March 6, 1951 C. BANCROFT 2,544,480

ROTARY DISPLACEMENT DEVICE

Filed Jan. 13, 1945 6 Sheets-Sheet 1

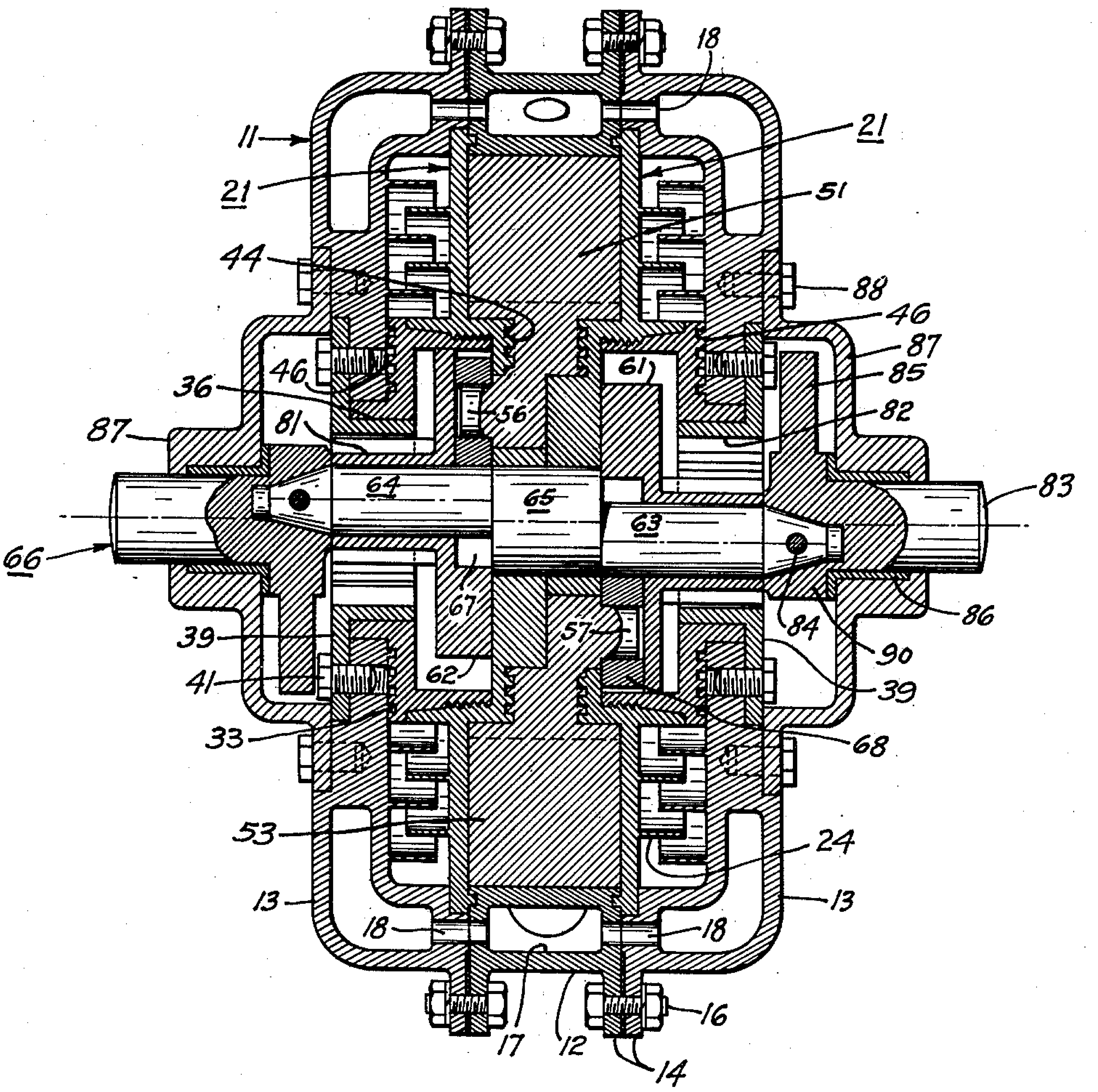

Fig. 1

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2,544,480

ROTARY DISPLACEMENT DEVICE

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6 Sheets-Sheet 2

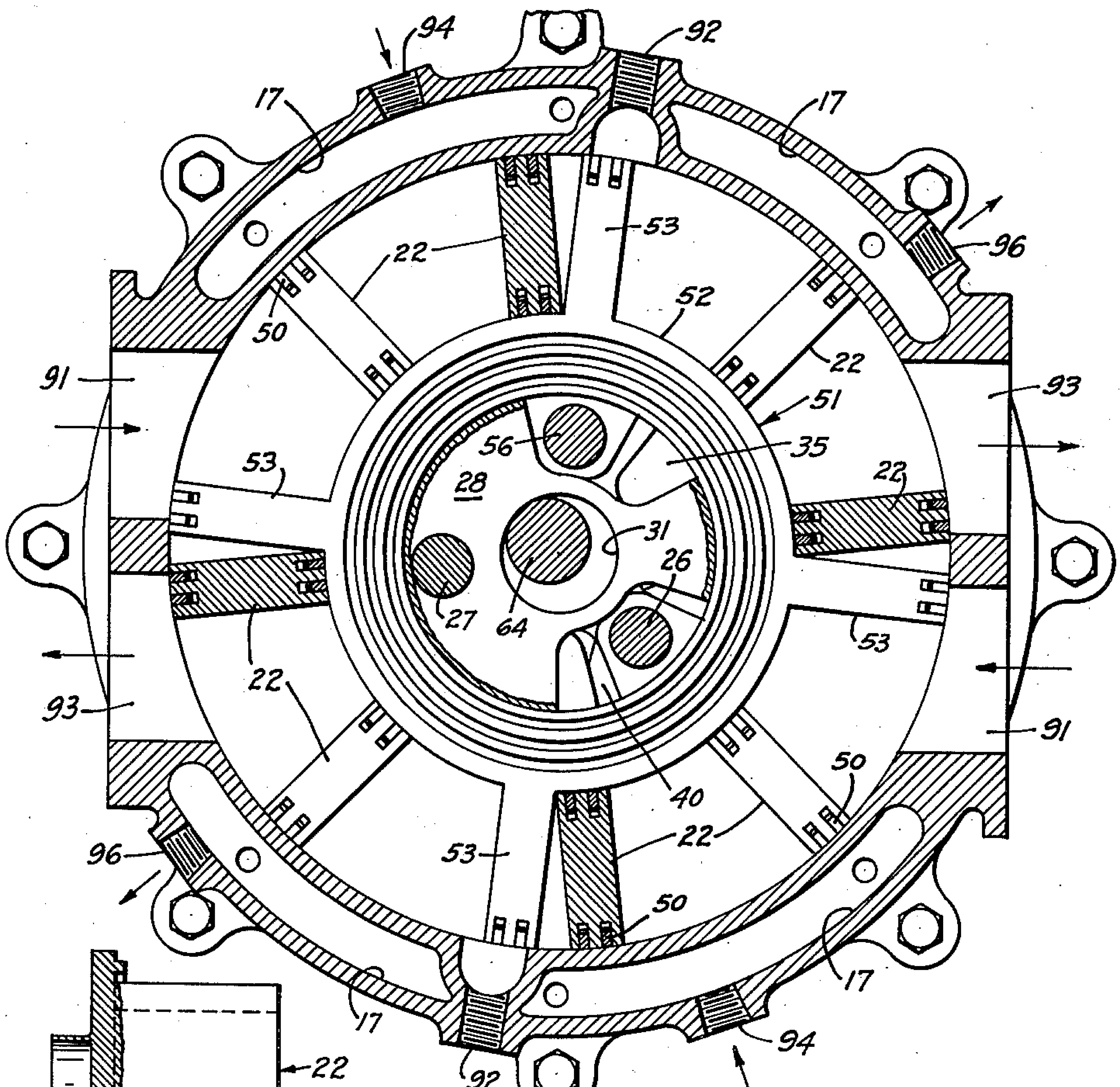

Fig. 2

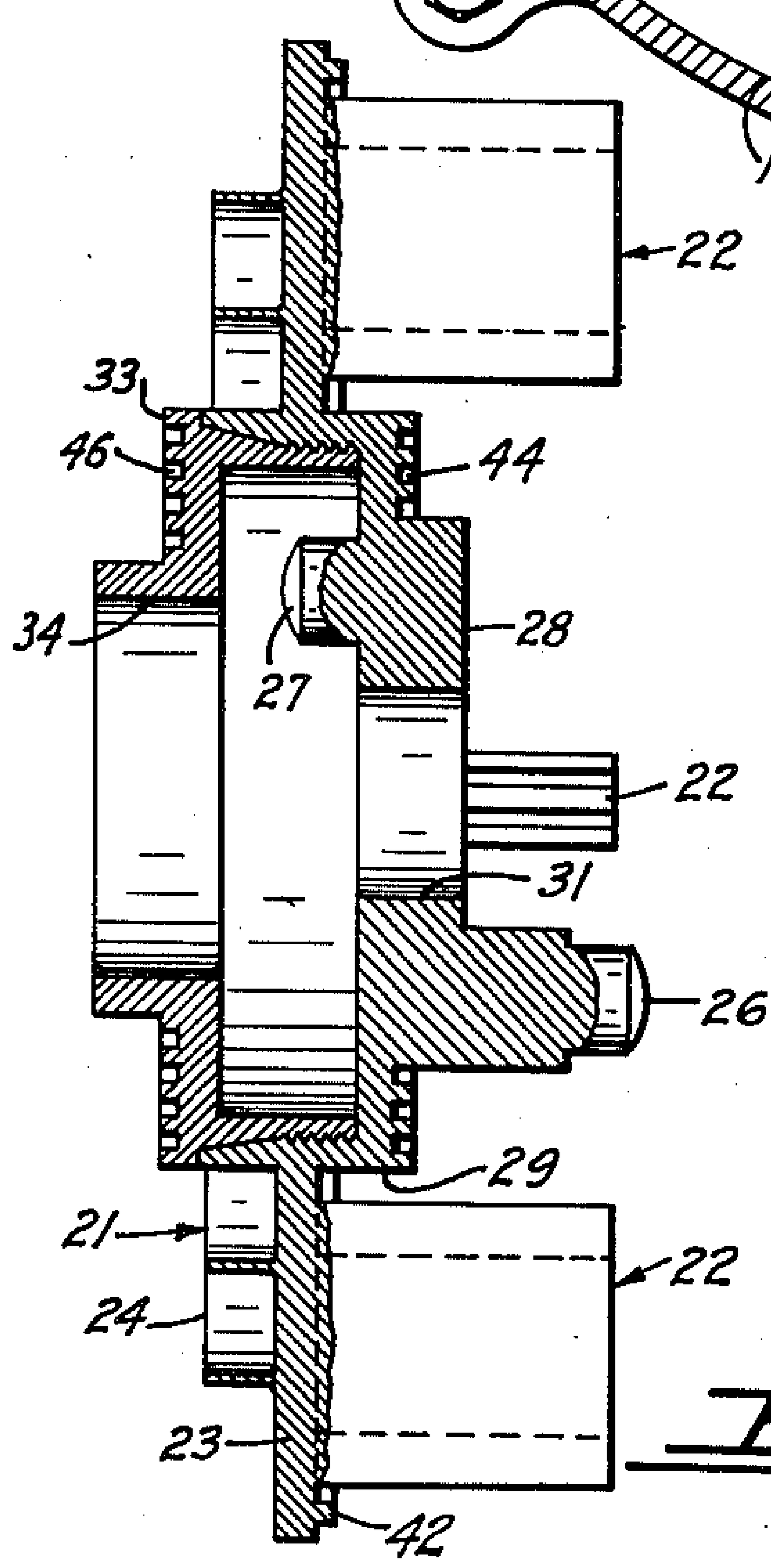

Fig. 3

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ROTARY DISPLACEMENT DEVICE

Filed Jan. 13, 1945 6 Sheets-Sheet 3

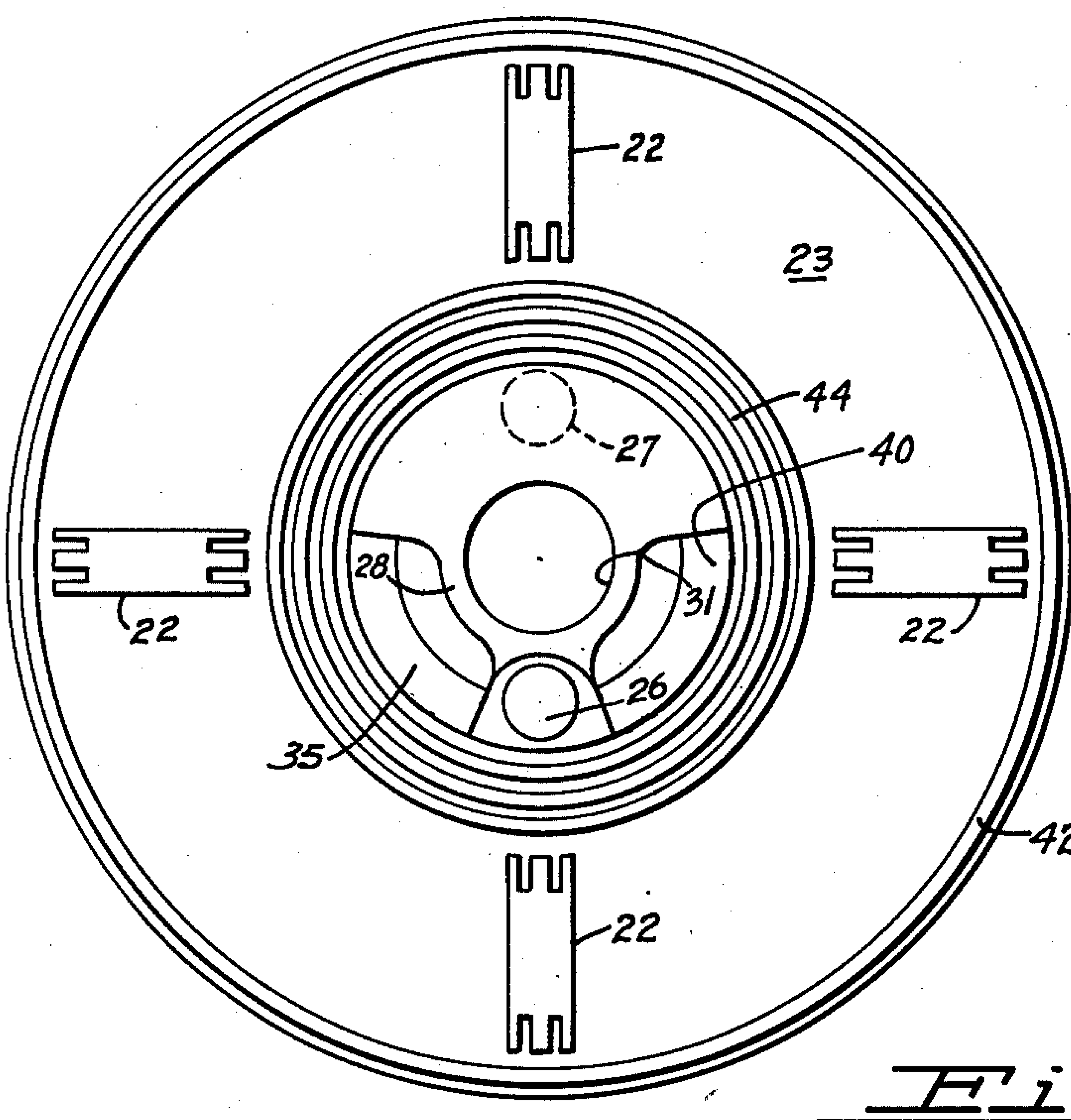

Fig. 4

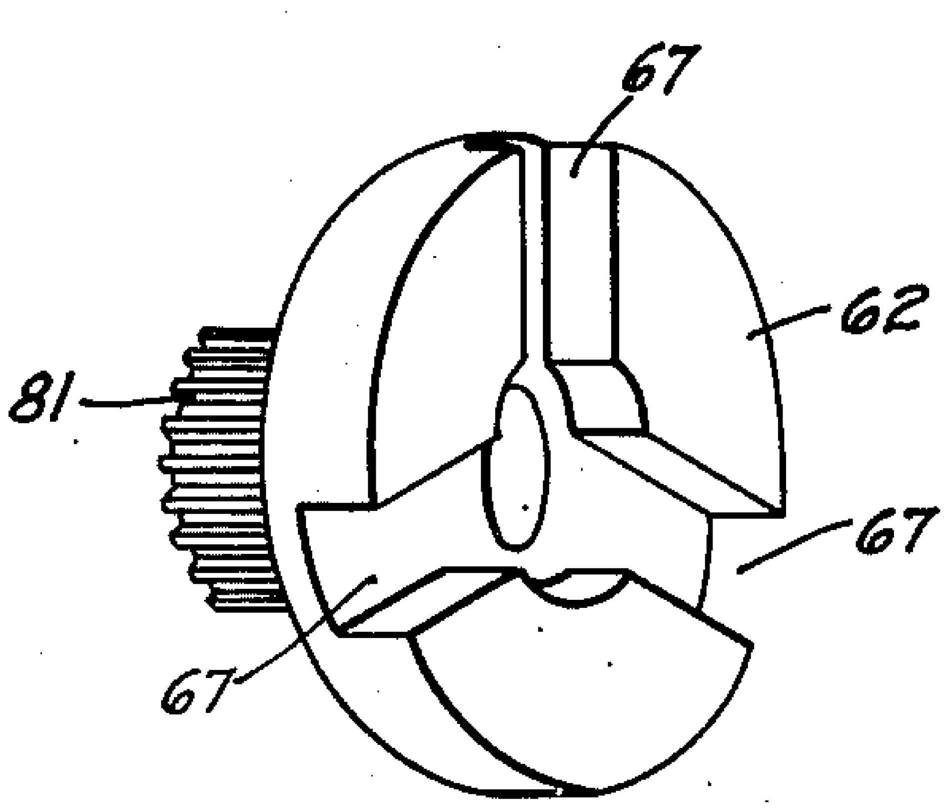

Fig. 5

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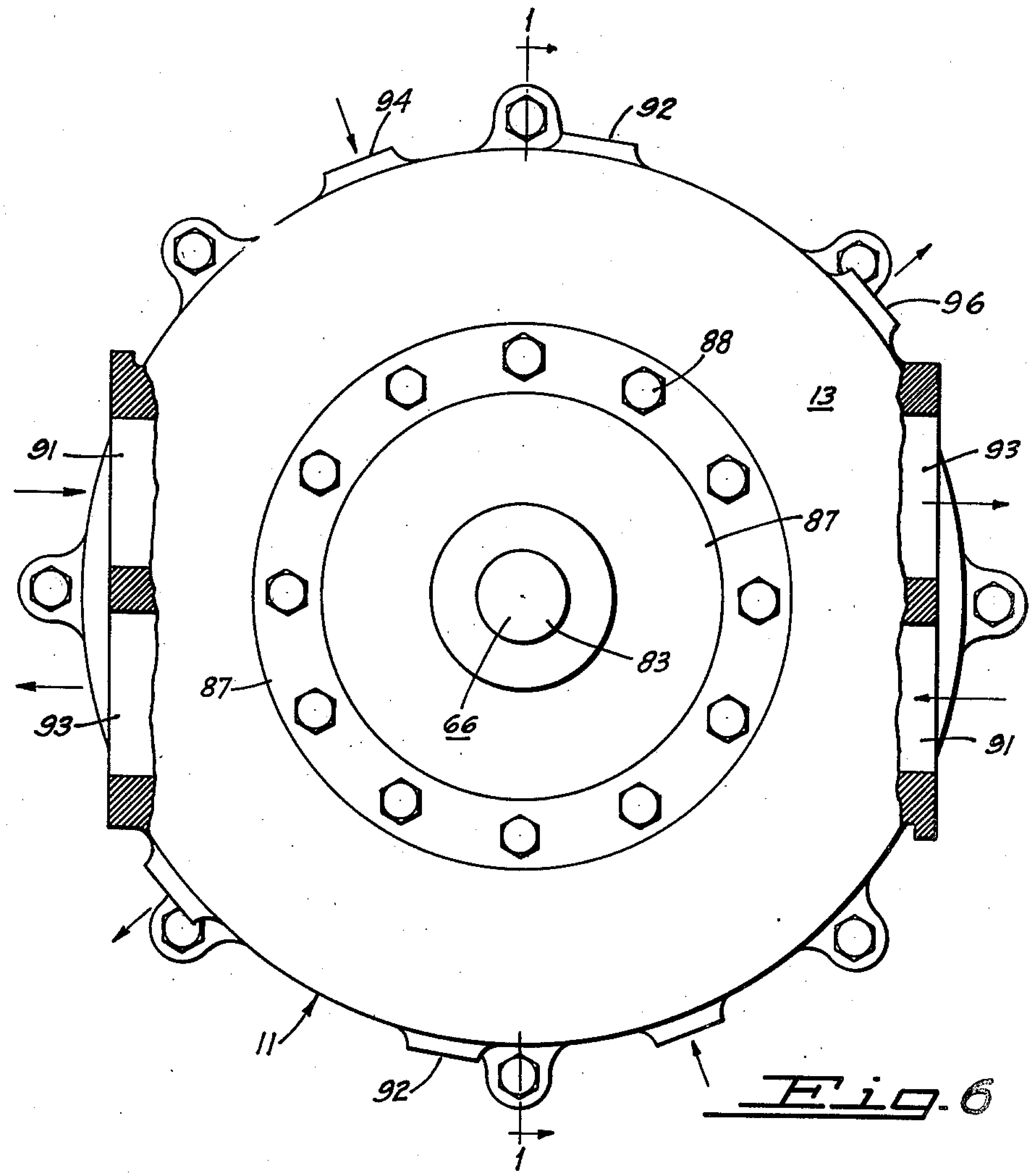

Fig. 6

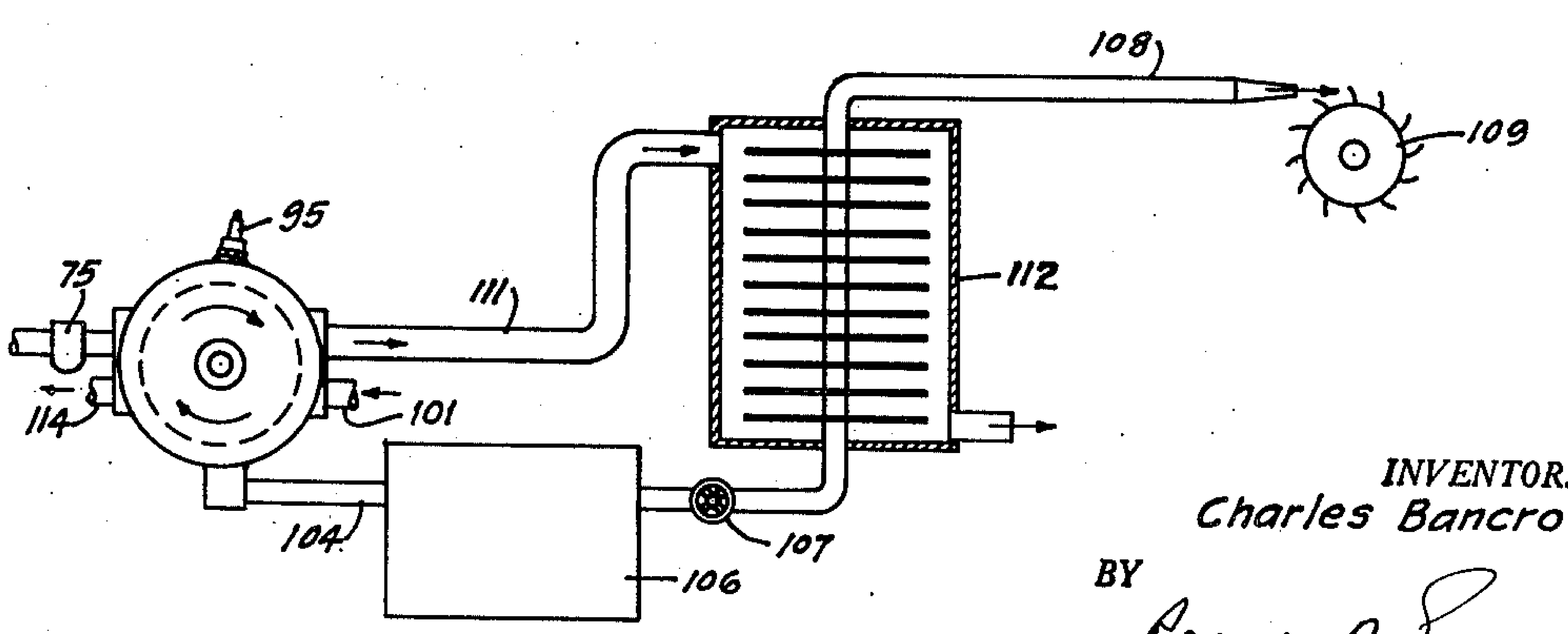

Fig. 7

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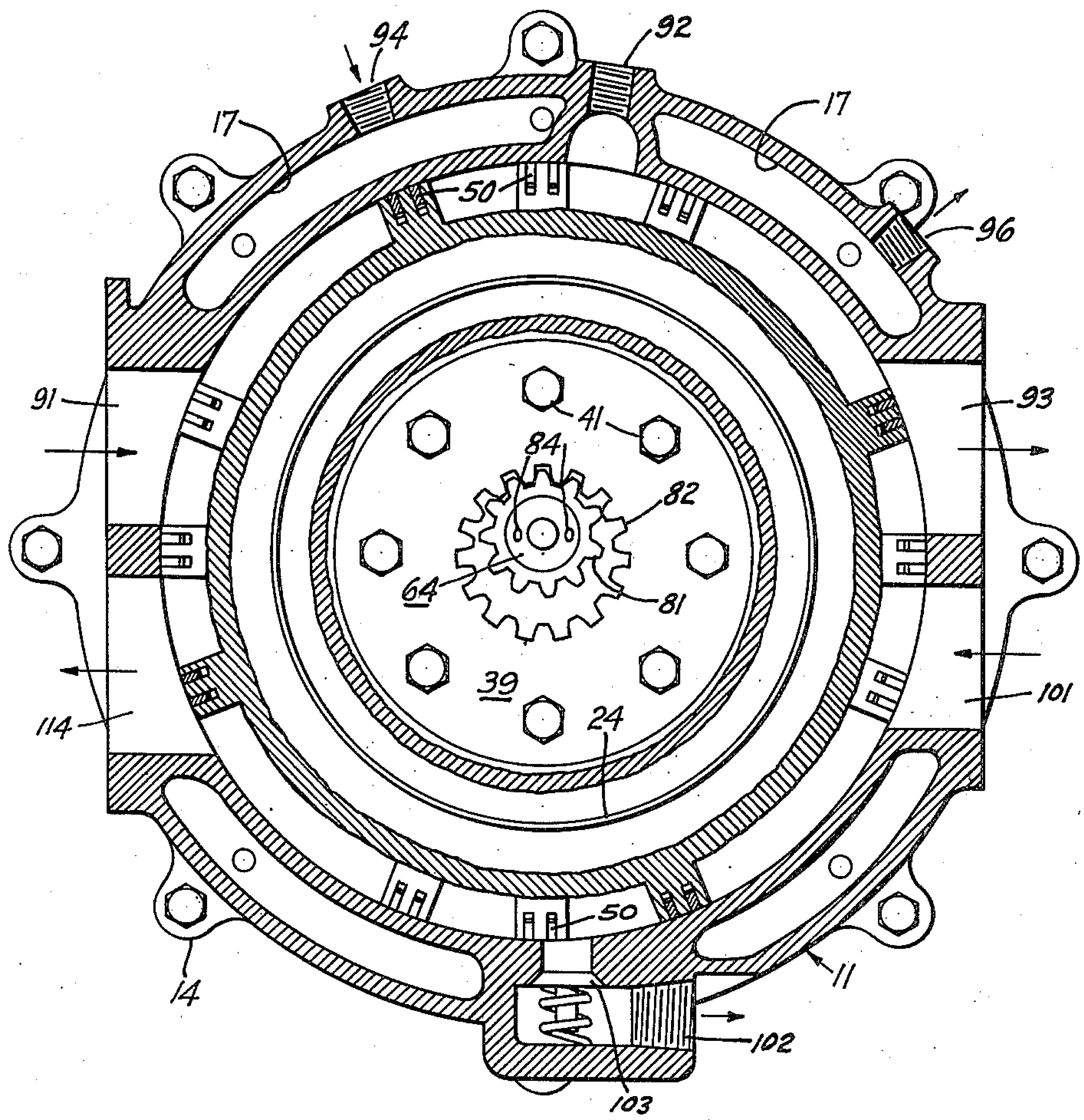

Fig-8

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March 6, 1951 C. BANCROFT 2,544,480

ROTARY DISPLACEMENT DEVICE

Filed Jan. 13, 1945 6 Sheets-Sheet 6

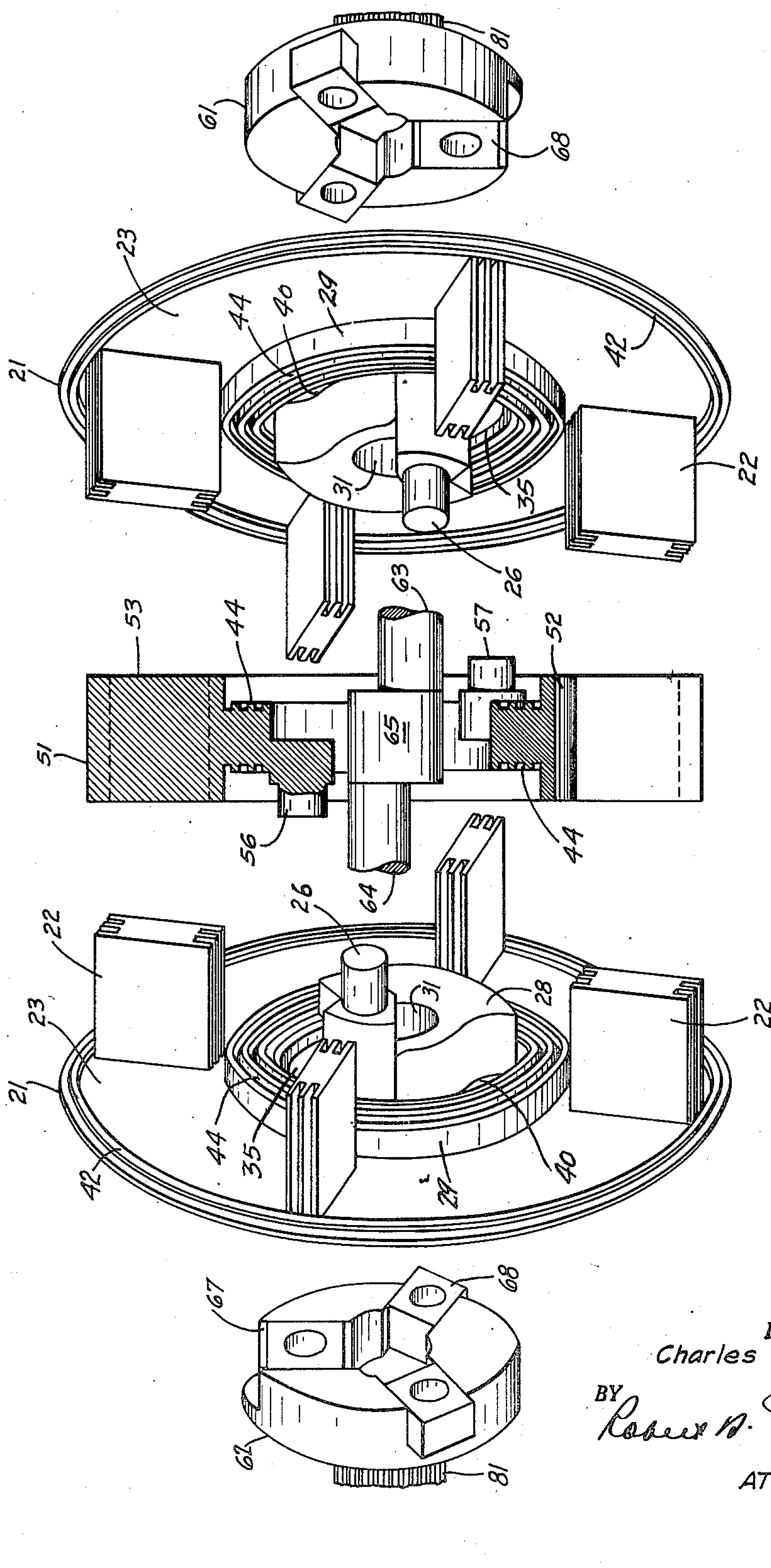

Fig. 9

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Patented Mar. 6, 1951

2,544,480

UNITED STATES PATENT OFFICE

2,544,480

ROTARY DISPLACEMENT DEVICE

Charles Bancroft, New Canaan, Conn.

Application January 13, 1945, Serial No. 572,611

2 Claims. (Cl. 103—129)

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This invention relates to rotary displacement devices of the alternately accelerating piston type such as are disclosed in my prior Patents 2,132,596 and 2,270,493. In these patents I have disclosed rotary displacement devices of the alternately accelerating piston type wherein the fluids are handled in a chamber having walls movable with the working vane pistons. Thus I avoid using the common and well known combination of a piston moving in a stationary chamber of large area. So far as I am aware, it has not been possible heretofore to construct such rotary displacement devices with more than two vane pistons in each set of pistons. While a device so constructed will operate satisfactorily, the loss due to friction between the several moving parts is considerable. In accordance with the present invention, I provide a simple rotary displacement device in which three or more vane pistons on each set of pistons can be utilized. This enables the useful work to be increased in a unit of given size and makes possible the balancing of fluid pressures found at given points in the device so that loads on piston bearings can be cancelled out and friction and wear reduced.

The rotary displacement device of the present invention also utilizes a multiple throw crankshaft, in cooperation with multiple members connecting the piston sets, whereby crankshaft bearing pressures resulting from mechanical torque conversion are reduced and rotation of the piston sets is mechanically controlled from more than one point so that the greater part of the loads on piston bearings resulting from mechanical torque is also balanced out.

By utilizing more than two vane pistons in each piston set I am also able to reduce the rate of movement of the several piston sets relative to the crankshaft by providing means controlling rotation of the members connecting the piston sets in their rotation on the crankpin so that while a given connecting member makes one revolution in one direction with respect to the stator, the crankshaft completes as many revolutions, with respect to the given connecting member, in the opposite direction, as there are individual vane pistons on each set of pistons. For example, if each piston set includes four vane pistons, then the crankshaft will complete four revolutions relative to the connecting member in a direction opposite to that of rotation of the connecting member during each rotation of the connecting member. Stated otherwise, for each revolution of the connecting member with respect to the stator in one direction, the crankshaft rotates

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that number of revolutions with respect to the stator in an opposite direction which is equal to the number of vane pistons in each set of pistons minus one.

Inasmuch as the rotary displacement device of the present invention includes multiple piston sets, having a multiple number of vane pistons which are alternately accelerated, it is possible to utilize the device as an internal combustion engine, admitting fuel at one or more points in the travel of the pistons, firing the admitted charge or charges, and subsequently scavenging the exploded charge or charges after useful work has been performed. Thus, a single device may include one or more fuel admission means, one or more firing means, and one or more scavenging means, positioned about the periphery of the device. In one form of the device which is presently disclosed, two separate power impulses are imparted to each vane piston during one complete revolution of the piston in the casing. It should be readily apparent that in such a device one can oppose various pressures so that, in effect, they neutralize each other. This simplifies construction, operation and maintenance.

In another modified form of the device of the present invention, it is possible to generate power in the device and to use simultaneously in the same device the generated power to draw in, compress and eject a fluid. Thus, it is possible in a single stator to generate power used for the pumping or compressing of a fluid in the same stator. In the case of gas compression, the heat in the exhaust gases from the internal combustion engine portion of the rotary displacement device can be utilized to heat the compressed gas and so impart additional energy to that gas. In addition, and as will presently appear further in detail, the compressed gas which is not completely scavenged from the device is utilized to improve the efficiency of operation of the device.

A further difficulty which I have observed in the operation of rotary displacement devices including movable walls and piston sets is that of providing an adequate seal about these same parts. I have found that this can be simply and feasibly cared for by bleeding fluid under pressure from the piston channel and applying the pressure provided by the bled fluid against those members providing the piston forming channel. The pressures found within the piston channel are thus substantially neutralized on the opposite side, the members forming the piston channels being pressed against the pistons and so maintained in position that a positive seal of the channel is effected.

It is in general the broad object to provide an improved rotary displacement device.

A further object of the present invention is to provide a rotary displacement device in which multiple sets of pistons having multiple vane pistons are utilized in conjunction with a multiple throw crankshaft so that various bearing pressures, stresses, etc., are considerably reduced or are neutralized in the device whereby the construction, operation and maintenance of the device is improved and simplified.

A further object of the present invention is to provide a rotary displacement device which is capable of simultaneous use as an internal combustion engine and a fluid pump or compressor.

A further object of the present invention is to provide a rotary displacement device having multiple vane pistons movable in a piston channel which is maintained substantially fluid-tight by pressure applied on the walls opposite to the channel and supplied by fluid bled or allowed to leak from some point in the piston channel or supplied from an external source.

The invention includes other objects, novel features and advantages, some of which, together with the foregoing, will appear hereinafter wherein the present preferred form of rotary displacement device of this invention is disclosed.

In the drawings accompanying and forming a part hereof,

Figure 1 is a longitudinal section through a rotary displacement device embodying the present invention.

Figure 2 is a partial transverse section with portions of the device cut away to illustrate certain features of the internal construction of the device but with the crankshaft turned 45 degrees from the position shown in Figure 1.

Figure 3 is a longitudinal section illustrating construction of one of the several piston sets employed.

Fig. 4 is a side elevation of the construction shown by Fig. 3.

Figure 5 is an isometric view illustrating the construction of a connecting member.

Figure 6 is a side elevation partly in section illustrating construction of a device operated entirely as an internal combustion engine.

Figure 7 is a schematic sketch illustrating utilization of a device embodying the present invention as a combined internal combustion engine and an air compressor with the compressed air employed to drive a turbine wheel to produce rotary torque, the device being shown in conjunction with other apparatus whereby heat of the exhaust is used to add additional energy to the compressed air.

Figure 8 is a transverse section partly in elevation illustrating a device adapted to be employed as an internal combustion engine and an air compressor.

Figure 9 is an exploded isometric view of the principal driving members and the piston sets.

Referring particularly to the form of device shown in Figures 1–4, a stator, generally indicated at 11, is provided. The stator is generally held against rotation by a suitable base or other means. It is made up of three main elements, a central section 12 and two like end sections or end bells 13, the central section and each of the end sections having ears 14 joined together by bolts 16. Each of the end bells and the central

sections are cored out as at 17 and are connected by passages 18 to permit the circulation through the stator of a cooling fluid admitted through inlet 94 and withdrawn through outlet 96. Caps 87 are secured to each end bell by studs 88, the caps supporting crankshaft 66 for rotation.

In the form of the device illustrated, several piston sets are provided, two of which are identical. Numeral 21 is applied to each of these and in Figure 3 I have illustrated the piston set 21 which appears on the left hand side of Figure 1. Each piston set 21 includes four vane pistons 22 thereon joined to one side of a wall 23. A plurality of circular fins 24 extend from the other side of the wall to assist in transfer of heat to the end bells which are provided with similar fins cooperatively positioned.

Wall 23 on each piston set 21 is formed with an inner circular flange or annular member 29 which extends on both sides of the wall. On one side of member 29 a plurality of labyrinth grooves 44 are formed to provide a seal between each piston set 21 and a third, presently described piston set 51. To provide for rotational support of each piston set 21, the other side of member 29 is engaged with a removable bearing support member 33 having a bearing 34 formed thereon. This bearing is engaged with a bearing 36 (Figure 1) on a presently described ring gear member 39 which is secured by studs 41 to each end bell 13. The bearing support member 33 is removable to enable connecting members 61 and 62 to be inserted and engaged with each piston set 21 and piston set 51. This engagement is accomplished by providing crankpins 26 and 27 on each piston set 21, the pins being 180° apart and extending in opposite directions from a wall portion 28 (Figures 2, 3 and 9) formed on one side of annular member 29. Each wall 28 is slotted as at 40 to permit the crankpin 26 from one piston set 21 to pass and as at 35 to permit crankpin 56 or 57 from piston set 51 to pass and to be engaged with one connecting member 61 or 62 as will be described. Each slot is elongated to permit the requisite degree of oscillatory motion to occur between the several piston sets.

To support further each of piston sets 21, each wall 28 is provided with a bearing 31 to receive central bearing 65 on crankshaft 66.

In addition to the piston sets 21 so far described, a third piston set is provided and is indicated generally at 51. This includes an annular central portion 52 which completes the piston channel defined by walls 23 and the central stator portion. The set 51 has four vane pistons 53 extending radially therefrom. This set is movable between the walls provided by piston sets 21 and within the annulus provided by the interior of stator central section 12. Each of the vane pistons on piston sets 21 includes sealing means generally indicated at 50 on the inner and the outer end of each vane. On piston set 51, the sealing means is provided only at the outer end of each piston vane.

Each of piston sets 21 includes an annular ring 42 formed on one face thereof. Each end bell on the stator is formed to receive the periphery of a piston set wall while the central portion of the stator receives each ring 42 and so provides a seal for the piston channel formed between the piston set walls. Any fluid leaking past the piston set wall between the ring 42, the wall and the stator, passes into a space between the piston set and the adjacent interior surface of each end bell 13. To assist in maintaining fluid pressure in this region, labyrinth seals are provided as indicated at 46 in the bearing support 33. Each labyrinth is provided by forming a plurality of circular grooves and providing like annular projections on the immediately adjacent surface, the two interengaging to provide a labyrinth seal. By bleeding fluid under pressure in the piston channel into this space, the pressure on opposite sides of the movable walls can be equalized and the walls sealed without the necessity of close tolerances between the several parts.

As appears in Figure 1, the central piston set 51 also includes two crankpins 56 and 57 placed 180° apart and extending through suitable slots 35 in wall 28 of each of piston sets 21 for engagement with a crosshead bearing 68 in each of the presently described connecting members 61 and 62.

A labyrinth seal 44 is provided between each piston set 21 and the third piston set to prevent fluid leakage from the piston channel into the central or crankshaft section of the device. This section is normally vented to the atmosphere and is maintained partially filled with a fluid lubricant to lubricate the several working parts.

The piston sets 21 and 51 rotate together as a unit. In addition, they have a limited rotary movement relative to each other, each set alternately accelerating and decelerating so that the rate of travel of alternate sets of pistons varies in such a way that the distance between adjacent sets of piston vanes changes from a maximum to a minimum during compression or scavenging of a charge and from a minimum to a maximum during the intake or power stroke as when the device is used as an internal combustion engine.

In accordance with the present invention, means are provided to ensure that corresponding variations in distance between adjacent pistons always occur cyclically and at the same point about the periphery of the stator. These means include a crankshaft 66 having crankpins 63 and 64 spaced 180° apart and on opposite sides of a central bearing 65 mounted in piston sets 21. These means also include identical connecting members 61 and 62 mounted respectively upon opposite crankpins 63 and 64. As appears in Figure 1, each of the connecting members is mounted in the space between wall 28 on each piston set 21 and its bearing support 33. By making each piston set 21 and its bearing support member 33 in two separate parts, I am able to insert the connecting members and at the same time provide adequate bearing support for each of the piston sets 21. Each of the connecting members includes three slots 67. In each slot is mounted a crosshead bearing 68 which in turn receives one of the crankpins 26 or 27 on one of the piston sets 21 or one of the crankpins 56 or 67 on the central piston set.

To control rotation of the connecting members and the several elements associated with them, and to ensure rotation of these in a cyclic manner, an integral spur gear 81 is formed at one end of each connecting member and each spur gear is meshed with one of ring gears 82 on each ring gear member 39. To enable the device to be assembled in a simple manner, and to eliminate any unbalance during its rotations, counterweights 85 are provided on each crankshaft extension 83, the latter being joined by pins 84 to ends of the crankshaft crankpins. Bearing 86 in each cap 87 supports the shaft portion 83 on each throw, the caps being positioned on each end bell by studs 88.

The device described is readily utilized as an internal combustion engine, power being taken off from either shaft portion 83. In this case, as appears in Figure 6, a suitable fuel charge is supplied and is admitted to intakes 91 provided on diametrically opposite sides of the stator casing. A sparkplug or other firing means is provided at each of points 92 on the casing, the two being again diametrically opposed and spaced approximately 80° from each intake. The products are scavenged and exhausted after firing through exhaust ports 93. The device as described is suited to the Otto cycle of operation. It will be obvious to those skilled in the art that it can be adapted to other cycles as the Diesel cycle.

The device operates cyclically, the several piston sets rotating in the stator casing and alternately accelerating and decelerating whereby, in effect, the piston sets oscillate with respect to one another. In the device described, with three piston sets, each including four vanes, four charges will be drawn into the engine, four charges compressed, four charges fired and four charges scavenged for each revolution of the crankshaft, the charges being divided into two parts which are drawn in, compressed, fired, and scavenged on opposite sides of the piston channel. Each charge is drawn in on one side of the stator and exhausted at a point approximately 150° removed from the point of intake. Since each charge is divided into two parts, any pressure found at a given point in the piston channel will be duplicated in the piston channel at a point 180° away so that all loads on piston bearings resulting from fluid pressures are balanced out. In addition, the rotation of each of the piston members is mechanically controlled from two points 180° apart so that the greater part of the loads on the piston bearings resulting from mechanical torque conversion is also balanced out. It should also be observed that while the crankshaft rotates three revolutions with respect to the stator in a given direction, the connecting members and sets of pistons will only make one revolution with respect to the stator and that in a direction opposite to the direction of rotation of the crankshaft.

While I have specifically discussed a rotary displacement device including three piston sets, it will be obvious to those skilled in the art that any desired plural number of piston sets can be included. In addition, while my discussion has been limited to a structure in which each piston set includes four piston vanes, it should be obvious that any plurality of vanes can be employed, four being chosen purely for purposes of illustration.

In the form of the device shown in Figures 7 and 8 I have illustrated a combined internal combustion engine and fluid compressor including an explosive charge device as carburetor 75, inlet port 91, sparkplug port 92, sparkplug 95 and exhaust port 93 on one side of the device. On the other side of the device I have provided an air or other fluid inlet 101 diametrically opposite to the inlet port 91. The gas admitted is compressed between one piston and the immediately adjacent piston, the compressed gas being released through port 102, preferably against the pressure of a suitable spring loaded valve indicated at 103. The gas is removed through line 104 into a suitable container 106 which is useful to damp out pulsations in the rate of fluid delivery. From this container the gas can be withdrawn for use as desired. Referring particularly to Figure 7, I have shown a valve 107 as controlling release of the gas into a line 108 leading to a gas motor diagrammatically illustrated at 109, or other means for utilizing the fluid. If maximum utilization of fuel supplied to the device is desired, conduit 111 is preferably interposed between exhaust port 93 and a heat exchange indicated by numeral 112 through which the exhaust gases pass from the engine to heat the gas flowing through line 108 to the motor 109. In place of motor 109, the gas stream can be used in any other form of device for utilizing the compressed gas. For example, if the gas is air, the stream can be released to mix with a fuel and burn in a jet device.

Referring again to Figure 7, that portion of the fluid which is not released against the pressure of spring loaded valve 103 is carried on for release through exhaust ports 114, the resulting expansion of the fluid serving to return to the pistons any stored up energy in the fluid and, in addition, to cool the device prior to admission of the fuel charge and so remove heat from the device whereby the operating efficiency is improved.

I claim:

1. In an apparatus of the character described, a stator, at least three piston sets rotatably mounted in said stator as a unit and having a limited rotation with respect to one another, one of said piston sets including a central annular portion concentric with at least a portion of said stator and defining with said portion an annular piston channel, two other piston sets each having a wall closing a side of said annular piston channel and defining a fluid pressure chamber with said stator on that side of said wall opposite to said channel, a crankshaft rotatably mounted in said stator, a connecting member rotatably mounted on said crankshaft, coupling means between each piston set and said connecting member, and means for controlling rotation of said connecting member on said crankshaft.

2. In an apparatus of the character described, a stator having a plurality of ports for admitting a fluid to a piston channel and a plurality of ports for releasing fluid from said piston channel, at least three piston sets rotatably mounted in said stator as a unit and having a limited rotation with respect to one another, one of said piston sets including a central annular portion concentric with at least a portion of said stator and defining with said portion an annular piston channel, two other piston sets each having a wall closing a side of said annular piston channel and defining a fluid pressure chamber with said stator on that side of said wall opposite to said channel, a crankshaft rotatably mounted in said stator, a connecting member rotatably mounted on said crankshaft, coupling means between each piston set and said connecting member, and means for controlling rotation of said connecting member on said crankshaft.

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Certificate of Correction

Patent No. 2,544,480 March 6, 1951

CHARLES BANCROFT

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 61, for the numeral "67" read *57*; column 8, list of references cited, under the heading "UNITED STATES PATENTS" add the following:

2,284,186 Wolstenholme ------------------ May 26, 1942

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of July, A. D. 1951.

[SEAL]

ERNEST F. KLINGE,
Assistant Commissioner of Patents.