

Aug. 29, 1961

TAKEHIKO KIMIJIMA ET AL

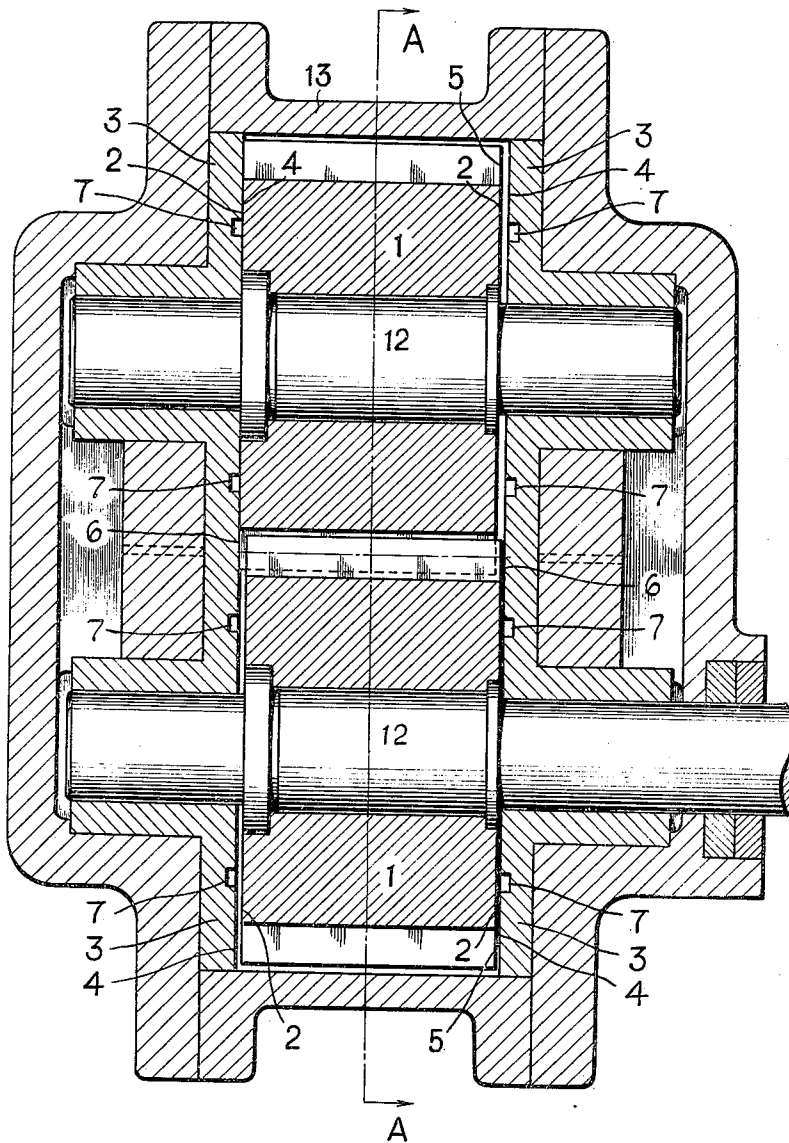
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GEAR PUMP

Filed Dec. 20, 1957

7 Sheets-Sheet 1

FIG. 1



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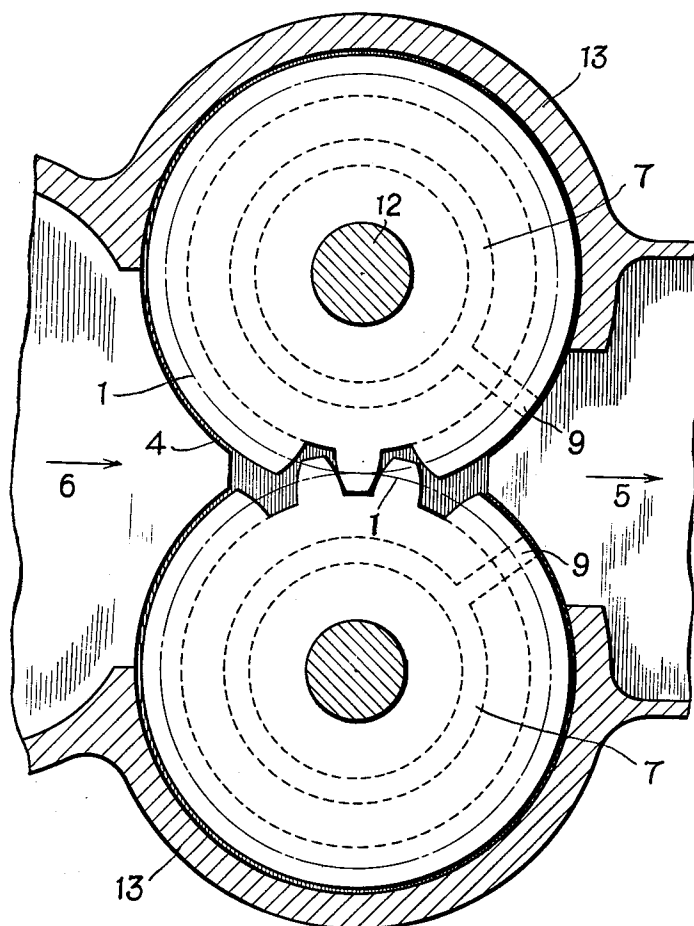
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GEAR PUMP

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7 Sheets-Sheet 2

FIG. 2



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2,997,960

Filed Dec. 20, 1957

7 Sheets-Sheet 3

FIG. 3

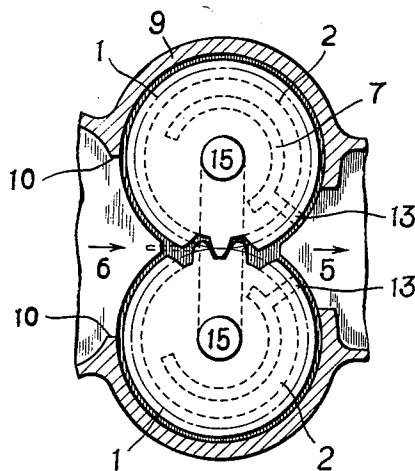
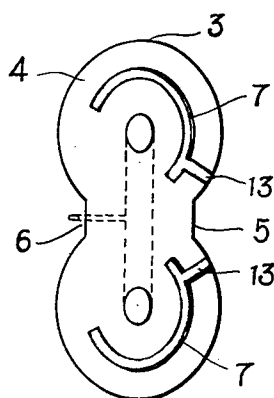


FIG. 4



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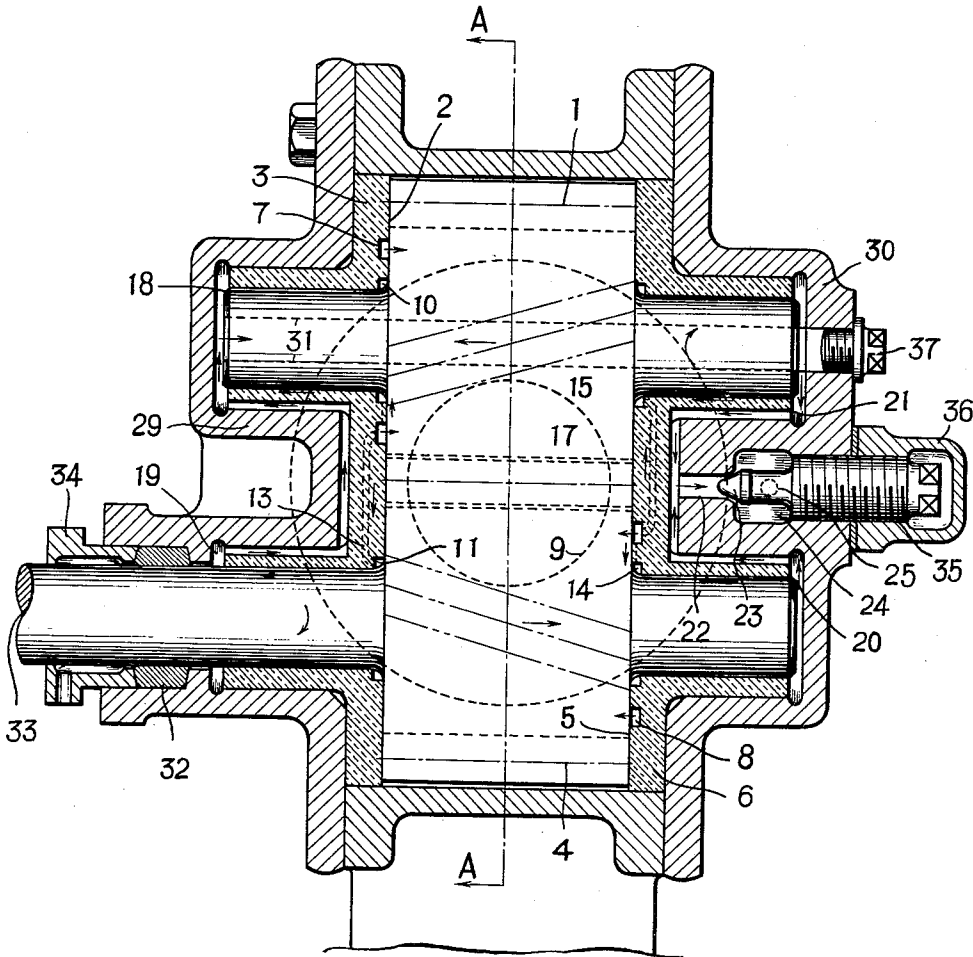
TAKEHIKO KIMIJIMA ET AL  
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2,997,960

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7 Sheets-Sheet 4

FIG. 5



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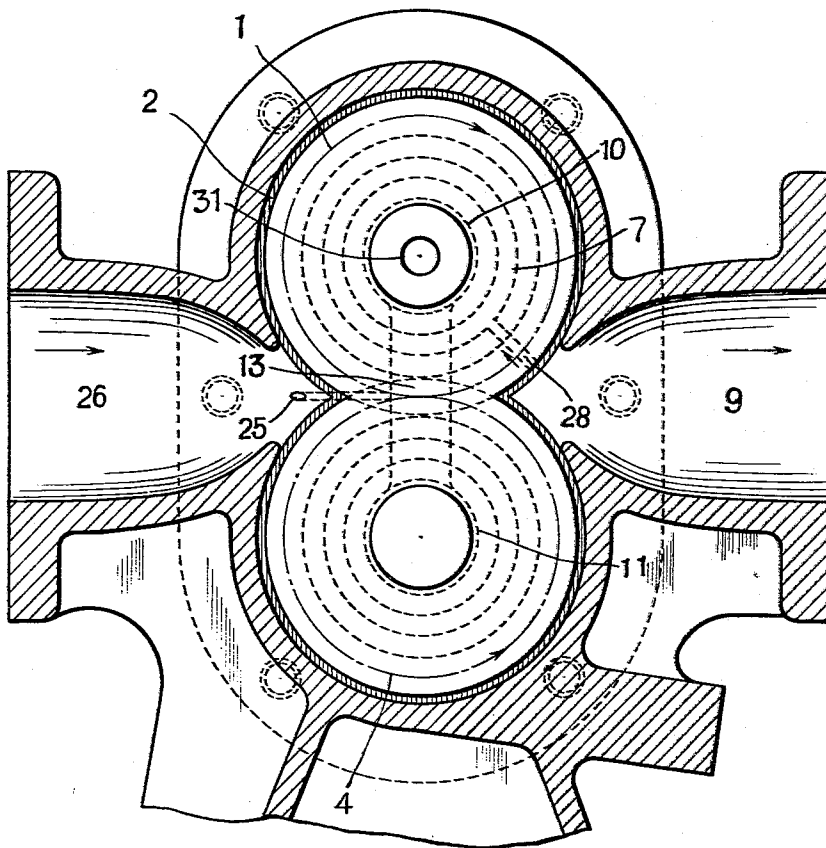
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GEAR PUMP

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7 Sheets-Sheet 5

FIG. 6



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2,997,960

GEAR PUMP

Filed Dec. 20, 1957

7 Sheets-Sheet 6

# PERFORMANCE CURVES FOR WATER GEAR PUMP

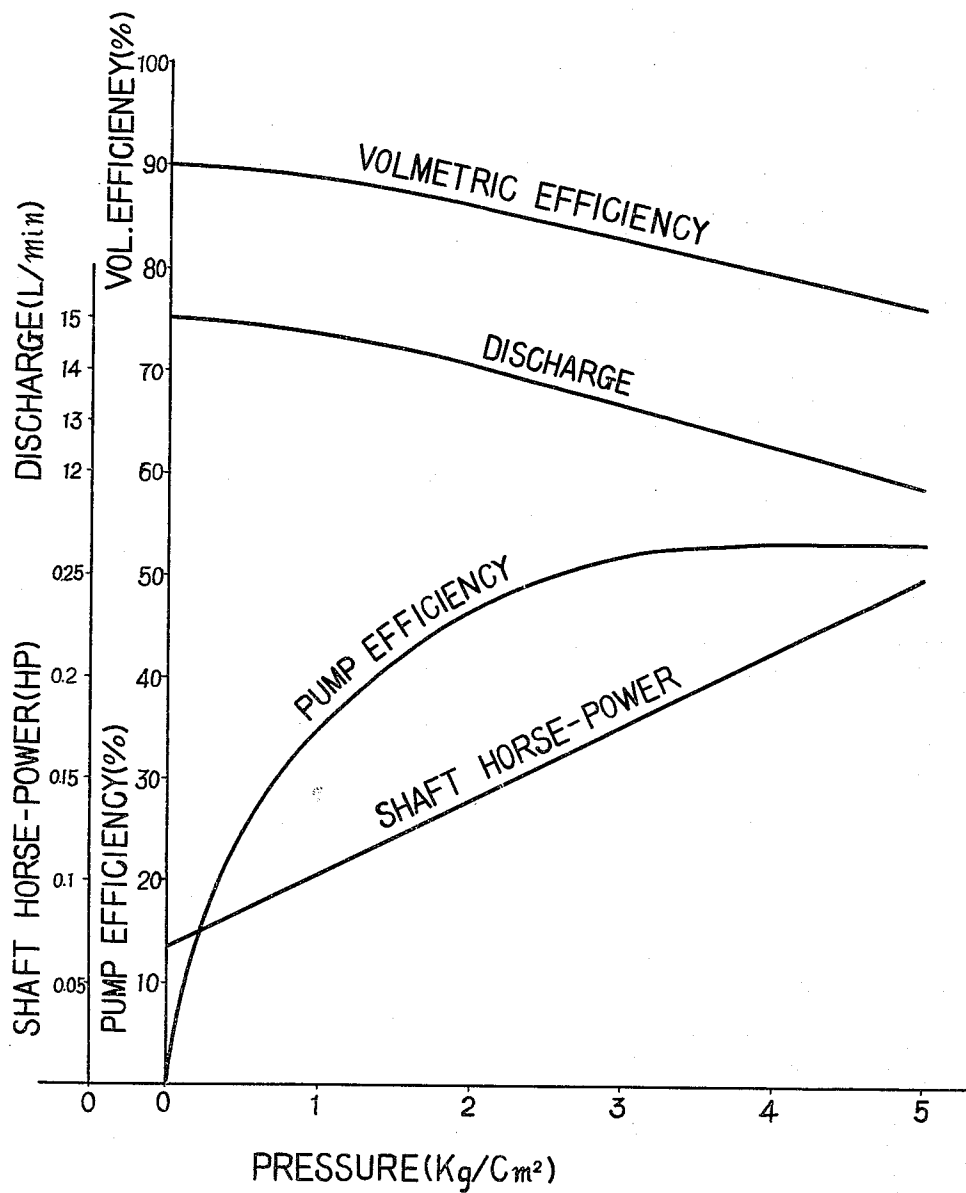


FIG. 7

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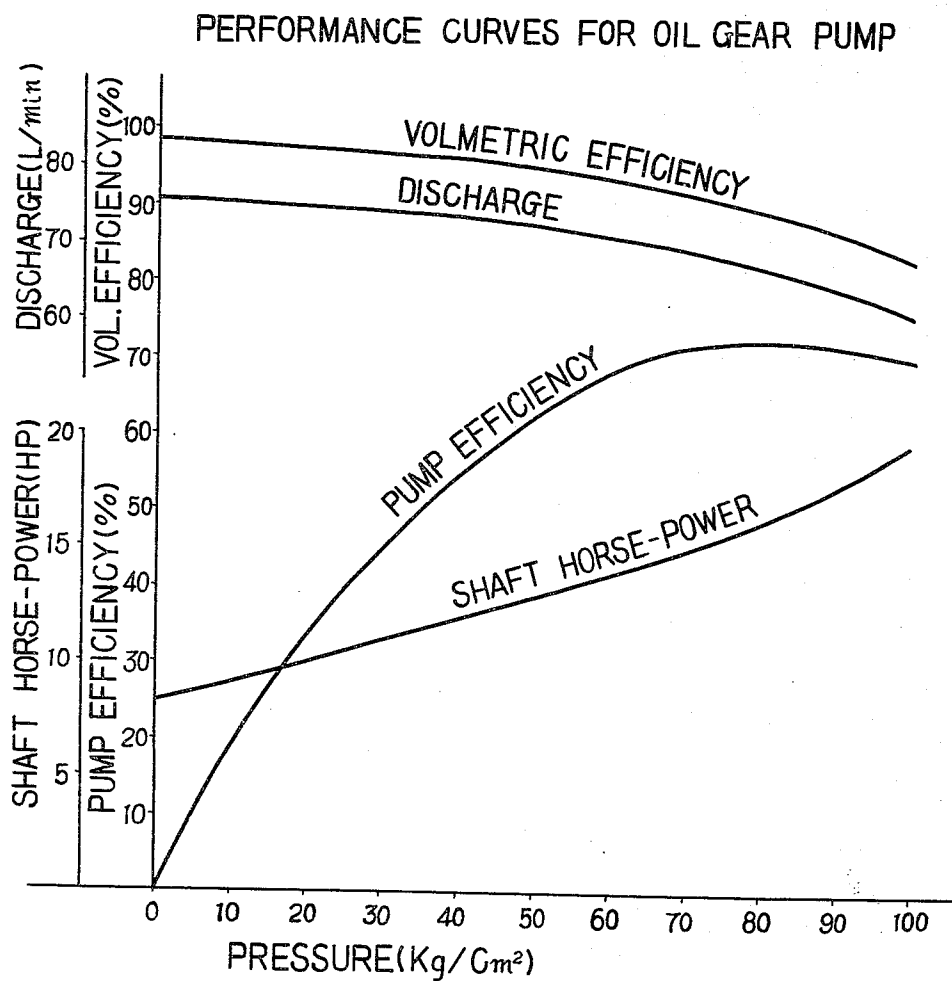
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GEAR PUMP

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7 Sheets-Sheet 7

FIG. 8



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GEAR PUMP

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2 Claims. (Cl. 103-126)

This invention relates to the improvements in a gear pump, wherein a groove of suitable shape is provided on each inner face of gear casing, bush or liner, and a connecting groove is provided thereon at a portion of said groove to connect it to the delivery side of the gear pump.

The groove may be provided on each side face of a pair of gears and may be made optionally in its shape, such as a circle, polygon, irregular form etc. and as closed or non-closed form, located concentrically or eccentrically to the axis of each gear.

In the abovementioned construction, the pressure liquid leaks from the delivery side to the suction side through side grooves and through side clearances of gears and either through bearings or directly.

In the known gear pumps comprising a pair of spur gears or of double helical gears, especially of single helical gears, running efficiency thereof is considerably lowered due to the friction between both side faces of gears and both inner faces of the gear casing, bush or liner of the casing facing therewith, even though the meshing of gears and the bearings of gear shaft are arranged with the greatest possible care.

Conventional gear pumps are generally used up to 1,800 r.p.m. and 1,000 lb./in.<sup>2</sup> as their maximum capacity, however, their characteristics are considerably lowered with the increase of running time, accompanied with noise due to the friction between the side faces of the gears and the inner faces of the casing, bushes or liners, when used at high pressure and high speed. Especially, when light oil or water which has poor lubricating property is used as working liquid, known gear pumps are not durable in continuous running even when operating at low speed and low pressure.

It is an object of the invention to facilitate better operation of gear pumps running at high pressure and high speed by keeping a pair of gears under balanced pressure of a working liquid, free from axial thrust, noise of running, and trapping of liquid between gears, etc.

Another object of the invention is to obtain gear pumps of high efficiency with simple construction and easy workmanship without requiring any precise finish.

A further object of the invention is to obtain gear pumps of larger capacity than heretofore in use, not only of horizontal axes but also of vertical axes.

The details of the invention will be made clear from the following description of exemplified embodiments in connection with the accompanying drawings, in which

FIG. 1 is a longitudinal sectional view including gear axes of a spur gear pump with circular grooves.

FIG. 2 is a cross sectional side view taken along the line A-A of FIG. 1.

FIG. 3 is a sectional view of a spur gear pump with non-closed grooves.

FIG. 4 is a perspective view of the inner face of the gear casing, facing to one side of a pair of spur gears in FIG. 3.

FIG. 5 is a longitudinal sectional view of a single helical gear pump.

FIG. 6 is a cross sectional view taken along the line A-A of FIG. 5.

FIG. 7 shows performance curves for a water gear pump.

FIG. 8 shows performance curves for an oil gear pump.

In FIG. 1 and FIG. 2, on each inner face 4 of both

2

side faces of gear casing 3, 3 facing both side faces 2, 2 of a pair of gears 1, 1, there are provided circular grooves 7, 7 respectively and out of portions thereof, connecting grooves 9, 9 are arranged radially extending to the delivery side 5 of the gear pump. 12, 12 are shafts of gears 1, 1 and 13 is the gear casing.

In the above construction, when gears 1, 1 running in normal conditions are not subjected to any axial thrust between both sides 3, 3 of the casing, the pressure liquid at the delivery side 5 (in FIG. 2) flows to grooves 7, 7 through the connecting grooves 9, 9 and both side faces 2, 2 of the gears 1, 1 are pressed by equal pressure from right and left, and the gears are running in a completely balanced condition. However, when any gear (or gears) is thrust for any reason to one direction, for example to the left side as shown at the upper gear 1 of FIG. 1, the clearance between the inner face 4 of right side 3 of the gear casing and the right side face 2 of the gear 1 is increased, and the pressure liquid in the right side groove 7 flows to the suction side 6, through said increased clearance. At this moment, the pressure in right side groove 7 becomes lower naturally, so that the gear 1 is pushed back to the right as shown by an arrow mark in FIG. 5 by higher pressure in the left side groove 7, which pressure being equal to the delivery pressure. Reversely, when the gear (or gears) is thrust to the right side, the pressure in the left side groove 7 becomes lower, so that the gear 1 is pushed back to the left, and in either case, the gear 1 is restored to its normal position and smooth running is maintained.

In the above construction, when the liquid pressure becomes 50-80 p.s.i. and the gear teeth become larger compared with the size of gears 1,1, the pressure liquid supplied from the delivery side 5 to the grooves 7, 7 will be able to maintain the balancing, however, the proportion of the liquid quantity, which leaks directly from the suction side 6 of the grooves 7, 7 to the same suction side, increases comparatively, so that the volumetric efficiency of the gear pump tends to drop to about 60%.

To eliminate the above defect, the above construction is improved as shown in FIG. 3 and FIG. 4, wherein the grooves 7, 7 are so formed that they are not integral circles but are limited arcs of a curvature over 180° but are lacking a segment of the circles in wider ranges than the space from the ends 10, 10 of the suction side 6 of the gear casing 9 to the center of gearing of the gears 1, 1. The space between the ends of said grooves 7, 7 is greater than the distance from the inlet openings 10, 10 to the center of the gears 1, 1.

Consequently, in the grooves 7, 7, there is no such portion as to face the suction side 6, so that the quantity of pressure liquid, which leaks to the suction side 6, is remarkably decreased and the volumetric efficiency becomes 70-75%, while the balancing of the gears 1, 1 is maintained without any trouble.

Grooves or restricted passages 13 extend from each of the arcuate grooves 7 defined on the bearings on each side of the gears to the outlet 5. The passages are dimensioned so that the pressures in grooves 7 will be substantially the same as the delivery pressure at 5 when the gears are in a balanced condition. However, when the gears are displaced in a direction toward a groove on one side the pressure therein will rise since flow out the passage 13 is restricted. The rise in pressure causes a force on the side of the gear face urging it back to a correct balanced location.

It is noticed that above mentioned construction of the gear casing is available not only for spur gears but also for double helical gears with much higher volumetric efficiency.

In case of a single helical gear pump, it is well known that gear cutting and assembling thereof are more simple

3

than those of the double helical gear pump, however, there are inevitable defects such as axial thrust due to the meshing of inclined gear teeth.

According to the invention, such axial thrust can easily be eliminated by adjustable balancing with the liquid pressure of the delivery side of the gear pump, which is shown in FIG. 5, FIG. 6 and is described in detail as follows, for an example of method.

The circular grooves 7 and 8 provided on the respective faces of bush 3, which is facing the thrust face 2 of driven gear 1, and of bush 6 of the opposite side, which is facing the thrust face 5 of driving gear 4, and said grooves are connected with the delivery side 9 through guide grooves provided on each bush 3, 6, and the circular groove 7 is connected with bearing portion 10 of the same side of the driven gear 1 and with bearing portion 11 of the same side of the driving gear 4 respectively through side clearance of gears and groove or bore hole 13 which is provided on bush 3, and similarly on bush 6 of the opposite side, the circular groove 8 is connected with bearing part 14 of driving gear 4 and with bearing portion 15 of driven gear 1 respectively through groove or bore hole 17, and further on a valve opening 22, which is connected with outer ends 18, 19, 20 and 21 of each of bushes 10, 11, 14 and 15, a control valve 23 is faced, and its valve chamber 24 is connected with suction side 26 through a return hole 25.

More particularly, the circular groove 7 is connected with the delivery side 9 by means of a guide groove 28 and similarly the circular groove 8 is connected with the delivery side 9 and the outer ends 18, 19, 20 and 21 of the bush of each bearing portion are connected with a valve opening of the cover 30 on the side where the control valve chamber is provided; through the clearance or passage between the cover 29, 30 and bush 3, 6 and through bore hole 31 of the driven gear shaft.

Consequently, the liquid partly returning from the delivery side 9 to the suction side 26 flows as the arrow marks in the drawing, while the counter balancing of the thrust for the gears 1, 4 and the lubrication for their bearings are effectuated.

In the drawings, 32 denotes a packing provided at the portion where the end of driving shaft 33 of the driving gear 4 is penetrating through the cover 29, and 34 is the gland thereof, 35 is a screw rod which moves the control valve 23 of the cover 30 of the opposite side against the valve opening 22, 36 is a cap nut to cover the exposed head portion of the screw rod, and 37 is a plug of connecting hole for the pressure gauge.

When this gear pump is in operation, the pressure liquid at the delivery side 9 flows to the circular groove of bush 3 through the guide groove 28, and the thrust side face 2 of the driven gear 1 is pushed as the arrow marks, counter-balancing the thrust of the gear 1, so that the gear side face 2 will be free from any friction from bush 3, and similarly no friction will be found between the opposite side bush 6 which is provided with the circular groove 8 connecting to the delivery side 9 and the thrust side face 5 of the driving gear 4, thus obtaining smooth running even for high pressure gear pumps with very high efficiency.

In practice, if the total pressure of the liquid led to circular grooves 7, 8 is adopted larger than the expected thrust of the gears 1, 4 respectively, the pressure liquid will flow out from each clearance which is slightly increased between the gear side faces 2, 5 and bush faces 3, 6, making liquid films and the gears 1, 4 are rotated in balanced conditions. The formation of liquid films is of help for raising volumetric efficiency as well as total efficiency of the gear pump. In the next place, the liquid, which is led from the circular grooves 7, 8 to the bearing parts 10, 11 and 14, 15 of each same side bush 3, 6 through the groove or bore hole 13, 17 respectively, lubricates the inner faces of bearings for bush 3, 6 and then flows together to the valve opening 22 through

4

said passages. Now, it is possible to make an easy control of liquid pressure against said thrust by adjusting the valve 23 and controlling the resistance of liquid which returns to the suction side 26 from the valve chamber 24 through the hole 25.

Thus, in the gear pumps according to the invention, there are always imposed liquid films between the side faces of a pair of gears and the faces of bush or liner of the casing, so that, at high speed and high pressure, the running of the pump is very smooth for any kind of liquid even above 3,000 r.p.m., and therefore, not only in small type oil pumps, it is possible to produce high pressure maintaining high revolution and high efficiency, but also in case of pure water of poor lubrication, it is easy to produce liquid pressure of more than 500 lb./in.<sup>2</sup>.

The following are some technical data obtained by practical gear pumps according to the invention.

| Gears                      | No. of teeth | Mod-<br>ule | Out-<br>side<br>dia.<br>(mm.) | Breadth<br>of teeth<br>(mm.) | Pres-<br>sure<br>angle,<br>degrees | Angle<br>of twist<br>degrees |
|----------------------------|--------------|-------------|-------------------------------|------------------------------|------------------------------------|------------------------------|
| Use:<br>1. For water...    | 10           | 2.5         | 31.845                        | 14                           | 20                                 | 10                           |
| 2. For oil.....            | 18           | 2.5         | 50.66                         | 40                           | 20                                 | 8                            |
| 3. For fire<br>service.... | 18           | 2.5         | 50.66                         | 44                           | 20                                 | 8                            |

As to the above table, the performance curves of a gear pump for water (Use 1) are shown in FIG. 7 and for oil (Use 2) in FIG. 8, and the following data are a running record of a water gear pump for fire service (Use 3).

| R.p.m. of pump | discharge<br>pressure,<br>kg./cm. <sup>2</sup> | discharge<br>quantity,<br>ltr./min. | volumetric<br>efficiency,<br>percent | electric<br>voltage,<br>volt | electric<br>current<br>ampere, |
|----------------|------------------------------------------------|-------------------------------------|--------------------------------------|------------------------------|--------------------------------|
| 3,480.....     | 0                                              | 110                                 | 91.7                                 | 220                          | 14.5                           |
| 3,460.....     | 10                                             | 105                                 | 88.0                                 | 220                          | 16                             |
| 3,440.....     | 20                                             | 98                                  | 82.6                                 | 220                          | 18                             |
| 3,400.....     | 30                                             | 92                                  | 78.4                                 | 220                          | 22.5                           |
| 3,350.....     | 35                                             | 87                                  | 75.3                                 | 220                          | 25                             |
| 3,250.....     | 40                                             | 84                                  | 74.9                                 | 220                          | 27                             |

It is hereby noticed that the above mentioned examples are not intended to limit the extent of the claim of the invention.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. A gear pump comprising a pump casing having an inlet and an outlet opening, spaced bearing walls defined in said casing having spaced bearing recesses, a pair of gears each having a shaft rotatably supported in respective ones of said bearing recesses, said gears being disposed between said inlet and outlet openings and having teeth, said teeth being in meshing engagement at a location between said openings, a groove defined in said bearing walls adjacent each side of each of said gears, each groove being located intermediate and out of communication with said bearing recesses and said gear teeth in respect to a radial direction and extending circumferentially from a spaced location from said inlet opening to a location adjacent said outlet opening by a total extent at least equal to one half the circumference of the associated gear at such radial location but less than the total circumference, a restricted passage other than clearance defined on each of said bearing walls and extending from each of said grooves to said outlet opening, said gears having side faces spaced from said bearing walls, the clearance between said gear side faces and said bearing walls, the dimension of said groove and the dimension of said restricted passage all being such that the pressure in said grooves is maintained at substantially the delivery pressure at said outlet when said pump is operating normally and when the gear shifts and the clearance between one side face of said gear and said bearing walls adjacent a respective groove becomes small the fluid will be trapped in said

groove and compressed therein and the pressure in the affected groove will rise while the fluid in the groove on the axially opposite end will leak to the inlet and the pressure therein will be reduced tending to restore the gear to a balanced condition disposed centrally between said bearing walls.

2. A gear pump comprising a housing having an inlet defined on one side and an outlet defined on an opposite side, bearing members disposed in said housing with opposed bearing walls laterally spaced and each including vertically spaced aligned bearing openings, a pair of gears each having a shaft rotatably supported in respective openings in said bearing members on each side of said gears and having teeth, said teeth being in meshing engagement between said inlet and outlet openings, said bearing walls extending radially to the periphery of said gears, a groove defined in each of the opposed faces of said bearing walls at locations spaced radially from said bearing openings and the root diameter of said gears and extending in an arc of at least 180° and less than 360° from a spaced location adjacent said inlet opening to a location adjacent the meshing engagement of said gears, a restricted passage, other than clearance, defined in said bearing members and extending from each of said grooves into communication with said outlet opening, said gears having side faces spaced from said bearing walls, the clearance between said gear side faces and said bearing walls, the dimension of said groove and the dimension of said restricted passage all being such that the pressure in said grooves is maintained at substantially the delivery pressure at said outlet when said pump is operating normally and when the gear shifts and the clearance between one side face of said gear and said bearing walls adjacent a respective groove becomes small the fluid will

be trapped in said groove and compressed therein and the pressure in the affected groove will rise while the fluid in the groove on the axially opposite end will leak to the inlet and the pressure therein will be reduced tending to restore the gear to a balanced condition disposed centrally between said bearing walls.

# References Cited in the file of this patent

## UNITED STATES PATENTS

|           |                  |                |
|-----------|------------------|----------------|
| 1,096,186 | Nesmith          | May 12, 1914   |
| 1,620,261 | Kennedy          | Mar. 8, 1927   |
| 1,795,579 | Storey           | Mar. 10, 1931  |
| 1,861,708 | Miki             | June 7, 1932   |
| 2,176,322 | Barrett          | Oct. 17, 1939  |
| 2,336,294 | Rea              | Dec. 7, 1943   |
| 2,391,072 | Pugh             | Dec. 18, 1945  |
| 2,412,588 | Lauck            | Dec. 17, 1946  |
| 2,424,751 | Heckert          | July 29, 1947  |
| 2,471,149 | Girz             | May 24, 1949   |
| 2,527,941 | Lauck et al.     | Oct. 31, 1950  |
| 2,626,570 | Armington et al. | Jan. 27, 1953  |
| 2,665,641 | Lauck            | Jan. 12, 1954  |
| 2,676,548 | Lauck            | Apr. 27, 1954  |
| 2,682,836 | Orr              | July 6, 1954   |
| 2,718,758 | Minshall et al.  | Sept. 27, 1955 |
| 2,756,684 | Renzo            | July 31, 1956  |
| 2,816,511 | Korkowski et al. | Dec. 17, 1957  |
| 2,820,416 | Compton          | Jan. 21, 1958  |
| 2,823,616 | Toyoda           | Feb. 18, 1958  |
| 2,870,719 | Murray et al.    | Jan. 27, 1959  |
| 2,870,720 | Lorenz           | Jan. 27, 1959  |
| 2,891,483 | Murray et al.    | June 23, 1959  |