

April 7, 1959

J. F. HOFFER

2,880,678

HIGH PRESSURE GEAR PUMP

Filed April 29, 1954

2 Sheets-Sheet 1

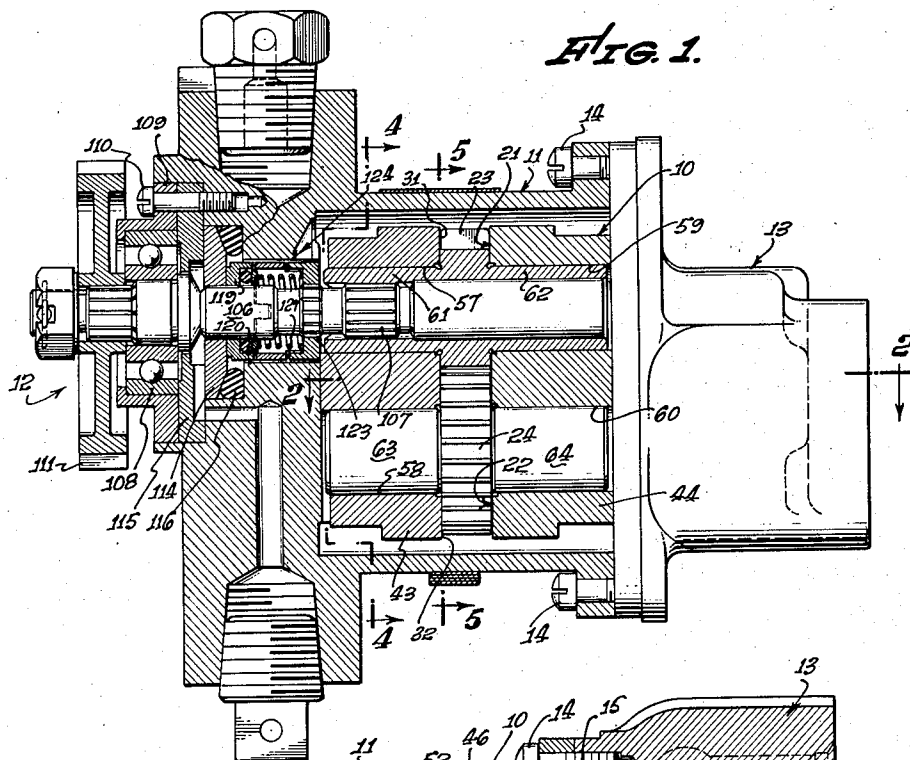


FIG. 2.

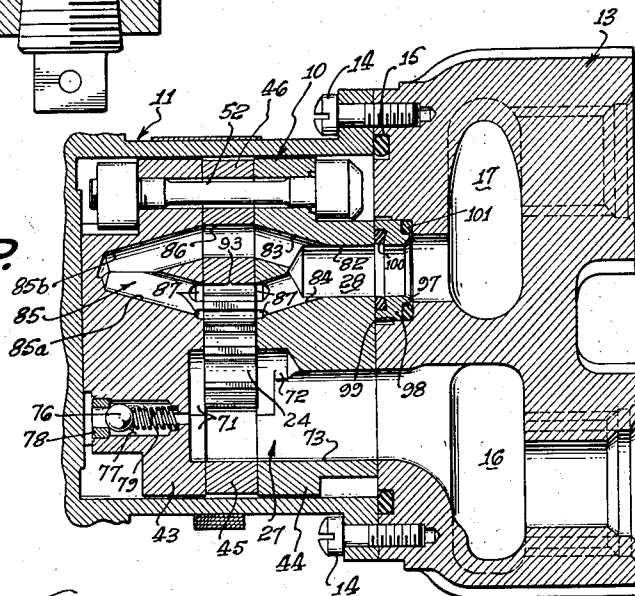
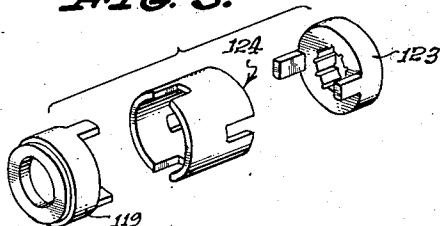


FIG. 3.



INVENTOR.

JAMES F. HOFFER,
BY HIS ATTORNEYS.

HARRIS, KIECH, FOSTER & HARRIS.

April 7, 1959

J. F. HOFFER

2,880,678

HIGH PRESSURE GEAR PUMP

Filed April 29, 1954

2 Sheets-Sheet 2

FIG. 4.

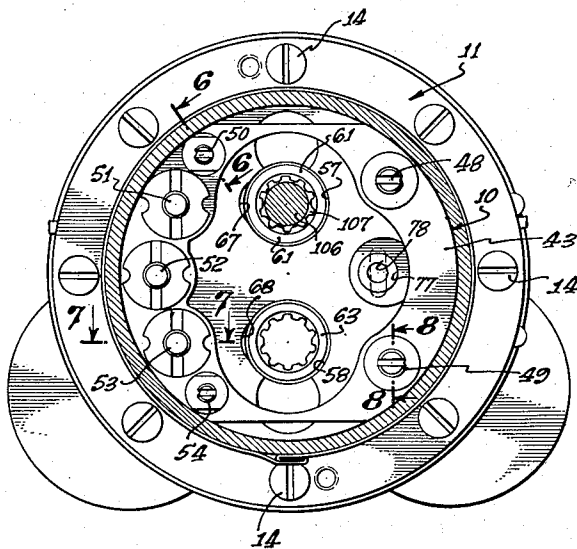


FIG. 6.

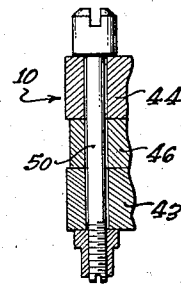


FIG. 7.

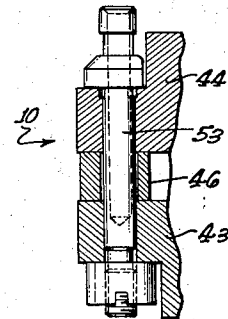


FIG. 5.

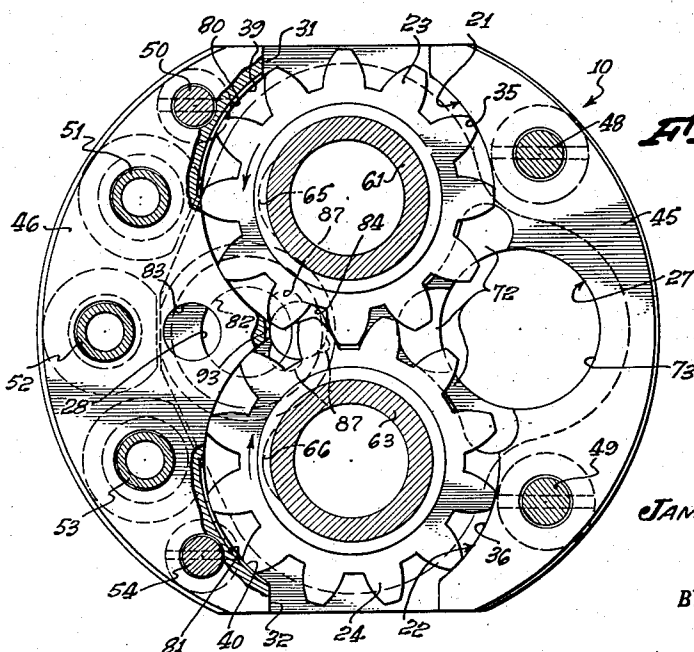
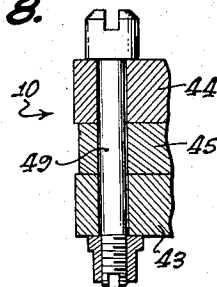


FIG. 8.



JAMES F. HOFFER,
INVENTOR.

BY HIS ATTORNEYS.

HARRIS, KIECH, FOSTER & HARRIS.

1

2,880,678

HIGH PRESSURE GEAR PUMP

James F. Hoffer, Altadena, Calif., assignor to General Metals Corporation, Burbank, Calif., a corporation of California

Application April 29, 1954, Serial No. 426,421

16 Claims. (Cl. 103—126)

The present invention relates to the gear pump art and a primary object thereof is to provide a low cost gear pump capable of developing discharge or outlet pressures of the order of magnitude of 1000 to 5000 lbs. per square inch, or more.

General objects of the invention are to provide a gear pump which includes a case subassembly including drive means for the pump, a pump cartridge subassembly, and a port head subassembly, the pump cartridge subassembly being disposed within the case subassembly and the port head subassembly being secured to the case subassembly. Each of these subassemblies may be varied independently of the others to meet various requirements, which is an important feature. For example, a particular pump cartridge subassembly may be utilized with various case and port head subassemblies depending upon mounting and drive requirements, or upon port size and location requirements.

Of particular importance in the foregoing connection is the provision of a self sufficient pump cartridge or pump cartridge subassembly capable of use with a wide variety of cases, drives, and the like, the pump cartridge being insertable into and removable from any complementary case as an independent unit.

More particularly, an object of the invention is to provide a cartridge which includes a housing having therein intersecting gear chambers occupied by gears in mesh at the intersection of the chambers, the housing including end plates which define the end walls of the gear chambers and including spacer means between the end plates which define the circumferential walls of the gear chambers, the spacer means being clamped between the end plates by dowel bolts which form part of the cartridge. In other words, the entire bolting configuration is in the cartridge so that the cartridge may be installed in and removed from any complementary case as an independent unit, which is an important feature of the invention.

An important advantage of the foregoing is that substantially all of the leakage in the cartridge may be discharged into the case, which is an important object of the invention. Actually, all of the leakage in the cartridge goes into the case, except for direct leakage past the gears from an outlet means of the cartridge back to an inlet means thereof, such leakage being a very small percentage of the total.

A related object is to provide pressure relief valve means for providing communication between the interior of the case and the inlet means of the cartridge whenever a predetermined differential exists therebetween, such pressure differential preferably being of the order of magnitude of one or two atmospheres. Consequently, with this construction, it is impossible for any high pressure external leakage to occur at any time, all high pressure leakage being from the cartridge into the case, or directly back to the cartridge inlet means, which is an important feature of the invention.

Another object of the invention is to provide a pump

2

wherein the drive means is engageable with either of the two gears in the cartridge by positioning the cartridge and port head subassembly relative to the case in either of two positions spaced 180° apart, thereby rendering the pump readily reversible as to its direction of rotation, which is an important feature.

Another important object of the invention is to localize the high outlet pressure developed in the cartridge to a relative small area in the vicinity of the outlet or discharge means by covering only a small fraction of the total number of intertooth spaces in each gear. The inlet and outlet means communicate with the gear chambers in inlet and outlet zones which are spanned by circumferential walls of the gear chambers, such circumferential walls being materially less than 180° in angular extent and preferably being not more than 90° in angular extent so that not more than one quarter of the intertooth spaces are covered at any instant, depending upon the angular positions of the gears relative to such circumferential walls. In actual practice, the angular extent of such circumferential walls may be of the order of not more than 60°, so that not more than approximately one-sixth of the intertooth spaces are covered. With this construction, the area of high outlet pressure is severely localized and occupies only the outlet zone plus one or two adjacent intertooth spaces in each gear.

Such localization of the high outlet pressure has several advantages, among these being the minimizing of the areas of the gears to which the high outlet pressure is applied so that bearing loads are minimized. Also, the tendency of the high outlet pressure to spread the end plates may be offset by applying the outlet pressure to a small area of one of the end plates, this being an important object of the invention. A related object is to provide an outlet means which includes an outlet passage through one of the end plates, this outlet passage communicating with an annulus which is axially aligned with the area of high outlet pressure within the cartridge and which has the outlet pressure applied thereto to balance the high outlet pressure within the cartridge so as to prevent any spreading of the end plates.

Another object of the invention is to provide a pump wherein the cartridge includes main inlet means communicating with the gear chambers both radially and axially of the intertooth spaces throughout approximately one quadrant of each gear chamber.

A very important object of the invention is to provide a cartridge having auxiliary or boost inlet means communicating with the gear chambers intermediate the main inlet means and the outlet means and also communicating with the interior of the case. As hereinbefore indicated, the case receives substantially all of the leakage from the cartridge and the case pressure is maintained above the pressure in the main inlet means by pressure relief valve means with the result that the intertooth spaces can receive additional fluid at elevated pressure through the auxiliary inlet means to insure maximum filling of the intertooth spaces, which is an important feature of the invention. As an example, assuming that the intertooth spaces are filled to 90% of their capacity by the main inlet means, and assuming that leakage from the cartridge into the case in this example is at least 10% of the theoretical pump capacity, the intertooth spaces will be completely filled, or at least substantially completely filled, by the auxiliary or boost inlet means, any excess leakage into the case being returned to the main inlet means through the pressure relief valve means mentioned.

Another object of the invention is to provide a cartridge having outlet or discharge means for receiving the fluid under high pressure discharged from the intertooth spaces which communicates with the intertooth

3

spaces axially thereof only, the outlet means preferably communicating with both ends of the intertooth spaces. By discharging the fluid from the intertooth spaces axially only, the teeth may be covered by the circumferential walls of the gear chambers down to, or substantially down to, the intersection of the outside diameters of the gears, which is an important feature of the invention.

Another object is to provide restricted relief passage means in the cartridge housing at the intersection of the circumferential walls spanning the spaces between the auxiliary inlet means and the outlet means for restrictedly by-passing the gear teeth as they engage and disengage such circumferential walls at the intersection so as to minimize hydraulic shock loads as the numbers of intertooth spaces covered by the circumferential walls vary during rotation of the gears. Preferably, such restricted relief passage means includes a small slot at the intersection of the circumferential walls.

Another important object of the invention is to provide a method of machining and assembling the components of the cartridge which results in extremely close control of gear clearances, in the vicinity of the outlet means only, without necessitating the maintenance of extremely close tolerances in machining operations. In this connection, one object is to bore the dowel holes and bearing bores in the end plates through both end plates simultaneously with the end plates clamped together. By doing this, virtually perfect alignment of the dowel holes and bearing bores is attained, yet the tolerances for the locations of the dowel holes and bearing bores relative to each other in the end plates may be several times as large as they would have to be if the end plates were bored separately.

Another method of obtaining close clearance control resides in utilizing a spacer means between the end plates which comprises two spacer plates, one on the high pressure side of the gear chambers and the other on the low pressure side thereof. The dowel holes in the spacer plate on the high pressure side of the gear chambers are drilled slightly oversize so that, when assembling the cartridge, this spacer plate can be so positioned as to contact the peripheries of the gear teeth lightly, this spacer plate preferably being of a material such as bronze so that while there may be zero clearance between it and the gear teeth initially, the gear teeth generate their own running clearances when the pump is put into operation. In other cases in which a small initial clearance is desired between the spacer plate and the gear peripheries, a shim having a thickness equaling the desired initial clearance can be placed between the spacer plate and gear peripheries during assembly of the cartridge, the shim to be removed following assembly. Thus, with this method, the ultimate in clearance control for outside diameter clearance is attained with generous tolerances and could not be duplicated in accordance with prior practice with impossible tolerances, which is an important feature of the invention.

With respect to gear end clearance control, gear end clearances can be made very close initially and will remain so throughout the entire pressure range since all forces tending to spread the end plates are balanced out, as hereinbefore discussed.

Another object of the invention is to provide large bearing areas for the gears, by providing the gears with large integral shafts journaled in bearing bores which extend entirely through the end plates. Thus, bearing loads are distributed over large areas, which is an important feature. Another object in this connection is to provide recesses in the bearing bores adjacent the high pressure side of the gear chambers through which radial leakage from the gear chambers passes to lubricate and provide continuous oil circulation for cooling the bearing bores and the gear shafts therein.

Another object is to provide a drive means for the

4

pump which includes a shaft carried by the case and adapted to plug into either gear in the pump cartridge, depending upon the position of the cartridge in the case. A seal encompasses the shaft to prevent external leakage from the case, case pressure being applied to the seal to insure proper seating thereof and the seal being driven through a flexible coupling to insure proper contact at the sealing faces despite misalignment of any elements of the drive means, which are features of the invention.

Another object is to provide dowel bolts whose cross-sectional areas intermediate the ends thereof do not exceed the cross-sectional areas at the roots of the threads on such bolts. With this construction, maximum thread areas are attained while providing the dowel bolts themselves with sufficient flexibility to assist in compensating for any differential expansion between the dowel bolts, which are preferably steel, and the end and spacer plates, at least some of which are preferably bronze, or a similar material.

The foregoing and various other objects, advantages and features of the present invention may be attained with the exemplary embodiment of the invention illustrated in the accompanying drawings and described in detail hereinafter. Referring to the drawings:

Fig. 1 is a longitudinal sectional view of a high pressure gear pump which embodies the present invention;

Fig. 2 is a fragmentary sectional view taken along the arrowed line 2—2 of Fig. 1;

Fig. 3 is an exploded perspective view of a flexible coupling forming a seal drive means of the invention;

Figs. 4 and 5 are transverse sectional views respectively taken along the arrowed lines 4—4 and 5—5 of Fig. 1, Fig. 5 being on an enlarged scale; and

Figs. 6, 7 and 8 are fragmentary sectional views respectively taken along the arrowed lines 6—6, 7—7 and 8—8 of Fig. 4 of the drawings.

Referring to the drawings, the high pressure gear pump of the invention illustrated therein includes a pump cartridge or pump cartridge subassembly 10 in a case or case subassembly 11 which includes drive means 12 for the pump, the case having an open end closed by a port head or port head subassembly 13. The latter is secured to the case 11 by bolts 14 and a fluid-tight seal between the port head and the case is provided by a sealing element 15 disposed therebetween. The port head 13 is provided with inlet and outlet ports or passages respectively designated by the numerals 16 and 17.

Considering the cartridge 10 in detail it includes a housing having therein intersecting gear chambers 21 and 22 respectively occupied by gears 23 and 24 in mesh at the intersection of the chambers, as best shown in Fig. 4 of the drawings, it being understood that the particular numbers of teeth shown on the gears may be varied. Communicating with the gear chambers 21 and 22 are a main inlet means 27 on one side of the gear chambers and an outlet or discharge means 28 on the opposite side of the gear chambers, the main inlet means 27 communicating with the inlet passage 16 in the port head 13 and the outlet means 28 communicating with the outlet passage 17 in the port head. Providing communication between the interior of the case 11 and the gear chambers 21 and 22 intermediate the main inlet means 27 and the outlet means 28 is an auxiliary or boost inlet means comprising auxiliary inlets 31 and 32 respectively communicating with the gear chambers 21 and 22. The auxiliary inlets 31 and 32 are spaced from the main inlet means 27 by circumferential walls 35 and 36, respectively, of the gear chambers 21 and 22 and the auxiliary inlets 31 and 32 are spaced from the outlet means 28 by circumferential walls 39 and 40, respectively, of the gear chambers.

Considering the structure of the housing of the pump cartridge 10, the pump cartridge housing includes two end plates 43 and 44 having therebetween a spacer

means comprising spacer plates 45 and 46 respectively disposed adjacent the main inlet means 27 and the outlet means 28, i.e., respectively disposed on what hereinafter will be termed the low pressure and high pressure sides of the gear chambers 21 and 22. The spacer plate 45 is clamped between the end plates 43 and 44 by the bolts 48 and 49 extending through these plates and the spacer plate 46 is clamped between the end plates 43 and 44 by dowel bolts 51, 52 and 53 and bolts 50 and 54 extending through these plates. The end plates 43 and 44 define the end walls of the gear chambers 21 and 22, the spacer plate 45 defines the circumferential walls 35 and 36 of the gear chambers 21 and 22, and the spacer plate 46 defines the circumferential walls 39 and 40 of the gear chambers 21 and 22. The end plate 43 is provided with bearing bores 57 and 58 therethrough which are concentric with the gear chambers 21 and 22, respectively, and the end plate 44 is provided with bearing bores 59 and 60 therethrough which are concentric with the gear chambers 21 and 22, respectively. The gear 23 is provided with integral shafts 61 and 62 respectively disposed in the bearing bores 57 and 59, and the gear 24 is provided with integral shafts 63 and 64 respectively disposed in the bearing bores 58 and 60. The bearing bores 57 to 60 and the shafts 61 to 64 are of large diameter and the shafts extend almost entirely through the corresponding end plates 43 and 44 to provide large bearing areas to minimize bearing pressures, which is an important feature.

The bearing bores are relieved or undercut adjacent the high pressure side of the gear chambers 21 and 22 to provide recesses through which radial leakage from the gear chambers passes on its way into the case 11, as hereinafter described, to lubricate and cool the bearing bores and the shafts. The recesses in the bearing bore 57 and 58 are visible in Fig. 4 of the drawings and are identified by the numerals 67 and 68, respectively, and the recesses in the bearing bores 59 and 60 are shown in Fig. 5 of the drawings and are identified by the numerals 65 and 66, respectively. As will be apparent, the high pressure developed in the outlet means 28 biases the gears 23 and 24 and their shafts toward the low pressure side of the gear chambers 21 and 22 and thus biases them away from the lubricating and cooling recesses mentioned. It will be understood that while the gear shafts have been described as integral with the corresponding gears 23 and 24, they may be formed separately and the gears keyed or otherwise secured thereto.

Turning now to a consideration of the fluid flow through the pump cartridge 10, the main inlet means 27, as hereinbefore mentioned, communicates with the inlet passage 16 in the port head 13, the inlet passage 16 and inlet means 27 being as large as possible to improve the filling characteristics of the pump, especially at high altitudes and low temperatures. The main inlet means communicates with the gear chambers 21 and 22 throughout approximately one quadrant of each, and communicates with the intertooth spaces in the gears 23 and 24 both radially and axially, the end plates 43 and 44 being recessed at 71 and 72, respectively, to provide axial filling of the intertooth spaces from both ends throughout approximately one quadrant, as best shown in Figs. 2 and 5 of the drawings. These same recesses also cooperate with a port or passage 73 in the end plates 43 and 44 and the spacer plate 45 to provide radial filling of the intertooth spaces throughout approximately one quadrant of each gear. Thus, with this construction, maximum filling of the intertooth spaces is achieved, which is an important feature.

As the intertooth spaces move out of communication with the main inlet means 27, they are covered by the circumferential walls 35 and 36 of the gear chambers 21 and 22, the intertooth spaces in the gears 23 and 24 thereafter coming into communication with the auxiliary

inlets 31 and 32, respectively. These auxiliary inlets are merely ports in the pump cartridge housing (being bounded by the end plates 43 and 44 and the spacer plates 45 and 46) which communicate with the interior of the case 11. The case interior receives substantially all of the leakage from the gear chambers 21 and 22, radial leakage from these chambers, for example, escaping into the case interior by way of the lubricating recesses in the bearing bores 57 to 60 which were discussed previously. Of course, a very small amount of leakage directly to the main inlet means 27 occurs, past the gears, but this is very small and virtually all of the leakage goes into the case interior. The interior of the case 11 is maintained at a pressure somewhat above atmospheric pressure, e.g., one or two atmospheres above atmospheric pressure, by a pressure relief valve means which includes a ball valve 76, Fig. 2, disposed in a passage 77 connecting the interior of the case 11 with the main inlet means 27, the valve 76 being biased into engagement with a seat 78 in the passage 77 by a spring 79.

As will be apparent, since the case interior is maintained under pressure in this manner and since the intertooth spaces communicate with the case interior through the auxiliary inlets 31 and 32, any incomplete filling of the intertooth spaces through the main inlet means 27 is virtually completely eliminated by the auxiliary inlets 31 and 32. In other words, the leakage is utilized to provide a source of boost pressure to insure substantially complete filling of the intertooth spaces in the gears 23 and 24 through the auxiliary inlets 31 and 32, which is an important feature. As an example, assuming that the intertooth spaces are filled to approximately 90% of their capacity by the main inlet means 27, and assuming that leakage from the cartridge 10 into the case 11 in this example is at least 10% of the theoretical pump capacity, the intertooth spaces will be at least substantially completely filled through the auxiliary inlets 31 and 32 by the boost pressure maintained within the case 11 by the valve 76, any excess leakage into the case being returned to the main inlet means 27 through the valve 76, which acts as a pressure relief valve means. Thus, volumetric efficiency is materially improved, which is an important feature of the invention.

Another feature of handling the leakage from the pump cartridge 10 in this manner is that it is impossible for any high pressure leakage to the exterior of the case 11 to occur since the pressure differential between the interior of the case and the exterior thereof is maintained at a value of the order of magnitude of one or two atmospheres. Thus, if a leak should develop tending to permit the escape of fluid to the exterior of the case 11, such leakage will be at a relatively low rate, which has obvious advantages and which represents an important feature of the invention.

After the intertooth spaces, now completely filled, or substantially completely filled, with fluid move out of communication with the auxiliary inlets 31 and 32, they are covered by the circumferential walls 39 and 40 of the gear chambers 21 and 22, the fluid being discharged from the intertooth spaces as the gear teeth mesh in the vicinity of the outlet means 28. As hereinbefore mentioned, the high outlet pressure attained by the pump of the invention, which may exceed 5000 lbs. per square inch, is localized in the vicinity of the outlet means, with attendant advantages to be discussed hereinafter, and the manner in which this is accomplished will now be considered.

First of all, it will be noted that, as best shown in Fig. 5 of the drawings, the walls 39 and 40 are provided, respectively, with relief passages, e.g., slots, 80 and 81 which extend from the auxiliary inlets 31 and 32, respectively, toward the intersection of the walls 39 and 40 so that the effective circumferential extent of the walls 39 and 40, i.e., the circumferential extent thereof effective to cover the intertooth spaces, is relatively small, being ma-

terially less than 180° and preferably being not more than approximately 90°, this effective circumferential extent being not more than about 60° in the particular construction shown. Thus, if the gears 23 and 24 have twelve teeth each, as shown in the drawings for illustrative purposes only, alternately one and two intertooth spaces of each gear are covered by the corresponding circumferential wall 39 or 40. Actually, only one intertooth space of each gear is covered at any instant, since the intertooth space of each gear nearest the outlet means 28 begins to uncover as the next intertooth space is completely covered, attention being directed to the gear 23 in Fig. 5. Consequently, the pressure gradients between the outlet means 28 and the auxiliary inlets 31 and 32 are very steep. For example, assuming that the discharge pressure is 5000 lbs. per square inch, the pressures obtaining in the covered intertooth spaces farthest from the outlet means 28 will be only a small fraction of 5000 lbs. per square inch. Thus, with this construction, the area of high outlet pressure is severely localized and occupies only the zone in which the outlet means 28 is located plus the adjacent intertooth space in each gear, the pressures between the localized area of high outlet pressure and the auxiliary inlets 31 and 32 falling off rapidly because of the steep pressure gradients utilized.

Another factor in localizing the area of high outlet pressure to the immediate vicinity of the outlet means 28 is that the intertooth spaces are covered by the circumferential walls 39 and 40 down to, or virtually down to, the point of intersection of the gear chambers 21 and 22, as best shown in Fig. 5 of the drawings. This has the effect of providing a pressure gradient between that intertooth space of each gear which is in communication with the outlet means 28 and an adjacent intertooth space covered by one of the circumferential walls 39 or 40 so that the pressure to which the structure of the pump cartridge 10 is subjected falls off sharply in directions away from the outlet means 28 for this reason also.

Virtual point intersection of the circumferential walls 39 and 40 when viewed in cross section is attained by causing the outlet means 28 to communicate with the intertooth spaces axially only. While the outlet means 28 may communicate with the intertooth spaces at one end only, it is shown as communicating with both ends of the intertooth spaces to facilitate fluid discharge therefrom. Considering how this is accomplished with particular reference to Fig. 2 of the drawings, the outlet means 28 includes a passage 82 in the end plate 44 which registers with the outlet passage 17 in the port head 13. At its inner end, the passage 82 is provided with branch passages 83 and 84 in the end plate 44, the latter branch passage communicating with one end of the gear chambers 21 and 22 in the area where the gears 23 and 24 begin to mesh. Communicating with the opposite end of the gear chambers 21 and 22 in alignment with the branch passage 84 is one arm 85a of a V-shaped passage 85 in the end plate 43, the other arm 85b of this V-shaped passage communicating with a passage 86 through the spacer plate 46, the passage 86, in turn, communicating with the aforementioned branch passage 83. Thus, fluid discharged from one end of each intertooth space flows into the passage 82 by way of the branch passage 84, while fluid discharged from the other end of each intertooth space flows into the passage 82 by way of the V-shaped passage 85, the passage 86 and the branch passage 83. Relief ports 87 are provided in the end plates 43 and 44 at the inner ends of the branch passage 84 and the arm 85a of the V-shaped passage 85 to prevent fluid trapping.

Pressure pulsations tend to occur as the numbers of teeth on the gears 23 and 24 which are covered by the circumferential walls 39 and 40 vary between the maximum number covered and the minimum number covered. To smooth out such pressure pulsations, restricted relief passage means is provided at the intersection of

the circumferential walls 39 and 40, such restricted relief passage means restrictedly by-passing each gear tooth in turn as it is uncovered at the intersection of the circumferential walls 39 and 40 so as to minimize hydraulic shock loads as the numbers of intertooth spaces covered by the circumferential walls vary during rotation of the gears 23 and 24. As shown in Fig. 5 of the drawings, such restricted relief passage means comprises a small relief slot 93, which may be a V-groove, in the spacer plate 46 at those ends of the circumferential walls 39 and 40 which are adjacent the outlet means 28, the relief slot 93 extending across the apex formed by the intersection of the circumferential walls 39 and 40.

The high pressure developed within the pump cartridge 10 in the vicinity of the outlet means 28 tends to spread the end plates 43 and 44 even though such end plates are of substantial thickness, as shown, and are clamped together by a substantial number of dowel bolts. An important feature of the present invention is to balance out the pressure tending to spread the end plates 43 and 44 and this may be done very simply in accordance with the present invention because of the fact that the area of high pressure is concentrated or localized in the vicinity of the outlet means 28 as hereinbefore discussed. Referring to Fig. 2 of the drawings, it will be seen that an annular shoulder 97 encircles a portion of the outlet passage 17 which is an extension of the passage 82 and which is in axial alignment with the localized area of high pressure in the vicinity of the outlet means 28. Thus, the outlet pressure acts on this annular shoulder 97 to balance or cancel out the concentrated or localized high pressure within the pump cartridge 10 so as to eliminate the tendency to spread the end plates 43 and 44. In the construction shown, the annular pressure balancing shoulder 97 is provided by one end of a pressure balancing button 98 disposed in a complementary recess 99 in the port head 13, the button 98 being sealed with respect to the pump cartridge 10 and the port head 13 by sealing elements 100 and 101, respectively. The effective balancing area is defined and limited by the outside diameter of button 98.

Thus, it will be seen that the present invention balances out the discharge pressure developed within the pump cartridge 10 by applying the discharge pressure to the pressure balancing button 98, and that the desired pressure balance is attained by applying the outlet pressure to only a relatively small area because of the fact that the discharge pressure within the pump cartridge is severely localized or concentrated in the manner hereinbefore discussed in detail, which are important features of the invention.

As hereinbefore indicated, an important object of the invention is to provide a method of machining and assembling the various elements of the pump cartridge 10 which results in extremely close control of gear clearances, in the vicinity of the outlet means 28 only, without necessitating the maintenance of extremely close tolerances in machining operations. In this connection, the end plates 43 and 44 are clamped together, after which the holes for the dowel bolts 51 to 53 and the bearing bores for the gears 23 and 24 are bored through both end plates, the holes for the bolts 48, 49, 50 and 54 being drilled at the same time. The end plates 43 and 44 which are bored together will always be used together and, in view of this, the tolerances on dowel hole locations and bearing bore locations may therefore be several times as large as they would be if these holes were bored in the end plates 43 and 44 independently of each other. Also, the number of boring operations is reduced, which is another feature. In drilling the dowel holes through the high pressure spacer plate 46, the dowel holes are drilled oversize, as shown throughout the drawings and as best shown in Fig. 5 of the drawings, so that, when assembling the cartridge 10, the high pressure spacer plate may be adjusted so that the circumferential walls 39 and 40

thereof lightly contact the teeth of the gears 23 and 24, respectively. In other words, the high pressure spacer plate 46 is adjusted to provide either zero clearance or any desired initial clearance with respect to the gear teeth. The high pressure spacer plate 46 is preferably formed of bronze, or a similar material, and the gears are preferably formed of steel so that the gear teeth can readily generate their own running clearances when the pump is put into operation in those instances where zero clearance between the high pressure spacer plate 46 and the gear teeth is provided initially. If a fixed clearance greater than zero is desired initially, this may be provided by placing shims of a thickness equal to the desired clearance between the gears and the spacer plate 46, these shims being removed after assembly.

Thus, the ultimate in clearance control for outside diameter clearance is attained with generous tolerances and this clearance control could not be duplicated in accordance with prior practices with impossible tolerances, which is an important feature of the invention. With respect to gear end clearance control, the tolerances on gear length and spacer plate thickness may be equivalent to those utilized in prior pumps. Gear end clearances can initially be very close and will remain so throughout the pressure range since all deflection forces are balanced out, as hereinbefore discussed. Preferably, the end plates 43 and 44 are also of a material such as bronze so that the initial gear end clearances may be the minimum permissible running clearance with no danger of seizure or galling in operation. Close gear end clearances are necessary throughout approximately only 60° to 90° because of the high-pressure localization hereinbefore discussed, which renders gear end clearances less critical with respect to both overheating and gear face misalignment.

The low pressure spacer plate 45, which may be formed of steel, need not be either adjustable or a precision part in any way except for thickness since large clearances over gear outside diameters are permissible on the inlet side because of the low pressures involved. As a matter of fact, the principal function of the plate 45, other than providing rigidity, is to separate the auxiliary inlets 31 and 32 from the main inlet means 27 to maintain the desired boost pressure.

For purposes of strength, the dowel bolts 51 to 53 are preferably of steel, and, in order to make these dowel bolts sufficiently flexible to accommodate differences in thermal expansion of parts without sacrificing thread strength, these dowel bolts are preferably of reduced cross-sectional area intermediate their ends, the net cross-sectional area of each of these dowel bolts being approximately equal to the cross-sectional area thereof at the thread roots. As shown in Fig. 2, this effect is attained with the dowel bolt 52 by reducing its external diameter intermediate its ends. As shown in Fig. 7 of the drawings, this is attained with the dowel bolt 53 by making the dowel bolt hollow for the major portion of its length. The dowel bolt 51 may be similarly handled.

As hereinbefore suggested, an important advantage of locating the entire bolting configuration in the pump cartridge 10 makes the pump cartridge an independent, self sufficient unit which may be used with a wide variety of cases, drives, and the like. Also, by making the pump cartridge an independent unit, its position in the case 11 may be reversed, i.e., the cartridge may be turned 180° about its axis, so that the drive means 12 may be connected to either one of the gears 23 and 24. Consequently, the drive means 12 may rotate in either direction, it merely being necessary to rotate the pump cartridge 10 and port head subassembly 13 through 180° to attain the proper directions of gear rotation.

Considering the drive means 12, it includes a shaft 106 which extends into the case 11 and which is provided at

its inner end 107 with means for driving connection to either of the gears 23 and 24, depending upon the position of the cartridge 10 within the case. In the particular construction illustrated, the inner end 107 of the shaft 106 is externally splined for engagement with internal splines formed in either the gear shaft 61 or the gear shaft 63, depending upon the position of the cartridge 10 in the case 11. Thus, if the shaft 106 is driven in one direction, the gear shaft 61 is engaged with the splined inner end 107 thereof, and, if the shaft 106 is driven in the opposite direction, the gear shaft 63 is engaged with the splined end 107 thereof, this being accomplished by rotating the pump cartridge 10 through 180° relative to the case 11 as hereinbefore discussed.

The drive shaft 106 is mounted in a bearing 108 carried by a closure member 109 which is secured to the case 11 by bolts 110, or the like. The shaft 106 is driven in any suitable manner, as by a gear 111 splined or otherwise secured to the outer end thereof. It will be apparent that with the construction shown, minor misalignments of parts are compensated for and the pump cartridge 10 is isolated from driving loads.

Considering the manner in which the drive shaft 106 is sealed relative to the case 11, encircling the drive shaft is a stationary sealing element 114 which is held in place by an annular retainer 115 and which is sealed relative to the case 11 by a sealing ring 116. The stationary sealing element 114 is engaged by a rotatable sealing element 119, a fluid-tight seal between the sealing element 119 and the shaft 106 being provided by a sealing ring 120 disposed in an annular recess in the sealing element 119. Splined or otherwise secured to the shaft 106 so as to rotate therewith is a driver 123 which is connected to the rotary sealing element 119 to drive same by means of a flexible coupling, such as the Oldham-type coupling 124 best shown in Fig. 3 of the drawings. By driving the sealing element 119 through a flexible coupling in this manner, proper contact between the sealing faces on the sealing elements 114 and 119 is maintained despite misalignment of parts, which is an important feature. The sealing element 119 is biased into engagement with the sealing element 114 by a compression spring 127 seated at one end against the driver 123 and at its other end against a washer which engages the sealing ring 120. It will be noted that the pressure within the case 11 also acts on the sealing element 119 to bias it into engagement with the sealing element 114. With this sealing arrangement, leakage from the case 11 by way of the drive means 12 is eliminated for long periods of time, especially in view of the fact that the pressure differential across the seal is of the order of magnitude of one or two atmospheres.

Although I have disclosed an exemplary embodiment of my invention herein for purposes of illustration, it will be understood that various changes, modifications and substitutions may be incorporated in the embodiment disclosed and that various features of the invention may be incorporated in other embodiments, all without departing from the spirit of the invention as defined by the claims hereinafter appearing.

I claim as my invention:

1. A gear pump including two meshed gears respectively disposed in intersecting gear chambers in a housing having inlet means communicating with said gear chambers in inlet zones, respectively, and having outlet means communicating with said gear chambers in an outlet zone, said inlet zones being spaced from said outlet zone and the spaces between said inlet and outlet zones being spanned by circumferential walls of said chambers which cover said gears, the effective angular extent of each of said circumferential walls being such that not more than one sixth of the intertooth spaces of the corresponding gear are covered thereby, said housing including restricted relief passage means at the adjacent ends of said circumferential walls and interconnecting said gear chambers

for restrictedly by-passing the gear teeth as they engage and disengage said circumferential walls so as to minimize hydraulic shock as the numbers of intertooth spaces covered by said circumferential walls vary, the cross-sectional area of said relief passage means being very small as compared to that of said intertooth spaces.

2. A gear pump including two meshed gears respectively disposed in intersecting gear chambers in a housing having inlet means communicating with said gear chambers in inlet zones, respectively, and having outlet means communicating with said gear chambers in an outlet zone adjacent the intersection thereof, said housing including end plates respectively defining end walls of said gear chambers and including spacer means between said end plates and defining circumferential walls of said gear chambers, said end plates and said spacer means being rigidly secured together, said gear pump including means communicating with said outlet means for applying the outlet pressure developed by said gear pump to one of said end plates of said housing in axial alignment with said outlet zone and in a direction inwardly toward said outlet zone.

3. A gear pump including a housing having two end plates and spacer means clamped between said end plates for axially spacing said end plates apart, said gear pump including two meshed gears respectively disposed in intersecting gear chambers located between said end plates and defined by said spacer means, said housing having inlet means communicating with said gear chambers in inlet zones, respectively, and having outlet means communicating with said gear chambers in an outlet zone adjacent the intersections thereof, said inlet zones being spaced from said outlet zone and the spaces between said inlet and outlet zones being spanned by circumferential walls of said gear chambers which cover the teeth of said gears and which are of such effective angular extent that not more than approximately one sixth of the intertooth spaces are covered by said circumferential walls so as to localize the outlet pressure developed by said pump to the vicinity of said outlet zone, said gear pump including means communicating with said outlet means for applying the outlet pressure developed by said pump to one of said end plates of said housing in the axially inward direction and in axial alignment with said outlet zone.

4. A gear pump as defined in claim 3 wherein said outlet means includes an outlet passage through said one end plate, the means last defined in claim 3 including an annulus encircling said outlet passage and exposed to the outlet pressure therein.

5. A gear pump including a housing having therein two intersecting gear chambers respectively occupied by gears in mesh at the intersection of said gear chambers, said housing providing inlet means communicating with said gear chambers and providing outlet means communicating with said gear chambers adjacent the intersection of said chambers, said housing having a restricted relief passage adjacent the intersection of and connecting said chambers, said outlet means including an outlet passage communicating with an end of said gear chambers so that the pumped fluid is discharged axially from the corresponding ends of the intertooth spaces, said outlet passage being spaced from said relief passage slightly in the direction of rotation of said gears so that said intertooth spaces communicate first with said relief passage, and then with said outlet passage.

6. In a gear pump, the combination of: a cartridge comprising a housing having therein two intersecting gear chambers respectively occupied by gears in mesh at the intersection of said chambers, said housing providing circumferentially spaced main inlet means, auxiliary inlet means and outlet means communicating with each of said gear chambers; and a case enclosing said cartridge and having inlet and outlet passages respectively communicating with said main inlet means and said outlet means, the interior of said case communicating with said auxiliary

inlet means so that fluid leakage from said cartridge into said case is delivered to said auxiliary inlet means.

7. A gear pump as defined in claim 6 including passage means communicating between the interior of said case and said main inlet means, there being pressure relief valve means in said passage means for permitting fluid flow from the interior of said case into said main inlet means in response to a predetermined pressure differential therebetween.

8. A unitary gear pump cartridge insertable into a case which provides inlet and outlet passages, said cartridge having therein intersecting gear chambers defined by end and peripheral walls and respectively occupied by gears in mesh at the intersection of said chambers, said cartridge providing main inlet means and outlet means which communicate with said gear chambers and which communicate with said inlet and outlet passages, respectively, when said cartridge is disposed in the case, said cartridge also providing two auxiliary inlet means which communicate with said gear chambers, respectively, between said main inlet means and said outlet means and which communicate with the interior of the case when said cartridge is disposed therein, said cartridge being insertable into and removable from said case as a unit.

9. A unitary gear pump cartridge insertable into and removable from a case and having therein intersecting gear chambers respectively occupied by gears in mesh at the intersection of said chambers, said cartridge providing main inlet means and outlet means communicating with said chambers, said cartridge also providing two auxiliary inlet means which communicate with said gear chambers, respectively, between said main inlet means and said outlet means and which communicate with the interior of the case when said cartridge is disposed therein, said cartridge including end plates which define end walls of said gear chambers and including spacer means between said end plates which define circumferential walls of said gear chambers, said cartridge including dowel means for clamping said end plates and spacer means together.

10. In a gear pump, the combination of: a case containing gear pump means; means for maintaining the interior of said case at a predetermined pressure; drive means extending into said case for driving said gear pump means; and seal means exposed to case pressure and encompassing said drive means for preventing leakage from said case therealong, said seal means including stationary and rotary sealing elements and flexible coupling means coupling said rotary sealing element to said drive means.

11. A gear pump including a housing having therein intersecting gear chambers respectively occupied by gear pumps in mesh at the intersection of said chambers, said housing including end plates defining end walls of said gear chambers and including spacer means between said end plates and defining circumferential walls of said gear chambers, said spacer means being clamped between said end plates by dowel bolts extending through said end plates and spacer means, each of said dowel bolts being threaded at one end and having a nut threaded on such end thereof, the maximum cross-sectional area of each of said dowel bolts intermediate the ends thereof being approximately equal to the cross-sectional area thereof at the roots of said threads on said end thereof.

12. A gear pump including a housing having therein intersecting gear chambers respectively occupied by gears in mesh at the intersection of said chambers, said housing providing inlet means communicating with said gear chambers on a low pressure side thereof and providing outlet means communicating with said gear chambers on a high pressure side thereof, said housing including end plates respectively defining end walls of said gear chambers, and said housing including spacer means between said end plates and defining circumferential walls of said gear chambers, said spacer means including a low pressure spacer plate on the low pressure side of said gear chambers and a high pressure spacer plate on the high pressure

13

side of said gear chambers, said spacer plates being clamped between said end plates by dowel bolts extending through holes in said end plates and spacer plates, the dowel holes in said high pressure spacer plate being larger than the dowel bolts extending therethrough to permit displacing said high pressure spacer plate into any desired relation with the teeth of said gears to control radial clearances therebetween.

13. A method of assembling a gear pump having a housing which includes a spacer plate adapted to be clamped between two end plates to space said end plates apart for the reception of meshed gears therebetween, said spacer plate being adapted to at least partially surround the outer peripheries of said gears, said method including the step of clamping said spacer plate between said end plates with said gears disposed between said end plates while maintaining said spacer plate in contact with the outer peripheries of the teeth of said gears so that there is zero clearance between said spacer plate and the outer peripheries of said gear teeth, whereby said gear teeth generate their own running clearances when said gear pump is put into operation.

14. A method of assembling a gear pump having a housing which includes a spacer plate adapted to be clamped between two end plates to space said end plates apart for the reception of meshed gears therebetween, said spacer plate being adapted to at least partially surround the outer peripheries of said gears, said method including the steps of: clamping said spacer plate between said end plates with said gears disposed between said end plates and with shims between said spacer plate and the outer peripheries of the teeth of said gears; and thereafter removing said shims to provide predetermined clearances between the outer peripheries of said gear teeth and said spacer plate.

15. A method of making a gear pump housing defined by end plates and central spacer means which are adapted to be secured together by dowel bolts extending through the end plates and the spacer means to clamp the spacer means between the end plates, said end plates and said spacer means providing intersecting gear chambers for meshed gears having shafts extending axially therefrom in both directions, said spacer means being adapted to at least partially surround the outer peripheries of said gears, said method including the steps of: securing the end plates together; and boring dowel bolt holes for said dowel bolts and bearing bores for said shafts through said end plates while so secured together.

16. In a gear pump, the combination of: a pump cartridge including a housing providing intersecting gear chambers and providing inlet means communicating with said gear chambers on a low pressure side thereof and outlet means communicating with said gear chambers on a high pressure side thereof, said housing providing bearing bores axially aligned with said gear chambers and providing large undercuts in said bearing bores on the high pressure sides of said gear chambers, said pump

14

cartridge including gears respectively disposed in said gear chambers and meshing at the intersection of said chambers, said gears having shafts journaled in said bearing bores; and a case containing and receiving leakage from said pump cartridge, said undercuts communicating with said gear chambers and said case, whereby radial leakage between the ends of said gears and end walls of said gear chambers flows through said undercuts into said case to lubricate and cool said bearing bores and shafts, the centers of said undercuts being spaced circumferentially from the zone of meshing of said gears, and being spaced therefrom not more than 90°, to register same with said high pressure sides of said gear chambers.

References Cited in the file of this patent

UNITED STATES PATENTS

367,374	Deming	Aug. 2, 1887
683,614	Meston	Oct. 1, 1901
1,105,312	Sundh	July 29, 1914
1,111,160	Larsen et al.	Sept. 22, 1914
1,271,970	Wood	July 9, 1918
1,348,772	Auger	Aug. 3, 1920
1,372,576	Tullmann	Mar. 22, 1921
1,379,587	Fisher	May 24, 1921
1,424,312	Leonard	Aug. 1, 1922
1,673,262	Meston et al.	June 12, 1928
1,688,342	McCuen	Oct. 23, 1928
1,706,829	Thomson	Mar. 26, 1929
1,716,105	Brandt	June 4, 1929
1,783,209	Wilsey	Dec. 2, 1930
1,891,793	Kauffman	Dec. 20, 1932
2,062,045	Van Deventer	Nov. 24, 1936
2,188,848	Svenson	Jan. 30, 1940
2,233,709	Osborne	Mar. 4, 1941
2,277,270	Schmitter et al.	Mar. 24, 1942
2,301,496	Aldrich	Nov. 10, 1942
2,354,992	Gottlieb	Aug. 1, 1944
2,395,824	Herman	Mar. 5, 1946
2,420,622	Roth et al.	May 13, 1947
2,505,809	Svenson	May 2, 1950
2,540,235	Berkley	Feb. 6, 1951
2,622,529	Parsons	Dec. 23, 1952
2,635,552	Dale et al.	Apr. 21, 1953
2,639,694	Johnson	May 26, 1953
2,641,192	Lindberg	June 9, 1953
2,655,108	Osborne	Oct. 13, 1953
2,665,636	Lauck et al.	Jan. 12, 1954
2,714,856	Kane	Aug. 9, 1955
2,718,758	Minshall et al.	Sept. 27, 1955
2,726,604	Aspelin et al.	Dec. 13, 1955
2,742,862	Banker	Apr. 24, 1956
2,746,132	Oliver	May 22, 1956
2,758,548	Rockwell	Aug. 14, 1956
2,764,100	Maisch	Sept. 25, 1956
2,772,638	Nagely	Dec. 4, 1956
2,817,297	Mosbacher	Dec. 24, 1957

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 2,880,678

April 7, 1959

James F. Hoffer

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 61, for "spaces ar" read ~~ar~~ spaces are ~~ar~~; column 4, line 53, for "Fig. 4" read ~~Fig. 4~~ Fig. 5 ~~ar~~.

Signed and sealed this 21st day of July 1959.

(SEAL)

Attest:

KARL H. AXLINE

Attesting Officer

ROBERT C. WATSON
Commissioner of Patents