is operating in the high-speed, low-torque mode. One result of each volume chamber being a recirculating volume chamber is a condition referred to as "oddly spaced" recirculating volume chambers which, it is believed, has led to an uneven torque ripple when operating in the high-speed, low-torque mode.

[0007] Accordingly, it is an object of the present invention to provide an improved multiple speed ratio arrangement, especially suited for use with a gerotor motor, which will eliminate or substantially reduce the undesirable effects of the "oddly spaced" recirculating volume chambers, including reducing the unevenness of the torque ripple in the high-speed, low-torque mode.

[0008] It is now understood that another disadvantage of the prior art two speed arrangements is that, in the prior art devices, all recirculating flow would have to pass through the commutating valving. As is well understood by those skilled in the art, the fact that some fluid is recirculating in the high-speed, low-torque mode means that the flow rate through the non-recirculating volume chambers is substantially greater in the high speed mode. Unfortunately, in the typical, prior art arrangements, the addition of the two speed capability has resulted in commutating valving passages which are somewhat constricted in terms of flow capacity, by comparison to a conventional, single speed ratio motor of the same speed and torque capacity. The result has been an undesirable increase in the pressure drop across the prior art two speed motors and, as is well known to those skilled in the art, the higher the pressure drop across a hydraulic motor, the less commercially desirable the motor is.

[0009] Accordingly, it is another object of the present invention to provide an improved multiple speed ratio arrangement which does not require more constricted commutating valve passages, and therefore, does not result in an increased pressure drop across the motor.

[0010] The problem associated with all of the recirculating flow passing through the commutating valving is dealt with in the device illustrated and described in co-pending application U.S.S.N. 09/291,671, filed April 14, 1999 in the names of Marvin L. Bernstrom, Jarett D. Millar, Karen J. Radford, and Ryan C. Bergerson, for a "Two-Speed Gerotor Motor With External Pocket Recirculation", assigned to the assignee of the present invention and incorporated herein by reference. In the device of the incorporated application, flow to and from recirculating volume chambers does not pass through the commutating valving, but instead, is controlled by separate valving, such that each recirculating volume chamber is put in fluid communication with a recirculation chamber (hence the term "external" recirculation) during operation in the high-speed low-torque mode. In accordance with one feature of the above-incorporated

application, the recirculation chamber contains relatively high pressure fluid, and thus, all of the recirculating volume chambers contain relatively high-pressure, thus substantially eliminating the tendency for cavitation to occur during operation in the HSLT mode.

[0011] In the prior art two-speed gerotor motor arrangements, as well as in that of the above-incorporated application, the "ratio" in the LSHT mode is, by definition, 1.0:1, and the ratio in the HSLT mode is determined by the number of volume chambers which don't recirculate (such that the "ratio" in the HSLT mode is the total number of volume chambers divided by the number of volume chambers which are "active", i.e., don't recirculate). In the prior art arrangements, the shift between the low speed and high speed modes has, in many cases, occurred fairly abruptly and the prior art design has effectively dictated that operation of the motor can occur in only the low speed and high speed modes. For example, in the device of the above-incorporated application, the control of flow to and from all of the recirculating volume chambers is controlled by a single control valve spool, such that typically, the change (shift) between the LSHT and HSLT modes will occur simultaneously for all of the recirculating volume chambers.

[0012] Accordingly, it is another object of the present invention to provide an improved multiple speed ratio gerotor motor arrangement having the actual capability of providing for one or more operating ratios between a minimum speed ratio and a maximum speed ratio, i.e., being able to shift the recirculating volume chambers independently.

BRIEF SUMMARY OF THE INVENTION

[0013] The above and other objects of the invention are accomplished by the provision of a fluid pressure operated device comprising housing means defining a fluid inlet port and a fluid outlet port. A fluid pressure displacement mechanism is associated with the housing means and includes an internally-toothed ring member and an externally-toothed star member eccentrically disposed within the ring member. The ring member and the star member have relative orbital and rotational movement, and inter-engage to define a plurality of expanding and contracting fluid volume chambers in response to the orbital and rotational movement. A motor valve means cooperates with the housing means to provide fluid communication between the fluid inlet port and the expanding volume chambers and between the contracting volume chambers and the fluid outlet port. The motor valve means comprises a stationary valve member fixed to be non-rotatable relative to the housing means, and a moveable valve member operable to move relative to the stationary valve member in synchronism with one of the orbital and rotational movements. The stationary valve member defines a plurality N of stationary valve passages, each of the stationary valve passages including an upstream passage portion

adapted for commutating fluid communication with the moveable valve member, and further including a downstream passage portion in continuous fluid communication with one of the plurality N of fluid volume chambers. In a plurality N-M of the stationary valve passages, the upstream passage portion and the downstream passage portion are in direct, relatively unrestricted, continuous fluid communication.

[0014] The improved fluid pressure operated device is characterized by, in a plurality M of the stationary valve passages, the upstream and the downstream passage portions are blocked from direct fluid communication. A plurality M of control valve members is provided, each operably associated with the stationary valve member, and with one of the plurality M of the stationary valve passages. Each of the control valve members is operable in a first position to provide relatively unrestricted fluid communication between each upstream passage portion and its respective downstream passage portion, and operable in a second position to block fluid communication between each upstream passage portion and its respective downstream passage portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1 is an axial cross-section of a low-speed, high-torque gerotor motor made in accordance with the teachings of the present invention.

[0016] FIG. 2 is a transverse cross-section taken on line 2-2 of FIG. 1, and on a somewhat larger scale than FIG. 1.

[0017] FIG. 3 is a transverse cross-section taken on line 3-3 of FIG. 1, and on a somewhat larger scale than FIG. 1.

[0018] FIG. 4 is a transverse cross-section taken on line 4-4 of FIG. 1, and on a somewhat larger scale than FIG. 1.

[0019] FIG. 5 is a transverse cross-section taken on line 5-5 of FIG. 1, and on a somewhat larger scale than FIG. 1.

[0020] FIG. 6 is a transverse cross-section through the control valve plate, taken on line 6-6 of FIG. 1, and on a somewhat larger scale than FIG. 1.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] Referring now to the drawings, which are not intended to limit the invention, FIG. 1 illustrates a valve-in-star (VIS) type of low speed, high torque (LSHT) motor, made generally in accordance with the above-incorporated patent, and in accordance with the above-incorporated application, and also, in accordance with U.S. Patent No. 5,211,551, also assigned to the assignee of the present invention, and incorporated herein by reference.

[0022] The VIS motor shown in FIG. 1 comprises a plurality of sections secured together such as by a plu-

rality of bolts 11, only one of which is shown in FIG. 1, but all of which are shown in FIGS. 2 through 6. The motor includes an end cap 13, a spacer plate 15, a shifter plate 17 (which may also be referred to as a "selector plate"), a stationary valve plate 19, a gerotor gear set, generally designated 21, a balancing plate assembly 23 and a flange member 25.

[0023] The gerotor gear set 21, best seen in FIG. 2, is well known in the art, is shown and described in greater detail in the above-incorporated patents, and therefore will be described only briefly herein. The gear set 21 is preferably a Geroler® gear set comprising an internally toothed ring member 27 defining a plurality of generally semicylindrical openings, with a cylindrical roller member 29 disposed in each of the openings, and serving as the internal teeth of the ring member 27. Eccentrically disposed within the ring member 27 is an externally-toothed star member 31, typically having one less external tooth than the number of internal teeth or rollers 29, thus permitting the star member 31 to orbit and rotate relative to the ring member 27. The orbital and rotational movement of the star 31 within the ring 27 defines a plurality of fluid volume chambers 33, most of which are, at any given instant in time, either an expanding volume chamber 33E, or a contracting volume chamber 33C. However, as is well known to those skilled in the art, each volume chamber is in a state of "transition", between expanding and contracting, twice during each orbit of the star 31, and in FIG. 2, those volume chambers in transition are merely designated "33". In the subject embodiment, and by way of example only, there is a total of ten volume chambers 33.

[0024] Referring again primarily to FIG. 1, the star 31 defines a plurality of straight, internal splines which are in engagement with a set of external, crowned splines 35, formed on one end of a main drive shaft 37. Disposed at the opposite end of the shaft 37 is another set of external, crowned splines 39, adapted to be in engagement with another set of straight, internal splines defined by some form of rotary output member, such as a shaft or wheel hub (not shown).

[0025] Referring again primarily to FIG. 2, in conjunction with FIG. 1, the star member 31 will be described in some additional detail. Although not an essential feature of the present invention, the star 31, in the subject embodiment, comprises an assembly of two separate parts, including a main star portion 41, which includes the external teeth, and an insert or plug 43 (the relationship therebetween being best shown in FIG. 1). The main portion 41 and the insert 43 cooperate to define the various fluid zones, passages, and ports which will be described subsequently. The star member 31 defines a central manifold zone 45, defined by an end surface 47 of the star 31, the end surface 47 being disposed in sliding, sealing engagement with an adjacent surface 49 (see FIGS. 1 and 6) of the stationary valve plate 19.

[0026] The end surface 47 of the star 31 defines a set of fluid ports 51, each of which is in continuous fluid com-

munication with the manifold zone 45 by means of a fluid passage 53 (see also FIG. 1) defined by the insert 43. The end surface 47 further defines a set of fluid ports 55 which are arranged alternately with the fluid ports 51, each of the fluid ports 55 including a portion 57 which extends radially inward, about halfway to the manifold zone 45. The portions 57 together define an "outer" manifold zone, surrounding the inner or central manifold zone 45.

[0027] Referring again to FIG. 1, the end cap 13 includes a fluid inlet port 59 and a fluid outlet port 61, although those skilled in the art will recognize that most motors of the type to which the invention relates are meant to be "bi-directional" in operation, such that the ports may be reversed. The end cap 13 defines an annular chamber 63 which is in open, continuous fluid communication with the inlet port 59. The end cap 13 also defines a cylindrical chamber 65 which is in open, continuous fluid communication with the outlet port 61. Finally, the end cap 13 defines an annular chamber 67 (also referred to hereinafter as the "recirculation region" or "recirculation chamber"), which is also in continuous, open fluid communication with whichever of the ports 59 or 61 contains high pressure, which, as the motor has been described herein is the inlet port 59. The annular chamber 67 communicates with either the annular chamber 63 or the chamber 65 by means of a passage and shuttle valve arrangement, not shown herein, which are well known to those skilled in the art, the details of which are not essential features of the present invention. It is considered a desirable feature of the present invention for the annular chamber 67 to be in continuous fluid communication with a source of relatively high pressure fluid, such as the motor inlet port 59, for reasons which are explained in greater detail in the above-incorporated application.

[0028] Referring still primarily to FIG. 1, it will be assumed for purposes of subsequent description that the fluid port 59 is the inlet port, containing high pressure, which is then communicated into the annular chamber 63, and from there, through openings in the spacer plate 15 to a series of bores 69 defined by the shifter plate 17 (see FIGS. 4, 5 and 6).

[0029] Referring now primarily to FIG. 3, the stationary valve plate 19 defines a central opening 71, which is in open communication with the cylindrical chamber 65. The surface 49 of the stationary valve plate 19 also defines an annular groove 73, and in communication therewith, a series of openings 75, each of which is in fluid communication with one of the bores 69. As is well known to those skilled in the art of VIS-type motors, the stationary valve plate would, in a conventional VIS motor be either immediately adjacent the end cap 13, or may even be formed integrally with the end cap. However, for reasons which were explained in the above-incorporated application, the stationary valve plate 19 is, in the present invention, separated from the end cap 13 by the spacer plate 15 and the shifter plate 17, in

order to accomplish the multiple speed valving of the invention.

[0030] The stationary valve plate 19 defines a plurality of stationary valve passages 77, also referred to in the art as "timing slots". In the subject embodiment, each of the stationary valve passages 77 would typically comprise a radially-oriented slot, each of which would be disposed in continuous, open fluid communication with an adjacent one of the volume chambers, either an expanding volume chamber 33E, or a contracting volume chamber 33C. Preferably, the valve passages 77 are disposed in a generally annular pattern which is concentric relative to the central opening 71. If the stationary valve plate 19 were made in accordance with conventional VIS motor teachings, there would be ten of the valve passages 77, one for each volume chamber 33. However, in accordance with one important aspect of the invention, there are five of the stationary valve passages 77 and five other, different stationary valve passages, generally designated 79A, 79B, 79C, 79D and 79E. The stationary valve passages 79A through E differ from the conventional valve passages 77 in a manner to be described.

[0031] Those skilled in the art will understand that the specific number of passages 77 and passages 79 can, within the scope of the invention, vary somewhat, although the total number of passages 77 and 79 together will be determined by the particular gerotor gear set utilized. In the subject embodiment, and by way of example only, the roller gerotor gear set 21 is a "nine-ten" gerotor, i.e., the ring member 27 has ten internal teeth (rollers 29) and the star member 31 has nine external teeth. Therefore, there are a total of ten volume chambers (33, 33E, and 33C), and for each volume chamber, there is provided either a passage 77 or a passage 79 (A through E), thus a total of ten passages.

[0032] As is also well known to those skilled in the art, in the conventional VIS motor, the radially inner portion of each of the valve passages 77 is in commutating communication with the fluid ports 51 and 55, whereas the radially outer portion of each valve passage 77 is in permanent, continuous communication with the respective volume chamber 33 (or 33E or 33C). In other words, communication from one of the fluid ports 51 or 55 to the adjacent volume chamber 33 is effected through the radially oriented passage 77 in which the radially inner portion and the radially outer portion are in direct, open communication (as may be seen in FIG. 3). However, in accordance with the present invention, and as was taught in the above-incorporated application, in each of the valve passages 79A through 79E, there is a radially inner (upstream) portion 81 and a separate, radially outer (downstream) portion 83. Therefore, in accordance with an important aspect of the present invention, in each of the stationary valve passages 79A through 79E, the radially inner portion 81 and the radially outer portion 83 are not in direct, open fluid communication. Instead, the radially inner and outer portions are in communica-

tion with each other through the control valving in the shifter plate 17, in the normal, LSHT mode, but are blocked from communication with each other by the valving in the HSLT mode. The two modes will be described in greater detail subsequently, in connection with the description of the operation of the invention.

[0033] Referring now primarily to FIGS. 4, 5 and 6, the shifter plate 17, and the control valving of the present invention, will be described. In viewing and attempting to reconcile FIGS. 4, 5 and 6, it should be remembered that FIG. 5 is looking toward the left in FIG. 1, i.e., toward the end cap 13, whereas FIGS. 4 and 6 are views looking to the right in FIG. 1, i.e., toward the shaft 37.

[0034] The shifter plate 17 defines a central opening 85 which provides open communication between the cylindrical chamber 65 and the central opening 71 of the stationary valve plate 19 (FIG. 3). The shifter plate 17 also defines an annular groove 87 (see also FIG. 1), and in communication therewith is a series of bores 89, the function of which will be described in greater detail subsequently. Finally, the shifter plate 17 defines a plurality of recirculation bores 91, each of which is in open fluid communication with the annular chamber (recirculation chamber) 67.

[0035] Referring now primarily to FIG. 5, the opposite surface of the shifter plate 17 will be described. Disposed in an annular pattern around the central opening 85 are the bores 69, which extend axially throughout the entire thickness of the shifter plate 17. It should be noted that FIGS. 3 and 5 are views taken in the same direction, and therefore, at locations corresponding to the stationary valve passages 79A through E, the shifter plate 17 defines port arrangements 93A through 93E. Each of the port arrangements 93A through 93E comprises a radially inner recess 95 which is in open communication with an adjacent upstream portion 81 defined by the stationary valve plate 19. In addition, each port arrangement 93A through 93E includes a radially outer recess 97, which is generally L-shaped, and includes an outer, tangentially-oriented portion which is in open communication with each of the downstream portions 83 defined by the stationary valve plate 19.

[0036] Referring now primarily to FIG. 6, but in conjunction with FIGS. 4 and 5, the shifter plate 17 defines a plurality of radially-extending bores 99, each of which is sealed at its radially outer end by a threaded plug 101 (shown only in FIG. 1). Disposed within each bore 99 is a valve spool 103 including an inner land 105 and an outer land 107. At the radially inner end of each bore 99 is a reduced diameter bore 109 (also referred to hereinafter as a "shift pressure chamber"), each of which is in open fluid communication with its respective bore 89 and annular groove 87, for purposes which will be explained in connection with the description of the operation of the invention.

[0037] Each of the recirculation bores 91 shown in FIG. 4 extends axially part way through the shifter plate 17 and intersects its respective bore 99 at a location

which, in FIG. 6 is covered by the outer land 107. Referring now primarily to FIGS. 5 and 6, each of the radially inner recesses 95 is in communication with a short axially extending bore 111 which opens into the radially extending bore 99 as shown in FIG. 6. Similarly, each of the radially outer recesses 97 is in communication with a short axially extending bore 113 which opens into the radially extending bore 99 as shown in FIG. 6.

[0038] Each of the valve spools 103 is biased radially inward to the position shown in FIG. 6 by a compression spring 115, which has its radially outer end seated against the threaded plug 101. Thus, in the absence of sufficient fluid pressure in the bores 109, the valve spools 103 will all be biased radially inward to the position shown in FIG. 6, in which the bores 111 and 113 are in open communication with each other, and therefore, the inner and outer recesses 95 and 97 are in open communication with each other. With the recesses 95 and 97 in open communication, the upstream portion 81 and the downstream portion 83 (of each of the stationary valve passages 79A through E) defined by the stationary valve plate 19 are also in open communication with each other, such that each of the stationary valve passages 79A through 79E functions in substantially the same manner as each of the conventional stationary valve passages 77. Thus, with the valve spools 103 in the position shown in FIG. 6, the gerotor motor will operate in the normal, low-speed, high-torque mode.

[0039] Referring still primarily to FIGS. 3 through 6, when pressurized fluid (e.g., from the system charge pump) is communicated to the annular groove 87, pressure will be communicated through each of the bores 89 and 109, biasing the valve spools 103 radially outward in opposition to the force of the compression springs 115. In the radially outward position of the valve spool 103, the inner land 105 blocks the bore 111 from communication with the bore 113, such that the radially inner recess 95 is no longer in communication with the radially outer recess 97. Thus, the upstream portion 81 of each of the stationary valve passages 79A through 79E is no longer in communication with the downstream portion 83. Instead, with the valve spool 103 in its radially outward (HSLT) position, the outer land 107 now uncovers the respective recirculation bore 91, such that the recirculation bore 91 is now in open communication with the bore 113.

[0040] Therefore, five of the volume chambers are no longer in communication with the fluid inlet port 59 or the fluid outlet port 61, by means of the commutating valving. Instead, those five "recirculating" volume chambers are each in communication with the pressurized recirculation chamber 67, by means of the recirculation bores 91, the bores 113, the radially outer recesses 97, and the downstream portions 83. As a result, only the five remaining volume chambers (i.e., those in communication by means of the stationary valve passages 77) effectively serve as expanding and contracting volume chambers, alternately. This is the same result as if the

displacement of a conventional gerotor motor were reduced by one-half, which, given a fixed rate of fluid flow, would cause the motor output speed to double.

[0041] As was stated in the BACKGROUND OF THE DISCLOSURE, one of the objects of the invention is to have true multi speed capability, i.e., a minimum (1.0:1) speed ratio (LSHT), a maximum (2.0:1) speed ratio (HSLT), and at least one speed ratio in between the minimum and maximum ratios. The present invention, by valving each of the recirculating volume chambers separately, makes it possible to have less than five of the volume chambers recirculate fluid. For example, in the subject embodiment, if three of the valve spools 103 were shift radially outward by pressure in the respective bores 109, but the other two valve spools 103 remained in the radially inward position of FIG. 6, then seven of the volume chambers would operate normally for an intermediate (1.43:1) speed ratio. In order to accomplish such intermediate speed ratio, it would be necessary for three of the bores 109 to be connected to one source of control (pilot) pressure, and the other two bores 109 to be connected to another source of control pressure. It is believed to be well within the ability of those skilled in the art to provide such a dual source of control pressure. Those skilled in the art will understand that, in the above example, instead of three recirculating volume chambers, there could be only two, with eight volume chambers operating normally. In that case, the intermediate speed ratio would be a ratio of 1.25:1. Thus, the present invention provides a previously unknown flexibility in achieving various speed ratios.

[0042] The invention has been described in great detail in the foregoing specification, and it is believed that various alterations and modifications of the invention will become apparent to those skilled in the art from a reading and understanding of the specification. It is intended that all such alterations and modifications are included in the invention, insofar as they come within the scope of the appended claims.

Claims

1. A fluid pressure operated device comprising housing means (13) defining a fluid inlet port (59) and a fluid outlet port (61); a fluid pressure displacement mechanism (21) associated with said housing means (13) and including an internally-toothed ring member (27) and an externally-toothed star member (31) eccentrically disposed within said ring member (27); said ring member and said star member having relative orbital and rotational movement, and interengaging to define a plurality N of expanding (33E) and contracting (33C) fluid volume chambers in response to said orbital and rotational movement; motor valve means (43,19) cooperating with said housing means (13) to provide fluid communication between said fluid inlet port (59) and said ex-

panding volume chambers (33E), and between said contracting volume chambers (33C) and said fluid outlet port (61); said motor valve means comprising a stationary valve member (19) fixed to be non-rotatable relative to said housing means (13), and a moveable valve member (43), operable to move relative to said stationary valve member (19) in synchronism with one of said orbital and rotational movements; said stationary valve member (19) defining a plurality N of stationary valve passages, each of said stationary valve passages including an upstream passage portion adapted for commutating fluid communication with said moveable valve member (43), and further including a downstream passage portion in continuous fluid communication with one of said plurality N of fluid volume chambers (33); and, in a plurality (N-M) of said stationary valve passages (77), said upstream passage portion and said downstream passage portion being in direct, relatively unrestricted, continuous fluid communication; **characterized by**:

(a) in a plurality M of said stationary valve passages (79A, 79B, 79C, 79D, 79E), said upstream (81) and said downstream (83) passage portions being blocked from direct fluid communication; 25

(b) a plurality of control valve members (103), each operably associated with said stationary valve member (19), and with one of said stationary valve passages (79A through E); 30

(c) each of said control valve members (103) being operable in a first position (FIG. 6) to provide relatively unrestricted fluid communication between each upstream passage portion (81) and its respective downstream passage portion (83), and operable in a second position to block fluid communication between each upstream passage portion (81) and its respective downstream passage portion (83). 40

2. A fluid pressure operated device as claimed in claim 1, **characterized by** said plurality M of said control valve members (103) being operable, in said second position, to provide relatively unrestricted fluid communication among said plurality M of downstream passage portions (83). 45
3. A fluid pressure operated device as claimed in claim 2, **characterized by** said plurality M of control valve members (103) cooperating with one of said stationary valve member (19) and said housing means (13) to define a fluid recirculation region (67), said control valve member (103), in said second position, providing relatively unrestricted fluid communication between each of said plurality M of downstream passage portions (83) and said fluid recirculation region (67). 50 55

4. A fluid pressure operated device as claimed in claim 3, **characterized by** said fluid recirculation region (67) being in fluid communication with a source (59) of relatively high pressure fluid, said source comprising said fluid inlet port (59). 5
5. A fluid pressure operated device as claimed in claim 1, **characterized by** each of said plurality M of control valve members (103) is biased toward one of said first (FIG. 6) and second positions by one of a plurality M of biasing springs (115), and toward the other of said first and second positions by fluid pressure in a shift pressure chamber (109). 10
6. A fluid pressure operated device as claimed in claim 5, **characterized by** each of said plurality M of control valve members (103) is biased toward said first position (FIG. 6) by one of said biasing springs (115), and toward said second position by fluid pressure in said shift pressure chamber (109). 15 20

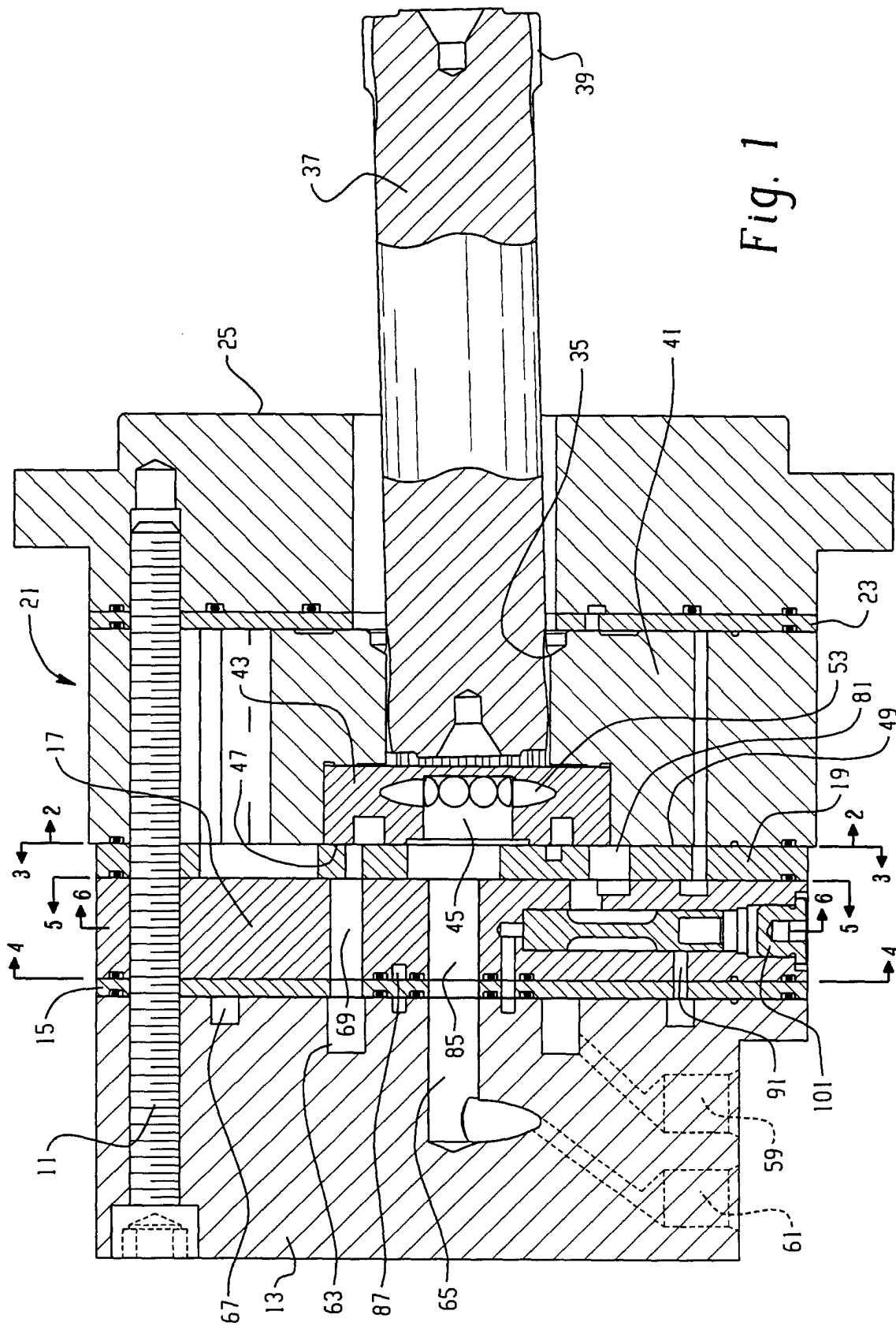


Fig. 1

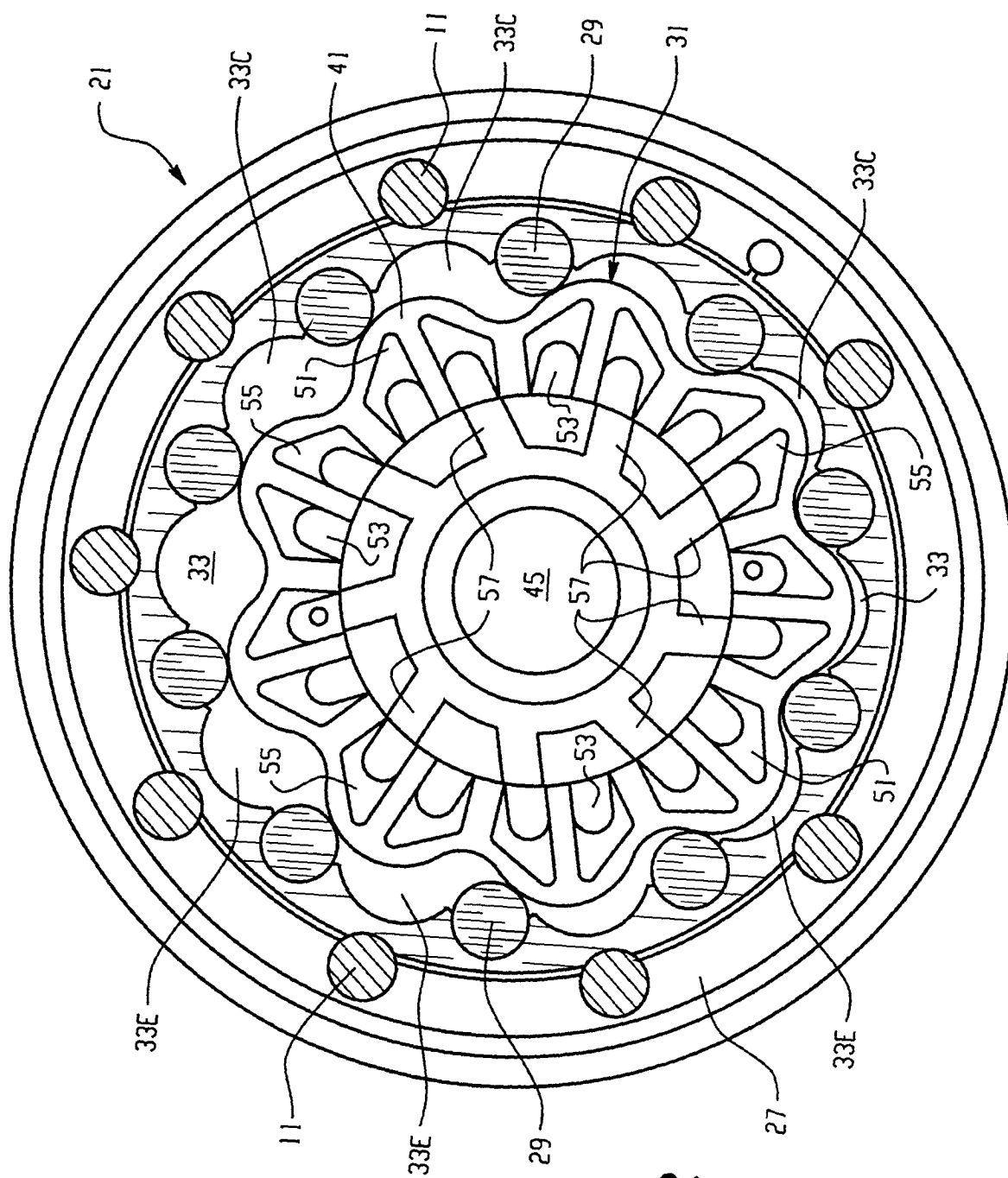


Fig. 2

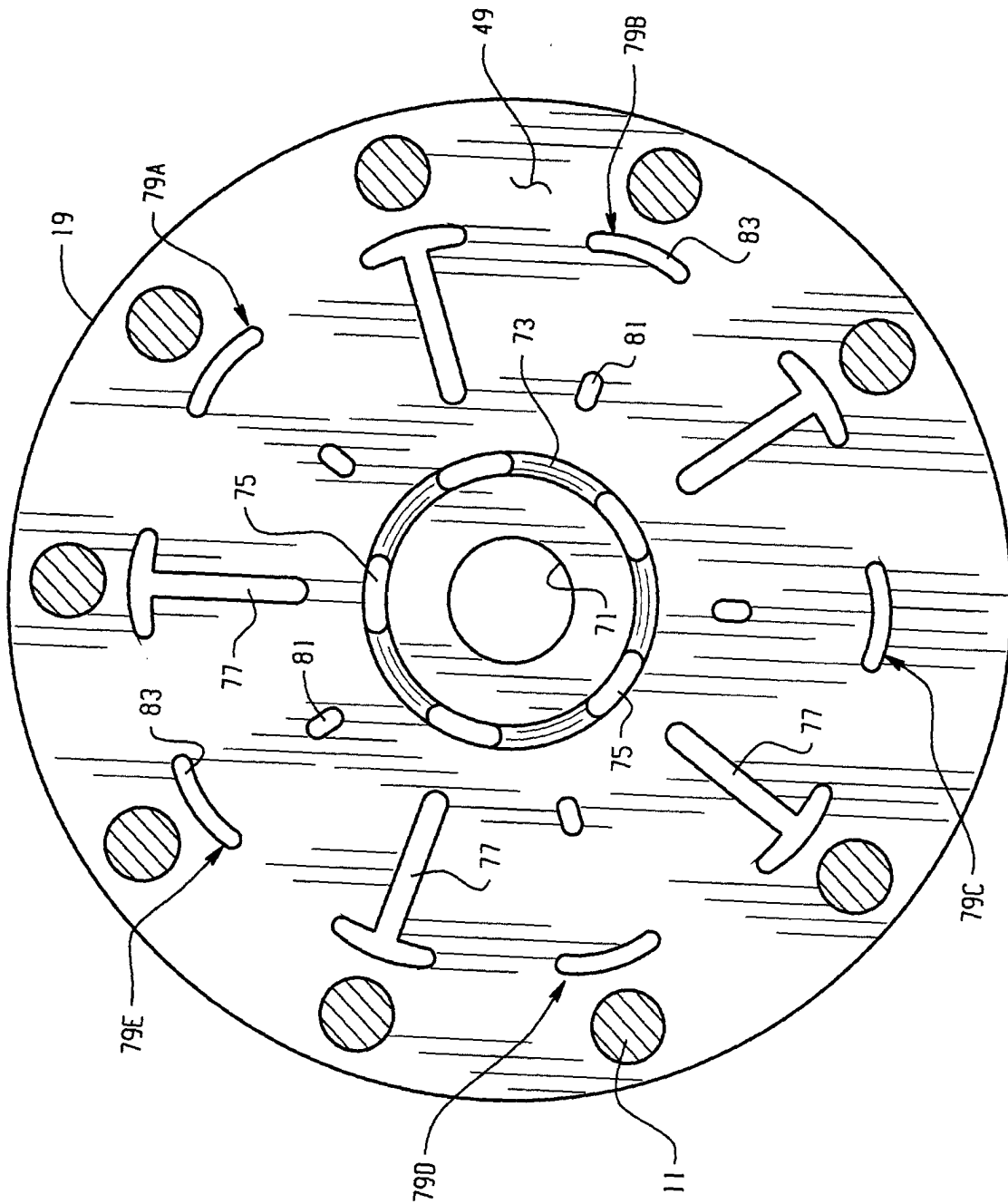


Fig. 3

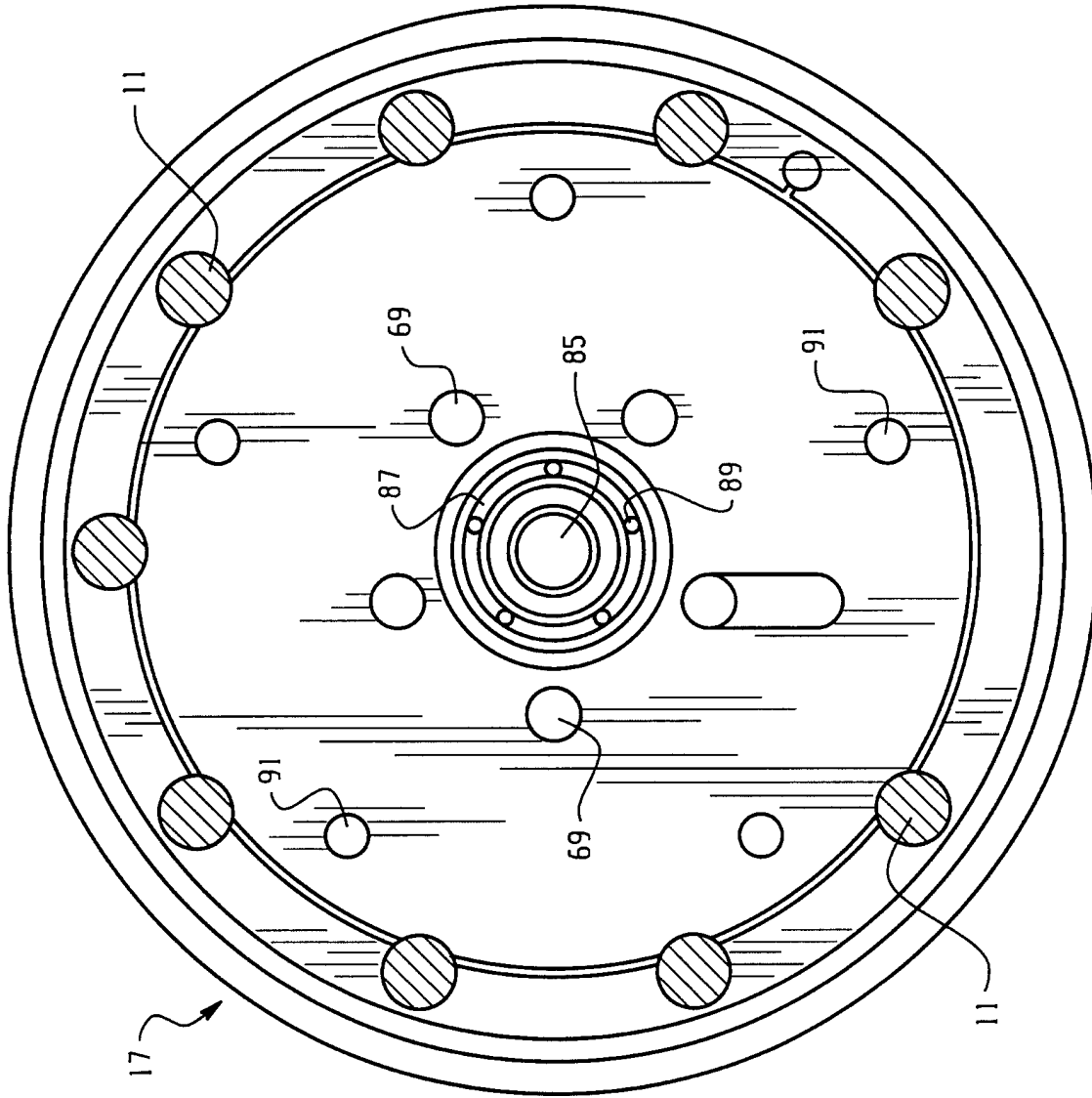


Fig. 4

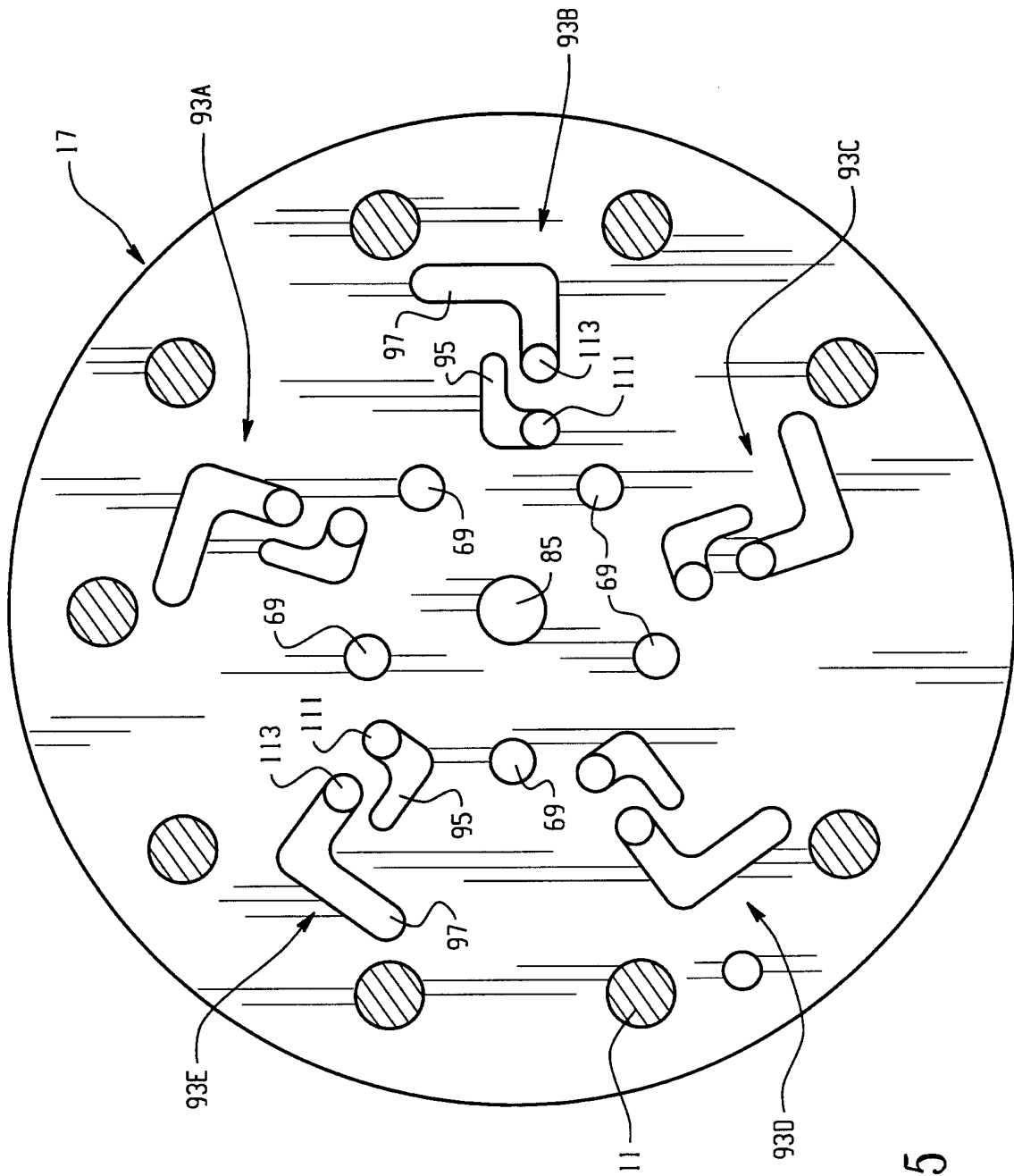


Fig. 5

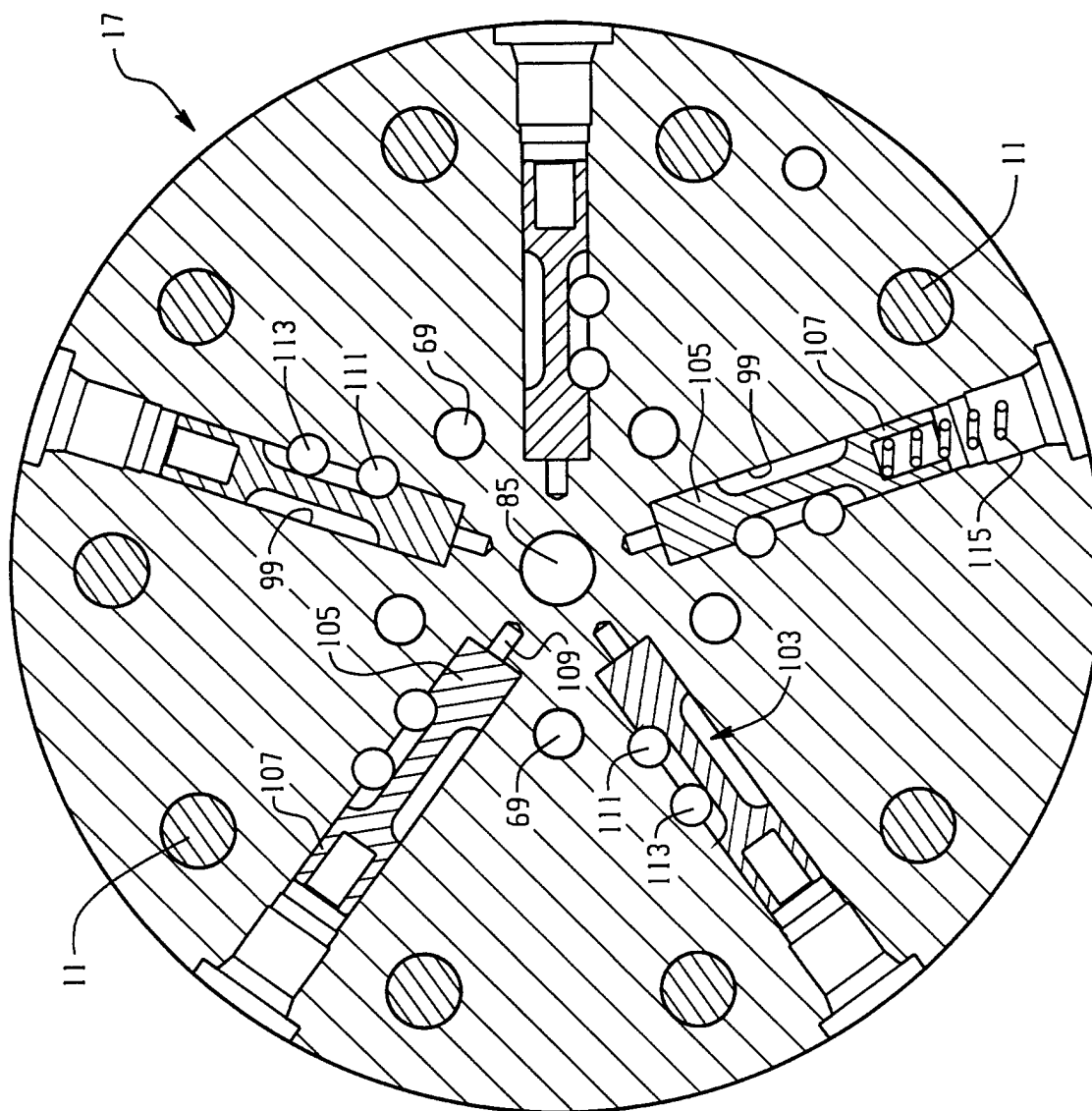


Fig. 6