THREE GEAR PRESSURE LOADED PUMP

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Application July 22, 1955, Serial No. 523,804
3 Claims. (Cl. 103—126)

This invention relates to a gear pump and more particularly to a gear pump of the type employing pressure loaded bushings or end plates, such pumps sometimes being referred to as pressure loaded pumps.

In pressure loaded pumps of the type including means defining a set of axially movable, pressure loadable bushings and end plates, hereinafter referred to as bushings, a part of the discharge pressure communicated by the pump is communicated to the rear or motive pressure surface of the axially movable bushings to urge the bushings into sealing relationship with their associated gears. As described in United States Patent No. 2,420,622 to John A. Lauck et al., by carefully selecting the relative areas of the forward surfaces and the rear or motive surfaces of the bushings, it is possible to control within very close limits the actual sealing pressure established during operation of the pump. Gear pumps so constructed are capable of delivering fluid at an extremely high pressure with considerable volume.

In the aforementioned pressure loaded pump of John A. Lauck et al., there are provided a pair of intermeshing gears for pumping fluid from an inlet to an outlet under pressure, one of the gears comprising a drive gear and the other a driven gear. It has been found that by providing a pump with three gears, one a drive gear and the other two driven gears, it is possible to materially increase the pumping capacity without a corresponding increase in size and weight of the pumping unit. By employing such a tri-geared pump, it is possible to increase the pumping capacity by 100%, with a size and weight increase of only 50% thereafter.

Still more particularly, an object of this invention is to provide a pressure loaded pump incorporating three pumping gears; a drive gear and two driven gears.

More particularly, it is an object of this invention to provide a pressure loaded pump having an increased pumping capacity of 100% over the prior art type incorporating the same size gears, yet having a size and weight increase of only 50% thereafter.

Still more particularly, an object of this invention is to provide three gear pressure loaded pumps incorporating a drive gear and a pair of driven gears, having an increased pumping capacity of 100% over prior art types incorporating the same size gears, yet having a size and weight increase of only 50% thereafter.

Further, it may be seen that given a particular capacity, it is possible to construct a tri-geared pump with a saving in mounting space requirements and weight over the prior art type. Therefore, another important object is to provide a pump with a capacity of prior art types yet requiring less mounting space and being lighter in weight.

Other objects and features of this invention will become apparent from the following description when taken with the accompanying drawing, wherein the same reference character is employed to refer to the same part and wherein:

Figure 1 is an axial cross-sectional view of a gear pump constructed in accordance with this invention; and

Figure 2 is a partial sectional view taken on line 2—2 of Figure 1, looking in the direction of the arrows, and showing to advantage the gear engaging faces of the bushings, and showing diagrammatically the inlets and outlets associated with the pumping gears.

Referring in greater detail to the figures of the drawings, 10 denotes generally a liquid gear pump adapted to be driven from a suitable source of power, such as an aircraft motor (not shown) and incorporating the preferred embodiments of this invention. A main pump housing 11 is formed with parallel overlapping or intersecting cylindrical chambers 12, 13 and 14 receiving gears 15, 16 and 17, the gear 16 meshing with the gears 15 and 17, the meshing occurring in the overlapping areas of the chambers. The gear 16 comprises a drive gear while the gears 15 and 17 comprise driven gears. A housing end wall closure plate 18 is attached to the open end of the housing 11, as by threaded stud bolts 19 (only one of which is shown). The inner end of the closure member 18 forms end walls 20, 21 and 22 of gear chambers 12, 13 and 14 which end walls extend radially parallel to the opposite end walls 23, 24 and 25, the gears having a co-axial thickness less than the co-axial dimension of chambers 12, 13 and 14 providing annular spaces on both sides of the gears. The gear chambers end walls 20, 21, 22, 23, 24 and 25 are formed with reduced bore extensions 26, 27, 28, 29, 30 and 31, respectively, and the gears 15, 16 and 17 are provided with oppositely extending co-axial hollow journals 32, 33, 34, 35, 36 and 37 of smaller cross section than the extension bores and received co-axially in said bores.

Of particular importance in pumps of this type is the provision of specially constructed and operated end plates or bearing bushings, these bushings being interposed between the housing and the gears and being constructed of suitable bearing material. There are preferably six of these bushings, each having substantially the same formation and each associated with one of the gear journals. Thusly, bushings 38, 39, 40, 41, 42 and 43 are provided and include tubular portions 44, 45, 46, 47, 48, 49 and 49 received in embraced relation about the gear journals 32, 33, 34, 35, 36 and 37, respectively, and outwardly extending flange terminal portions 50, 51, 52, 53, 54 and 55, respectively, received in the adjacent gear chamber in the space between the gear face and the gear chamber end wall. Flexible sealing rings 56 are interposed between the tubular portions 44, 45, 46, 47, 48, 49 and 49 and the surrounding extension bores for preventing the passage of liquid therethrough. These sealing rings may be disposed within grooves formed in the member 18, as illustrated, or within grooves formed in the bushing tubular portions.

The terminal flanges 50, 52 and 54 are arranged to have a limited axial piston-like operation or adjustment in chambers 12, 13 and 14 adjacent one side of the gears 15, 16 and 17 for bringing the gears 15, 16 and 17 and the flanges 50, 52 and 54, respectively, into sealed contact, which arrangement provides three annular liquid pressure chambers or spaces 57, 57a and 58 between the end walls 20, 21, 22 and 23 and the bushing side or side of the adjacent flanges 50, 52 and 54, respectively, and the corresponding tubular portions 44, 46 and 48 within the co-axial extensions 26, 27 and 28, respectively, likewise having a limited piston-like adjustment therein. The annular pressure chambers 57, 57a and 58 are arranged to be supplied with liquid pressure from the high pressure side of the gear teeth by a specially formed set of conduits to be described in detail. If necessary, the...
flanges 51, 53 and 55 and the tubular portions 45, 47 and 49 may be arranged for limited axial-piston-like operation and adjustment.

The opposite or inner terminal portions of the flanges 50, 51, 52, 53, 54 and 55 are formed with front or inner radially extending faces 59, 60, 61, 62, 63 and 64 parallel to the adjacent side faces of the respective gears 15, 16 and 17 and are arranged to normally engage the same to provide a pumping seal therewith. As in the pressure loaded pump described in the aforementioned patent to Lauck et al., it has been found that where the gear engaging faces of the bushings have been made co-extensive with the gear proper from a point adjacent the journal outwardly to the periphery of the gear teeth, an improper operation of the pump has resulted. When high pressures are approached, then the pressure acting between the flange faces and the adjacent gear faces becomes sufficiently great to force the flange away from the gear face resulting in a drop in volumetric efficiency. While in the aforementioned patent to Lauck et al., this condition exists for both gears (there being only two), it has been found that in the tri-gear pump of the instant application, this condition exists for only two gears, namely, the driven gears 15 and 17. Therefore, the bushing is constructed to fit snugly within the flanges 27 and between the adjacent gear face and the face 21 of the chamber 13. The bushing 40 is subject to diametrically opposed balanced high pressures within the pump chamber, the total pressure being of much smaller extent than that to which the bushings 39 and 42 are subjected.

The bushing faces 59, 60, 63 and 64 are machined to provide small recesses 65, 66, 69 and 70 adjacent the juncture of the journals 32, 33, 34, 35, 36 and 37, respectively, which function as relief recesses and accomplish a solution of the problem set forth above and are placed in communication with a low pressure zone, as will be described in greater detail hereinafter. For pumps of small displacement, the same results may be obtained by employing only the recesses 65 and 69 as relief recesses, and in such case, only these two will be in communication with a zone of low pressure. It is to be expressly understood that the recesses above described may alternatively be formed in the bushing faces of the gears 15 and 17, if so desired.

A very important function of the relief recesses 65, 66, 69 and 70 is to reduce the effective pressure areas between the flange front faces 59, 60, 63 and 64 and the adjacent gear radial faces to a value below the effective pressure or axial force acting in the opposite direction off the back faces of the flanges 58 and 59 within the annular pressure chambers 57 and 58. It is important to note that it is only necessary for this differential of pressure or axial force to be a relatively low fraction of the total pressure within the annular pressure or axial force acting chambers or spaces 57 and 58, since as long as a small differential is maintained, the bushings will not be pushed away from the gear face regardless of the extremely high pressure that may be involved. Since the flange 52 is not subjected to as high pressures in the pumping chamber as the flanges 50 and 54, the pressures in the pressure chamber 57a will always slightly exceed that applied to the flange face 64 and no relief recess is required to maintain the small differential as in the case of the flanges 50 and 54. The bushing flanges 59, 52 and 54 thus have the pressure on the annular pressure chamber side thereof always slightly predominating to produce an unbalance in the direction of the gear to maintain the required seal with no excessive pressure which would produce objectionable wear.

Since it is extremely difficult to machine the juncture of the gear faces and the gear journals, grooves such as 67 and 68, are provided on all the gears. It will be seen that each of the bushing flanges has at least one arcuate portion thereof removed to form complementary flat chordal cooperating or meeting surfaces, generally indicated at 71 (see Figure 2) in the areas of meshing of the gear teeth. Due to manufacturing imperfections, the bushing flanges at the terminal portions of surfaces 71 do not always fit accurately, and hence a certain amount of leakage or by-passing of liquid would normally occur between the high pressure side of the gear teeth and the low pressure side, the leakage taking place through the relieved areas. As in the aforementioned patent to Lauck et al., a solution to this problem is provided by the insertion of closure plugs (not shown).

Main liquid conducting passages 72, 73, 74 and 75, diagrammatically shown in Figure 2, lead to the opposite sides of the gear teeth in the areas of meshing for conducting the main flow of liquid to the gear teeth and discharging the same therewith. More specifically, the passages 72 and 74 function as inlets for the flow of liquid to the meshing gear teeth and the passages 73 and 75 function as outlets for discharge passages for the flow of liquid under pressure therethrough. The inlets and outlets may be connected in any suitable manner to attain the increased output of the tri-gear pump. The direction of rotation of the gears is indicated by the arrows in Figure 2.

In order for the relief recesses 65, 66, 69 and 70 to perform their function, the same must be placed in communication with a zone of pressure lower than that existing either at the high pressure side of the gear teeth or in the annular pressure chambers 57 and 58. This is accomplished by placing the relief recesses in communication with a low pressure zone, which communication is effective by forming the bushings 38, 39, 42 and 43 with axially extending channels or grooves 76, 77, 78 and 79, respectively, two such grooves or channels being shown for each bushing, as this improves the distribution and makes it possible to employ grooves of smaller cross-section. It will also be noted that the ends of a very small capacity pump where the relief recesses are employed in the bushings on only one side of the gears; then the bushings on the opposite side of the gears will not require any co-axially extending channels or grooves. Also, in order for the pressure chambers 57, 57a and 58 to be effective to perform their function, the same must be placed in communication with a source of high pressure.

This is accomplished by providing axially extending channels or grooves 80 and 81 in the pumping housing (see Figure 2) intersecting the outlets 73 and 75, so that high pressure fluid may be conducted to the respective pressure chambers.

The bore extensions 26, 29, 31, 29, 33, 31, 29, 28, 27, 28 and 31 are placed in communication with one another through a passage 82, so that any liquid escaping therearound through the hollow gear journals 32, 33, 34, 35, 36 and 37 may be returned to a zone of lower pressure. Washer-like elements 83, 84 and 85 are positioned in the bore extensions 26, 27 and 28, respectively, and are held in engagement with the ends of the tubular bearing portions 44, 46 and 48 by springs 86, 87 and 88 for maintaining initial engagement between the gear faces and the bushing flanges. As in the aforementioned patent to Lauck et al., a fluid pressure operated flexible coupling, generally indicated at 89 is provided and is placed in communication with the hollow journal 33 by means of a passage 90. Since the coupling is essentially the same as shown and described in the aforementioned patent to Lauck et al., no further description of its construction or operation is deemed necessary, reference is made to the patent for the details of such construction and operation. However, it will suffice to say that the coupling member terminates on its outer end with a splined or gear connector 91 adapted to cooperate in driving relation with an auxiliary power shaft of an aircraft engine or other driving member.

In the prior description, the end plates or bushings have been specifically described as including flanged por-
tions and tubular portions and the housing has been so described as formed to receive this particular configuration of bushing. It is to be expressly understood that it is within the scope of this invention, and the appended claims should be so construed, that the bushings or end plates may be constructed with a substantially constant diameter. In such a case, the housing chambers would necessarily be modified to receive this configuration of bushing. To construct bushings of a substantial constant diameter, it is only necessary to increase the axial length of the flange portion of the bushing shown and described and to exclude or to diminish the axial length of the tubular portion, the sealing ring 56 then being employed to define the pressure chambers.

While this invention has been described in connection with a certain specific embodiment thereof, it is to be understood that this is by way of example, rather than limitation, and it is intended that the invention be defined as the appended claims, which should be given a scope as broad as consistent with the prior art.

We claim:

1. A pump device comprising: a housing containing three adjoining substantially cylindrical chambers having radial end walls, said housing also having a pair of high pressure ports and a pair of relatively low pressure ports, one of each pair of ports communicating with another pair of housing chambers, a toothed gear member in each of said housing chambers, one pair of which meshes at the juncture of one pair of said housing chambers and another pair of which meshes at the juncture of another pair of said housing chambers; end plate means disposed in each of said chambers and being associated with said gear members; means defining a pair of flat chordal surfaces on one of said end plate means, said end plate means being so disposed that each end plate means has a flat chordal surface thereof cooperating with a flat chordal surface of its adjacent end plate means, said end plate means including front faces cooperating with the adjacent side faces of the associated gear members, said front faces and said side faces constituting pairs of adjacent faces which provide a pumping seal between said gear members and said end plate means, said front faces being subject to the pressures in said housing chambers and said side faces being subject to the pressures in said housing chambers and having portions communicating with each other of said end plate means; and means establishing communication between the associated high pressure ports and said pressure spaces to subject the backs of said end plate means associated with said driven gears to the pressure in the respective high pressure ports of the housing.

2. A pump device comprising: a housing containing three adjoining substantially cylindrical chambers having their axes parallel and having radial end walls, said housing also having a pair of high pressure ports and a pair of relatively low pressure ports, one of each of said pair of ports communicating with one pair of said housing chambers and the other of each of said pair of ports communicating with another pair of said housing chambers, a toothed gear member in each of said housing chambers, one of which comprises a drive gear and the other two of which comprise driven gears, said drive gear meshing with one of said driven gears at the juncture of said one pair of said housing chambers and said drive gear meshing with the other of said driven gears at the juncture of said another pair of said housing chambers; end plate means disposed in each of said chambers and being associated with said gears; means defining a pair of flat chordal surfaces on the end plate means associated with said drive gear and a flat chordal surface on each of the other end plate means, said end plate means being so disposed that each end plate means has a flat chordal surface thereof cooperating with a flat chordal surface of its adjacent end plate means, said end plate means including front faces cooperating with the adjacent side faces of said associated gear members, said front faces and said side faces constituting pairs of adjacent faces which provide a pumping seal between said gear members and said end plate means, said front faces being subject to the pressures in said housing chambers and having portions communicating with each other of said end plate means; and means establishing communication between the associated high pressure ports and said pressure spaces to subject the backs of said end plate means associated with said driven gears to the pressure in the respective high pressure ports of the housing.

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