June 14, 1932. E. HILL 1,863,335

ROTARY PUMP

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Fig. 1

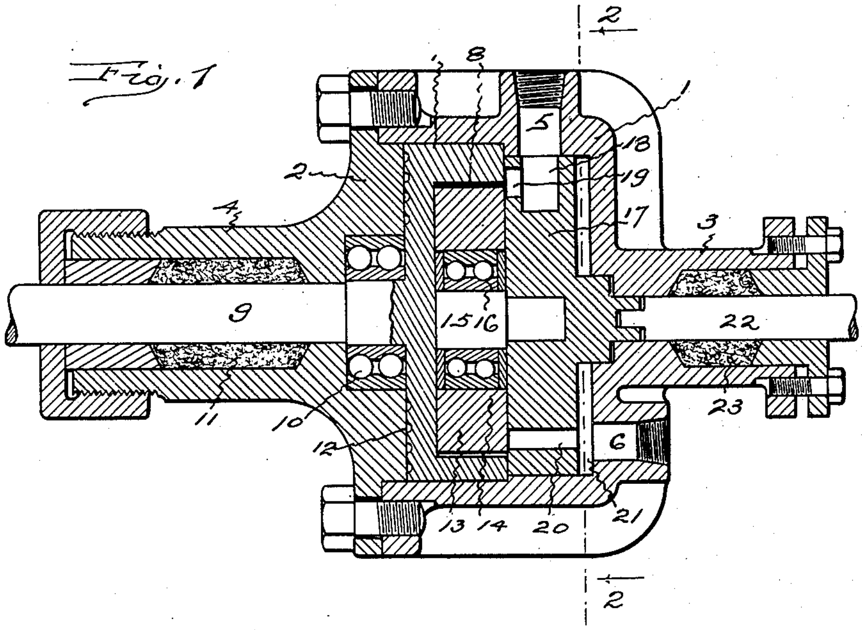

Fig. 2

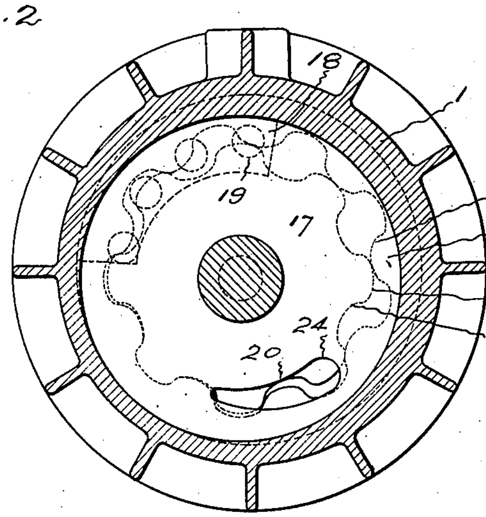

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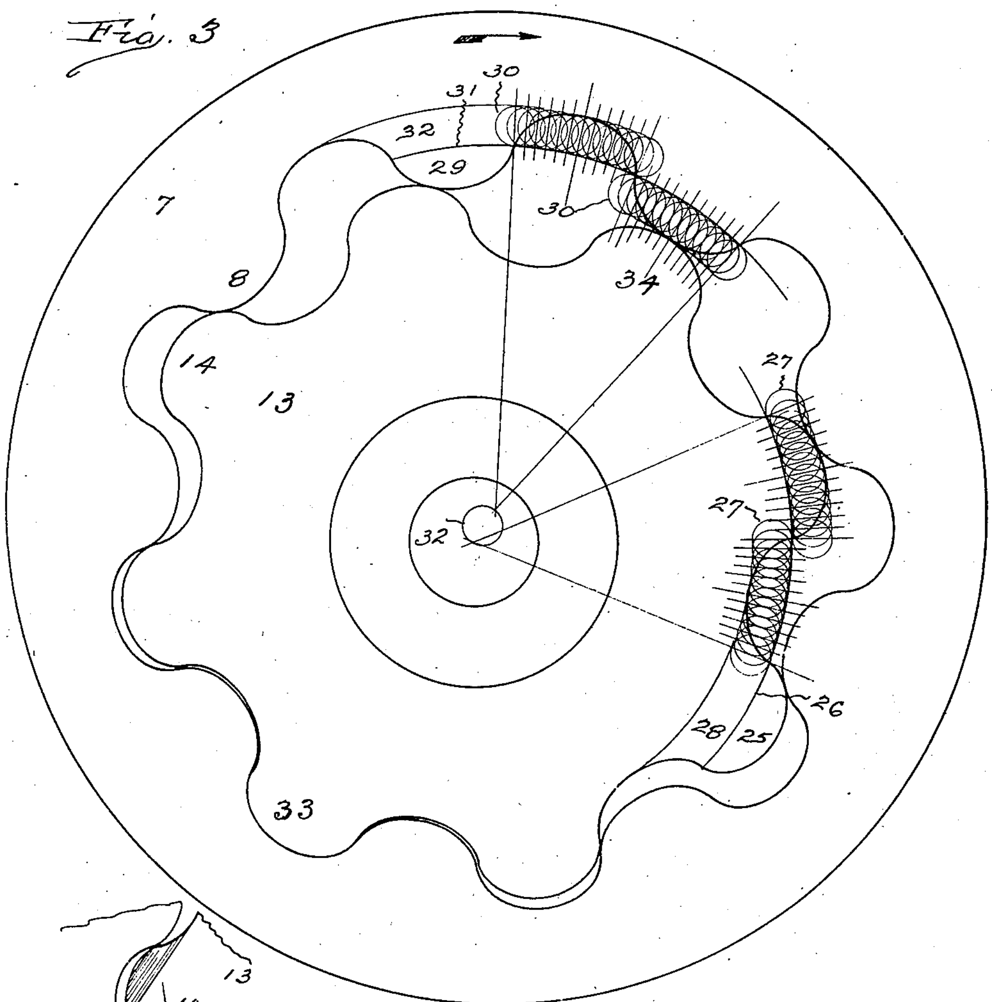
Fig. 3



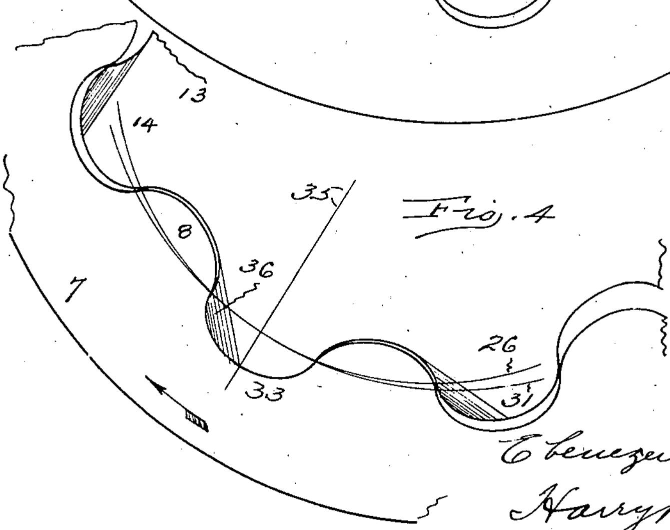


Fig. 4

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UNITED STATES PATENT OFFICE

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ROTARY PUMP

Application filed December 20, 1922. Serial No. 607,947.

This invention relates to rotary pumps of the gear type, that is, those pumps which have an outer driving gear and an inner driven gear that has a different number of teeth than, and is eccentrically mounted within the outer gear, which pumps are particularly adapted for pumping and compressing gases to relatively high degrees.

The object of the present invention is to provide a pump of this nature in which the gears have driving teeth and driven teeth that engage for forming the chambers which increase in capacity as the gas is received and which diminish in capacity for compressing the gas, so shaped that there will be a close but rolling contact between the engaging surfaces of the teeth whereby no leakage back from one chamber to the following chamber can occur and frictional slip between the engaging surfaces will be eliminated with a consequent reduction of wear and economy of driving power.

In the accompanying drawings Figure 1 shows a longitudinal section of a pump which embodies the invention. Fig. 2 is a transverse section of the pump taken on the plane indicated by the dotted line 2—2 on Fig. 1. Fig. 3 shows a face view, on larger scale, of the inner and outer gears and illustrates diagrammatically the shapes of the engaging teeth and eccentricity of the gears. Fig. 4 illustrates a form in which the teeth may be made when the pump is to be used for pumping liquids.

The pump casing 1 is cylindrical and it has a head 2 fastened in such manner that the head may be removed to allow access to the interior of the casing. The casing has an axial hub 3 and the head has an axial hub 4. In the side of the casing is an intake opening 5 and in the end face of the casing is a discharge opening 6.

The outer gear 7 has internal teeth 8 and its periphery is shaped so that there will be a close but rotatable fit within the cylindrical casing. The outer gear is shown as attached to a driving shaft 9 that extends through the hub of the head. The shaft is mounted on anti-friction bearings 10 arranged in the head and is made tight by an ordinary gland packing 11 in the hub. In the face of the outer gear next to the head are grooves 12 for containing material which will not only lubricate the engaging surfaces but will provide an additional packing for preventing the leakage of gas between the gear and the head.

The inner gear 13 has external teeth 14. This gear is mounted on an arbor 15 with interposed anti-friction bearings 16. The axis of the arbor is eccentric to the axis of the shaft so the axis of the inner gear will be eccentric to the axis of the outer gear. The arbor extends into the center of a valve plate 17. The valve plate has a circular periphery which fits a circular wall of the chamber in the casing. In one edge of the valve plate is an intake chamber 18 and leading from one side of this intake chamber are holes 19 which extend over the pitch lines of the gears on the intake side. The valve plate has a discharge port 20 that extends over the pitch lines of the gears on the discharge side. This discharge port is made in the shape of an arcuate slot. The valve plate floats in the casing and a space 21 is left between it and the wall of the casing which space is in communication with the discharge port so that the pressure of the gas which is compressed will be exerted against the outer surface of the valve plate and force its inner face tightly against the faces of the gears. A spindle 22 is rotatably connected with the valve plate. This spindle extends through the casing hub and is kept tight by an ordinary gland packing 23. The spindle may be provided with any desired means whereby it may be rotated for turning the valve plate and advancing and retracting the discharge port. The discharge port in the valve plate is made in the shape of an arcuate slot so that any gas in the compression spaces beyond the point at which it is desired to take off gas, may escape and not be carried to a higher pressure than is desired on account of not being able to get out. The relation of the edge 24 of the discharge port in the valve plate to the intake opening determines the discharge pressure within the limits of capacity of the pump.

The inner gear is illustrated as having

eight teeth and the outer gear as having nine teeth. The invention is not limited, however, to this exact number of teeth. The faces of the teeth and the walls of the interdental spaces of both gears are curved.

The addendum sections 25, or the portions beyond the pitch circle 26 of the teeth of the inner gear are formed on epicycloidal curves, that is, curves traced by a point on the circumference of a circle 27 which rolls upon the convex surface of another circle, which latter circle in this case is the pitch circle 26 of the inner gear. The dedendum sections 28, or portions inside of the pitch circle 26 of the teeth of the inner gear are formed on hypocycloidal curves, that is, curves traced by a point on the circumference of a circle 27 which rolls upon the inside surface of the pitch circle 26.

The addendum sections 29 of the teeth of the outer gear are formed on hypocycloidal curves, that is, curves traced by a point on the circumference of a circle 30 which rolls upon the inside surface of the pitch circle 31 of the outer gear, while the dedendum sections 32 of the teeth of the outer gear are formed on epicycloidal curves, that is, curves traced by a point on the circumference of a circle 30 which rolls upon the convex surface of the pitch circle 31 of the outer gear. The circles 27 indicated as rolling on the outside and inside of the pitch circle of the inner gear and the circles 30 indicated as rolling on the outside and inside of the pitch circle of the outer gear for illustrating the generation of the epicycloidal and hypocycloidal curves of the gear teeth are the same in diameter, and the diameter of these circles is the same as the amount of eccentricity of the inner gear to the outer gear, as indicated by the circle 32 in Fig. 3.

With this construction the gear teeth contact in various relations as the outer gear is rotated and drives the inner gear, and this contact of the teeth is rolling, or in the nature of the contact of two cylinders. As the gears rotate the spaces between the teeth from the point 33 where the teeth bottom, that is, at the point where the radii 35 of the two gears coincide and the pitch circles 26 and 31 of the two gears are tangent, to the point 34 where the crests of the teeth engage, increase, while the spaces between the teeth from the point of crest engagement to the bottoming point, decrease, and a close seal is made between the gears on the compression side by reason of the forced facing of the teeth under the pressure of the gas being compressed.

Gas is allowed to enter the spaces between the teeth at some interval intermediate the bottoming point and the crest contact point, and is discharged from the spaces between the teeth at some place between the crest contact point and the bottoming point. As the rotation of the gears progresses the volume of gas drawn in on the entrance side increases owing to the expansion of the spaces between the teeth on that side, and this volume of gas is compressed on the discharge side due to the contraction of the spaces on this side. The degree to which the gas will be compressed in pumps of fixed rated capacity depends on the distance on the compression side, of the discharge port from the crest contact point. The further around the discharge port is from the crest contact point the greater is the compression, for the spaces between the gears decrease and the density of gas is consequently increased until it can escape through the discharge port. The pressure on the back of the valve plate causes that plate to hug the faces of the gear teeth and follow up wear, and also forces the outer gear against the head and tends to compress any lubricant in the grooves in the back of that gear so as to not only lubricate the adjacent surfaces but seal the joint. With teeth of the form described there is space for the lubricant to be drawn into between the teeth in each cavity, even that cavity in which the pitch circles of the two gears are tangent, and this ensures a tight sealing of the joints from one chamber to the following.

The teeth of the gears of the shape described engage with a rolling contact so as to eliminate friction and economize power. The spaces between the teeth are of maximum capacity and the thickness of the teeth is such that the danger of breaking the seal and the escape of gas backward from one chamber to the following chamber, across the sides of the teeth is reduced to a minimum, with gears formed as herein set forth.

A pump having teeth of the form described is particularly serviceable for compressing gases. For pumping liquids where compression is not required but easier influx is desired, the edges of the teeth on the front or advance side of the inner gear may be chamfered, as seen at 36 in Fig. 4. This merely increases the clearance, that is, it connects the cavities and forms one long intake chamber without affecting the driving contact of the teeth or the sealing engagement of the teeth on the compression or discharge side.

The invention claimed is:—

1. A rotary pump comprising a casing having intake and discharge openings and co-operating eccentrically arranged internal and external pump gears rotatable in the casing, the entire engaging faces of the teeth of said gears being formed on epicycloidal and hypocycloidal curves, the height and depth from the pitch circles of the teeth being the same but the chords of the curves of the external gear are longer than the chords of the curves of the internal gear.

2. A rotary pump comprising a casing having intake and discharge openings and co-acting eccentrically arranged internal and

external pump gears rotatable in the casing, the front and back faces of the teeth of the driving gear and the front and back faces of the teeth of the driven gear being formed on epicycloidal and hypocycloidal curves, said curves being generated on the pitch circles of the respective gears by generating circles of the same diameter.

3. A rotary pump comprising a casing having intake and discharge openings and co-acting pump gears rotatable one within the other in the casing, the addendum sections of the teeth of the inner gear being formed on epicycloidal curves, the dedendum sections of the teeth of the inner gear being formed on hypocycloidal curves, said curves having chords of equal length, the addendum sections of the teeth of the outer gear being formed on hypocycloidal curves and the dedendum sections of the teeth of the outer gear being formed on epicycloidal curves, said curves having chords of equal length, the chords of the curves of the inner gear being shorter than the chords of the curves of the outer gear.

4. A rotary pump comprising a casing having intake and discharge openings and co-acting internal and external pump gears rotatable in the casing, the addendum sections of the teeth of the inner gear being formed on epicycloidal curves, the dedendum sections of the teeth of the inner gear being formed on hypocycloidal curves, both of said curves being generated by the same circle on the pitch line of the inner gear, the addendum sections of the teeth of the outer gear being formed on hypocycloidal curves and the dedendum sections of the teeth of the outer gear being formed on epicycloidal curves, both of said curves being generated by the same circle on the pitch line of the outer gear, the outer gear having more teeth than the inner gear, and said gears being mounted eccentrically with relation to each other, which eccentricity is equal to the diameter of the generating circle for the said curves.

5. A rotary pump comprising a casing having intake and discharge openings and co-acting pump gears rotatable one within the other in the casing, the teeth of the inner gear being formed on epicycloidal and hypocycloidal curves both of which are generated on the pitch circle of the inner gear, and the teeth of the outer gear being formed on epicycloidal and hypocycloidal curves both of which are generated on the pitch circle of the outer gear.

6. A rotary pump comprising a casing having intake and discharge openings, co-acting eccentrically arranged internal and external pump gears rotatable in the casing, the entire engaging faces of the teeth of said gears being formed on epicycloidal and hypocycloidal curves, the generating circles of which curves are of equal diameter, which diameter is equal to and determined by the eccentricity of the gears.

7. A rotary pump comprising a casing having intake and discharge openings and co-acting pump gears rotatable one within the other in the casing, the addendum sections of the teeth of the inner gear being formed on epicycloidal curves, the dedendum sections of the teeth of the inner gear being formed on hypocycloidal curves, the addendum sections of the teeth of the outer gear being formed on hypocycloidal curves, the dedendum sections of the teeth of the outer gear being formed on epicycloidal curves, and the forward faces of the inner gear being cut away to connect the cavities without altering the shapes of the engaging driving and sealing faces of the gears.

8. A rotary pump comprising a casing having intake and discharge openings and co-acting pump gears rotatable one within the other in the casing, the addendum sections of the teeth of the inner gear being formed on epicycloidal curves, the dedendum sections of the teeth of the inner gear being formed on hypocycloidal curves, the addendum sections of the teeth of the outer gear being formed on hypocycloidal curves, the addendum sections of the teeth of the outer gear being formed on epicycloidal curves, the teeth of one of said gears on the front or advanced face being shaped to form one continuous chamber on the intake side without affecting the driving contact of the teeth and the sealing of the teeth on the compression side.

9. A rotary pump comprising a casing having intake and discharge openings and co-acting eccentrically arranged internal and external pump gears rotatable one within the other in the casing, the addendum and dedendum sections of the teeth of both gears being formed on continuous epicycloidal and hypocycloidal curves generated on the pitch circles of the respective gears, whereby the engaging faces of the gears will have at all times a rolling contact with each other.

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