July 9, 1946. J. C. HANNA 2,403,796

GEAR PUMP

Filed May 15, 1943 2 Sheets-Sheet 1

Fig. 1

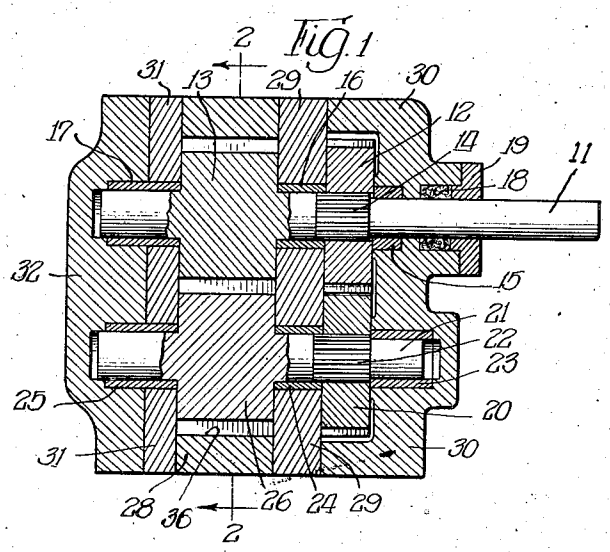


Fig. 2

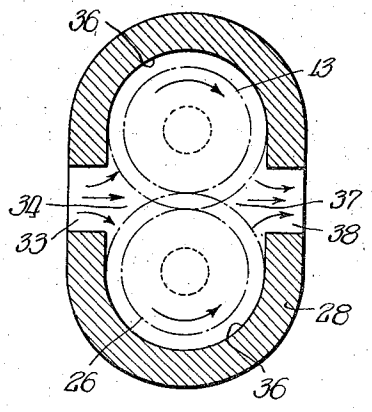


Fig. 3

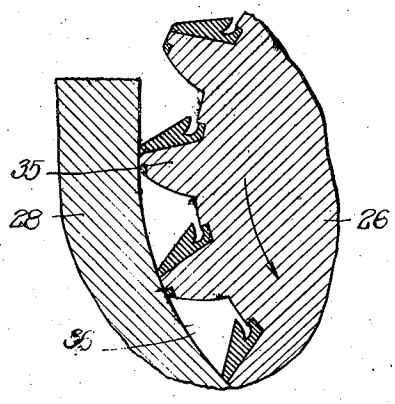


Fig. 8

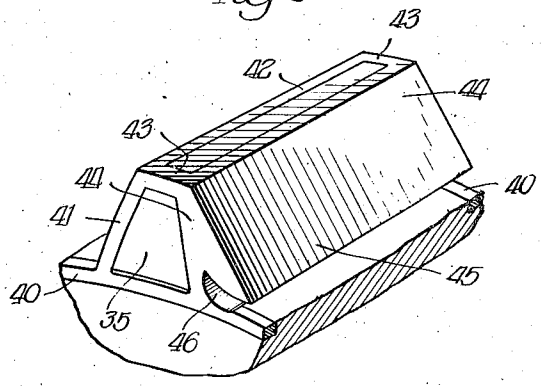
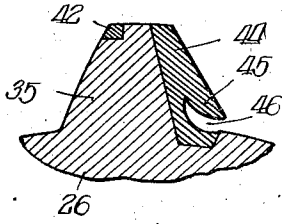


Fig. 9



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July 9, 1946. J. C. HANNA 2,403,796

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Filed May 15, 1943 2 Sheets-Sheet 2

Fig. 4.

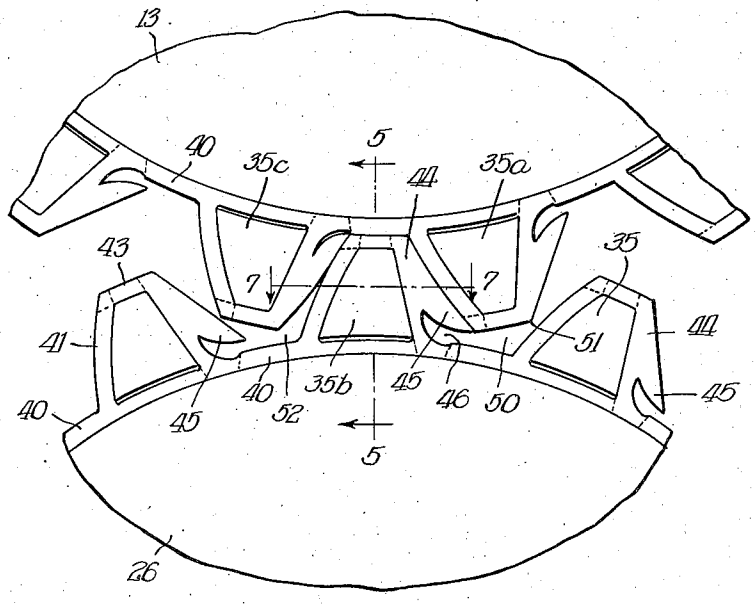


Fig. 5

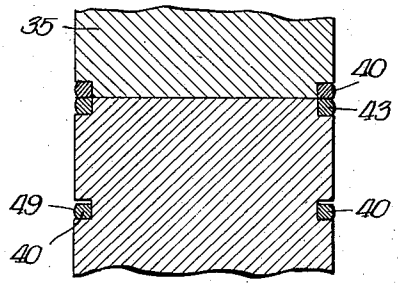


Fig. 6.

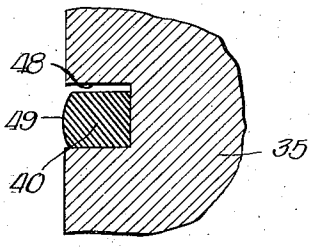
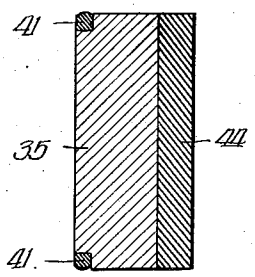


Fig. 7



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UNITED STATES PATENT OFFICE

2,403,796

GEAR PUMP

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Application May 15, 1943, Serial No. 487,076

7 Claims. (Cl. 103—126)

1

The invention relates to gear pumps and has reference more particularly to an improved construction of pump which will operate with a minimum of slippage and noise and which will have increased output per revolution in comparison to other gear pumps of equal size operating at the same speed.

The conventional gear pump essentially consists of two mating gears of equal diameter and equal width rotating in a closely fitting housing. The oil or other liquid is drawn into the housing at one side of the gear pump and is propelled to the opposite side by means of the gear teeth which trap the liquid in the spaces between the gear teeth and a wall of the housing and carry it around in the direction of rotation of the gears. Since it is the function of a pump to deliver liquid at an increased pressure over that supplied to the pump and since present day requirements demand higher and higher pressures, the prevention of leakage or slippage, as it is commonly called, is of the first importance. In the case of a gear pump with its metal to metal construction, extreme accuracy in forming and aligning and close watchfulness in operation and maintenance are required. Notwithstanding the care that may be exercised in the construction and operation of gear pumps, nevertheless slippage is at all times a serious factor even at rated outputs. When the pumps are operated below their rated capacities obtained by a reduction in speed, extremely low operating efficiencies result.

With the pump in operation liquid is delivered by each gear to the outlet side of the pump which thus contains liquid under a high pressure. The teeth on the respective gears approach each other as they enter and pass through this outlet space, gradually coming in contact. The space between the teeth is irregular due to the shape of the teeth and as the teeth approach each other, finally coming into contact, most of the liquid is forced out, being actually forced in a direction opposite to the direction of movement of the teeth. At a certain point in its rotary travel a tooth is located in a tooth space in a manner to close the space, with the result that a small quantity of liquid is nipped off and pinched between the gears. This trapped liquid is infinitesimally compressible and thus the same acts like a solid to push the gears apart. This action takes place for each passing tooth and the same is truly a toggle action, being destructive to the gears, shafts and bearings, and causing excessive vibration and noise which for many applications makes this type of pump impractical.

2

When the teeth leave their line of contact and enter the inlet of the pump, which is a space of low pressure, a totally opposite action takes place since the teeth are separating at this time with the formation of small sealed spaces under negative pressures, which negative pressures tend to draw the gears together. This vacuum forming action, although probably not as great as the pressure forming action, nevertheless adds to the wear, vibration and noise heretofore produced by pumps of this type.

Therefore an object of the invention is to provide a gear pump of improved construction which will obtain maximum output with acceptable operation by eliminating the nipping and pinching of the liquid between the gears and by the use of resilient material on the gear teeth which aids in accomplishing the above and also is substantially eliminating slippage.

In conventional gear pumps as heretofore constructed the gears had two very distinct and in a sense contradictory or opposing functions, namely, to transmit power, and to pump liquid. It is a well known fact in the transmission of power by gears that over-all efficiency, which takes into account friction, abrasion, smoothness of running, noise and other factors, is best secured when the number of teeth on the gears is relatively large, that is, when the size of each tooth is small in relation to the diameter of the gear. On the other hand, when used in the gear pump, delivery increases closely in proportion to the increase in the size of the teeth, the gear diameter and width remaining constant.

Another object of the invention is to provide a gear pump having teeth of relatively large size on the pumping gears and wherein means are provided in the nature of driving gears to obtain a smooth driving connection between the pumping gears.

With these and various other objects in view, the invention may consist of certain novel features of construction and operation, as will be more fully described and particularly pointed out in the specification, drawings and claims appended hereto.

In the drawings which illustrate an embodiment of the invention and wherein like reference characters are used to designate like parts—

Figure 1 is a sectional view of the improved pump of the invention in the plane of the axes of the two shafts;

Figure 2 is a sectional view of the pump taken through the pumping gears substantially along line 2—2 of Figure 1;

Figure 3 is a fragmentary sectional view showing the manner in which the liquid is trapped in the spaces between the gear teeth and the housing and propelled in the direction of rotation of the gears;

Figure 4 illustrates the mode of operation of the mating gear teeth as they initially make contact on the outlet side and break contact on the inlet side;

Figure 5 is a sectional view taken substantially along line 5—5 of Figure 4;

Figure 6 is an enlarged view of a portion of Figure 5;

Figure 7 is a sectional view of one of the teeth substantially along line 7—7 of Figure 4;

Figure 8 is a perspective view of one of the teeth of the pumping gears showing the manner of fitting the resilient packing thereto; and

Figure 9 is a sectional view more clearly illustrating the combination metal and resilient packing gear tooth.

Referring more particularly to Figure 1, the gear pump of the invention is suitably driven from any external source of power by means of shaft 11 which carries the driving gear 12 and the pumping gear 13. The pumping gear 13 is shown integral with shaft 11, whereas gear 12 is splined to the shaft by means of internal teeth formed in the central opening of the gear, which teeth have interfitting relation with grooves 14 on shaft 11. Shaft 11 is suitably journalled in the gear housing by means of bearings 15, 16 and 17. The packing 18 and the packing gland 19 serve to prevent leakage of the liquid in an axial direction along shaft 11. The gear 12 has meshing relation with a similar gear 20. Said gear 20 drives the follower shaft 21 since said gear is splined to the follower shaft by means of teeth formed in the gear which have interfitting relation with grooves 22 provided on said follower shaft. The bearings 23, 24 and 25 suitably journal follower shaft 21 and thus the integral pumping gear 26 of substantially the same size and width as gear 13 and which has meshing relation with said gear.

The housing for the present pump consists of a gear section 28, a bearing section 29, a cover 30 for the driving end, a second bearing section 31, and a cover 32 for the closed end. In assembling the pump the shafts with their pumping gears are inserted within a portion of the housing formed by the gear section 28, the bearing section 31 and the end cover 32. The bearing section 29 is then applied, whereupon the driving gears 12 and 20 are fitted to the driving and follower shafts respectively. The end cover 30 is then applied to complete the housing, it being understood that the various sections of the housing are suitably bolted or otherwise secured together to provide a unitary structure.

The driving gears 12 and 20 are so named because shafts 11 and 13 are driven by them. The splined relation which the driving gears have with their respective shafts provides for an accurate and permanent fit such as will give minimum play and therefore a minimum of back lash. By this means the relatively angular motions of gears 12 and 20 are definitely controlled while at the same time the splined connection permits easy assembly with longitudinal adjustment. Ample clearance is provided between driving gears 12 and 20 and the end cover 30 so that said gears may have free rotation. This arrangement makes possible the necessary lubrication of the gears under a low level of oil with the avoidance of undue heating of said gears and likewise the oil.

Figure 2 illustrates the manner in which the pumping gears operate to pump liquid which is drawn into the housing through the inlet 33, the inlet space thus provided being indicated by numeral 34. The liquid is propelled in the direction of rotation of the gears since it is trapped in the spaces formed by the gear teeth 35 and the arcuate surfaces 36 of the groove in the gear section 28 of the housing. The liquid is discharged into the outlet space 37 and eventually said liquid is conducted from the housing through outlet 38. In Figure 3 a portion of Figure 2 has been enlarged to illustrate the smooth gradual approach of the teeth 35 into contact with the arcuate surface 36 of the gear section.

The present invention is based on the concept that the best means of preventing leakage between two relatively moving parts is to make one of these parts of metal or other rigid material with as perfect surfaces as possible both as to form and finish and to make the contacting portions of the other relatively moving parts of a soft and highly resilient material which will rub against the hard surfaces with sufficient pressure to prevent leakage of the liquid between them. In the following description this resilient part is called packing and the same is mounted upon and securely attached to the metal of each gear tooth.

Referring more particularly to Figures 4, 5, 7 and 8, it will be seen that each gear tooth indicated in its entirety by numeral 35 consists partly of metal and partly of resilient packing. The packing includes strips 40 of small cross sectional area which extend around each gear on the respective sides thereof approximately at the clearance circle and which therefore have contact with the gear teeth at the roots of the teeth. The circular strips 40 for each gear are joined by integral portions having interfitting relation with the metal of the their respective tooth. As shown in Figure 8, the circular strip 40 has an integral strip 41 extending upwardly at the corner of the tooth 35 and on the leading side thereof which is integral with a strip 42 extending along the top edge of the tooth also on said leading side. The connecting strips 43 join the portion 44 thereto, which portion covers the entire area of the tooth on the follower side. The said portion 44 of the resilient packing applied to each tooth includes a flap 45 adapted to fit into a recess or space 46 when pressure is applied to said flap.

The resilient packing applied to each gear tooth effectively prevents leakage between the trunk portion of the gears and the bearing sections 29 and 31 from the high pressure or outlet side back into the low pressure or inlet side. The circular strips 40 function primarily to accomplish this objective. In Figures 5 and 6 the strips 40 are shown in section and it will be observed that groove 48 is somewhat larger than said strips. This groove makes it possible for the liquid under pressure to act against the surface of the strip thus exposed by the groove in such manner as to force the curved front surface 49 against the wall of its adjacent bearing section.

Leakage between the pump gears and said bearing sections from one tooth space to the next tooth space is prevented by the pressure of portion 44 of the packing which is mounted on the follower side of each tooth, against the said bearing sections 29 and 31, which pressure is caused

by the lateral spread of portion 44 under the pressure of the liquid while the teeth are moving from the outlet space to the inlet space. Corner strips 41 are provided to guard against leakage between the end areas of the teeth and said bearing sections during the passage of the teeth from the inlet space to the outlet space. Leakage over the addendum from one tooth space to the next tooth space during travel of the teeth between the outlet side and the inlet side is prevented by the contact between the mating teeth. Tightness over the addenda of the teeth is made more secure by the action of centrifugal force upon the flaps 45 which acts additionally with the pressure of the liquid to force the flap against the following tooth. Leakage over the addendum from one tooth space to the following tooth space during the travel of the teeth from the inlet space to the outlet space is prevented by the corner strips 42.

The trapping and pinching of the liquid during a portion of the angle of approach of the gear teeth is a source of vibration and noise as already described and said action additionally causes stresses on the gears and shaft. The resilient packing for the gear teeth eliminates the above objection in the following manner:

Referring more particularly to Figure 4, it will be seen that tooth 35 on gear 26 is just coming into contact with tooth 35*a* on gear 13. Tooth 35*a* is in contact with tooth 35*b*. This full contact is due to the differential pressure effect on the flap caused by the pressure of the liquid. The centrifugal action on the flap serves to make this contact more effective. In the position of the gears shown in Figure 4 the liquid is escaping from space 46 through the gap 50 which is still open although the same is gradually closing. Due to the resilient character of the packing material slight excess of pressure created in the liquid which is being forced from between the gears deforms the tooth 35*a* at the corner 51 sufficiently to allow practically all the liquid to be forced out of the gap 50. During this discharging action space 46 has been closed by its flap 45, which flap is gradually forced into closing position beginning at the extreme inner end of its space 46. This closed condition is shown by contact of gear tooth 35*c* with tooth 35*b*. Rotation of the teeth away from the line of contact causes movement of the teeth away from each other to produce a gradually opening gap identified by numeral 52. The provision of the flap with its free end toward this increasing space makes it possible for the liquid to be drawn into this space as the same is being created.

It can be shown mathematically that a pump having gear teeth of large size will deliver a greater volume of liquid per revolution than if the gear teeth were smaller in size, their pitch diameter and width being the same in both cases. The per revolution output of the present pump is therefore increased over present designs by making the gear teeth of ample size insofar as is practicable and smooth operation is attained by providing auxiliary driving gears which leave the pumping gears with only one operation to perform, namely, that of pumping the greatest volume of liquid for any particular speed and with the minimum of slippage. Smooth operation is further assured by the provision of resilient packing on each gear tooth of the pumping gears. This eliminates nipping and pinching of the liquid between gears which has been the

source of excessive strain, noise and vibration in pumps as heretofore constructed. In providing a resilient contact with the rigid metal parts of a coacting tooth the packing additionally prevents leakage of the liquid especially past the line of contact from the high pressure side to the low pressure side. Any reduction in leakage or slippage, as it is generally called, increases the efficiency of the pump.

The invention is not limited to or by details of construction of the particular embodiment thereof illustrated by the drawings as various other forms of the device will of course be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims. For example, although the present gear pump has been described as having particular utility in the pumping of oil and other liquids, the said device is not necessarily limited thereto since it can be used very advantageously in the pumping or compressing of air and other gases.

What is claimed is:

1. In a gear pump, a housing, a driving shaft and a follower shaft journalled by the housing in spaced parallel relation, a pumping gear fixed to each shaft, said gears having meshing relation whereby the teeth of said gears have contact as they approach, pass through, and leave the plane of said shafts, a compartment provided by the housing adapted to receive said gears, an inlet to said compartment on one side of the plane of contact, an outlet for said compartment on the opposite side of said plane of contact, and resilient material on the teeth of each pumping gear whereby said teeth consist partly of rigid material and partly of resilient material, said material being located at the edges only of each tooth on the leading side thereof and extending to completely cover the follower side of each tooth from edge to edge and from top to bottom thereof.

2. In a gear pump, a housing, a driving shaft and a follower shaft journalled by the housing in spaced parallel relation, a pumping gear fixed to each shaft, said gears having meshing relation whereby the teeth of said gears have contact as they approach, pass through, and leave the plane of said shafts, a compartment provided by the housing adapted to receive said gears, an inlet to said compartment on one side of the plane of contact, an outlet for said compartment on the opposite side of said plane of contact, and resilient material on the teeth of each pumping gear whereby the teeth consist partly of rigid material and partly of resilient material, said material having location only in recesses at the edges of each tooth on the leading side of the same and extending in recesses on the top of each tooth at the respective sides to completely cover the follower side thereof edge to edge and from top to bottom of the tooth.

3. In a gear pump, a housing, a driving shaft and a follower shaft journalled by the housing in spaced parallel relation, a pumping gear of metal fixed to each shaft, said gears having meshing relation whereby the teeth of said gears have contact as they approach, pass through, and leave the plane of said shafts, a compartment provided by the housing adapted to receive said gears, an inlet to said compartment on one side of the plane of contact, an outlet for said compartment on the opposite side of said plane of contact, resilient material on the teeth of each pumping gear whereby said teeth consist partly

of metal and partly of resilient material, said resilient material having location in recesses at the edges of each tooth on the leading side and extending in recesses on the top of each tooth to completely cover the follower side thereof, and said resilient material on the follower side providing a flap located adjacent the base of each tooth space for eliminating the pinching and trapping of liquid in said tooth space during meshing of the gear teeth.

4. In a gear pump, a housing, a driving shaft and a follower shaft journalled by the housing in spaced parallel relation, a pumping gear of metal fixed to each shaft, said gears having meshing relation whereby the teeth of said gears have contact as they approach, pass through, and leave the plane of said shafts, a compartment provided by the housing adapted to receive said gears, an inlet to said compartment on one side of the plane of contact, an outlet for said compartment on the opposite side of said plane of contact, resilient material on the teeth of each pumping gear, said material completely covering the follower side of each tooth and providing a flap located adjacent the base of its tooth space, and a gap located directly below said flap, whereby the pinching and trapping of liquid in said tooth space during meshing of the gear teeth is substantially prevented by the maintenance of an exit from the diminishing tooth space made possible by the resilient nature of said material.

5. In a gear pump, a housing, a driving shaft and a follower shaft journalled by the housing in spaced parallel relation, a pumping gear of metal fixed to each shaft, said gears having meshing relation whereby the teeth of said gears have contact as they approach, pass through, and leave the plane of said shafts, a compartment provided by the housing adapted to receive said gears, an inlet to said compartment on one side of the plane of contact, an outlet for said compartment on the opposite side of said plane of contact, resilient material on the teeth of each pumping gear, said material completely covering the follower side of each tooth and providing a flap located adjacent the base of its tooth space, and a gap located directly below said flap, whereby suction action caused by a tooth moving out of its tooth space is substantially prevented by

the maintenance of a passage into the increasing space made possible by the resilient nature of the material.

6. In a device for providing fluid power, a pair of cooperating rotary pumping elements, a housing for said pumping elements providing an inlet and an outlet on the respective sides of the housing, a pair of driving gears for operatively connecting said rotary pumping elements whereby the elements are maintained in definite relation with each other, resilient material in associated relation with the individual gear teeth of each said rotary pumping element for preventing leakage past said teeth from the high pressure side to the low pressure side of the housing during a pumping operation, said resilient material completely covering the follower side of each tooth and including portions located in recesses at the edges of each tooth on the leading side thereof and extending in recesses across the top of each tooth at the sides thereof, and circular strips of resilient material having location on the respective sides of each rotary pumping element approximately at the clearance circle for joining with said portions on the gear teeth.

7. In a device for providing fluid power, a pair of cooperating rotary pumping elements, a housing for said pumping elements providing an inlet and an outlet on the respective sides of the housing, a pair of driving gears for operatively connecting said rotary pumping elements whereby the elements are maintained in definite relation with each other, resilient material in associated relation with the individual gear teeth of each said rotary pumping element for preventing leakage past said teeth from the high pressure side to the low pressure side of the housing during a pumping operation, said resilient material completely covering the follower side of each tooth and including portions located in recesses at the edges of each tooth on the leading side and extending in recesses on the top of each tooth at the sides thereof, and circular strips having location in recesses on the respective sides of each rotary pumping element approximately at the clearance circle for joining with said portions on the gear teeth and with said resilient material covering the follower side of the teeth.

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