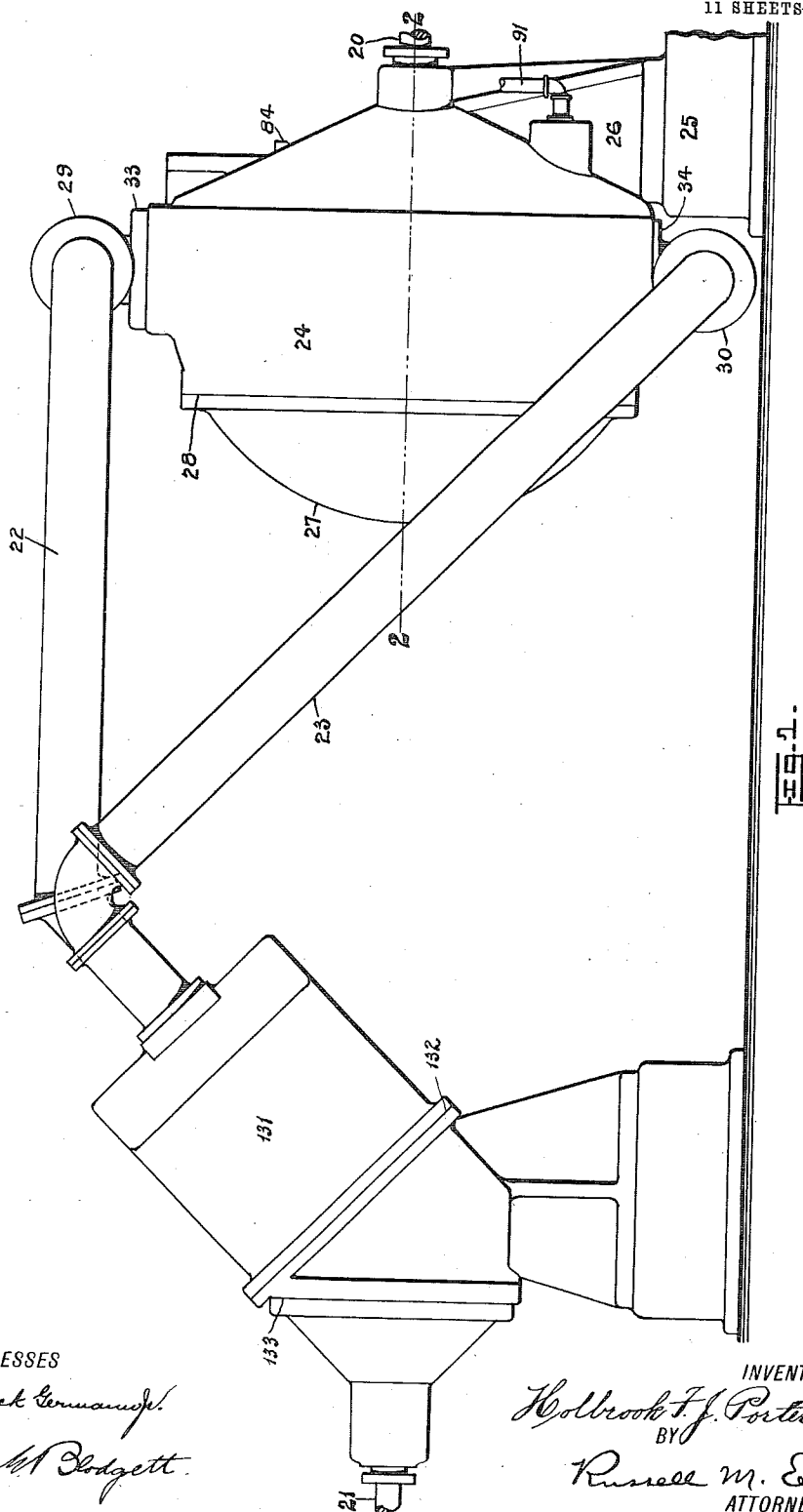


985,835.

H. F. J. PORTER.
VARIABLE FLUID GEAR.
APPLICATION FILED DEC. 28, 1908.

Patented Mar. 7, 1911.

11 SHEETS—SHEET 1.



WITNESSES

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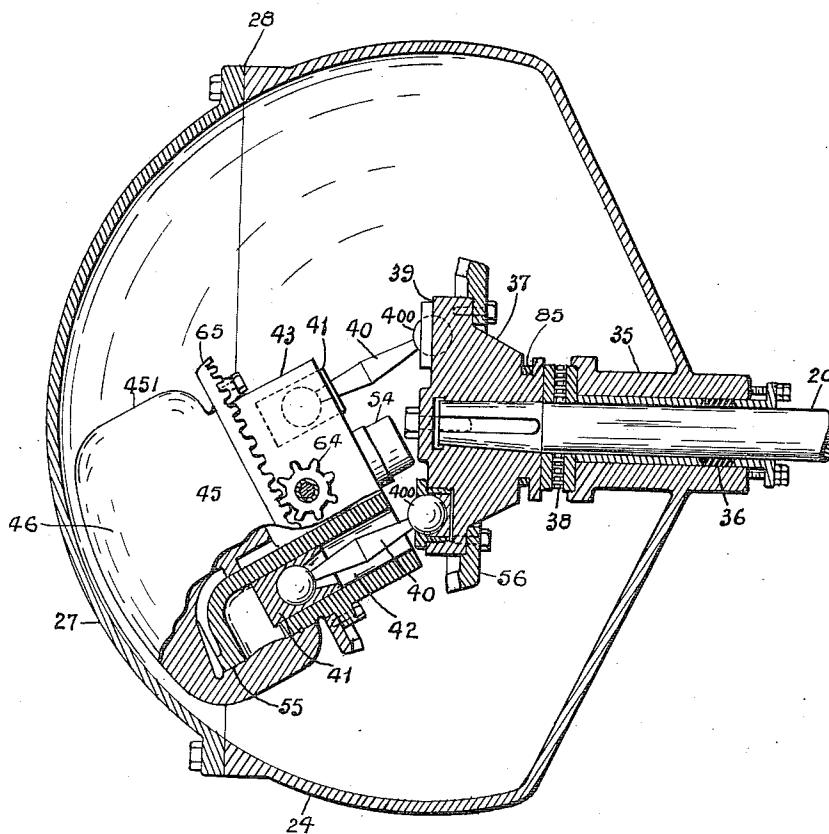
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11 SHEETS—SHEET 2.

FIG. 2.



WITNESSES

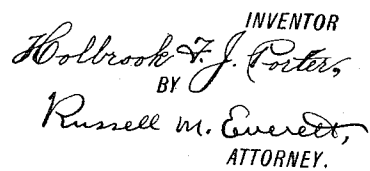
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Patented Mar. 7, 1911.
11 SHEETS—SHEET 3.

Fig. 3.

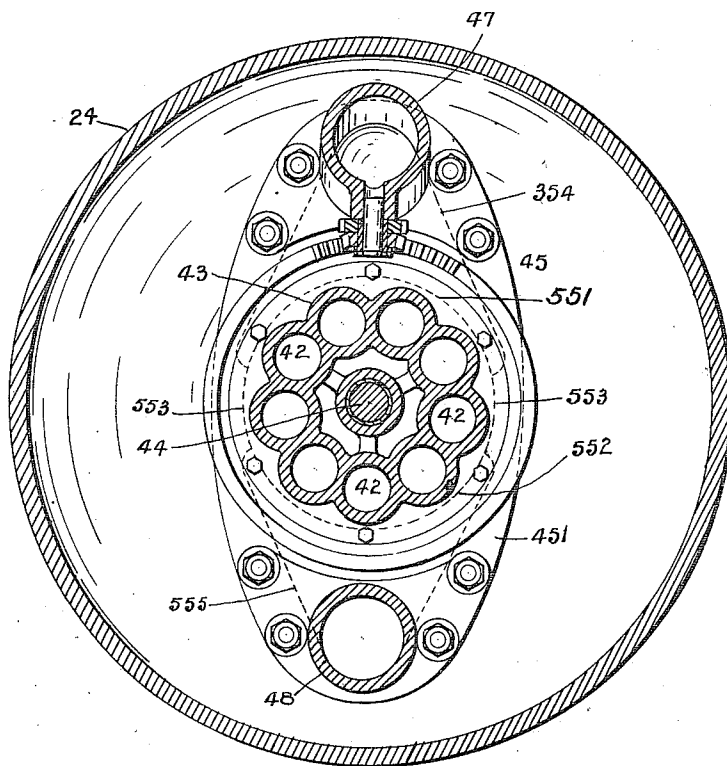


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FIG. 4.



WITNESSES

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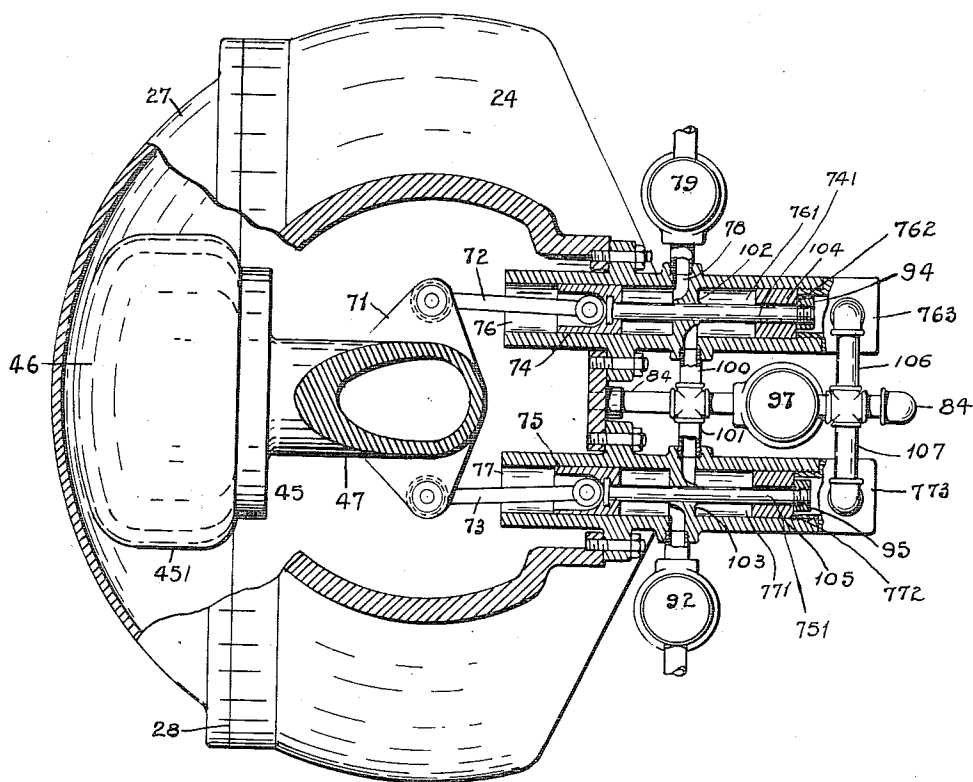
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FIG. 5.



WITNESSES

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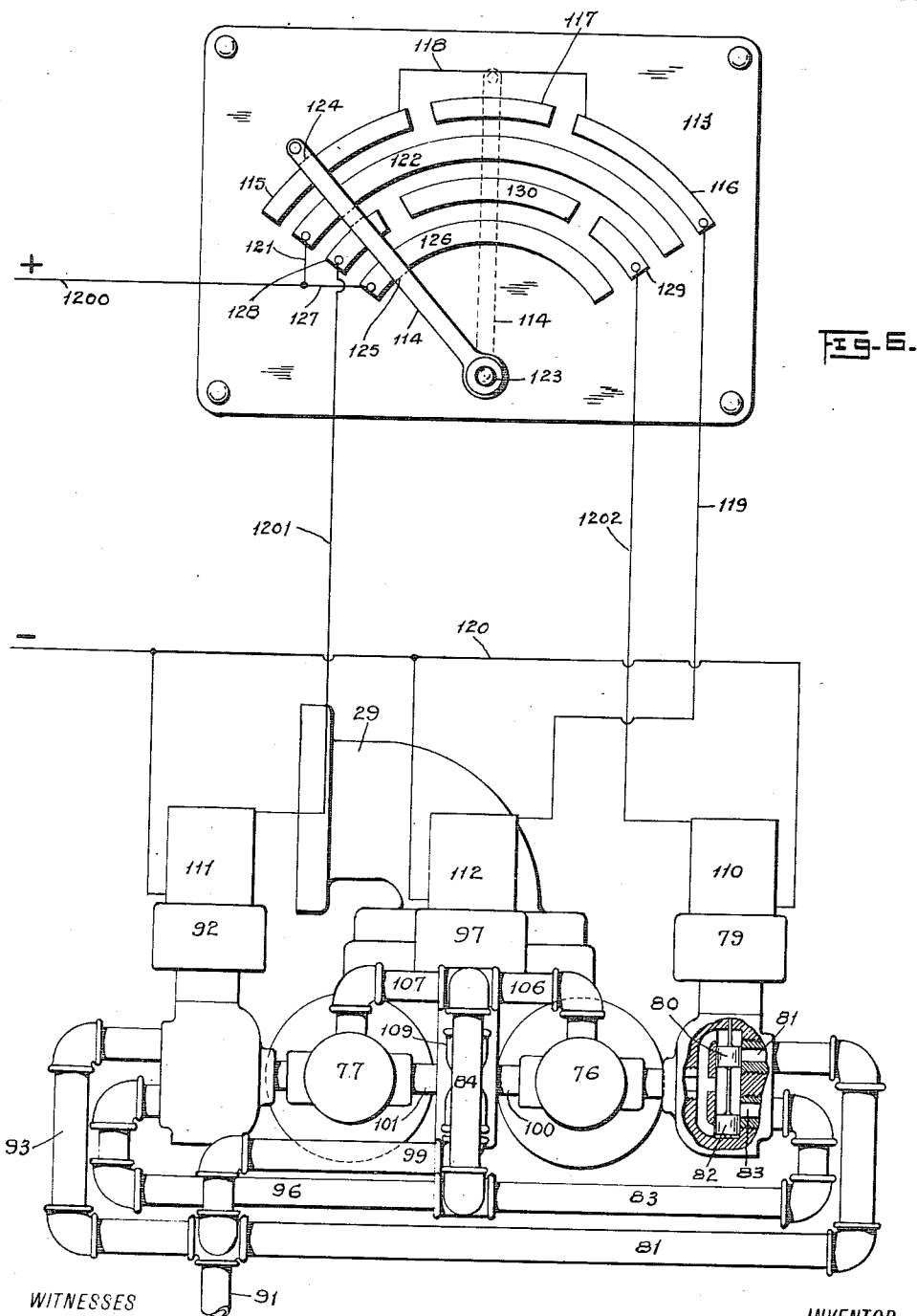
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11 SHEETS—SHEET 6.



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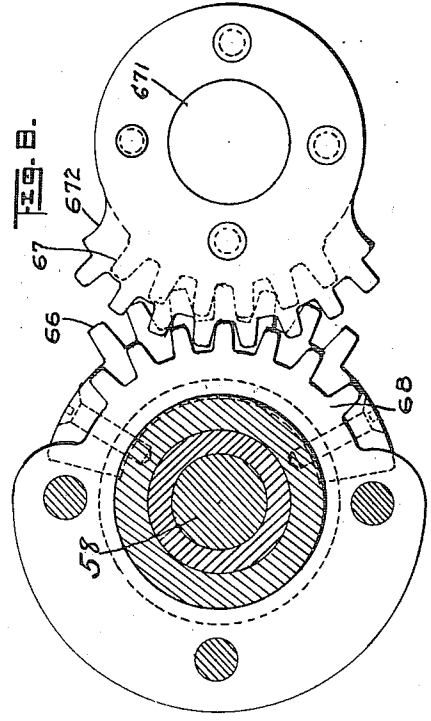
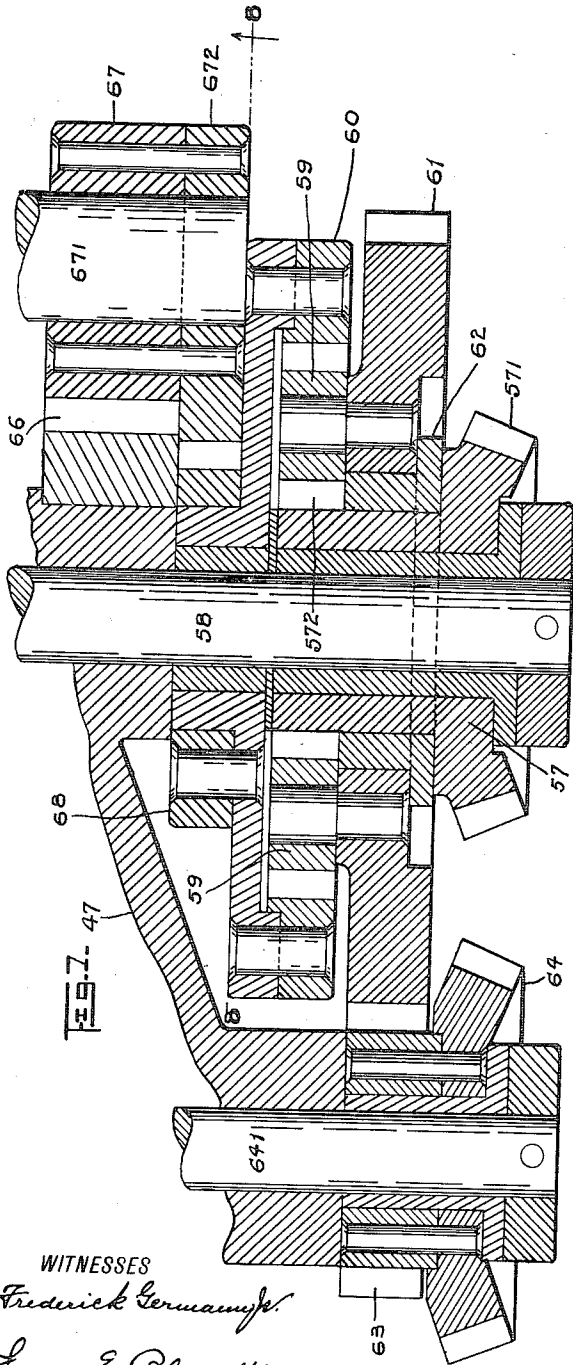
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11 SHEETS—SHEET 7.



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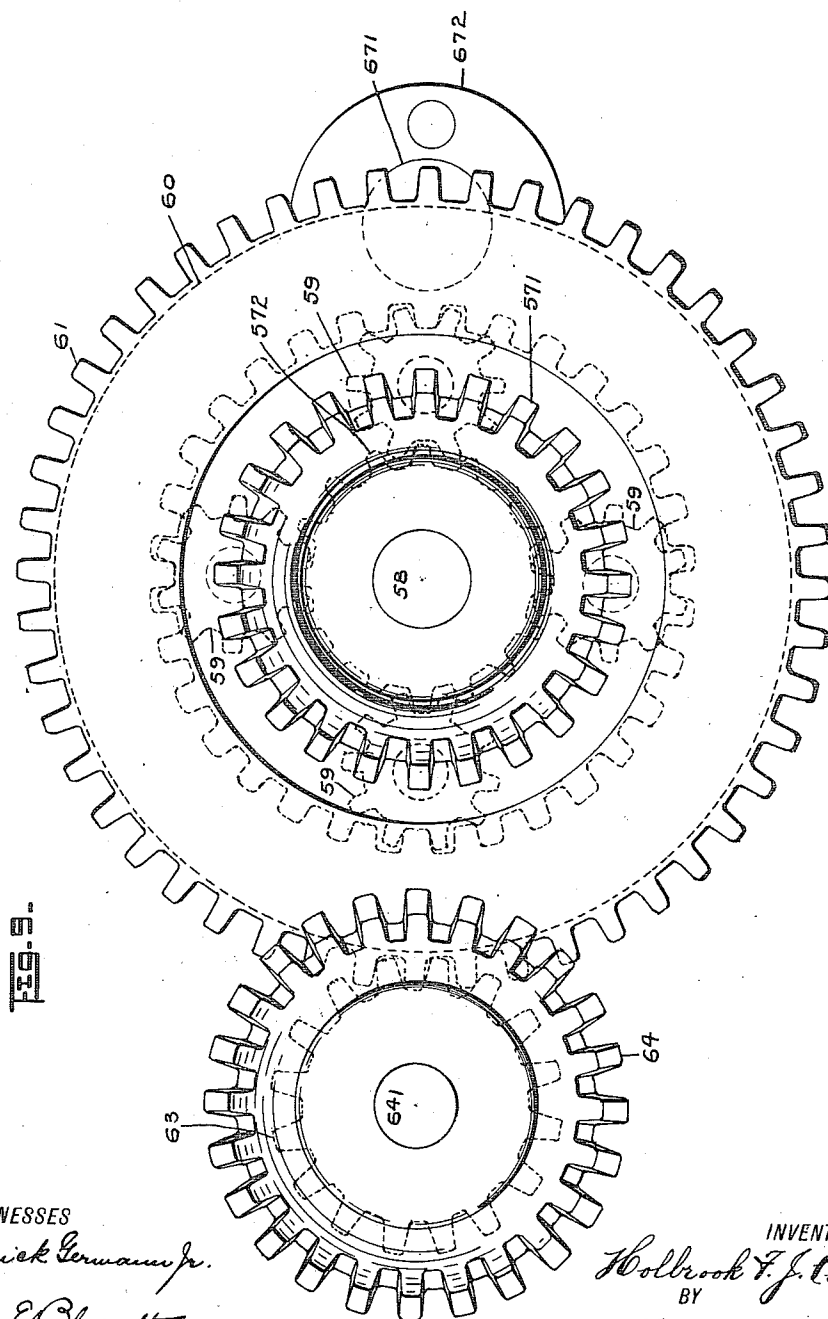
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11 SHEETS—SHEET 8.



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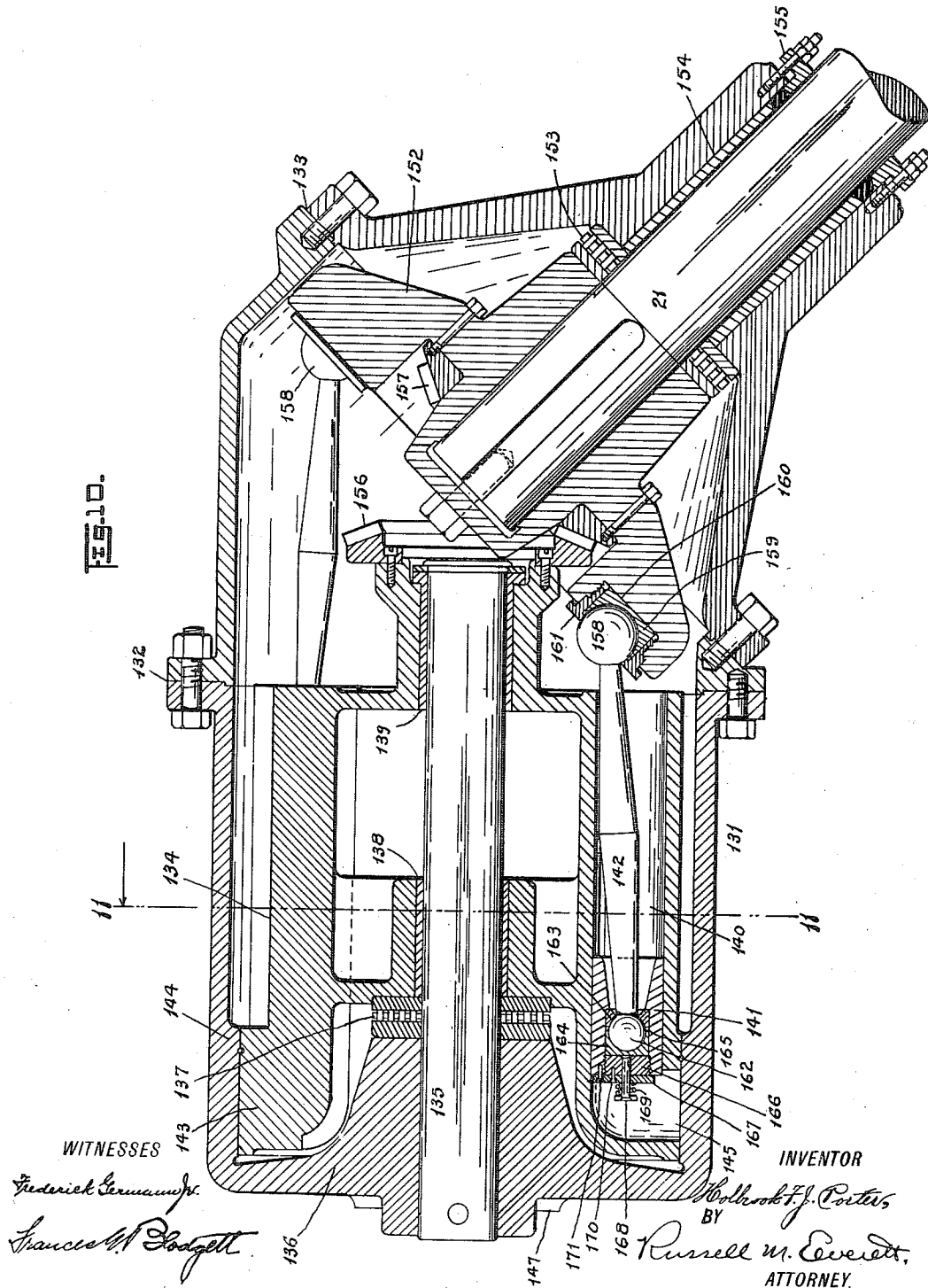
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11 SHEETS—SHEET 9.

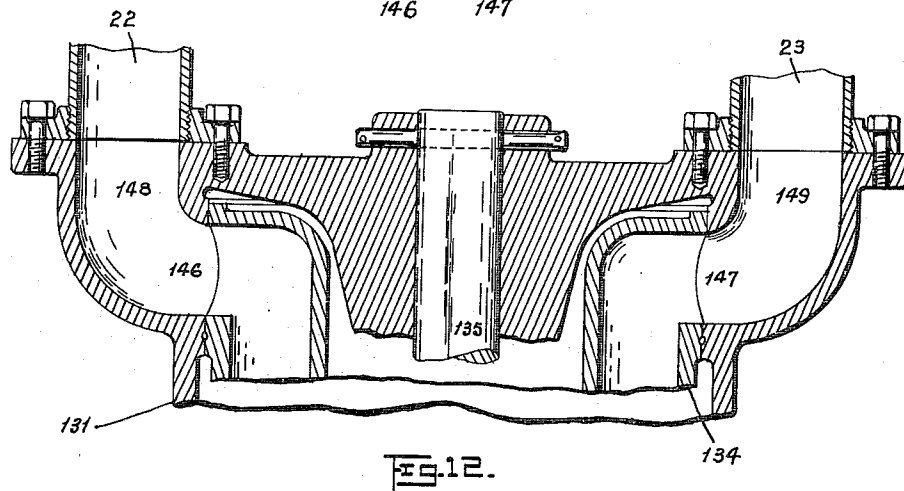
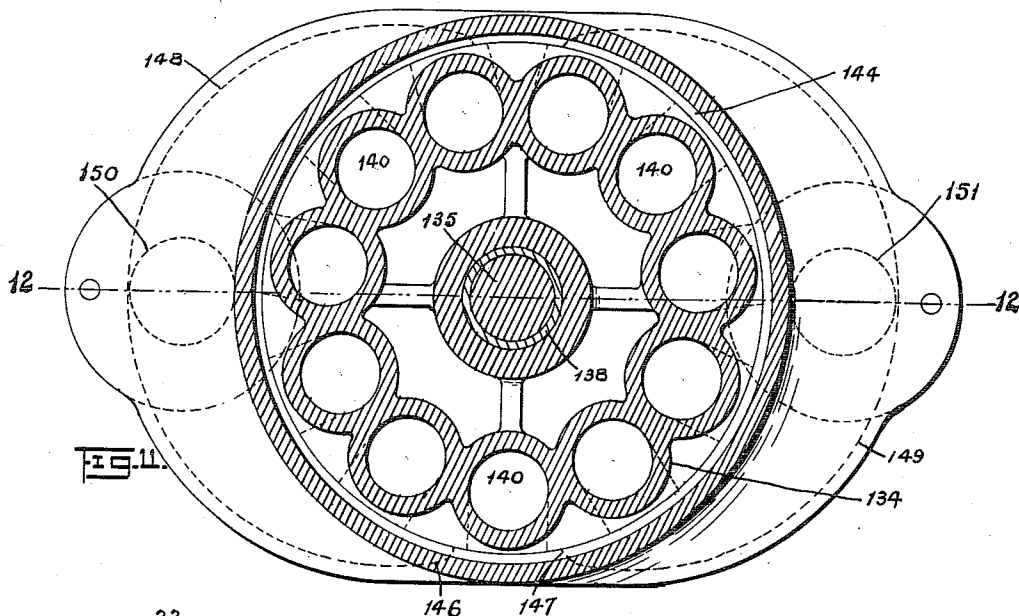


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11 SHEETS—SHEET 10.



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Patented Mar. 7, 1911.

11 SHEETS—SHEET 11.

Fig. 13.

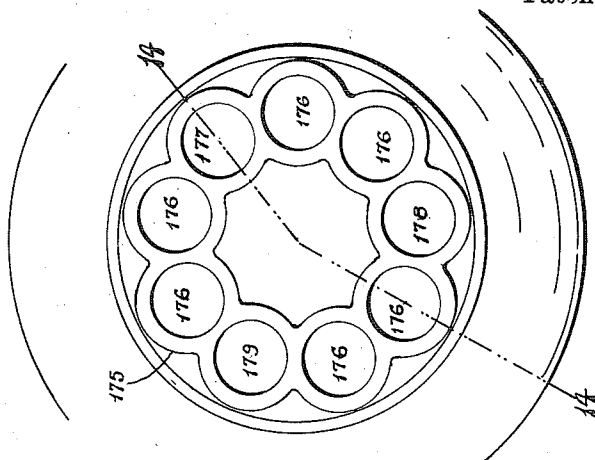
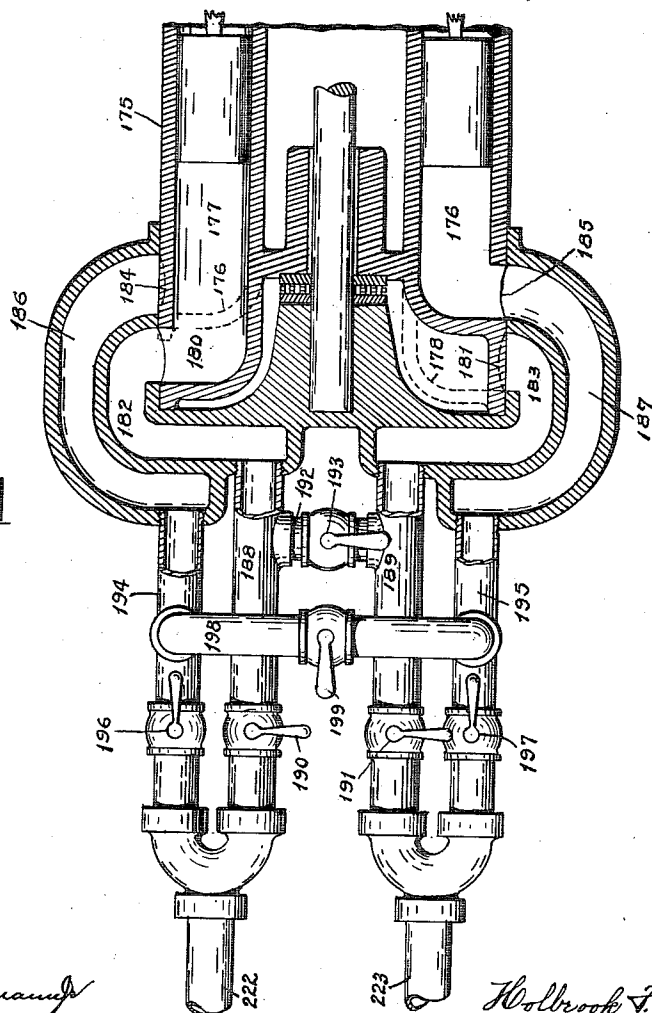


Fig. 14.



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UNITED STATES PATENT OFFICE.

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VARIABLE-FLUID GEAR.

985,835.

Specification of Letters Patent.

Patented Mar. 7, 1911.

Application filed December 28, 1908. Serial No. 469,696.

To all whom it may concern:

Be it known that I, HOLBROOK F. J. PORTER, a citizen of the United States, residing at New York city, borough of Manhattan, in the State of New York, have invented certain Improvements in Variable-Fluid Gears, of which the following is a specification.

The objects of this invention are to secure improved means for transmitting motion from one rotating shaft to another through the medium of an interposed fluid; to provide simplified means by which such motion may be varied either in speed or direction; to secure evenness and uniformity of transmission; to obtain a compact construction which can be cheaply and easily built; to secure great efficiency, ease of control, durability and safety; to secure both an improved pump member and an improved motor member; to enable different numbers of the motor cylinder chambers to be utilized at different times, and thus increase the speed of the motor without increasing the velocity and volume of the actuating fluid; to thus secure different speeds of the motor or driven shaft without changing the pump action, in addition to variations by adjustment of the pump member; to secure cylinder ports balanced as to hydraulic pressure, and no cylinder valves; to secure an efficient angle of transmission between the pistons and adjacent shaft ends; to facilitate variations of such angle of transmission; to obviate the necessity for any mechanism to transmit motion between the shaft ends and pistons; to provide means for rotatably supporting a shaft end and its adjacent cylinder independent of each other; to change the angular relation of the cylinder to its adjacent shaft end; to provide means for transmitting rotary motion between said shaft end and cylinder independent of variation of the angular relation of their axial lines; to preserve the relative rotation of shaft and cylinder by means other than the power transmission mechanism; to provide improved controlling means for varying the action of the pump, and to obtain other advantages and results as may be brought out in the following description.

Referring to the accompanying drawings, in which like numerals of reference indicate

corresponding parts in each of the several 55 figures, Figure 1 is a side elevation of my improved fluid gear or transmission means; Fig. 2 is a horizontal longitudinal section of the pump member on line 2—2, Fig. 1, a portion of the cylinder and its carrier being 60 in central section; Fig. 3 is a vertical central longitudinal section of the pump member; Fig. 4 is a vertical transverse section on line 4—4, Fig. 3, looking in the direction indicated by the arrow; Fig. 5 is a 65 horizontal sectional view on line 5—5, Fig. 3; Fig. 6 is an end elevation, looking toward the driving shaft, of the pump-cylinder controlling means; Fig. 7 is a detail view of certain gearing shown in Fig. 3, and Fig. 8 70 is a view on line 8—8, Fig. 7, looking in the direction indicated by the arrow; Fig. 9 is a view of the gearing shown in Fig. 7, looking upward from beneath the same; Fig. 10 is a central longitudinal section of the motor 75 member of my improved device; Fig. 11 is a cross section of said motor member, taken on line 11—11, Fig. 10, looking in the direction indicated by the arrow; Fig. 12 is a detail longitudinal section on line 12—12, 80 Fig. 11; Fig. 13 is a cross section of the cylinder of a motor member of modified construction, and Fig. 14 is a plan of said motor member, partly in section on line 14—14, Fig. 13; showing certain valve connections 85 for cutting out a portion of the cylinders.

In said drawings, 20 indicates the driving shaft from which it is desired to transmit motion to the driven shaft 21 to rotate the latter in either direction and at any speed from nothing up to a maximum. 90 The said driving shaft 20 may receive its motion from any suitable source of power, not shown, and the driven shaft 21 may of course be utilized for any purpose to which 95 a rotating shaft is adapted to be applied.

At the extremity of the driving shaft 20 is certain mechanism constituting what I have designated as the pump member of my apparatus, and at the end of the driven shaft 100 21 is other mechanism constituting the motor member of my apparatus. Between the said pump and motor members extend ducts 22 and 23, through which the fluid circulates, and these ducts may be of any length, construction or form to suit special conditions. 105

The pump member of my improved device comprises a casing 24 which is shown as ap-

proximately spherical at its end away from the driving shaft 20, and conically tapered at its other end, for convenience. This casing is supported in any suitable manner, as by a bed 25 to which brackets 26 of the casing are bolted. An end-piece 27 of the casing is removable on a vertical plane, as at 28, to permit access to the interior. At the extreme top and bottom of the casing 24 are tubular connections 29, 30, removably fixed to the casing 24 and to which the pipes 22, 23 are coupled. These connections 29 and 30 have inner ends 31 and 32, respectively, which project into the interior chamber of the casing to form hollow trunnion bearings in alinement with each other, as shown most clearly in Fig. 3. The said connections 29 and 30 are shown as secured to the casing by means of exterior flanges 33, 34, respectively, and obviously any well-known packing means may be provided at the joints to prevent leakage.

The driving shaft 20 has a bearing 35 where it enters the casing 24, and which bearing is provided with an exterior stuffing box 36 of any ordinary type. The extremity of said shaft 20 has inside the casing 24 a head 37, and any ordinary well-known friction reducing means, such as the roller bearing 38, is placed between said head and the bearing 35. The forward end of the head 37 provides a circular plate 39 in which is mounted by ball and socket joints in annular series the ends of piston rods 40. These piston rods 40 are connected at their opposite ends by ball-and-socket joints each to an individual piston 41, and these pistons 41 work in chambers 42 also arranged in annular series in a cylinder 43. The said cylinder 43 is rotatably mounted upon a stud 44 adapted to be brought into axial alinement with the shaft 20, said stud projecting from a carrier 45 which is adapted to swing from side to side to give the stud different angular relations to the driving shaft 20. The said swinging carrier 45 comprises a body portion 451 which is spherically rounded at its forward end, as at 46, to conform more or less closely to the spherical curvature of the front wall of the casing 24, although there is a space between said carrier and casing. In end view of the pump member, this carrier 45 is of elliptical shape with its longer axis vertical, as shown, and from the side next the driving shaft of its upper and lower ends hollow arms 47 and 48 project and are bent upwardly and downwardly, respectively, to form trunnions 49 and 50 which receive the trunnion bearings 31, 32 before referred to. The carrier thus swings upon the axial line of said trunnion bearings and this axial line intersects the axial line of the driving shaft 20 in a plane through the centers of the ball ends 400 of the piston rods 40 at the head 37.

The cylinder 43 provides central bearings 51, 52 for the stud 44, a roller-bearing 53 being placed between said cylinder and the carrier 45 at the base of said stud to receive the thrust, and a collar 54 on the end of the stud securing the cylinder in place rotatably. The forward end of the cylinder fits nicely at its peripheral surface into a recess 55 of the carrier 45, and the chambers 42 of the cylinder 43 open laterally or radially outward at their bottoms to ports 551, 552 in the walls of said recess 55. Each of these ports extends around a considerable portion of the circumference of the cylinder, and the portions of walls 553 between them are as narrow as possible to be and still prevent a cylinder chamber opening into both ports at the same time, as clearly shown in Fig. 4 particularly. Ducts 554 and 555 lead from the ports 551, 552, respectively, through the carrier 45 and open into its tubular arms 47 and 48, respectively, so that from each port communication is established out through the hollow trunnions to the pipes 22 and 23 connecting the two ends or members of my device. At the same time, as will be understood, the carrier 45 can be swung from right to left to cause the cylinder 43 to depart more or less from axial alinement with the driving shaft, whereby the stroke of the pistons 40 in their chambers will be varied and their pumping action correspondingly varied.

Obviously, it is necessary that the cylinder 43 rotate with the driving shaft and its head 37, and since said cylinder is not upon said shaft as heretofore in the art, I have provided the means next to be described for causing it to turn in unison with the driving shaft. The head 37 carries a bevel gear 56 which meshes into gear teeth 571 on the lower end of a sleeve 57 rotatable upon a stud 58 shown as depending from the upper arm 47 of the carrier 45. This sleeve 57 has at its upper end gear teeth 572 which drive planetary gears 59 engaging a normally stationary internal gear 60. The said planetary gears 59 are mounted upon a gear-wheel 61 loose upon the sleeve 57 with a bushing 62 between, and thus by rotation of the shaft 20 the gear wheel 61 is turned. Said gear 61 meshes into a gear 63 upon a second stud 641 in the under side of the adjacent hollow arm 47, and which gear 63 has fast to itself a bevel gear 64 meshing into a cooperating bevel gear 65 on the cylinder 43. The ratio of the gears in this train is such that the cylinder is positively and exactly rotated with the driving shaft head by rotation of said head.

The gear-train above described is sufficient as long as the cylinder stud 44 and driving shaft 20 are in alinement, but obviously when the carrier 45 is swung to adjust the transmission of power or speed, the gear 63 will

travel around the gear 61, and turn with respect thereto, so that the mutual relations of said gears will be disturbed and the piston rods thrown abnormally out of proper axial alinement with their cylinder chambers. To insure against this difficulty, I have formed upon the carrier or its upper arm 47, at the upper part of the device, gear teeth 66 which mesh into a gear 67 on a shaft 671 and fast to a second gear 672 thereon which meshes into a gear 68 on the stud 58 and which gear 68 is fast to the internal gear 60. Thus said internal gear is moved by the swinging of the carrier, and assuming the driving shaft 20 to be stationary, it will be understood that turning of this internal gear 60 is communicated through planetary gears 59, the gear teeth 572 on the sleeve 57 serving as a fulcrum, to rotate the gear wheel 61. The ratio of the gears in this train is such that said gear 61 is positively and exactly rotated with the carrier 45 as the cylinder carrier is swung, so that there is no relative movement of said gear 61 and pinion 63 and therefore the relation of the cylinder to the driving shaft 20 is not interfered with. So when the driving shaft is stationary swinging of the cylinder does not cause the cylinder to revolve by reason of engagement of the connecting gears which rotate it with the shaft, and this is equally true when the shaft and cylinder are rotating together as first described.

The means just above described therefore synchronize rotation of the cylinder and the driving shaft or its head 37, by which I mean that said parts are caused to turn through the same angular distance in a given interval of time, and furthermore such synchronism is obtained without regard to the interval selected or to variation of the angular relation of the axial lines of said rotary parts. In other words, I provide means for always synchronizing the rotations of said rotary parts.

Any suitable means may be provided for swinging the cylinder carrier, but I have shown in full lines one more or less elaborate system of effecting such swinging, and have also indicated in dotted lines a much simpler and cruder swinging means. This latter is found in Fig. 3, where the shaft of the pinion 67 is shown in dotted lines as extended outside of the casing 24, as at 69 and provided thereat with a hand lever or wheel 691 for turning. The more elaborate means is shown in Figs. 3, 5 and 6, where 71 indicates a cross-head fast upon the upper arm 47 of the cylinder carrier 45, transversely of the axis of turning of said carrier, and which cross-head is connected at its opposite ends by rods 72, 73 with pistons 74, 75 working in cylinders 76, 77. One of these cylinders, as 76, is connected back of its piston 74 by a duct 78 to a valve 79 having an upper por-

tion 80 normally closing an inlet 81 and a lower portion 82 which simultaneously uncovers an exhaust outlet 83 leading to a main exhaust 84. The pressure fluid used to operate these control pistons may come from any suitable source, but I have shown it as pumped from the interior of the casing 24 of the fluid gear and exhausting back into the same, as at 84. The pumping is shown as done by an eccentric strap 85 on an eccentric portion 86 of the driving shaft head 37, said strap being connected to the plunger 87 of a pump barrel 88 adapted to oscillate in a bearing 89 of the casing 24. The inlet to said barrel is by a port 90, having a puppet valve 900, and a pipe 91 leads from the barrel upward outside the casing 24 and connects to the branch inlet 81. When raised, the valve 79 allows pressure to enter behind the piston 74 and when dropped it permits exhaust therefrom through the pipes 83, 84. A similar valve 92 is provided for the cylinder 77 of the other piston 75, and is similarly adapted when raised to admit pressure behind the piston 75, through branch inlet 93 from the main inlet 91, and when dropped, to close by its upper portion the said inlet and open at its lower portion to exhaust through branch duct 96 of the main exhaust duct 84. Thus by lifting one valve the carrier 45 can be swung one way, and by lifting the other valve it can be swung the other way.

To quickly bring the carrier to central position and hold it there, a third valve 97 is provided, the lower portion 98 of which normally admits pressure through branch inlet 99 to ducts 100 and 101 to both control cylinders behind middle transverse partitions 102, 103 thereof, so that it acts against heads 104, 105 on the piston rods 741, 751 which extend slidably through said partitions 102 and 103. The rear ends of the cylinders are closed, and back of the heads 104, 105, they are connected by ducts 106, 107, respectively, to the main exhaust duct 84. Preferably the heads 104, 105 are slidable on the piston rods 741, 751, so that the pistons can move backward independent of said heads, although rearward movement of the heads to their final position to bring the carrier neutral or straight, as shown in Fig. 5, must move the piston-rods accordingly because of nuts 94 and 95 on the rear ends of the piston rods. Shoulders 762 and 772, in the rear end portions 761 and 771 of the cylinders, respectively, are adapted to engage the slidable piston heads 104, 105 and limit their rearward movement to the precise position requisite to hold the carrier 45 central or neutral. These shoulders are shown as formed by rear portions 763, 773 of the cylinders 76, 77 screwed thereto, but obviously could be provided in any suitable manner. The third valve 97 is also adapted when

raised to cover at its lower portion 98 the inlet 99, to uncover at its upper portion 108 an exhaust branch 109. Such raising must be done the first thing in operating the control, and then one or the other of the valves 79, 92 lifted to swing the carrier. All the valves normally assume by gravity, as shown positions to hold the carrier in its neutral or idle position more fully explained herein-
after.

For operating the particular type of valves, or gravity valves, which I have shown for purposes of illustration, I have also shown electromagnetic means, in Fig. 6 of the drawings. The valves 79, 92 and 97 are each provided with an electro-magnet, 110, 111 and 112, respectively, to raise the same, and these magnets are connected up to a switchboard 113 provided with a switch 114, as follows. Contact pieces 115, 116 are provided, with a dead section 117 between, and are wired as at 118, 119, to the magnet of the stop valve 97. This electro-magnet is connected to the circuit wire 120, and the other circuit wire 1200 leads, as at 121, to a contact piece 122 adjacent to the contacts 115, 116 and the dead section 117. The switch 114 is pivoted as 123, and has a brush 124 which always connects the contact piece 122 with one or the other of the contacts 115, 116 except when in central position upon the dead section 117, as dotted. There is also a second brush 125 on the switch lever 114 which slides upon a continuous contact piece 126 connected to the circuit wire 1200, as at 127, and also upon adjacent contacts 128 and 129 which are connected by wires 1201 and 1202 to the magnets of the valves 92 and 79, respectively, and a middle dead section 130. Said middle dead section 130 is longer than the afore-said dead section 117 between the stop valve contacts 115, 116, and thus it is insured that as the switch lever is swung, it operates the stop valve 97 before either of the other valves. This relieves the pressure in the back cylinders 761 and 771, to allow the piston heads 104, 105 to slide. Obviously, any other equivalent means of operating the control valves could be employed, or even control valves of any other common and well known construction could be employed instead of those I have shown, the details which I have shown for these features of the invention, being for purposes of illustration merely.

The motor end of my improved device comprises a casing 131 which is preferably in three sections bolted together as at 132, 133. Within this casing, at the end thereof away from the driven shaft 21, a cylinder 134 is mounted upon a stud 135 firmly supported in stationary position in the end wall 136 of the casing. A roller bearing 137 between the cylinder and end wall of the cas-

ing takes up the thrust, and the cylinder has axial bearings 138, 139 for said stud. The said cylinder 134 provides an annular series of chambers 140 in which are pistons 141 provided with rods 142 which are connected to said pistons by ball-and-socket joints and project from the cylinder chambers toward the driven shaft 21. The rear end of the cylinder has a portion 143 which fits peripherally against the inner wall of the casing, as at 144, and the said cylinder chambers 140 open laterally or radially, as at 145, to ports 146, 147 in said wall 144 of the casing. These ports, as clearly shown in Fig. 11, extend each around a considerable portion of the circumference of the cylinder so that the portions of walls between them are as narrow as possible and still prevent a cylinder chamber opening into both ports at the same time. Ducts 148, 149 from these ports 146, 147, respectively, lead to the end of the casing and terminate in openings 150, 151 to which the pipes 22 and 23 before described can be connected in any manner common to pipe fitting.

The pistons 141 are at their forward ends connected by ball-and-socket joints to the face of a head 152 fast upon the driven shaft 21. This head is in the form of a cap for receiving the end of the shaft, and a roller bearing 153 is placed between the said head and the wall of the casing 131 to take up the thrust. Said shaft 21 projects from the casing 131 at an angle of forty-five degrees to the cylinder stud 135, and such angle remains permanent since it is the angle of greatest efficiency and there is no need of adjustment at this end of the device. Obviously, however, if adjustment was desired it could be made in the same manner already described in connection with the pump end of my invention. Where the shaft 21 leaves the casing 131, it has a bearing 154 and is provided with a suitable stuffing-box 155.

In order to insure turning of the cylinder 134 in exact unison with the head 152, a bevel gear 156 upon said cylinder meshes into a second bevel gear 157 on the head, so that they rotate positively together. I have shown the balls 158 at the ends of the pistons 141 each seated in a cup 159 which drops into a recess 160 of the head 152, and is held by an annular nut 161. The ball 162 at the other end of the piston screws off to enable the ring 163 to be applied, and said ball seats in a cup 164 which is held in the recess 165 of the piston 141 by an interior nut 166. Turning of this nut 166 is prevented by a suitable lock, such as the plate 167 slidable on the pin 168 and normally held by the spring 169 with its two pins 170, 171 projecting one into the nut 166 and the other into the body of the piston 141.

It will be understood that in the opera-

tion of my device both casings 24 and 131 are filled with fluid and that by means of the pump member a current or circuit is established through the two casings and connecting pipes 22, 23, which serves to drive or rotate the motor member and thus the shaft 21.

The word "fluid" is used herein in its proper sense, including both liquids and gases, for although oil has heretofore been the fluid commonly employed I can by my improvements utilize not only other liquids, but also gases preferably in a condensed or compressed condition, for certain special purposes. It is not necessary to change the direction of rotation of the driving shaft nor vary the speed of the same, but by simply swinging the carrier 45 the driven shaft 21 can be rotated at any speed from nothing up to a maximum and in either direction. It will be noted that when the carrier 45 stands in central position of its range of movement, or with its cylinder stud 44 in alinement with the driving shaft 20, (which I have called neutral position), the pistons 41 will have no stroke and no movement will be transmitted to the driven shaft. If the carrier is swung in one direction from said neutral position, the driven shaft will rotate in one direction, and if the carrier is swung in the other direction the driven shaft will be reversed in its direction of rotation. In practice the range of angular movement of the carrier will be through about thirty degrees on each side of its neutral position.

In Figs. 13 and 14 of the drawings, I have shown means for increasing the speed of rotation of the driven shaft without increasing the flow of liquid or varying the action of the pump member in any way. To do this, a cylinder 175 is employed a portion of the chambers of which can be cut out of circulation. In the drawings I have shown, for example, nine cylinder chambers which are divided into two groups one comprising three chambers 177, 178 and 179, at 120 degrees apart, and the other group the six remaining chambers 176. The three cylinder chambers 177, 178 and 179 are longer than the others, so as to open through ports 180, 181 into ducts 182, 183, while the other six cylinder chambers open through ports 184, 185 into ducts 186, 187. The ducts 182 and 183 open into branches 188, 189 of pipes 222 and 223 corresponding to the pipes 22 and 23 already described. These branches 188 and 189 are provided with valves 190 and 191 and are also, between said valves and the casing of the member, joined by a by-pass 192 controlled by a valve 193. By opening said by-pass, therefore, and closing the valves 190 and 191, the three cylinders 177, 178 and 179 will be thrown out of circulation and the remaining six cylinders will receive the entire fluid supply from the

pump member. The pistons of those six cylinders will accordingly be given increased movement and the speed of the driven shaft increased by one-half.

The ducts 186 and 187 of the six cylinder chambers 176 are in communication with branches 194, 195 of the pipes 222 and 223, and said branches 194, 195 are provided with valves 196 and 197 and also, between said valves and the casing of the member, with a by-pass 198 controlled by valve 199. Thus by opening said by-pass 198 and closing the valves 196, 197, the six cylinder chambers are thrown out of circulation and the three chambers 177, 178 and 179 receive the entire supply from the pump member. The speed of the driven shaft is therefore further increased by one hundred per cent. or doubled over what was given by six cylinders and trebled over nine cylinders. The said Fig. 14 is a diagrammatic illustration of the above idea, and obviously the different connections could be made in any manner mechanical skill might suggest. The detail arrangement of pipes will undoubtedly be modified in actual practice, and instead of turning the different valves by hand and independently, as shown, some means of operating them unitedly and automatically, in proper sequence as commonly done by a lever or the like under analogous conditions, will be employed. This will be no departure from the spirit and scope of my invention, however.

Having thus described the invention, what I claim is:

1. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving one rotary part to vary the angular relation of its axial line to that of the other, means for driving one rotary part, gearing adapted to transmit rotary movement between said rotary parts, and means for synchronizing rotation of said rotary parts during variation of the angular relation of their axial lines.

2. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving one rotary part to vary the angular relation of its axial line to that of the other, means for driving one rotary part, gearing adapted to transmit rotary movement between said rotary parts, and other gearing

adapted to synchronize the rotations of said rotary parts during variation of the angular relation of their axial lines.

3. The combination of inlet and outlet
5 ducts, a cylinder having chambers adapted to communicate with said ducts, a prime mover, pistons in said cylinder chambers having rods connected to said prime mover, means for varying the angular relation of
10 the axis of said cylinder to the axis of said prime mover, means for transmitting rotary movement between said prime mover and cylinder, and means for synchronizing rotation of said prime mover and cylinder during
15 variation of the angular relation of their axial lines.

4. The combination of inlet and outlet ducts, a cylinder having chambers adapted to communicate with said ducts, a prime
20 mover, pistons in said cylinder chambers having rods connected to said prime mover, means for varying the angular relation of the axis of said cylinder to the axis of said prime mover, gearing adapted to transmit
25 rotary movement between said prime mover and cylinder, and other gearing adapted to synchronize the rotations of said prime mover and cylinder during variation of the angular relation of their axial lines.

30 5. The combination of inlet and outlet ducts, a cylinder having chambers adapted to communicate with said ducts, a prime mover, pistons in said cylinder chambers having rods connected to said prime mover,
35 means for varying the angular relation of the axis of said cylinder to the axis of said prime mover, and gearing adapted to transmit rotary movement between said prime mover and cylinder and synchronize the rotations of said parts.

40 6. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving
45 one rotary part to vary the angular relation of its axial line to that of the other, means for driving one rotary part, and means for transmitting rotary movement between said rotary parts and synchronizing the rotation of said parts.

50 7. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving
55 one rotary part to vary the angular relation of its axial line to that of the other, means for driving one rotary part, means adapted

to transmit rotary movement between said rotary parts, and means for synchronizing rotation of said rotary parts during variation of the angular relation of their axial lines.

70 8. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder having the outer ends of their rods connected to said
75 head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving the axis of one rotary part angularly upon the point of intersection of the axis of the other rotary part with the plane of connection of the piston rods to the rotary head as a center, and means for rotating said rotary parts.

80 9. The combination of inlet and outlet ducts, a cylinder having chambers adapted to communicate with said ducts, a shaft, pistons in said cylinder chambers having rods connected to said shaft at points radially out from its axial line, means for moving the axis of said cylinder angularly upon the point of intersection of the driving shaft and plane of connection of said piston rods thereto as a center, and means for transmitting rotation between said driving shaft and
85 90 95

100 10. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving the axis of one rotary part angularly upon the point of intersection of the axis of the other rotary part with the plane of connection of the piston rods to the rotary head as a center, means for rotating said rotary parts, and means for always synchronizing the rotation of said rotary parts.

110 11. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, a swinging carrier for one of said rotary parts, bearings for the other rotary part, means for swinging said carrier to vary the angular relation of the rotary part carried by it to the other rotary part, means for rotating said rotary parts, and means for always synchronizing the rotations of said rotary parts.

120 12. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, a swinging carrier for one of said rotary parts, stationary bearings
125 130

for the other rotary part, means for swinging said carrier to vary the angular relation of the rotary part carried by it to the other rotary part, means for rotating said rotary part in stationary bearings, means for transmitting rotary movement from said rotary part in stationary bearings to the rotary part in the swinging carrier, and means for always synchronizing the rotations of said rotary parts.

13. The combination of a swinging carrier having inlet and outlet ducts, a cylinder rotatably mounted on said carrier and having chambers adapted to communicate with said ducts, a prime mover independent of said carrier, pistons in said cylinder chambers having the outer ends of their rods pivotally connected to said prime mover, means for swinging said carrier, means for transmitting rotary motion between said prime mover and cylinder, and means for synchronizing the rotations of said cylinder and prime mover.

14. The combination of a swinging carrier having axial inlet and outlet ducts, a stud on said carrier, a cylinder on said stud having longitudinal chambers opening through the sides of the cylinder and adapted to communicate with said ducts, a prime mover independent of said carrier, pistons in said cylinder chambers having the outer ends of their rods pivotally connected to said prime mover, means for swinging said carrier, means for transmitting rotary motion between said prime mover and cylinder, and means for synchronizing the rotations of said cylinder and prime mover.

15. The combination of a swinging carrier having axial inlet and outlet ducts opening into a central recess, a stud in said recess, a cylinder rotatably mounted on said stud and having longitudinal chambers opening through the sides of the cylinder and adapted to communicate with said ducts, a prime mover independent of said carrier, pistons in said cylinder chambers having the outer ends of their rods pivotally connected to said prime mover, means for swinging said carrier, means for transmitting rotary motion between said prime mover and cylinder, and means for synchronizing the rotations of said cylinder and prime mover.

16. The combination of a shaft having at its extremity a head, ducts at opposite sides of said head forming hollow bearings, a swinging carrier having hollow trunnions engaging said bearings and passages leading from said trunnions to a central recess, a cylinder rotatably mounted with one end in said recess and having longitudinal chambers opening through the sides of the cylinder adapted to communicate with said passages, pistons in said cylinder chambers having the outer ends of their rods pivotally connected to the said shaft head, means for

swinging said carrier, means for transmitting rotary motion between said shaft and cylinder, and means for synchronizing the rotations of said cylinder and shaft.

17. The combination of a rotary cylinder having longitudinal chambers with ports at the sides of the cylinder, bearings for said cylinder, inlet and outlet ducts having ends adapted to engage the sides of said cylinder and communicate with said ports, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said rotary head, means for moving one of said rotary parts to vary the angular relation of its axial line to that of the other, means for rotating said rotary parts, and means for synchronizing the rotations of said rotary parts.

18. The combination of a rotary cylinder having longitudinal chambers open at one end of the cylinder and terminating short of the other end, said cylinder having ports in its sides at the inner ends of said chambers, bearings for the closed end of said cylinder, inlet and outlet ducts having ends adapted to engage the sides of the cylinder and to communicate with the ports thereof, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said rotary head, means for moving one of said rotary parts to vary the angular relation of its axial line to that of the other, means for rotating said rotary parts, and means for synchronizing the rotations of said rotary parts.

19. The combination of a rotary cylinder having longitudinal chambers, bearings for said cylinder, pistons in said chambers having rods projecting therefrom, a prime mover terminating short of said cylinder and connected to said piston rods, means for swinging said cylinder to vary the angular relation of its axis to that of said prime mover, said prime mover and cylinder having gear teeth, intermediate gearing between said prime mover and cylinder having relatively movable members, and means for shifting one of said members of the intermediate gearing to compensate for angular motion of the cylinder.

20. The combination of a rotary cylinder having longitudinal chambers, bearings for said cylinder, pistons in said chambers having rods projecting therefrom, a prime mover terminating short of said cylinder and connected to said piston rods, means for swinging said cylinder to vary the angular relation of its axis to that of said prime mover, a train of gearing adapted to transmit rotary motion between said shaft and cylinder, said train containing planetary gearing, and means for adjusting the fulcrum gear of said planetary gearing to compensate for said angular motion.

21. The combination of a rotary cylinder

having longitudinal chambers, bearings for said cylinder, pistons in said chambers having rods projecting therefrom, a prime mover terminating short of said cylinder and connected to said piston rods, means for swinging said cylinder to vary the angular relation of its axis to that of said prime mover, gears on said prime mover and cylinder, a train of gears between said first-mentioned gears containing planetary gearing, and a second train of gears between the swinging cylinder and the fulcrum of said planetary gearing adapted to adjust said fulcrum gear in compensation for relative movement of the gears upon the prime mover and cylinder due to swinging said cylinder.

22. The combination of a shaft, a carrier adapted to swing on an axis disposed diametrically of the axial line of said shaft, a cylinder rotatably mounted on said carrier and adapted to be brought into axial alinement with said shaft, a gear train for transmitting rotary motion between said shaft and cylinder and including planetary gearing, and a second gear train between said swinging carrier and the fulcrum gear of the planetary gearing adapted to adjust said fulcrum gear and compensate for angular motion of the carrier.

23. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving the axis of one rotary part to vary the angular relation of its axial line to that of the other, a gear train adapted to transmit rotary movement between said rotary parts, said train containing planetary gearing, and means for adjusting the fulcrum gear of said planetary gearing to compensate for said angular variation.

24. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, mountings each rotatably supporting one of said rotary parts independently of the other, means for moving the axis of one rotary part to vary the relation of its axial line to that of the other, gears on said rotary parts, a gear train between said first-mentioned gears containing planetary gearing, and a second gear train between the swinging rotary part and the fulcrum gear of said planetary gearing adapted to adjust said fulcrum gear to compensate for relative movement of said gears on the rotary parts when the swinging rotary part is swung.

25. The combination of inlet and outlet ducts, a rotary cylinder having chambers adapted to communicate with said ducts, a rotary head, pistons in said cylinder chambers having the outer ends of their rods connected to said head, a swinging carrier for one of said rotary parts, bearings for the other rotary part, means for swinging said carrier, means for rotating said rotary parts, gears on said rotary parts, a gear train between said first-mentioned gears containing planetary gearing, and a second gear train between the swinging carrier and the fulcrum gear of said planetary gearing adapted to adjust said fulcrum gear to compensate for relative movement of said gears on the rotary parts when the swinging carrier is swung.

26. The combination of two rotary parts adapted to be brought into axial alinement, means for displacing and adjusting the alinement of said rotary parts, a train of gearing adapted to transmit rotary movement from one of said parts to the other and containing planetary gearing, and means for shifting the fulcrum gear of said planetary gearing to revolve one of said rotary parts with respect to the other.

27. The combination of two rotary parts, means for driving one of said parts, gearing adapted to drive the other part from said first-mentioned part, means for bringing said parts into and displacing them from axial alinement with each other, and means for shifting the driven part rotatively with respect to the driving part to compensate for variation of their axial relation.

28. The combination of two rotatable parts detached or separate from each other, means for bringing said parts into and displacing them from axial alinement with each other, gear wheels on said rotatable parts, means for driving one of said rotatable parts, an internal gear, a gear engaging the gear wheel on the driving rotary part and having external teeth in the plane of said internal gear, a gear carrying pinions meshing with said internal and external gear teeth in the same plane, means connecting said last-mentioned gear to the gear wheel on the driven rotary part, and means for turning said internal gear.

29. The combination of a swinging carrier, rotary parts adapted to be brought into axial alinement, one of said rotary parts being mounted on said carrier and the other independent of the movement of said carrier, means for transmitting rotary movement between said rotary parts, and means for swinging said carrier comprising a cross head, pistons connected to opposite ends of said cross head, cylinders for said pistons having front and rear chambers, means for

supplying pressure to or exhausting pressure from the rear chambers simultaneously, and valves for admitting pressure to the front chamber of each cylinder independent of the other.

30. The combination with a swinging member, of a control comprising two stationary cylinders each having front and rear chambers, pistons in said chambers, shoulders for the pistons in the rear chambers adapted to hold them at stop position, and means for admitting and exhausting pressure fluid to or from said chambers.

31. The combination with a swinging member, of a control comprising two stationary cylinders each having front and rear chambers, pistons in said chambers, stop means adapted to hold either of the pistons in the front chambers at full speed position, other stops adapted to hold both pistons in the rear chambers simultaneously in stop position, and means for admitting and exhausting pressure fluid to or from said cylinders.

32. The combination with a swinging member, of a control comprising two stationary cylinders each having front and rear chambers, pistons in said chambers, shoulders for the pistons in the rear chambers adapted to hold them at stop position, piston rods in said chambers having a rearward movement or sliding independent of the pistons in the rear chambers, and means for admitting and exhausting pressure fluid to or from said cylinders.

33. The combination with a swinging member, of a control comprising two stationary cylinders each having front and rear chambers, pistons in said chambers, stops limiting movement of the pistons in forward direction to full speed position, shoulders limiting rearward movement of the pistons in the rear chambers to stop position, piston rods having a rearward movement or sliding independent of the pistons in the rear chambers and being fast to the other pistons, and means for admitting or exhausting pressure fluid to or from said cylinders.

34. The combination with a swinging member, of a control comprising two stationary cylinders each having front and rear chambers, pistons in said chambers, piston rods having a rearward movement or sliding independent of the pistons in the rear chamber and being fast to the other pistons, and means for admitting or exhausting pressure to or from the rear pistons simultaneously and to or from the front pistons alternately.

35. The combination with a swinging member, of cylinders each having front and rear chambers separated by a transverse partition, pistons in said chambers, piston rods extending slidably through said parti-

tions and the rear pistons, shoulders on the cylinders limiting rearward movement of the rear pistons, stops on the piston rods back of said rear pistons, and valves adapted to admit and exhaust pressure fluid to and from said cylinders.

36. In a fluid gear, the combination of a casing adapted to be filled with fluid, a rotary head in said casing a swinging carrier on said casing, a cylinder on said carrier, pistons in the chambers of said cylinders having rods connected to said head, a control for said carrier comprising cylinders and pistons therein having rods connected to said carrier, a shaft adapted to drive said rotary head, inlet and exhaust ducts leading from said casing to said control cylinders, a pump adapted to pump through said ducts, and means for operating said pump from said shaft.

37. The combination with a member adapted to turn upon an axis, of piston rods connected at opposite sides of said axis, cylinders having front and rear chambers, pistons in said chambers the rear ones being slidable or movable independent of said rods, shoulders for said rear pistons adapted to hold them in stop position, a gravity valve adapted in normal position to admit pressure in front of both said rear pistons, means for raising said valve to cut off such pressure and to exhaust from in front of both of said pistons, and other separate valves for said cylinders, each adapted to connect a front chamber back of its piston to pressure and exhaust alternately.

38. The combination with a member adapted to turn upon an axis, of piston rods connected at opposite sides of said axis, cylinders having front and rear chambers, pistons in said chambers the rear ones being slidable or movable independent of said rods, shoulders for said rear pistons adapted to hold them in stop position, a stop valve adapted when open to admit pressure in front of said rear pistons and when closed to exhaust from in front of them, other valves one for each cylinder normally connecting back of the front pistons with exhaust means, and means for controlling said valves adapted to first close the stop valve and then lift one of the other valves.

39. The combination of a rotary cylinder having chambers of different lengths with ports opening from their sides out through the cylinder at different points of its length, a plurality of sets of inlet and outlet ducts, each set leading to ports which are in circumferential alinement, and means for opening and closing said ducts to the operative circulation of fluid through the said cylinder chambers.

40. The combination of a rotary cylinder having chambers with ports opening from

their sides out through the cylinder at different points of its length, a plurality of sets of inlet and outlet ducts, each set leading to ports which are in circumferential alignment, a by-pass between the inlet and outlet duct of each set, valves in said ducts and by-passes, pistons in said cylinder chambers having rods projecting therefrom, a rotary head, and means connecting said piston rods to said rotary head.

41. The combination of a cylinder having a plurality of chambers, a rotary head, pistons in said chambers having rods connected to said head, means for rotating said head and cylinder, fluid inlet and outlet ducts having branches leading to different groups of said cylinder chambers, and means for opening and closing each of said branches to the operative circulation of fluid to said cylinder.

42. The combination with a cylinder having a plurality of chambers, and pistons in said chambers, of fluid inlet and outlet ducts having branches leading to different cylinder chambers, and means for permitting and preventing the circulation of fluid from each branch through its cylinder chambers.

43. The combination with a cylinder having a plurality of chambers, and pistons in said chambers, of fluid inlet and outlet ducts leading to said cylinder chambers, a by-pass between said inlet and outlet ducts, and valves in said ducts and by-pass.

44. The combination with a cylinder having a plurality of chambers, and pistons in said chambers, of fluid inlet and outlet ducts having branches leading to different groups of cylinder chambers, a by-pass between each inlet and outlet branch, and valves in said branches and by-pass.

45. In a fluid gear, the combination with a rotary cylinder having a plurality of chambers, pistons in said chambers, and means for supplying fluid under pressure to said chambers, of means for connecting and disconnecting one or more of said chambers with respect to said fluid pressure supply means independent of the other chambers.

46. In a fluid gear, the combination with a rotary cylinder having a plurality of chambers, a piston in each chamber, and means for supplying fluid pressure, of means for connecting one or more of said cylinder chambers to said fluid pressure and disconnecting the other cylinder chambers at the same time.

47. In a fluid gear, the combination of a rotary cylinder having a plurality of chambers with pistons therein, pressure fluid supply means branching to different groups of said cylinder chambers, and separate means for opening and closing each branch of said fluid pressure supply means.

48. In a fluid gear, the combination of a

rotary cylinder having a plurality of chambers with pistons therein, a plurality of pressure fluid inlet and outlet ducts, and means for placing different chambers of said cylinder in communication with different ducts.

49. In a fluid gear, the combination of a rotary cylinder having a plurality of chambers with pistons therein and having ports, a plurality of fluid pressure supply ducts each adapted to communicate with a different group of cylinder chambers, and means for supplying fluid under pressure.

50. The combination of a rotary cylinder having chambers of different lengths with ports opening from their sides out through the cylinder, inlet and outlet ducts having a plurality of sets of branches, one set leading to the said ports of each length of cylinder chamber, and means for opening and closing said branches to the operative circulation of fluid through the said cylinder chambers.

51. The combination of a rotary cylinder having chambers of different lengths with ports opening out through the sides of the cylinder, a plurality of sets of inlet and outlet ducts, one set for each length of cylinder chambers and adapted to communicate therewith, means for supplying fluid through said ducts to said chambers, pistons in said cylinder chambers having rods projecting therefrom, a rotary head, and means connecting said piston rods to said rotary head.

52. The combination of a rotary cylinder having chambers of different lengths with ports opening out through the sides of the cylinder, a plurality of sets of inlet and outlet ducts, one set for each length of cylinder chambers and adapted to communicate therewith, a by-pass between the inlet and outlet duct of each set, valves in said ducts and by-passes, pistons in said cylinder chambers having rods projecting therefrom, a rotary head, and means connecting said piston rods to said rotary head.

53. The combination of a support having a recess and a stud projecting therefrom, a cylinder mounted on said stud and having its peripheral walls near one end fitting the walls of said recess, said cylinder having longitudinal chambers opening out through said peripheral portion of itself at different points along the length of the cylinder, ducts in said support adapted to communicate one with each length of cylinder chamber, pressure fluid supply and exhaust means adapted to be connected to said ducts, pistons in said cylinder chambers having rods projecting therefrom, a rotary head, and means connecting said piston rods to said rotary head.

54. The combination of a rotary cylinder having chambers of different lengths with

ports opening out through the sides of the cylinder, a plurality of sets of inlet and outlet ducts one set for each length of cylinder chambers and adapted to communicate there-
 5 with, means for controlling the flow of fluid through each set of inlet and outlet ducts to said cylinder chambers, pistons in said cylinder chambers having rods projecting therefrom, a rotary head, and means con-
 10 necting said piston rods to said rotary head.

55. In a fluid gear, the combination with a motor member comprising a driven shaft, a cylinder having longitudinal chambers, means holding said cylinder and shaft with
 15 their axes of rotation at a fixed angle, pistons in said cylinder chambers having rods connected to said shaft, means for causing said shaft and cylinder to rotate in unison, ducts leading at one end to said cylinder
 20 chambers, a pump member at the other end of said ducts comprising a rotary cylinder and a rotary head, pistons in said cylinder connected to said head, means for driving one of said rotary parts, means for moving
 25 the other rotary part to vary the angular relation of the axes of said parts, gears adapted to transmit rotation between said rotary parts, and means for synchronizing rotation of said rotary parts during varia-
 30 tion of the angular relation of their axial lines.

56. In a fluid gear, the combination of a pump member comprising inlet and outlet ducts, a rotary head, a cylinder having a
 35 series of chambers adapted to communicate with said ducts, pistons in said chambers having rods connected to said rotary head at points radially distant from its axial central line, means for varying the angular
 40 relation of said cylinder and rotary head upon the point of intersection of the axial central line of the head and the plane of connection of the pistons to said head as a center, a motor member comprising inlet
 45 and outlet ports, a cylinder having chambers adapted to communicate with said ports, a driven shaft, means holding said shaft and cylinder in fixed relation to each other, pistons in said cylinders having rods
 50 connected to said driven shaft, means for causing said driven shaft and cylinder to run in unison, and ducts leading from the inlet port of one member to the outlet port of the other member.

55 57. In a fluid gear, the combination of a pump member comprising inlet and outlet ducts, a rotary head, a cylinder having a series of chambers adapted to communicate with said ducts, pistons in said chambers
 30 having rods connected to said rotary head, means for moving said cylinder to vary the angular relation of the axes of said cylinder and rotary head, a motor member comprising inlet and outlet ports, a cylinder

having chambers adapted to communicate 65 with said ports, a driven shaft, means holding said shaft and cylinder with their axes in fixed angular relation, pistons in said cylinders having rods connected to said driven shaft, and ducts leading from the
 70 inlet port of one member to the outlet port of the other member.

58. In a fluid gear, the combination of a pump member comprising a casing with inlet and outlet ports leading to its interior, a
 75 driving shaft projecting into said casing, a cylinder in said casing having an annular series of chambers, means for placing said chambers in communication with the said ports of the casing, pistons in said cham-
 80 bers having rods connected to said driving shaft at points radially removed from the axis of said shaft, means for moving the axis of said cylinder angularly upon the point of intersection of the driving shaft and
 85 plane of connection of said piston rods to the driving shaft as a center, a motor member comprising a casing with inlet and outlet ports leading to its interior, a cylinder in said casing having an annular series of
 90 chambers adapted to communicate with said ports, a driven shaft projecting into said motor member casing at a fixed angle to the axis of the said cylinder therein, pistons in said cylinder having rods connected to said
 95 driven shaft, means for causing said driven shaft and motor member cylinder to turn in unison, and ducts leading from the inlet port of one member to the outlet port of the other member.
 100

59. The combination of a rotary cylinder having a series of chambers, means for conducting pressure fluid to and from said chambers, a prime mover, pistons in said
 105 cylinder chambers having rods connected to said prime mover, means for transmitting rotary movement between said prime mover and cylinder, means for varying the angular relation of the axis of said cylinder to the axis of said prime mover, and gearing
 110 adapted to synchronize rotation of said prime mover and cylinder during variation of the angular relation of their axial lines.

60. The combination of a rotary cylinder having a series of chambers, means for conducting pressure fluid to and from said
 115 chambers, a prime mover, pistons in said cylinder chambers having rods connected to said prime mover, gearing adapted to transmit rotary movement between said prime mover and cylinder, means for varying the angular relation of the axis of said cylinder to the axis of said prime mover, and means for synchronizing rotation of said prime mover and cylinder during variation of the
 120 angular relation of their axial lines.
 125

61. The combination of a rotary cylinder having a series of chambers, means for con-

ducting pressure fluid to and from said chambers, a rotary head, pistons in said cylinder chambers having rods connected to said rotary head, means for transmitting rotary movement between said rotary parts, means for varying the angular relation of the axial lines of said rotary parts to each other, and gearing adapted to synchronize rotation of said rotary parts during variation of the angular relation of their axial lines. 10

HOLBROOK F. J. PORTER.

In the presence of—

FREDERICK GERMANN, Jr.,
FRANCES E. BLODGETT.