H. D. WILLIAMS.

VARIABLE SPEED GEAR.

APPLICATION FILED JULY 20, 1906.

925,148.

Patented June 15, 1909.

3 SHEETS—SHEET 1.

Fig. 3.

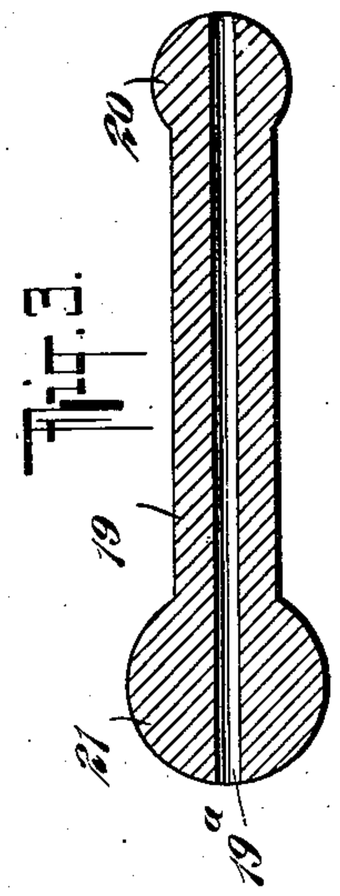

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Fig. 2.

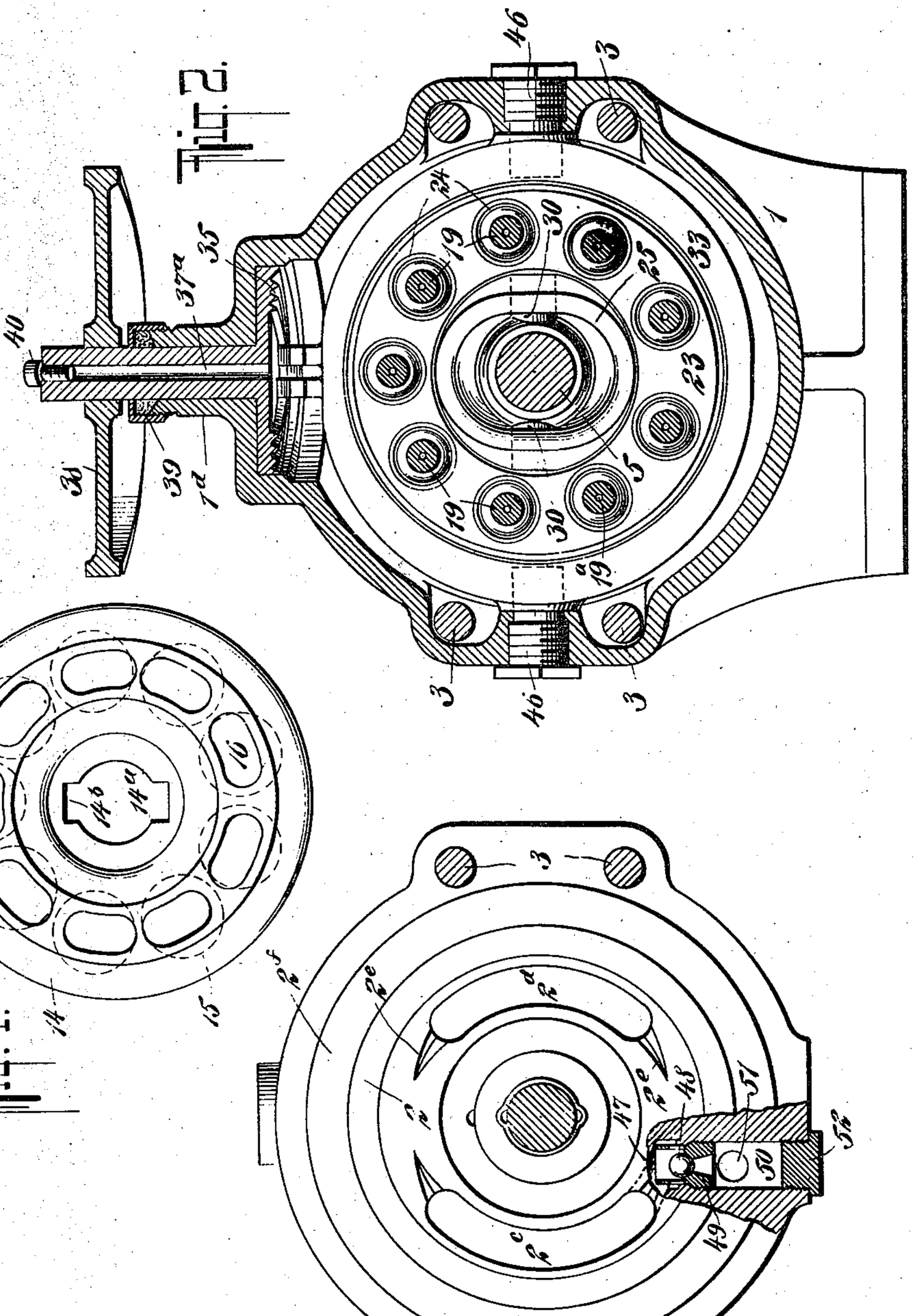

Fig. 4.

Fig. 3.

WITNESSES

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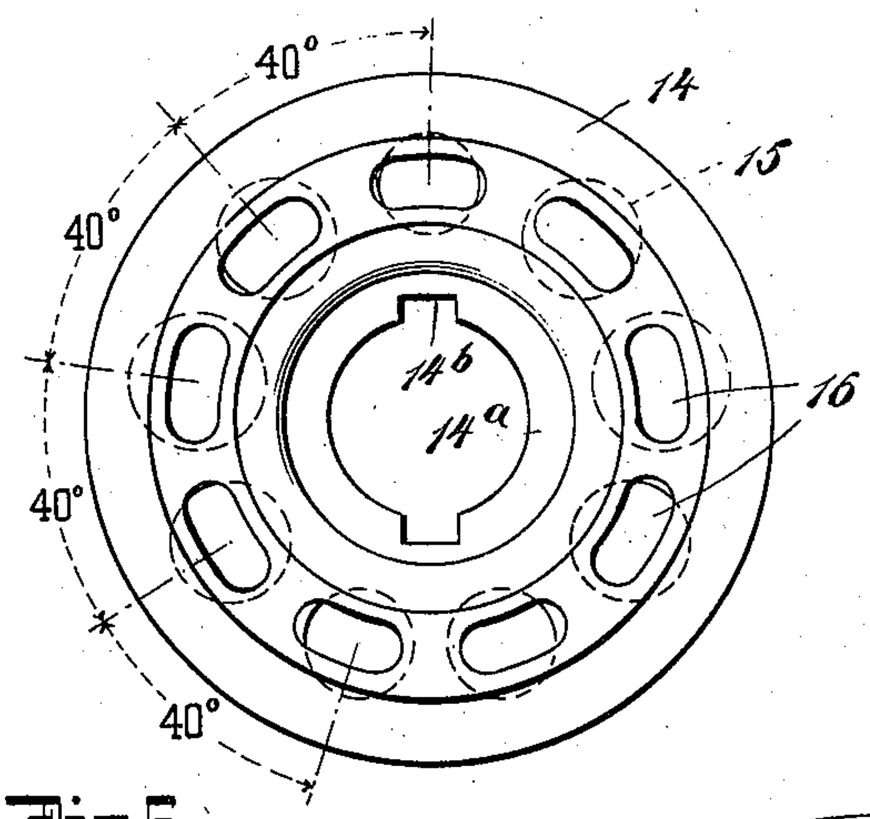

Fig. 6.

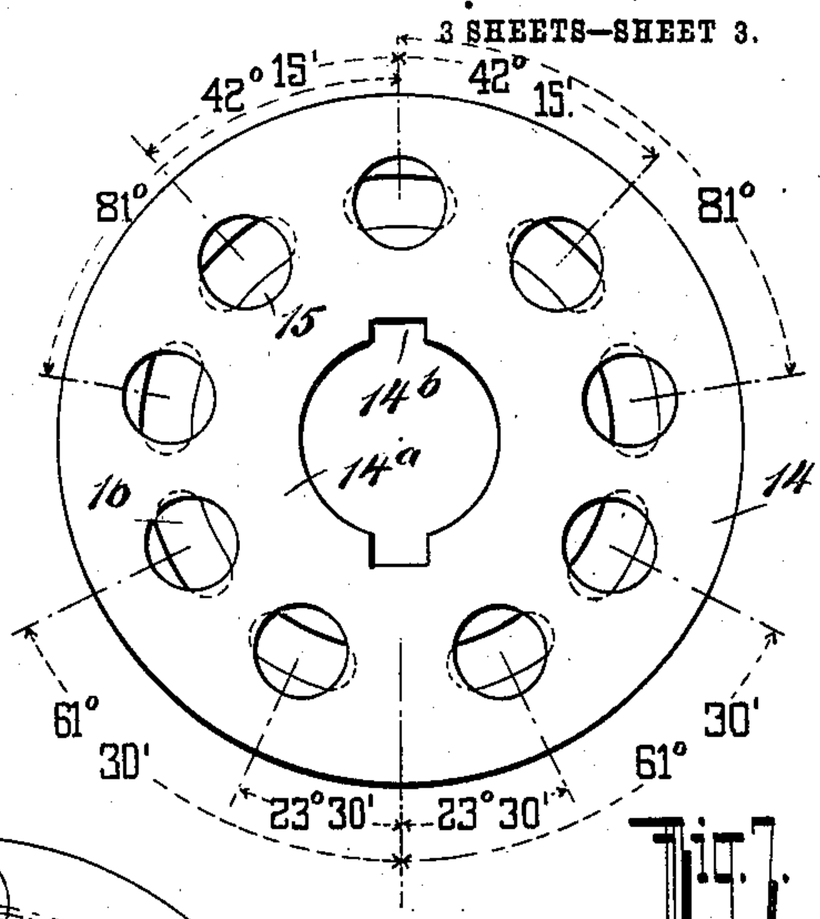

Fig. 7.

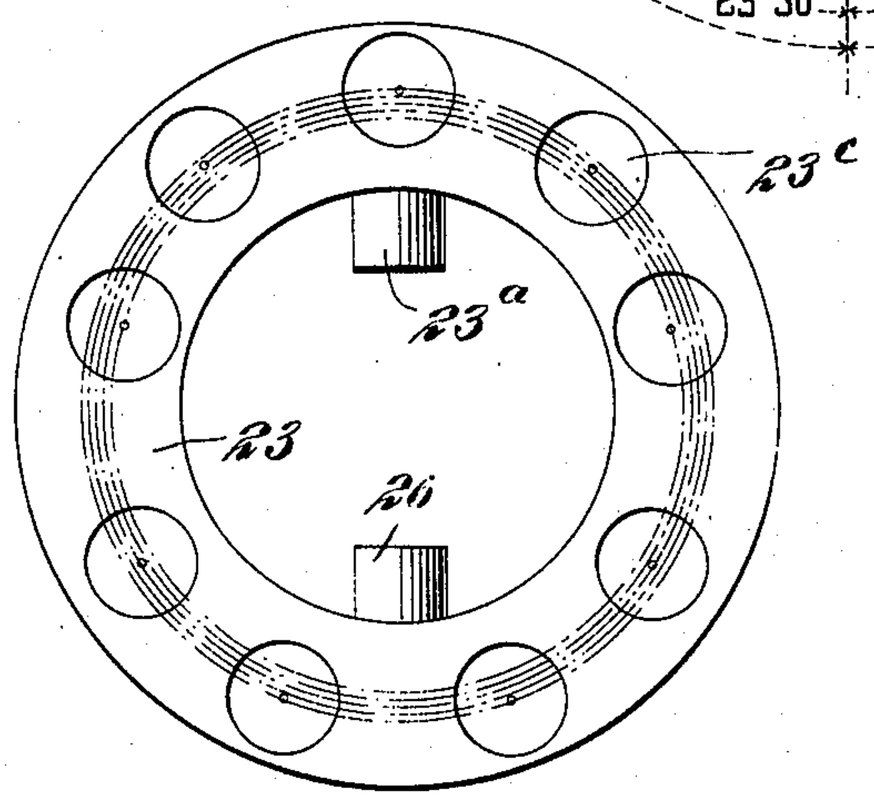

Fig. 8.

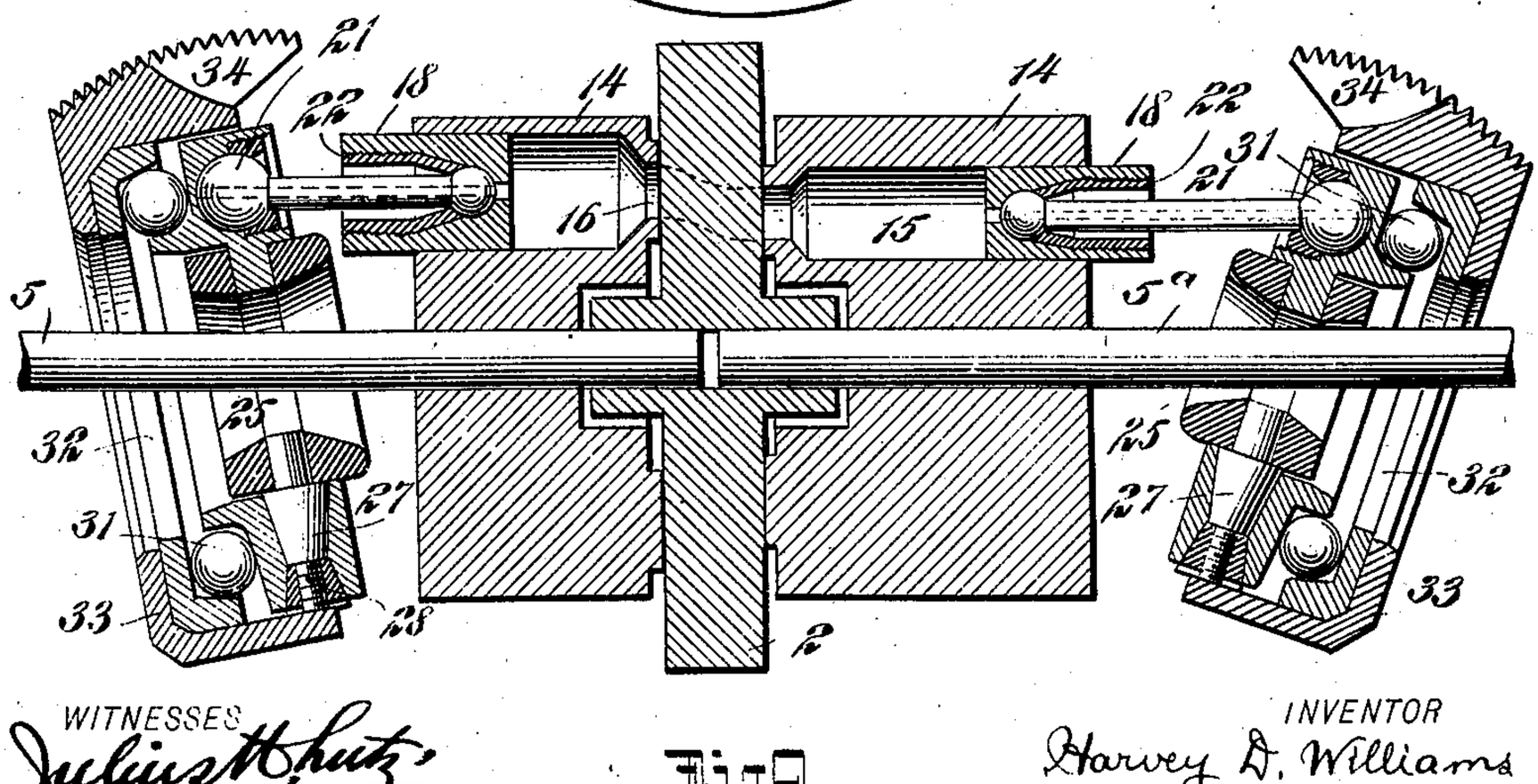

Fig. 9.

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UNITED STATES PATENT OFFICE.

HARVEY D. WILLIAMS, OF WASHINGTON, DISTRICT OF COLUMBIA, ASSIGNOR TO THE WATERBURY TOOL COMPANY, OF WATERBURY, CONNECTICUT, A CORPORATION OF CONNECTICUT.

VARIABLE-SPEED GEAR.

No. 925,148. Specification of Letters Patent. Patented June 15, 1909.

Application filed July 20, 1906. Serial No. 327,005.

To all whom it may concern:

Be it known that I, HARVEY D. WILLIAMS, a citizen of the United States, and resident of the city of Washington, in the District of Columbia, have invented certain new and useful Improvements in Variable-Speed Gear, of which the following is a specification.

My invention relates to variable speed gear of that class in which pistons are reciprocated within a rotary cylinder barrel by their connection with a rotary inclined member, the reciprocation of the pistons operating to drive a fluid into another section of the apparatus similar to the driving section, and bringing about the rotation of a shaft or other driven element.

The object of my present invention is to improve mechanism of the above-indicated class, in various respects, particularly for the purpose of securing a more uniform operation, free from jerks, of reducing the chances of leakage, of lubricating the moving parts of the device thoroughly, and of efficiently proportioning the driven part of the mechanism relatively to the driving part.

The invention will be fully described hereinafter and the features of novelty pointed out in the appended claims.

Reference is to be had to the accompanying drawings in which—

Figure 1 is partly an elevation and partly a longitudinal section of a variable speed gear embodying my improvements; Fig. 2 is a cross section thereof on line 2—2 of Fig. 1; Fig. 3 is a detail longitudinal section of one of the connecting rods; Fig. 4 is a face view of the rotary cylinder barrel; Fig. 5 is a face view of the central member of the device which I call the mid-plate, with parts in section; Fig. 6 is a diagrammatic view showing the cylinder barrels with an arrangement of cylinders and ports such as may be employed in accordance with my invention to secure an even driving action; Fig. 7 illustrates another expedient for obtaining the same result; Fig. 8 illustrates the construction of the socket ring with sockets arranged at different distances from the center, likewise for the purpose of obtaining a uniform driving action, and Fig. 9 shows diagrammatically a variable speed gear in which the driving and driven sections differ as to cylinder bore, as more fully explained hereinafter.

The apparatus comprises two more or less cylindrical shell sections 1 resting on legs 1^a, and holding between them a mid-plate 2, which is preferably provided with shoulders to receive the edges of the shells 1. The two shells 1 and the mid-plate are held together in a suitable manner, for instance, by means of tie-bolts 3, passing through extensions 1^b of the shells, and holding-nuts 4. The mid-plate is provided on each side with a hub 2^a into which are adapted to project the inner ends of the driving shaft 5 and the driven shaft 5^a respectively. At its outer end each of said shafts passes through a stuffing box 6 containing a packing ring 7 and held in position by means of a cap 8 screwing on the end of the shell 1 and preferably locked after adjustment by means of a keeper 9 engaging corrugations on the cap 8, and secured by a screw 10. On its inner end each of the shafts is provided with a pin 11 extending transversely through it, and each of said pins passes through an opening in a key 12, which is beveled from the pin 11 toward both ends and is received within a longitudinal groove 14^b on the hub 14^a of the cylinder barrel 14. This barrel contains a number of cylinders 15 extending lengthwise of the shaft 5 or 5^a, and as shown in Fig. 4, these cylinders, of which nine are shown, may be arranged at even intervals from each other. Each of the cylinders is provided with a port 16, in that face or end which is adjacent to the mid-plate 2, the said ports being smaller than the cylinders themselves, and for the securing of the best results, I prefer to give the said ports a shape elongated in the direction of rotation as clearly shown in Fig. 4. This figure also illustrates another feature of my invention which consists in arranging the said ports differently at the

different cylinders. Thus it will be seen that the ports shown are of the same size for each cylinder, but only in one cylinder (the one shown at the top in Fig. 4) is the port placed centrally, and for the other cylinders the ports are shifted more or less to one side or the other. It will be observed, however, that the arrangement of the ports is the same for those cylinders which occupy the same position relative to the cylinder having the central arrangement of the port. That end surface of the barrel 14 which engages the mid-plate 2, and preferably a rib portion 2^f of said mid-plate, is an annulus considerably narrower than the barrel proper, so as to produce free spaces 17 between the mid-plate and the barrel, both on the inside and on the outside of the rib 2^f. The object of this construction is to reduce the separating tendency exerted by any fluid which may escape under pressure between the barrel 14 and the mid-plate. Such fluid would exert a pressure only along the ring 2^f which is of relatively small surface, especially when taking into consideration the fact that in this ring are provided the mid-plate ports 2^c and 2^d shown in Fig. 5. These ports are elongated and are adapted to register with the cylinder ports 16 during the rotation of the barrel. Preferably, each of the ports 2^c and 2^d has a gradual entrance and termination, as for instance by means of V-shaped grooves 2^e extending from each end of the ports 2^c and 2^d; thus, as each port 16 of the barrel rotates, it will first communicate with the reduced extension 2^e, and gradually the size of the opening will increase to the full area of the ports 16 and similarly as the port 16 passes out of registry with the port of the mid-plate, a very gradual reduction of the passage will take place, thus assisting in preventing the shocks such as might be caused by the sudden establishing and cutting off of the communication. The barrel is normally pressed toward the mid-plate by means of a spring 5^b coiled about the shaft and engaging a shoulder thereof. In order to keep the barrel 14 connected with the shaft 5 when the machine is dismembered, I may provide a screw-threaded collar or nut 13. A fiber washer *a* may be placed between the adjacent ends of the shafts 5, 5^a, to take up end thrust. A bushing *b* is preferably interposed between the mid-plate bearing and the shaft ends.

Within each of the cylinders 15 is adapted to reciprocate a piston 18 having a socket adapted to receive a ball 20 at the end of the connecting rod 19 which has another ball 21 at its other end. A sleeve 22 is screwed within the outer end of the piston to hold the ball 20 in place. In order to secure efficient lubrication for each end of the connecting rod, and also for the piston, I prefer to provide a central lubricating channel 18^a in the piston and a similar channel 19^a in the connecting rod. The balls 21 are received in sockets contained in a socket ring 23, and are held in place by screwed sleeves 24. Preferably the circle formed by the sockets is of a larger diameter than that formed by the cylinders, so that in the extreme inclined position of the socket ring as shown in Fig. 1, or in some other position of said ring, the connecting rods 19 may extend parallel with the shaft. In any event, when the circle of sockets is of a larger diameter than the circle of the cylinders, the connecting rods 19 form a smaller angle with the shaft than they would otherwise. The socket ring 23 is provided with a trunnion-pin 23^a extending into a suitable opening in the ring 25, which is swiveled on the shaft 5 by means of pins 30 projected from the shaft. The pins 30 extend at right angle to the trunnion 23^a and to the trunnion-pin 26, projected from a tapering portion 27 set in an opening of the socket ring and provided with a screw-threaded extension 28 which receives a split wedge-shaped nut 29. The socket ring 23 runs on balls 31 engaging a race 32 carried by the inclined ring 33. This ring is supported on trunnions 46 and is adjustable for the purpose of tilting the socket ring more or less relatively to the shaft 5. In order to accomplish this adjustment, I may employ for instance teeth 34 on the ring 33, engaged by a scroll 35 on a rotatable disk 36, the stem 37 of which passes through a stuffing box 39 on a nipple 1^a, and is provided with a hand-wheel 38. The stem may be channeled lengthwise as shown at 37^a, the outer end of the channel being closed by a screw 40. In order to press the scroll 35 against the teeth 34, I may employ a block 41 pressed by a spring 42 which is arranged in a socket 1^e and engaged by an adjusting screw 43 having a head 43^a; a nut 44 serves to hold the screw tight after adjustment.

The entire space inclosed by the shell sections 1 is filled with oil or other suitable fluid, for instance through a suitable opening 1^f. At the time of the filling the screw 40 is removed, so that air may escape through the channel 37^a. The oil may be withdrawn when desired, through drain ports, such as 1^h, which may be closed by plugs 45. All the parts are thoroughly lubricated within the casing or shell, lubricating channels 2^b and 1^g being provided respectively at the inner ends of the shafts and near the outer ends. The two sections of the apparatus are exactly alike except that at the driven end of the apparatus the rings 33 instead of being adjustable may be permanently inclined at a predetermined angle. If desired, however, the rings 33 at both ends may be adjusted in exactly the same

manner. The reciprocation of the pistons 18 forces oil through the channels 18ª and 19ª, thus efficiently lubricating the joints at the ends of the connecting rods.

The angular position of the socket ring, the universal joint between the shaft and the socket ring, and the sudden change of conditions whenever a cylinder port comes into or out of communication with a mid-plate port, are three factors which cause volumetric variations in the combined actions of the pistons, and therefore certain vibrations or pulsations in the action of the mechanism. To secure a more uniform driving action, I may, as shown in Fig. 4, space the cylinder ports 16 unevenly. This arrangement is based on the fact that the instant of cut-off for each cylinder is not co-incident with the end of the stroke of the respective piston. The same result may be obtained in other ways. Thus in Fig. 6 I have shown the employment of cylinders 15 of different sizes. These cylinders are shown evenly spaced at an angle of 40 degrees from each other. It will be noticed that those cylinders which are at the same distance from the median line drawn through the cylinder shown at the top of Fig. 6, are of the same size. The two features, viz. varying the size of the cylinders and spacing the cylinder ports unevenly, may be used together, as shown in Fig. 6. Another way which may be employed in conjunction with the uneven spacing of the cylinder ports or without, is illustrated in Fig. 7 and consists of spacing the cylinders unevenly, as exemplified by the angle measurements given in said figure. Of course, I might also combine this uneven spacing of the cylinders with the variation in the size of the cylinders shown in Fig. 6.

The same variation in the spacing of the individual members may be applied to the sockets of the socket ring, that is, the sockets of said ring instead of being evenly spaced, as in Fig. 2, may be spaced unevenly in the same manner as indicated for the cylinders in Fig. 7.

In Fig. 8, I have shown a still further expedient which consists in arranging the sockets of the socket ring at different distances from the center of the ring. Thus the upper socket in Fig. 8 and the two at the bottom are farthest away from the center, while the other sockets are at varying distances nearer to the center, the dotted lines having been inserted to more readily show which sockets are at the same distance from the center. As in all the cases hereinbefore mentioned, those elements which are at the same distance from a certain median line, to wit, the line drawn through the trunnions 23ª and 26, are alike, so far as their distance from the center is concerned. The same variation might be applied to the cylinders; but whatever expedient is employed in the cylinders, their ports, or in the sockets of the socket rings, the arrangement would always be symmetrical to a certain median line, that is, the sockets, ports or cylinders which occupy the same relation to such median line would be alike. Through these means I am enabled to make the necessary correction for the somewhat irregular pumping action of the pistons due to the universal joint action between the shaft and the socket ring and to the angular tilting of the socket ring; thus I secure a much more uniform action than could be obtained if all the parts were arranged at even distances and made of the same size.

In order to secure a replenishing of the cylinders in case there should be any leakage, I have provided a channel 47 leading from one of the mid-plate ports to a chamber 50 which communicates with the lower part of the casing by means of a port 51. The outer end of the chamber 50 is normally closed by a plug 52; said chamber also contains a seat 49 for a check valve 48 opening toward the mid-plate. This channel 47 is connected with that mid-plate port which is on the suction side of the driving member, that is, the side on which the pistons 18 move away from the mid-plate. As soon as the contents of the cylinders have diminished through leakage, the suction within the port 2ᶜ will cause the check valve 48 to open, thus admitting the necessary additional supply of oil to the cylinders.

When the same port of the mid-plate, for instance the port 2ᶜ, is always the suction port, it will be sufficient to have only one check valve arrangement as shown in Fig. 5. If, however, the arrangement is reversible, as it may be in some cases, so that sometimes the port 2ᶜ would be the suction port and at other times the port 2ᵈ, then the arrangement of the check valve and channels would have to be duplicated for each of the ports.

In some cases it is desirable to make the driving section different from the driven section by giving the cylinders and pistons of one section a greater diameter than those of the other section. When the two sections are alike, and the socket rings of both are inclined at the same angle, the two sections will rotate at the same speed. If however, the cylinders and pistons of the driven section be made of a larger diameter than those of the driving section, then, with the socket rings of both sections standing at the same angle, the driven section will rotate more slowly than the driving section, or what may be termed a "gearing down" is obtained. Similarly, if it be desired to gear the machine up, the cylinders and pistons of the driving section will be made of a greater diameter than those of the driven section. This arrangement is shown in Fig. 9.

The mechanism described herein com-

prises two sections, one of which may be described as a pump and the other as a motor driven by the fluid which the pump propels. Each of the sections is "reversible" in function, that is, it may either be used as a pump, to set a fluid in motion, or it may be driven by a fluid under pressure, and thus used as a motor. Of course, each section is fully operative by itself. Thus I might remove all the parts shown on the right of the mid-plate, and use the remaining apparatus as a pump, one of the ports, say 2^c, forming the suction port and the other, 2^d, the delivery port; or the same apparatus might serve as a motor, by admitting a fluid under pressure through one of the ports of the mid-plate and using the other as an exhaust port.

Instead of making the cylinders of one barrel of a greater diameter than those of the other, I may accomplish the same result by making one barrel with a greater number of cylinders than the other, the object being in both cases to secure a greater aggregate or total cross section of cylinders for one barrel than for the other, so as to gear the machine up or down, as explained above.

I claim:

1. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrel arranged in engagement with said member, the cylinders being evenly spaced and having unevenly spaced ports adapted to register with those of the stationary member, pistons arranged to reciprocate in said cylinders, and a rotary inclined member connected with said pistons.

2. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrels arranged in engagement with those surfaces of the stationary member at which the ports terminate, the cylinders of the same barrel being evenly spaced and having unevenly spaced ports adapted to register with those of the stationary member, pistons arranged to reciprocate in said cylinders, a rotary adjustable tilting ring connected with the pistons of one barrel, and a rotatable inclined member connected with the pistons of the other barrel.

3. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrel arranged in engagement with said member, the cylinders of said barrel having unevenly spaced ports adapted to register with those of the stationary member, pistons in said cylinders, and a rotary inclined member connected with said pistons.

4. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrels arranged in engagement with those surfaces of the stationary member at which the ports terminate, the cylinders of said barrels having unevenly spaced ports adapted to register with those of the stationary member, pistons in said cylinders, a rotary adjustable tilting ring connected with the pistons of one barrel, and a rotatable inclined member connected with the pistons of the other barrel.

5. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrel arranged in engagement with said member, the cylinders of said barrel being of different diameters and having ports adapted to register with those of said stationary member, pistons in said cylinders, and a rotary inclined member connected with said pistons.

6. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrels arranged in engagement with those surfaces of the stationary member at which the ports terminate, the cylinders of the same barrel being of different sizes and having ports adapted to register with those of the stationary member, pistons in said cylinders, a rotary adjustable tilting ring connected with the pistons of one barrel, and a rotatable inclined member connected with the pistons of the other barrel.

7. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrel arranged in engagement with said member, pistons in said cylinders, a rotary inclined member having a socket ring the sockets of which are at different distances from the center, and connecting rods extending from the sockets to the pistons.

8. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrel arranged in engagement with said member, pistons in said cylinders, a rotary inclined member having a socket ring the sockets of which are at different distances from the center, those sockets which are at the same distance from a median line being also at the same distance from the center, and connecting rods extending from the sockets to the pistons.

9. The combination of the stationary member having ports for the passage of the fluid, the rotary barrel arranged in engagement with said member and having cylinders with ports adapted to register with those of said member, said ports being spaced unevenly, and the ports belonging to cylinders which occupy the same relation to a certain median line, being at even distances from said line, pistons in said cylinders, and a rotary inclined member connected with said pistons.

10. The combination of the stationary member having ports for the passage of the fluid, the rotary cylinder barrel arranged in engagement with said member, the cylinders of said barrel being of different diameters

and having ports adapted to register with those of said stationary member, those cylinders which are at the same distance from a certain median line being of the same diameter, pistons in said cylinders, and a rotary inclined member connected with said pistons.

In testimony whereof, I have hereunto signed my name in the presence of two subscribing witnesses.

HARVEY D. WILLIAMS.

Witnesses:

WM. K. H. SCHOFIELD,

W. A. HYDE.