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INTERNAL-EXTERNAL GEAR PUMP WITH SELF-SEALING TOOTH TIPS

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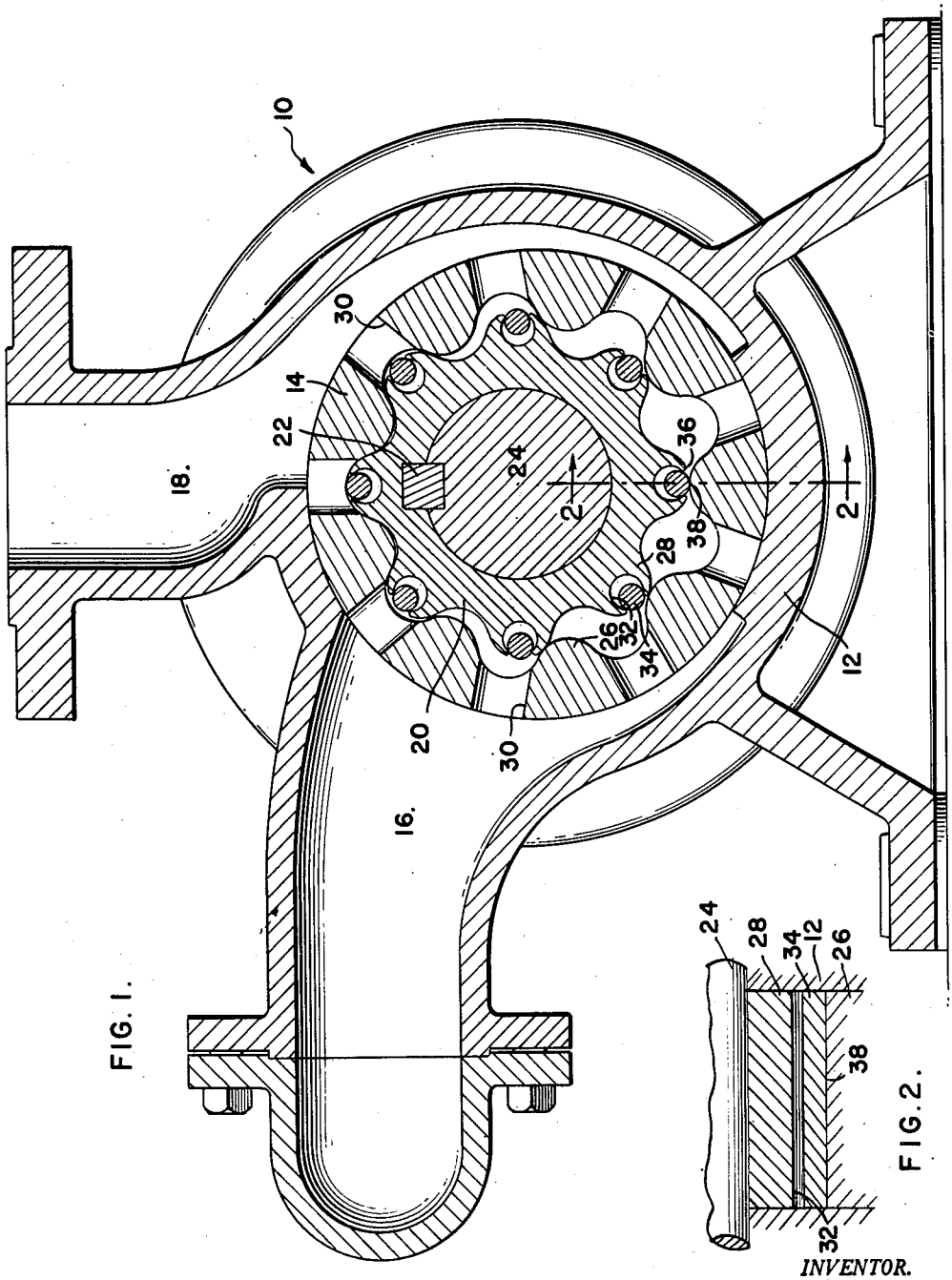


FIG. 1.

FIG. 2.

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INTERNAL-EXTERNAL GEAR PUMP WITH SELF-SEALING TOOTH TIPS

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4 Claims. (Cl. 103—126)

The present invention relates to new and useful improvements in internal-external gear pumps of the type disclosed in U. S. Patent No. 2,055,587 (Pigott) issued September 29, 1936, and more particularly pertains to means for preventing leakage between the tips of the external gear teeth and the tips of the internal gear teeth and the manufacture of such means.

With nominal tooth tip clearances in conventional pumps of the type to which the present invention relates, it has been found that with increasing discharge pressure, say in the neighborhood of 400 pounds per square inch and up, volumetric efficiency falls off with tooth tip leakage accounting for approximately sixty to seventy percent of the total leakage.

An obvious solution for minimizing the loss of high volumetric efficiency at high discharge pressures due to tooth tip leakage is to reduce clearance tolerances between tooth tips. However, there is an objection common to most conventional methods for accomplishing the desired reduction in tolerance between tooth tips; such as precision machining, and where hardened gears are required, the teeth must be form ground, lapped, or contour ground to fit, due to distortion of the gears in heat treating and hardening processes; and such objection is that gears so fashioned are not readily subject to mass production fabrication techniques, and require special operations which increase manufacturing costs considerably. Furthermore, such processes are obviously of avail in the manufacture of new pumps only, and gears of extant pumps may not be so modified as to maintain a high volumetric efficiency at high discharge pressures.

It is therefore the fundamental aim of the instant invention to provide an internal-external gear pump that will maintain a high volumetric efficiency at high discharge pressures, and to afford a method of manufacturing gear components of such a pump that is economical and well adapted to production basis manufacturing techniques.

A purpose ancillary to the above-mentioned fundamental aim is to provide an economical method of treating the internal gear component of extant conventional internal-external gear pumps so as to increase the volumetric efficiencies thereof at high discharge pressures.

The instant invention realizes the aim and purpose thereof by the provision of rollers loosely received in retaining sockets provided at the tooth tips of the internal gear; such sockets being expeditiously and economically formed by drilling an opening in each tooth parallel to the axis of the gear and substantially tangent to the tooth tip, removing the thin sections of metal adjacent the tooth tip, and inserting a roller endways into the opening. A pump provided with such a modified internal gear will operate in such a manner that the rollers are urged outwardly by centrifugal force into rolling and sealing contact with the tooth tips of the external gear to thereby avoid the excessive tooth tip leakage usually experienced by conventional pumps of this type, particularly at high pump discharge pressures.

The invention will be fully appreciated in the light of the hereinafter detailed description taken in conjunction with the accompanying drawings, wherein:

Figure 1 is a central sectional view of a conventional internal-external gear pump provided with an internal gear modified in accordance with the invention, with such view being taken upon a plane perpendicular to the axis of the gears; and,

Figure 2 is a fragmentary sectional detail view taken upon the plane of the section line 2—2 appearing in Figure 1.

The general type of pump illustrated in the drawings and to which the principle of the subject invention is shown applied is well known, and the specific pump illustrated is fully disclosed and the operation thereof described in the previously-mentioned U. S. Patent No. 2,055,587 (Pigott), issued September 29, 1936. Accordingly, the conventional components of the pump illustrated in the drawings and the operation thereof will only be dealt with briefly to afford a basic understanding of a typical environment in which the subject invention may be utilized.

The pump, designated generally at **10**, comprises a pump housing or casing **12** in which an external gear **14** is rotatably mounted. The housing **10** is shaped to form an inlet port **16** and an outlet port **18** with such ports being in communication with spaced peripheral portions of the external gear **14**. An internal gear **20** is disposed within the external gear **14** and keyed at **22** upon a rotatable drive shaft **24** that is eccentric to the external gear **14**.

The gears **14** and **20** are intermeshed and rotate at different speeds by virtue of the external gear **14** being provided with teeth **26** that are greater in number by one than the teeth **28** of the internal gear **20**. The external gear **14** is provided with radial openings **30** that extend from the spaces between the teeth **28** to the exterior of the gear.

It will be evident upon inspection of Figure 1 that counterclockwise rotation of the shaft **24** will cause corresponding rotation of the gears **14** and **20**, and that during rotation the space volume between corresponding teeth **26** and **28** will progressively increase during the time such space volume has communication through openings **30** with the inlet port **16**, and will progressively decrease during the time such space volume has communication through openings **30** with the outlet port **18**. Such operation will cause a fluid in the inlet port **16** to be drawn through openings **30** into space between the gears, and subsequently to expel such fluid through openings **30** from between the gears **14** and **20** into the outlet or discharge port **18**.

However, it is of importance to the successful realization of the above-described pumping function that fluid leakage does not occur in any substantial amount between contacting outer end portions or tips of the teeth **26** and **28**, particularly in that portion of tooth travel where the teeth are in open mesh or in the neighborhood of 180° rotation from where the teeth **26** and **28** are in mesh. It is to this consideration that the subject invention addresses itself, the heretofore described construction of the pump **10** being old.

In order to effect an adequate fluid-tight seal between the tips of teeth **26** and **28** of the character defined in the preceding paragraph, the present invention utilizes conventionally shaped cooperating teeth **26** and **28** that are contoured to establish driving and sealing contact therebetween, with the exception that the teeth **28** are modified to the extent hereinafter set forth.

Each tooth 28 is provided with a substantially circular hole or socket 32 that opens radially through the outer extremity of the tooth 28, and which hole or socket 32 extends throughout the axial length of the tooth 28. A roller 34 is loosely received in each of the sockets 32 and is of the same axial length as the tooth 28 in which it is disposed. Such rollers 34 are preferably metal, but may be formed of other materials as when a corrosion resistant pump is desired, it being apparent that various factors may govern the selection of a suitable material. The rollers 34 may be of the same material as teeth 28, or of softer or harder material as may be deemed expedient. Preferably, however, the rollers 34 are of hardened steel.

As clearly illustrated in Figure 1, each socket 32 is of reduced dimensions where it opens to the exterior of the tooth 28 to define a narrow entrance thereto, so as to limit radial movement of the roll 34 outwardly therefrom, yet permitting the roller to assume a position to constitute a tip for its associated tooth 28. In the preferred construction, the surfaces of the portions of the tooth 28 defining the restricted entrance to the socket 32 are rounded or convexly contoured, as at 36. The arrangement is such that a roller 34 may establish a line of contact with a tooth 26, as indicated at 38, that extends the entire axial length of the tooth 28, and that such a line of contact 38 may be continuously maintained for an angular interval, both preceding and following the angular position relative to the axis of the internal gear 20 of the line of position 38 shown in Figure 1. In addition, the arrangement is such that the roller 34, while establishing the line of contact 38, maintains at least one line of contact with the portions of the tooth 28 defining the restricted entrance to the socket 32, as will be apparent on inspection of Figure 1.

The operation of the pump 10 incorporating the modified internal gear teeth 28 will be readily understood. During rotation of the shaft 24, centrifugal force maintains the rollers 34 in their radial outward limited positions as shown in Figure 1. As a pair of teeth of the external gear 14 and the internal gear 20 move into opposition, the roller 34 involved establishes a sealing line of contact 38 with the tooth 26 involved and maintains such sealing line of contact at least until the roller 34 of the next following tooth 28 establishes a similar line of contact with its opposed tooth 26. By virtue of the roller 34 also being in contact with its associated tooth 28, fluid is prevented from by-passing the sealing line of contact 38 through the socket 32.

The contact between rollers 34 and the teeth 26 is of rolling character so that roller wear and wear of the tips of the teeth 26 are of very little consequence, particularly in view of the fact that the rollers 34 may rotate in the sockets 32 with more than rotational running clearance so as to present new wearing surfaces. Even with wear of the rollers 34, the condition is substantially self-compensating as the rollers 34 may then shift radially a corresponding amount to establish contact with the teeth 26. In addition, it should be noted that the relative rotation of the gears, one on the other, is small. For example, in the 8 to 9 ratio gear pump shown in Figure 1, the internally toothed gear rotates at 8/9 the speed of the externally toothed gear, so that the relative movement between such gears is 1/9 the rotational speed of the externally toothed gear.

It is also to be observed that the pump 10 may be operated as a fluid driven motor so that fluid pressure applied at the inlet port 16, or outlet port 18 for that matter, will cause the shaft 24 to rotate. Whether the pump 10 is used as a pump or a motor, the rollers 34 serve the same sealing function.

Although it is thought that it will be evident to those skilled in the art, it is thought advisable to emphasize that the use of the roller feature at the tooth tips of the internal gear is not restricted to the specific form of internal-external gear pump illustrated in the drawings, but is of general application in pumps of this type.

Tests have been conducted on a small conventional pump before and after the incorporation of rollers, in accordance with the invention, at a discharge pressure of 600 pounds per square inch with both a 100 SUS oil and a 70 SUS oil. With the 100 SUS oil the incorporation of rollers increased the rate of discharge from 1.81 to 2.29 gallons per minute, which corresponds to changing the volumetric efficiency percent from 74 to 93, a net increase in volumetric efficiency of 19 percent. With the 70 SUS oil, even more beneficial results were noted as the incorporation of the rollers changed the rate of discharge from 1.65 to 2.26 gallons per minute, corresponding to changing the volumetric efficiency per cent from 67.4 to 92, or a net increase in volumetric efficiency of 24.6 percent.

Attention is now invited to the method of making internal-external gear pumps incorporating the hereinbefore described roller feature. It should be noted at the outset that the method is applicable to the manufacture of new pumps, or the modification of extant pumps even though the latter may have been previously used so as to amount to a revitalization thereof.

Since the modified pump differs from conventional pumps of the internal-external gear type solely in the tooth construction of the internal gear, the pump, other than for such single distinguishing feature, may be fabricated by any of the known techniques. The method of the invention is specifically applicable to the formation of the sockets 32 and the positioning of the rollers 34 therein.

In describing such method, it is assumed as a starting point that an internal gear has been fabricated which, without further modification, would be operative in the usual manner with an external gear intended for use therewith. The treatment of such internal gear comprises drilling a circular hole through each tooth along an axis parallel to the axis of the gear with each of such holes being so disposed as to be in the neighborhood of tangency to the extreme tip of the tooth through which it is drilled. It will be noted that such a hole in a tooth will be in such a position as to be substantially tangent to the tip of a tooth of the external gear when such teeth are in open mesh and directly opposed. It will be appreciated that such holes will constitute the major portion of the sockets 32 previously described. The thin remaining portion or portions of the tooth adjacent the area that the circular hole most closely approaches the periphery of the tooth are then removed, as by grinding, cutting or machining, and preferably, though not essentially, to leave the portions of the tooth defining the restricted entrance to the socket 32 smoothly rounded, as at 36 in the drawings. Actually, the removal of such thin portion or portions of the tooth is essential only when the circular hole is tangent to the tooth tip or is entirely within the tooth. The critical consideration is that the hole drilled in the tooth must have radial communication through the tip of the tooth to permit the outer periphery of the roller to contact the teeth of the external gear, and that such communication be of such limited extent as to prevent a roller loosely positioned in the hole from passing entirely through the communication afforded.

Rollers of substantially less diameter than the circular holes and of greater diameter than the radial entrance to the sockets defined by the holes are inserted endways in the holes, after which the internal gear is assembled with the remaining parts of the pump in a conventional manner.

It is to be noted that in the use of the above-described method in manufacturing new pumps, only such integral peripheral portions of the internal gear teeth that are not removed in the formation of the sockets need be fashioned

to the desired tolerance, as the rollers serve as a substantial effective portion of the teeth.

The apparatus and method have been described in considerable detail in the interest of conveying a complete understanding thereof, and not to thereby limit the same as numerous modifications within the spirit of the invention will suggest themselves to the person skilled in the art, and reference should therefore be made to the appended claims to ascertain the actual scope of the invention.

I claim:

1. A method of treating the internal gear of internal-external gear type pumps of the type wherein the tips of teeth contact each other that are diametrically opposed to the teeth in full mesh to increase the volumetric efficiency of such pumps, comprising the steps of drilling a circular hole in each tooth of the internal gear that is parallel to the axis of the gear and that is approximately tangent to the tip of the tooth, removing the thin remaining portion of the tooth in the area that the drilled hole most closely approaches the tip of the tooth to define a restricted radial entrance to the drilled hole through the tip of the tooth, and inserting a roller endways into each drilled hole that is of a diameter substantially less than the drilled hole and substantially greater than the width of the restricted radial entrance to the drilled hole.

2. A method of treating the internal gear of internal-external gear type pumps of the type wherein the tips of teeth contact each other that are diametrically opposed to the teeth in full mesh to increase the volumetric efficiency of such pumps, comprising the steps of drilling a circular hole in each tooth of the internal gear that is parallel to the axis of the gear and that is tangent to the tip of the tooth, removing the thin remaining portions of the tooth adjacent the line of tangency between the drilled hole and the tip of the tooth to define a restricted radial entrance to the drilled hole through the tip of the tooth, and inserting a roller endways into each drilled hole that is of a diameter substantially less than the drilled hole and substantially greater than the width of the restricted radial entrance to the drilled hole.

3. An internal-external gear pump comprising a toothed external gear and a toothed internal gear, said

internal gear being eccentrically disposed within the external gear with teeth of said gears being in full mesh and with teeth diametrically opposed to such meshing teeth being in open mesh, the teeth of said gears having contours that establish driving and sealing contact therebetween except when the teeth are in open mesh, and means for establishing a seal between the teeth of said gears that are in open mesh, said means comprising each tooth of the internal gear having an axially extending hole of substantially circular cross section therethrough that opens radially throughout the length of the tooth through the outer extremity of the tooth to define a restricted radial entrance to the hole, a roller axially disposed in said hole, said roller having a diameter greater than the width of the restricted radial entrance, said roller having a diameter sufficiently less than the diameter of the hole to provide more than rotational running clearance for the roller and also to permit the roller to move radially outward with respect to the internal gear and into rolling and sealing contact with the outer end portion of a tooth of the external gear that is in substantially direct opposition to the internal gear tooth in which the roller is disposed.

4. The combination of claim 3, wherein the circular cylindrical surface generally defined by the hole in a tooth of the internal gear is substantially tangent to the outermost extremity of a tooth of the external gear when such teeth are in open mesh and in direct opposition, and wherein the surfaces of each internal gear tooth defining the restricted radial entrance into the hole therein are convexly contoured.

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