

July 28, 1942.

E. SIBLEY

2,291,354

ROTARY PUMP

Filed July 29, 1940

2 Sheets-Sheet 1

Fig. 1.

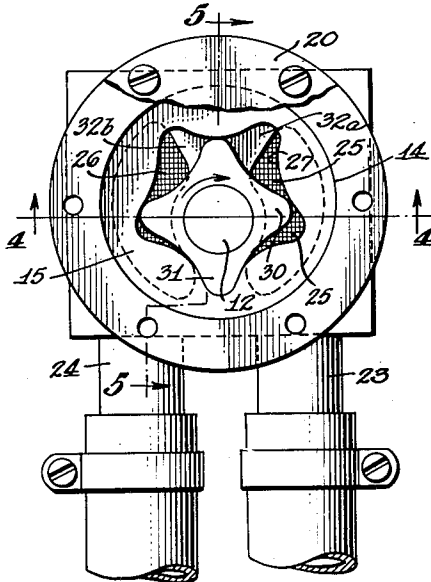


Fig. 2.

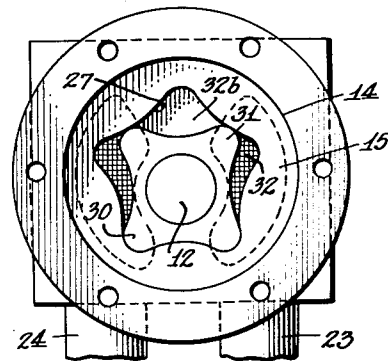


Fig. 3.

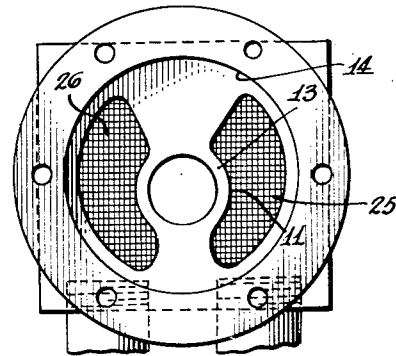


Fig. 4.

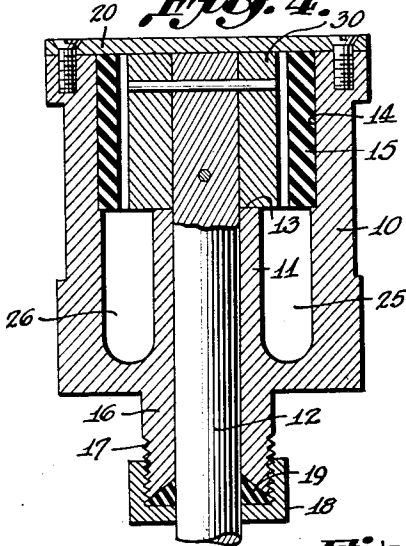


Fig. 5.

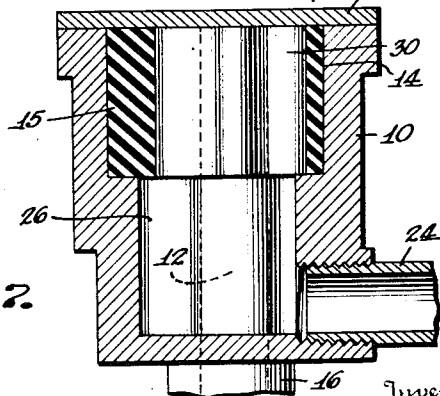


Fig. 6.

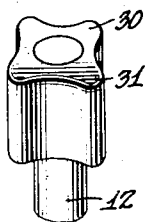
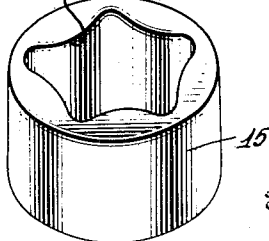


Fig. 7.



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2 Sheets-Sheet 2

Fig. 9.

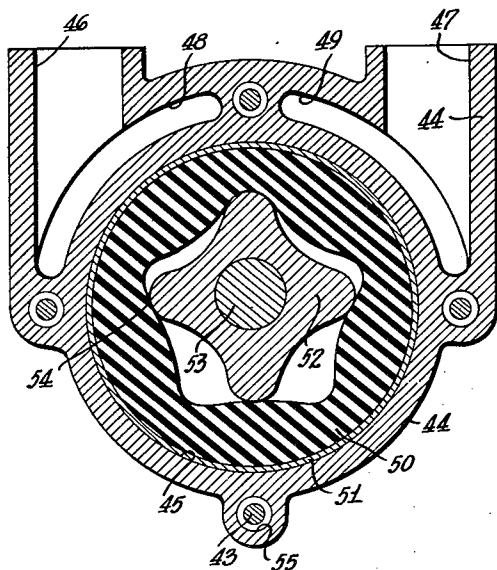


Fig. 8.

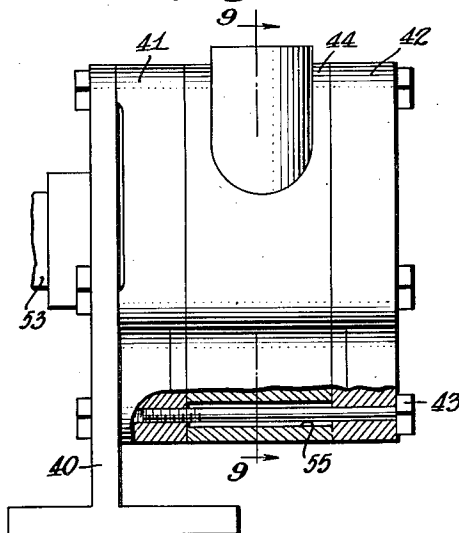


Fig. 10.

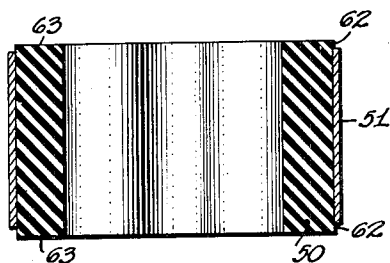
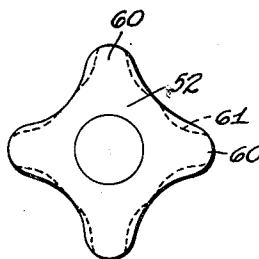


Fig. 11.



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UNITED STATES PATENT OFFICE

2,291,354

ROTARY PUMP

Eugene Sibley, Detroit, Mich., assignor, by mesne assignments, to Franklin D. Dougherty, trustee, Detroit, Mich.

Application July 29, 1940, Serial No. 348,256

9 Claims. (Cl. 103—126)

This invention relates to a rotary pumping machine and more particularly to a gear pump having eccentrically mounted intermeshing gears.

It is an object of the present invention to provide a gear pump in which the pumping elements comprise an internal annular gear in which one of said gears is formed of resilient material.

It is a further object of the invention to provide a gear pump characterized by resiliency of a pumping element to permit passage of solid particles without damage to the pump.

It is a further object of the present invention to provide a gear pump embodying an internal and external intermeshing gear in which one of said gears is formed of resilient compressible material and of a size such that in normal operation a substantially perfect seal is obtained.

It is a further object of the invention to provide a pump of the type described having an annular rotor provided with internal teeth formed of compressible, resilient material, the outer surface of said rotor being cylindrical and formed of a material adapted strongly to resist distortion.

It is a further object of the invention to provide a rotor of the type described in which the outer distortion resisting surface terminates short of the ends of the member.

It is a further object of the invention to provide a pump of the character described comprising an internally toothed annular gear, a driving pinion meshing with the annular gear, the pinion being modified from a strict conjugate to the internally toothed annular gear by being relieved throughout the spaces between the tips of adjacent teeth.

It is a further object of the present invention to provide a pump of the character described having meshing pumping gears, at least one of which is formed of compressible, resilient material, in which means are provided for adjusting one of said gears in a plane perpendicular to the axis of said gears.

Other objects of the invention will be apparent as the description proceeds and when taken in conjunction with the accompanying drawings, and wherein:

Figure 1 is a plan view of my pump with parts broken away for clearness;

Figure 2 is a view corresponding to Figure 1 in which the pumping elements are moved to a new position;

Figure 3 is a plan view of the casing for my improved pump;

Figure 4 is a section on the line 4—4, Figure 1; Figure 5 is a section on the line 5—5, Figure 1; Figure 6 is a perspective of the pumping pinion;

Figure 7 is a perspective of the annular internal gear forming an element of my pump;

Figure 8 is a side elevation, partly in section, of one embodiment of my pump;

Figure 9 is a section on the line 9—9, Figure 8;

Figure 10 is a transverse section through the annular rotor; and

Figure 11 is a diagrammatic view illustrating a modification preferably provided on the driving pinion.

Gear pumps embodying certain features disclosed in the drawings have long been known to the art and their principles are well understood. By providing an internal toothed annular gear of a certain number of teeth in combination with a pinion conjugate to the teeth of the annular gear and meshing internally therewith, the pinion having one less tooth than the annular gear and being mounted eccentrically thereto, a pump is provided which operates efficiently and exhibits a number of important properties.

The form of the teeth employed in this type of gear may be widely varied and in general it may be stated that it is necessary only for the teeth to be in constant contact.

Certain well known geometric shapes may be employed in the formation of the gear teeth, or in some cases one of the elements may be designed and the conjugate element may be generated from the first gear selected.

It will be understood that pumps of this type, that is, pumps embodying an internal gear and an internal meshing and eccentrically mounted pinion have long been known, and the particular form of gear tooth employed forms no part of the present invention.

On the other hand, the present invention relates particularly to the material employed and may be practiced with various forms of gears.

In the figures, I have disclosed an embodiment of my invention in which a pump casing 10 is provided with a central bushing 11 in which is rotatably mounted a drive shaft 12. The bushing 11 extends inwardly and terminates in a flat bearing surface 13 against which the pinion of my improved gear pump is adapted to rotate.

The casing 10 is open at one end and is accurately machined to provide a cylindrical recess 14 in which is rotatably mounted the annular gear member 15.

A projection 16 is provided with screw threads

17 and a sealing cap 18 is adapted to fit thereover to provide in combination with a packing 19 effective sealing means for the drive shaft 12. The open end of the casing 10 is provided with a closure plate 20, bolted or otherwise secured to the casing 10. The casing 10, which is preferably in the form of a casting, is also provided with a pair of projecting conduits 23 and 24 which have passageways extending therethrough and communicate with valve chambers 25 and 26, respectively. The valve chambers 25 and 26 open, as best shown in Figure 3, into the cylindrical chamber 14. These openings form inlet and outlet to the pump according to the direction of rotation.

The annular gear member 15, as best seen in Figure 7, is received within the cylindrical chamber 14 and is adapted to closely engage the curved side walls thereof and also the top closure plate 20. The gear member 15 is provided with a number of gear teeth of suitable form 27. The annular gear 15 is freely rotatable in the cylindrical chamber 14.

A pinion 30 is keyed or otherwise secured to the drive shaft 12 and has teeth 31 which are conjugate to the teeth 27 of the annular gear 15. In the present embodiment of my invention the annular gear 15 is shown as provided with five teeth, whereas the pinion 30 is shown as provided with four teeth. The number of teeth need not be as indicated, the only requirement being that the annular gear be provided with one more tooth than the meshing pinion.

As best seen in Figures 1 and 2, the pinion and the annular gear mesh so as to provide chambers 32 formed between the intermeshing teeth. As will be apparent, these chambers expand and contract as the two gears roll together. Furthermore, a gear tooth 31 on the pinion 30 is adapted to remain in contact with the opposed tooth 27 of the annular gear 15 so as to provide an effective seal for the chambers 32.

It will be noted in Figure 1, that the pinion 30 is mounted eccentrically of the annular gear 15, and if it is assumed that the pinion is positively driven in the direction of the arrow it will be apparent that the chamber 32a is decreasing in volume. The valve opening 25, indicated in this figure, is in communication with the chamber 32a and continued rotation of the parts results in the expelling of fluid from the chamber 32a through the valve 25 out through conduit 23, which in this case is the outlet line.

The chamber 32b in Figure 1 is expanding in volume and is in communication with the valve opening from the valve chamber 26 so that fluid is being drawn through the inlet line 24. It will be appreciated that the shape and area of the valve openings may be varied within relatively wide limits, but the shape indicated in the drawings has proved highly efficient in operation.

The driving shaft 12 positively rotates the pinion 30 and this pinion through its intermeshing engagement with the annular gear 15 also drives the annular gear 15. Due to the different number of teeth, as previously referred to, one rotation of the shaft 12 results in a tooth of the pinion 30 moving, for example, from one tooth space of the annular gear to the next succeeding tooth space.

In the past pumps of this kind have been formed with metal pinions and annular gears and in order to obtain any satisfactory degree of efficiency it was necessary that the parts be finished with extreme accuracy. This is neces-

sarily so because the efficiency of the pump depends upon a seal being maintained in any chamber 32 between the teeth. In other words, as seen in Figure 1, the tooth of the pinion 30 shown at the top is in sliding contact with the corresponding tooth of the annular gear 15.

This necessary high degree of accuracy in finishing also introduced another unsatisfactory element into the operation of this type of pump as constructed in the past. If fine particles, such as sand or grit, were passed through the pump, these elements would cause damage to the interengaging surface of the pinion and the gear. For this reason pumps of this type have not had a wide application, being in the first case extremely expensive to construct and in the second case being subject to irreparable damage upon introduction of foreign matter thereinto.

I have discovered that the difficulties referred to can be completely avoided by forming one of the elements of a resilient material. The advantages of this type of construction are numerous and will be pointed out specifically. Generally speaking, either the pinion 30 or the annular gear 15 may be formed of the resilient material, but for various reasons it is preferable to form the annular gear 15 of the resilient material. A number of materials may be employed in the construction of the resilient member, but I have discovered that highly satisfactory results are obtained when the resilient member is formed of a rubberous material.

The necessity for accurate machining of the parts is avoided by employing rubber. Furthermore, it is possible to obtain a much more efficient seal than has hitherto been obtained by forming one of the members of rubber. The use of rubber as a material for forming the resilient member also offers another important advantage in that it may be effectively lubricated by water when the pump is employed as a water pump.

I have found that the most efficient results are obtained when the annular member 15 is formed of rubberous material and is made to fit snugly without binding within the chamber 14. Also the annular member 15, if formed of rubber, is made so as to bear with a slight pressure against the closure plate 20, thus insuring a perfect seal at this point.

In addition to this, the pinion 30 may be made just slightly oversize so that when placed in mesh with the annular gear 15 the resilient material of the gear 15 is slightly compressed. The pinion 30 is made of such a size that it bears against the closure plate 20 and forms a tight seal therewith.

In operation I have found that the pump constructed in accordance with the present teachings operates with high efficiency and provides a substantially perfect seal. This may be readily explained by the fact that each tooth 31 of the pinion 30 as it slides against the corresponding surface of the annular gear 15 pushes a slight wave of the resilient material ahead and thus provides a sealing surface of substantial extent. Due to the material employed, this engagement between the parts does not produce excessive friction since the parts are efficiently lubricated by the fluid being pumped. Even where the pump is employed as an air pump, it has been found that the friction resulting from this efficient sealing engagement between the teeth is not excessive.

Another important advantage of the material specified herein is that if particles of sand or

grit pass through the pump they will readily embed themselves in the resilient member and will not cause damage to the metallic member. This is to be contrasted with pumps made according to prior teachings in which a particle of grit would cause irreparable damage to the surface. In order for pumps comprising two metallic intermeshing gears to operate with reasonable efficiency, it was necessary for the engaging surface to be ground or otherwise finished to an extremely high degree of accuracy.

According to the present teachings, inaccuracies in machining the parts do not seriously affect the efficiency of the pump, since by employing a resilient and slightly compressible material these inaccuracies do not permit leakage of fluid past the pumping members.

In Figures 8 and 9 I have indicated a complete pump which comprises a base 40 to which is secured a pair of plates 41 and 42. The plate 41 is bolted or otherwise rigidly secured to the base 40 and, as shown in Figure 8, the plate 42 is bolted directly to the plate 41 by bolts 43. Intermediate the plates 41 and 42 is a housing 44, whose shape is indicated best in Figure 9. The housing 44 has an internal cylindrical chamber 45 and is provided with inlet and outlet connections 46 and 47 communicating with valve slots 48 and 49. The closure plates 41 and 42 have valve openings of the shape indicated generally at 25 and 26 in Figures 1 to 3.

The internally toothed, annular rotor is indicated in Figure 9 at 50 and, as shown in this figure, has a cylinder or sleeve member 51 secured to the outer surface thereof, which will later be described in detail. The member 50 is for the most part formed of resilient, compressible material, such for example as a good grade of rubber, either natural or synthetic.

The driving pinion is indicated at 52 and is shown in Figure 9 as in internal meshing relation with the annular member 50. The pinion 52 is preferably of metal, although it may be formed of fiber or other material. The pinion 52 is keyed or otherwise secured to a shaft 53 which extends through suitably formed openings in the base 40 and the end plate and is connected to a motor or other suitable driving mechanism.

The internally toothed annular rotor 50 and driving pinion 52 are made slightly oversize relative to each other. The amount of oversize may be on the order of a few thousandths of an inch and results in the tips of the teeth of the pinion 52 being slightly embedded in the compressible, resilient material of the rotor 50 as indicated for example at 54.

When the term oversize or relatively oversize is employed, it is meant to imply that one or both of the parts is larger than would be possible for proper meshing relation if the parts were made of incompressible material. It will be appreciated, of course, that in making an internally toothed member oversize, the teeth extend farther towards the axis of the annular member, whereas in making an externally toothed pinion oversize the teeth extend farther from the axis than otherwise. This explanation is given at this time so as to avoid the necessity of importing unnecessary and merely explanatory verbiage into the claims. It will further be understood that with the parts relatively oversize as herein described, it is perfectly proper to speak of either part as oversize with respect to the other.

As best seen in Figure 8, the housing 44 is ad-

justable in all directions in a plane perpendicular to the axis of the rotor 50 and the pinion 52. This adjustment is provided by reason of the enlarged opening 55 through which pass the bolts 43. As indicated in Figure 8, the casing 44 is in a mid position and it may be adjusted either vertically or horizontally, or in a direction oblique to the vertical and horizontal an amount limited by the clearance between the walls of the openings 55 and bolt 43.

The driving shaft 53 is supported rigidly by suitable journaled bearings in the frame 40 and end plate 41 so that this adjustment of the housing 44 in effect provides for adjustment between the rotor 50 and pinion 52.

This adjustment is permitted by reason of the compressibility of the teeth of one of the parts, preferably the rotor, as will be readily apparent. It may be stated in general that this adjustment is useful in compensating for wear between the rotor and the pinion. It has a further important utility in modifying the pump operation in accordance with the characteristics of the fluid being pumped. Thus, for example, if heavy oil or a relatively viscous liquid is being pumped, it will be desirable to adjust the housing and, accordingly, the rotor 50 downwardly relative to the pinion 52 so as to provide an increasingly effective seal in the pressure zone. Where water, for example, is being pumped, the opposite adjustment may be made.

Referring now to Figure 10, I have indicated the annular, internally toothed rotor 50 as formed generally of a block of compressible, resilient material, such as rubber, and as provided with an integrally attached cylinder or sleeve 51 of a material adapted strongly to resist distortion. This is a very important feature of my improved pump. The resilient, compressible material of which the teeth of the rotor 50 are formed is, of course, subject to distortion, particularly under high pressure. Accordingly, without the provision of the cylinder or sleeve 51, it is found that sometimes the rotor 50 tends to bind in the housing 44. Even where actual binding does not occur, the tendency towards distortion inherent in the compressible, resilient material increases friction to an undesirable degree.

By providing a cylinder or sleeve 51 formed of hard rubber, metal, fiber, or other material, this tendency towards binding is almost entirely avoided.

Instead of providing a cylinder or sleeve 51 of metal or fiber, or some other material, the rubber rotor 50 may be treated in a particular manner so as to accomplish a substantially similar result. Thus, for example, while the inner surface on which the teeth of the rotor are formed may be relatively resilient and compressible, the outer surface may be compounded and treated of rubber so as to form a very strong, hard rubber which strongly resists distortion and which also slides freely within the housing 44.

A further modification of my pump is illustrated diagrammatically in Figure 11 in which I have indicated at 52 in full lines the outline of a pinion or an impeller whose teeth 60 are strictly conjugate to the tooth form of the rotor 50. I prefer to modify the tooth contour of the pinion or impeller 52 by relieving or cutting away the same intermediate the teeth 60 such relief being shown at 61. This, as will be readily appreciated, in operation provides clearance at all times between the relieved surfaces 61 and the portions

of the teeth of the rotor 50, which would otherwise engage in sliding contact therewith.

This relief is on the order of .030 of an inch or, in other words, considerably larger than the relative oversize condition existing between the rotor 50 and the pinion or impeller 52. Consequently, even with the oversize condition referred to, the relief at 61 will provide clearance under all conditions. This clearance is important in operating conditions where foreign matter, as for example grains of sand or the like, are carried by the fluid being pumped. It will be appreciated that the flow of fluid through the pump is axially with respect to the rotor 50 and pinion 52; that is, the fluid is introduced from one end between the gears and flows out, either from the same end or from the other end. In the embodiment illustrated, valve openings are preferably provided in the surfaces of the plates 41 and 42 to increase the capacity of the pump. Accordingly, sand which may be introduced into the pump in most cases is never introduced between the tips of the teeth 60 and the compressible material of the rotor 50. However, in cases where the sand may be thus included, it will merely be embedded in the rubber and will subsequently be expelled from the pump without causing permanent injury to the parts.

Referring again to Figure 10, it will be noted that the cylinder or sleeve 51 is of less width than the rotor 50 so that the rotor 50 extends beyond the edges of the cylinder or sleeve 51, as indicated at 62. This is an important structural feature, since it permits the end surfaces of the rotor which are formed of resilient, compressible material, as hereinbefore described, to engage directly and sealingly with the surfaces of the end plates or closures 41 and 42. This substantially increases the effectiveness of the seal without at the same time requiring highly accurate machining. If desired, slight pressure may be exerted between the plates 41 and 42 on the end surfaces 63 of the rotor 50.

It may be mentioned that the amount of adjustability provided for the housing 44 may be very slight, and adjustments of more than .010 of an inch is seldom required.

I have found that a pump constructed according to the present teachings offers another important advantage in that it runs with almost perfect quietness. This will be readily appreciated since it will be seen that only rotary parts are employed and that all engaging surfaces which might produce noise provide a metal to rubber or metal to other resilient material contact. The pump disclosed herein is capable of many applications and it will be understood that according to the fluid for which it is designed the materials may be selected so as to operate efficiently therewith. Thus for example, I have found that while rubber is highly efficient as a resilient material, in some cases it is desirable to substitute another resilient material which will not be adversely affected by the fluid being pumped. I, therefore, wish it clearly understood that I do not desire to be specifically restricted to rubber as a material but that other resilient materials may be employed without departing from the scope of my invention.

This application is a continuation in part of my prior copending application, Serial No. 217,524, entitled "Rotary pump," filed July 5, 1938.

While I have illustrated and described two specific embodiments of my rotary pump, it will be understood that the same has been done solely

to enable those skilled in the art to practice the invention, the scope of which is indicated by the appended claims.

What I claim as my invention is:

1. In a pump of the character described, a cylindrical housing having fluid inlet and outlet ports at an end thereof, an annular, internally toothed rotor having an outer smooth cylindrical surface closely fitting within said housing, the outer surface of said rotor being adapted strongly to resist distortion, the internally toothed portion of said rotor being formed of resilient compressible material, a driving pinion of lesser number of teeth than said rotor meshed internally therein, said pinion being slightly oversize radially with respect to said rotor and being formed of substantially incompressible material whereby the teeth of said pinion will be embedded slightly in the compressible material forming the teeth of said rotor, and means for driving said pinion.
2. In a pump of the character described, a cylindrical housing having fluid inlet and outlet ports at an end thereof, an annular, internally toothed rotor formed of resilient, compressible material, a cylinder or ring surrounding and secured to said rotor and fitting snugly within said housing, said ring being of a material adapted strongly to resist distortion, a driving pinion of lesser number of teeth than said rotor meshed internally therein, said pinion being slightly oversize radially with respect to said rotor and being formed of substantially incompressible material whereby the teeth of said pinion will be embedded slightly in the compressible material forming the teeth of said rotor, and means for driving said pinion.
3. In a pump of the character described, a cylindrical housing having fluid inlet and outlet ports at an end thereof, an annular, internally toothed rotor formed of resilient, compressible material, a metal cylinder or ring surrounding and secured to said rotor and fitting snugly within said housing, a driving pinion of lesser number of teeth than said rotor meshed internally therein, said pinion being slightly oversize radially with respect to said rotor and being formed of substantially incompressible material whereby the teeth of said pinion will be embedded slightly in the compressible material forming the teeth of said rotor, and means for driving said pinion.
4. In a pump of the character described, a cylindrical housing having fluid inlet and outlet ports at an end thereof, an annular, internally toothed rotor formed of resilient, compressible material, a cylinder or ring surrounding and secured to said rotor and fitting snugly within said housing, said ring being of a material adapted strongly to resist distortion, said cylinder or ring being of slightly less axial extent than said rotor, whereby said rotor may directly engage the end walls of said cylindrical housing, a driving pinion of lesser number of teeth than said rotor meshed internally therein, said pinion being slightly oversize radially with respect to said rotor and being formed of substantially incompressible material whereby the teeth of said pinion will be embedded slightly in the compressible material forming the teeth of said rotor, and means for driving said pinion.
5. In a pump of the character described, a cylindrical housing having fluid inlet and outlet ports at an end thereof, an annular, internally toothed rotor having an outer smooth cylindrical surface closely fitting within said housing, the

outer surface of said rotor being adapted strongly to resist distortion, the internally toothed portion of said rotor being formed of resilient compressible material, a metallic driving pinion of lesser number of teeth than said rotor meshed internally therein, said pinion being slightly over-size radially with respect to said rotor whereby the teeth of said pinion will be embedded slightly in the compressible material forming the teeth of said rotor, and means for driving said pinion, said casing being adjustable in a plane perpendicular to the axes of said rotor and pinion to vary the amount which the teeth of the pinion are embedded in the compressible material forming the teeth of said rotor at one side of said rotor.

6. A pump of the class described comprising a base, a plate rigidly secured thereto, said base and plate being apertured, a drive shaft passing through said apertures, a second plate secured to said base and first plate in spaced, parallel relation, a cylindrical housing mounted between said plates, an annular member having internal teeth formed of compressible, resilient material and an outer surface adapted strongly to resist distortion rotatably mounted in said housing, a rigid driving pinion carried by said shaft in said housing in meshing relation with said annular member, said housing being adjustable between said plates relative to the axis of said shaft in a plane perpendicular thereto whereby the tips of the teeth of said pinion may be embedded different amounts as desired in the compressible resilient material of the teeth at one side of said annular member.

7. A pump of the class described comprising a base, a plate rigidly secured thereto, said base and plate being apertured, a drive shaft passing through said apertures, a second plate secured to said base and first plate in spaced, parallel relation, a cylindrical housing mounted between said plates, an annular member having internal teeth formed of compressible, resilient material and an outer shell of material adapted strongly to resist deformation rotatably mounted in said housing for free rotation, a rigid driving pinion carried by said shaft in said housing in meshing relation with said annular member, said housing being adjustable between said plates relative to

the axis of said shaft in a plane perpendicular thereto whereby the tips of the pinion teeth may be embedded to a selected depth into the compressible resilient material of the internal teeth at one side of said annular member.

8. In a pump of the character described, a cylindrical housing having fluid inlet and outlet ports at an end thereof, an annular, internally toothed rotor having an outer smooth cylindrical surface closely fitting within said housing and rotatably mounted therein, the internally toothed portion of said rotor being formed of resilient compressible material and the outer surface of said rotor being adapted strongly to resist distortion, a rigid driving pinion of lesser number of teeth than said rotor meshed internally therewith, means for driving said pinion, and means for adjusting said housing together with said rotor relative to said pinion in a plane perpendicular to the axes of said rotor and pinion to cause the tips of said pinion teeth to become embedded a desired amount in the resilient compressible material of the internally toothed portion of said rotor.

9. A pump comprising a cylindrical housing having spaced inlet and outlet ports in an end of said housing; an annular, internally toothed rotor rotatably mounted in said housing, the inner or toothed portion of said rotor being resilient and compressible, the outer surface of said rotor being adapted strongly to resist distortion; a driving pinion having one less tooth than said rotor meshed internally therewith and forming pumping chamber therebetween; said chambers passing over and registering alternately within said inlet and outlet ports during rotation of said rotor and pinion, the teeth of said pinion being formed of substantially incompressible material, the peripheral surface of said pinion being cut away intermediate the teeth to form clearance with the rotor portion cooperating therewith at full intermesh therebetween; means for driving said pinion; said rotor and pinion being relatively sized and positioned such that, adjacent the said outlet and inlet ports, the tips of the teeth of said pinion are slightly embedded in the inner surface of said rotor.

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