Oct. 11, 1960 A. W. GAUBATZ 2,955,537

FUEL PUMP

Filed Nov. 18, 1955 3 Sheets-Sheet 1

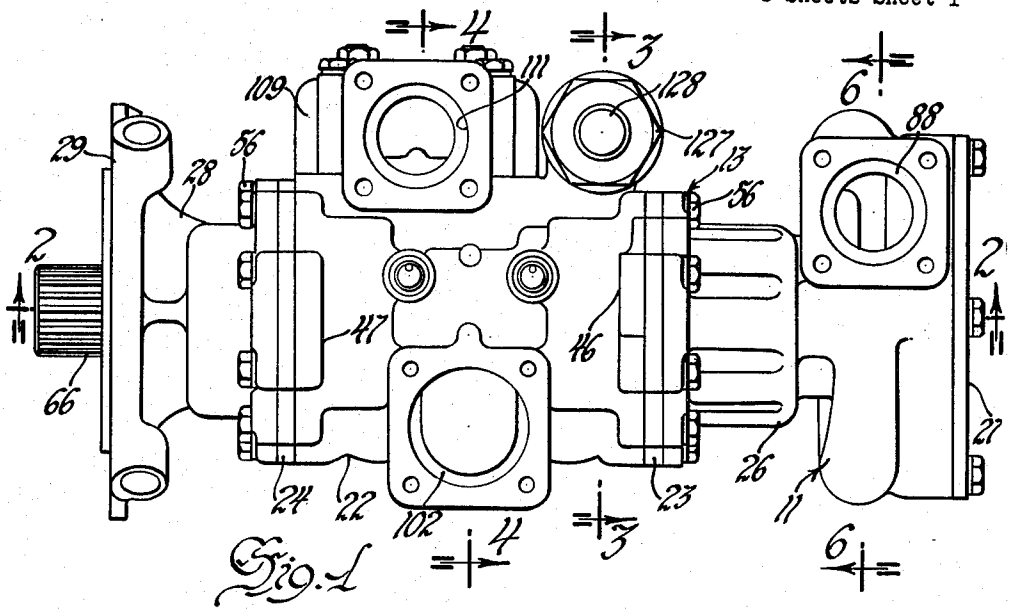


Fig. 1

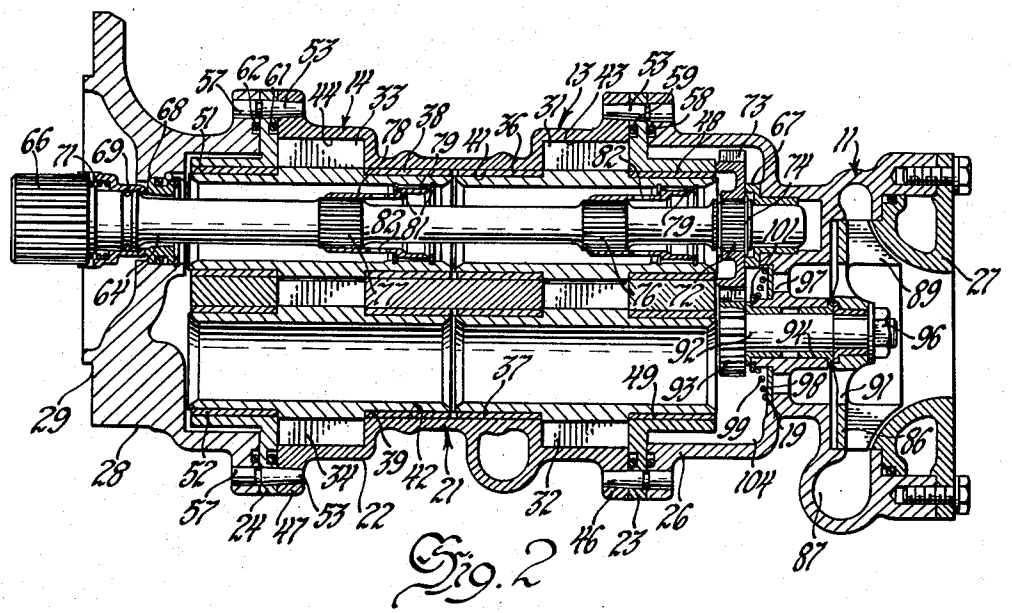


Fig. 2

INVENTOR.
Arthur W. Gaubatz
BY
Paul R. Fitzpatrick
ATTORNEY

Oct. 11, 1960 A. W. GAUBATZ 2,955,537

FUEL PUMP

Filed Nov. 18, 1955 3 Sheets-Sheet 2

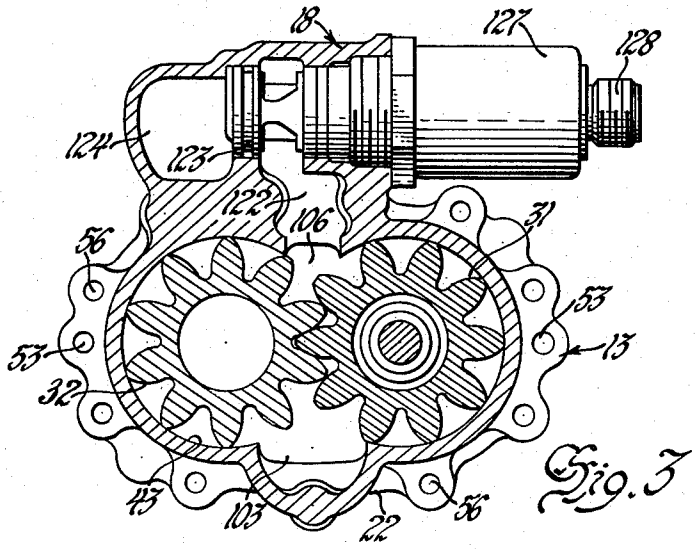


Fig. 3

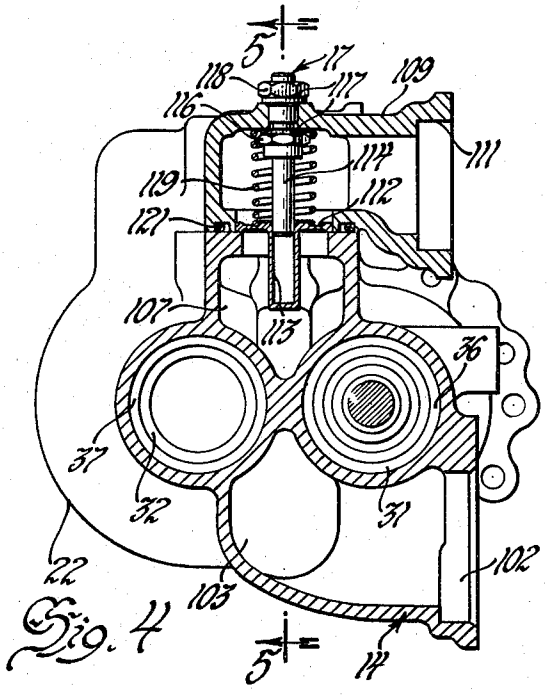


Fig. 4

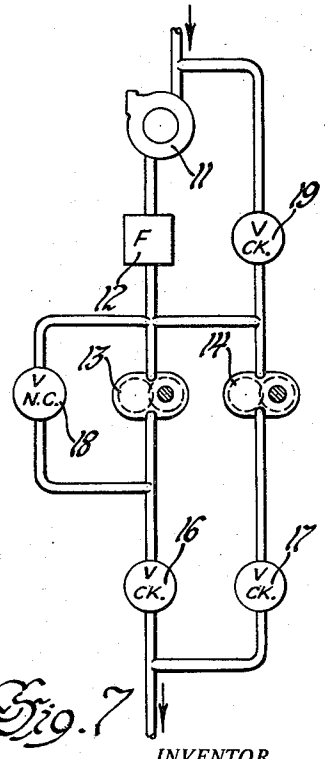


Fig. 7

INVENTOR.
Arthur W. Gaubatz
BY
Paul Fitzpatrick
ATTORNEY

Oct. 11, 1960 A. W. GAUBATZ 2,955,537

FUEL PUMP

Filed Nov. 18, 1955 3 Sheets-Sheet 3

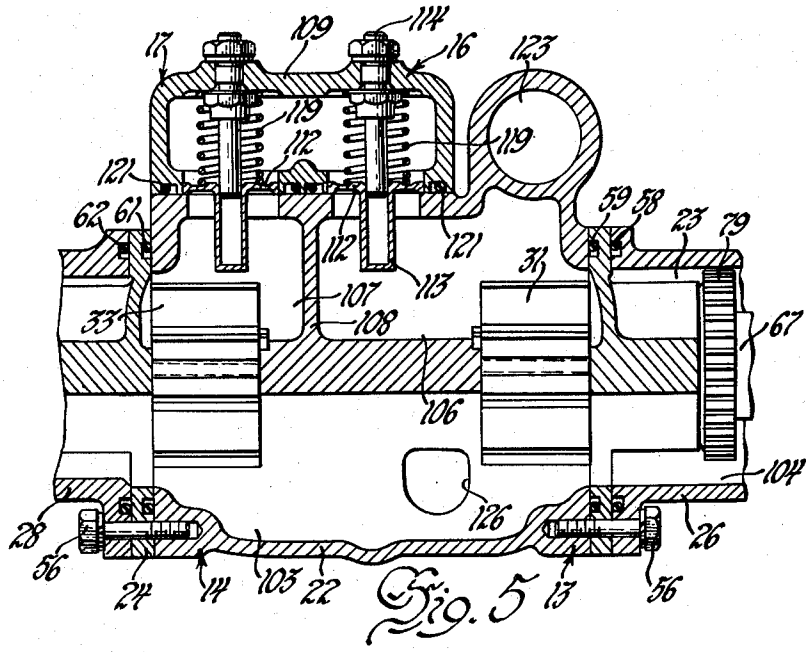


Fig. 5

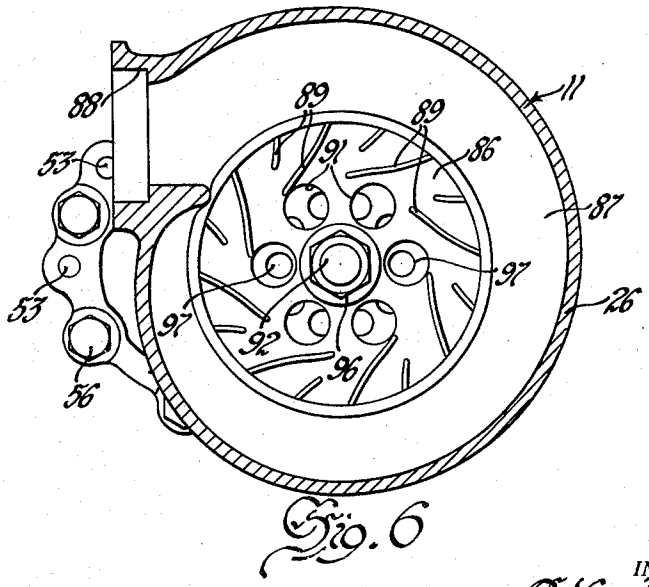


Fig. 6

INVENTOR.
Arthur W. Gaubatz
BY
Paul Fitzpatrick
ATTORNEY

United States Patent Office 2,955,537
Patented Oct. 11, 1960

2,955,537

FUEL PUMP

Arthur W. Gaubatz, Indianapolis, Ind., assignor to General Motors Corporation, Detroit, Mich., a corporation of Delaware

Filed Nov. 18, 1955, Ser. No. 547,690

5 Claims. (Cl. 103—4)

My invention relates to pumps, and is particularly applicable to pumps suited for supplying fuel under pressure to gas turbine engines. A pump according to the preferred embodiment of the invention includes a number of improvements over pumps previously known to me which render it particularly suitable for this purpose and which greatly simplify the production problems inherent in the manufacture of fuel pumps.

Typical gas turbine engines consume fuel at a high rate at pressure approaching a thousand pounds to the square inch under some conditions of operation. The demand varies greatly with engine operating conditions. The fluid is a very poor lubricant and of low viscosity, so that it is difficult to manufacture a pump to the tolerance limits necessary to minimize leakage of fluid past the pumping elements and to prevent unnecessary friction. The structure of the pump and the preferred manufacturing processes to which this structure lends itself are such as to minimize the difficulty of conforming to exacting tolerance requirements.

The pump embodies features conducive to reliability and flexibility in operation. Among these is the provision of two parallel gear pumps which discharge the fluid at high pressure with a centrifugal boost pump operating to prime the gear pumps and minimize cavitation. There is a common drive shaft for the three pumps which is coupled by means tolerant of radial misalignment of the shafts to the gear pump shafts. The coupling means includes shear connections so that jamming of one pump, which is a possible type of casaulty, will not interrupt the operation of the other pumps. The gear pumps are mounted in a housing which provides the pump cavities and the shaft supports or bearings for the gear pumps and constitutes a complete rigid sub-assembly. An end cover is fixed to each end of the housing, one end cover serving as a support for the pump and the other providing a case for the boost pump. A bypass valve included in the assembly can be opened to connect the outlet of one pump to its inlet to reduce the total pumping capacity when desired. The assembly also includes a check valve in the outlet of each pump to prevent back flow through a disabled or bypassed pump.

Uniting these various features in a single pumping assembly or system provides a device particularly suited to the requirements of aircraft gas turbine installations. However, features of the invention may also be advantageously applied to other installations.

The principal objects of the invention are to provide an improved pump particularly suitable for pumping fluids of poor lubricating qualtiy at high pressures, to provide a pump which remains operable upon failure of one or more components, to provide a pump which embodies dual pumps one of which may be cut of service, and to facilitate the precise manufacture and assembly of such pumps.

The nature of the invention and the advantages thereof will be apparent to those skilled in the art from the succeeding detailed description of the preferred embodiment

of the invention and the accompanying drawings, in which:

Figure 1 is an elevation view of a pump;

Figure 2 is a longitudinal sectional view taken on the plane indicated by line 2—2 in Figure 1;

Figure 3 is a transverse sectional view taken on the plane indicated by line 3—3 in Figure 1;

Figure 4 is a transverse sectional view taken on the plane indicated by line 4—4 in Figure 1;

Figure 5 is a partial longitudinal sectional view taken on a plane at right angles to that of Figure 2 indicated by line 5—5 in Figure 4;

Figure 6 is a transverse sectional view taken on the plane indicated by the line 6—6 in Figure 1; and

Figure 7 is a schematic diagram of the pump circuit.

Referring first to Figure 7 to explain the general nature of the system, the circuit includes a centrifugal boost pump 11 which takes fuel from any suitable source and normally delivers it through a filter 12 to gear pumps 13 and 14 connected in parallel. The gear pumps deliver to a common discharge line through check valves 16 and 17 individual to each pump. A normally closed bypass or dump valve 18 is connected in a bypass line around the pump 14. The inlet of the boost pump is also connected to the inlets of the gear pumps through a check valve 19 which may open if the filter 12 becomes clogged. All of the elements described except the filter 12 are mounted in a common assembly, with the filter externally mounted.

Referring now to Figures 1 to 6, boost pump 11, gear pumps 13 and 14, check valves 16 and 17, dump valve 18 and check valve 19 are indicated generally by the same numerals as on Figure 7.

Referring to Figure 2, the entire pump assembly is housed in a body 21 comprising a case 22, end plates 23 and 24, an inlet end cover or boost pump case 26, an inlet fitting 27 mounted in the boost pump case, and a drive end cover 28 including a mounting flange 29 for the assembly which may be bolted to a drive case on the engine.

Gear pump 13 includes a driving gear 31 and a driven gear 32 meshing therewith, each of these gears being integral with a hollow shaft or trunnion extending from both faces of the gear. Gear pump 14 similarly comprises a driving gear 33 and a driven gear 34, which may be identical to gears 31 and 32 respectively. The two driving gears are coaxial, and likewise the two driven gears. The inner or adjacent ends of the gear shafts are journaled in bushings 36, 37, 38, and 39 pressed into cylindrical bores 41 and 42 in the case 22. The outer ends of bores 41 and 42 are bored to a larger diameter and overlap to define pump gear chambers or cavities 43 and 44. The case 22 terminates at end flanges 46 and 47, the outer faces of which are substantially in the same plane as the outer faces of the gears. The end plates 23 and 24 have flanges with plane inner faces which abut the outer faces of flanges 46 and 47. These plates define the outer walls of the gear cavities and are bored to receive bushings 48, 49, 51, and 52 which journal the outer ends of the gear shafts. The length of the gear cavities axially of the shafts is just sufficiently greater than the width of the gears to provide running clearance for the gears.

The bushings for the shafts of the gears must be accurately dimensioned for running clearance on the shaft and must be accurately aligned. This latter requirement is satisfied by the invention by using the gear shafts to locate the end plates. In assembly of the pump the gears are mounted in the case and the end plates are slipped over the shafts. An oil film is provided at each journal to center the shafts in the journal. With the end plate thus accurately located it is clamped to the case and a number of holes are reamed for fitted, preferably tapered

pins 53. When the pins are driven into place the exact alignment of the case and end plates is fixed and maintained.

The end covers 26 and 28 are bolted to the flanges 46 and 47 by cap screws 56 which pass through the flanges of the end plates with clearance. The cylindrical ends 57 of pins 53 extend into holes in the end covers to provide approximate location, but the alignment of the end covers is not critical. O-ring seals 58, 59, 61 and 62 extending around the case prevent leakage at the flange connections.

The pumps are driven by a drive shaft 64 having a splined end 66 extending from the drive end cover for coupling to a driving shaft. Shaft 64 extends through the hollow shafts of gears 33 and 31 and is journaled in a bushing 67 pressed into a bore in the boost pump case. The shaft is not otherwise supported in the pump, the drive end being supported by the shaft to which it is coupled. A shaft seal comprising a graphite seal ring 68, a rotating seal follower 69 coupled to the inner end of splines 66, and a coil spring 71 is provided where shaft 64 extends through the drive end cover. The details of this seal are immaterial to the invention to which this application is directed and therefore will not be described.

Shaft 64 is provided with three sets of splines to drive the pumps 11, 13 and 14. Splines 72 adjacent the bushing 67 mount a boost pump drive gear 73 which is held in place by contracting snap rings 74. Splines 76 are coupled to gear 31 and splines 77 are coupled to gear 33. The shaft is connected to each of the gears by a coupling member 78, the two members being identical. Each is a sleeve having internal splines at one end engaging the splines on shaft 64 and external splines indicated by 79 which drive internal splines on the gear 31 or 33. Each coupling member is held in place by expanding snap rings 81 lodged in grooves in the pump gears.

Because of the axial spacing of the two sets of splines on each coupling member 78 and the play in the splines, the coupling member permits a sufficient amount of radial misalignment of the shafts to accommodate any eccentricity of shaft 64 to the pump gear shafts that may be encountered in service; thus, misalignment of shaft 64 cannot load the bearings for the gears. The end or splined portions of the coupling members 78 are hardened and the intermediate portion, which is not hardened, constitutes a shear section. This shear section is further weakened by holes 82 through the coupling member. If either gear pump should jam in service for any reason, its shear coupling breaks, leaving the drive shaft 64, the other gear pump, and the boost pump free to operate.

Considering now the boost pump 11, this pump comprises an impeller or rotor 86 rotating within the boost pump case 26. Fuel is supplied to the impeller through the inlet fitting 27 bolted to the case 26. Case 26 defines a scroll 87 into which the fuel is discharged (see also Figure 6). The scroll terminates in a flanged discharge opening 88 to which a fuel line leading to the filter may be connected. The web of the impeller bears a number of vanes 89 and is provided with a number of holes 91 through the web through which fuel may flow if the filter is clogged. The impeller is mounted on a shaft 92 integral with gear 93 which meshes with previously described gear 73 on shaft 64. The shaft rotates in a bushing 94 pressed into a wall of the housing 26, and the impeller is retained on it by a nut 96 threaded on the end of the shaft. A number of holes 97 extend through the wall of the housing to provide a passage for fuel when the boost pump is bypassed. This passage is normally closed by an annular check valve plate 98 of check valve 19 which is urged against the wall by a conical coil spring 99 lodged against a retaining ring 101. If the filter should clog so that the pressure downstream of the filter is less than the pressure of fuel entering the boost pump, the check valve opens, allowing fuel to flow into the gear pump case and enter the inlets of the gear pumps. While pump efficiency may be reduced by the loss of the desired boost pressure, the gear pumps will still operate.

Fuel is normally supplied to the gear pumps through the filter and a conduit (not shown) which connects to an inlet flange or connection 102 (Figures 1 and 4) which discharges into an inlet chamber 103 extending longitudinally of the pump housing so as to communicate with both gear pumps. This inlet chamber also communicates with the chamber 104 into which the check valve 19 discharges. The two gear pumps have separate discharge chambers 106 and 107 (Figure 5) separated by wall 108. These chambers communicate through check valves 16 and 17 with an outlet fitting 109 (Figures 1, 4 and 5) fixed to the main case by bolts, not shown. This outlet fitting has a flanged opening 111 to which the pump discharge line may be connected.

The check valves 16 and 17 being identical, check valve 17 will be described with reference to Figure 4. This valve comprises a movable valve disk 112 integral with a hollow guide 113 which slides on a stem 114. Stem 114 has a hexagonal flange 116 which bears against the inner surface of the outlet fitting 109, with a gasket 117 interposed between the flange and the fitting. The stem extends through the wall of the outlet fitting and is held in place by a nut 118 threaded on the end of the stem. The valve disk 112 seals against the outer surface of the pump case 22 under the action of a coil spring 119. O-rings 121 mounted around the check valves prevent leakage between the case and the outlet fitting. Thus, if either gear pump fails to operate for any reason, the check valve in the outlet of that pump will be held closed by the pressure delivered by the other pump.

Referring to Figure 3, the normally closed dump valve 18 for pump 13 connects with the discharge chamber of pump 13 through a passage 122. This valve comprises a movable valve member 123 which may move to the right as shown in Figure 3 to connect passage 122 with a passage 124 cored in the pump case. This passage extends around the pump case and discharges at 126 (Figure 5) into the pump inlet chamber 103. Valve 18 may be a commercially available type operated by hydraulic pressure under the control of an electrically actuated pilot valve. Since the valve is commercial, its structure is not described. It comprises a case 127 screwed into the pump case and has an electrical terminal 128 for the controlling wiring (not shown).

The interior of case 22 except for the outlet chambers 106 and 107 is filled with fuel under pump inlet pressure. This fuel fills the hollow shafts and any high pressure fluid escaping along the pump gear shafts serves to lubricate the shafts and leaks into the pump case from which it flows again into the pumping gears.

The gear pump housing and covers 22, 23 and 24 are made of high strength hardened iron. The pump incorporates bronze lined steel backed bushings 36, 37, 38, 39, 48, 49, 51 and 52. The coefficient of expansion of the housing and the bushings is substantially the same as that of the gears and the journals; thus there is no change in the optimum running clearance of the gears and bearings due to temperature. In addition, the hardened iron housings will be highly resistant to the abrasion effects of dirt passing with the fuel.

The pump may include provision for supplying fuel under pressure to the gear trunnions to provide a radial force on the trunnions opposed to the force exerted on the gears by the fuel being pumped. Since it is not material to an understanding of the invention which is the subject matter of this application, it is not shown or described.

It will be apparent to those skilled in the art from the foregoing description that a pump according to the

invention is admirably suited to meet the exacting requirements of gas turbine fuel systems.

The detailed description herein of the preferred embodiment of the invention for the purpose of explaining the principles thereof is not to be construed as limiting the invention, as many modifications may be made by exercise of skill in the art within the principles of the invention.

I claim:

1. A pumping system comprising, in combination, a pump body, a centrifugal boost pump in the body having an inlet and having a rotor including a web and vanes on the web, a positive-displacement pump in the body, a connection from the outlet of the boost pump to the inlet of the positive-displacement pump, a passage from the inlet of the boost pump to the inlet of the positive-displacement pump passing through the said rotor web, and a check valve in the passage.

2. A pumping device comprising, in combination, a pump body; a centrifugal boost pump in the body having an inlet, a rotor having a web and having vanes thereon, and an outlet; a positive-displacement pump in the body having an inlet; means providing a connection from the outlet of the boost pump to the inlet of the positive-displacement pump; and means providing a passage from the inlet of the boost pump to the inlet of the positive-displacement pump bypassing the rotor vanes and the outlet of the boost pump, the last-named means including holes through the rotor web of the boost pump and the body; and a check valve in the passage closing the passage against flow from the positive-displacement pump inlet.

3. A pumping device comprising, in combination, two gear pumps each including two meshing gears rotating on parallel shafts, the shafts of the two pumps being coaxial, a pump case enclosing the gears having parallel bores receiving one end of the shafts, the ends of the bores being overlapping counterbores defining cavities for the gears, end plates for the case having bores receiving the other ends of the shafts, the case and end plates constituting a gear pump housing, the housing defining an inlet chamber for the gear pumps, an end cover fixed to each end of the housing, a drive shaft for the gear pumps journaled in one of the end covers and extending through the other end cover, a boost pump mounted in the said one of the end covers and having an inlet, a driving connection between the drive shaft and the boost pump, the boost pump comprising a centrifugal impeller having holes through the impeller connecting the boost pump inlet to the said one of the end covers, the said one of the end covers having at least one hole therethrough, and the housing defining means connecting the gear pump inlet chamber with the hole in the said end cover, thereby providing a passage from the boost pump inlet to the gear pump inlet chamber through the impeller, and a check valve in the passage closing the passage against flow from the gear pump inlet chamber.

4. A pumping device comprising, in combination, two positive-displacement pumps each including a shaft, the shafts of the two pumps being coaxial, a pump case enclosing the pumps having bores receiving one end of the shafts, end plates for the case having bores receiving the other ends of the shafts, the case meeting and abutting the end plates on plane interfaces normal to the shafts, the shafts thus establishing the alignment of the end plates with the case, and a set of fitted pins connecting each end plate with the case, the end plates being slidable on the case transversely of the shafts except for alignment thereof with the case by the shafts and fixing of the said alignment by the fitted pins, the case and end plates constituting a pump housing, and end cover fixed to each end of the housing, and a drive shaft for the pumps journaled in one of the end covers and extending through the other end cover, the drive shaft being coupled to the pump shafts.

5. A pumping device comprising, in combination, a gear pump including two meshing gears rotating on parallel shafts, a pump case enclosing the gears having parallel bores receiving one end of the shafts, the ends of the bores being overlapping counterbores defining a cavity for the gears, and end plate for the case having bores receiving the other ends of the shafts, the shafts thus establishing the alignment of the end plates with the case, the case meeting and abutting the end plate on a plane interface, coinciding with the plane of an end face of the gears, the end plate being slidable on the case transversely of the shafts except for alignment thereof with the case by the shafts and fixing of the said alignment by the fitted pins, and a set of fitted pins connecting the end plate with the case, the case and end plate constituting a gear pump housing.

References Cited in the file of this patent

UNITED STATES PATENTS

2,301,063	McConaghy	Nov. 3, 1942
2,377,556	Jeannin	June 5, 1945
2,391,577	Larson	Dec. 25, 1945
2,407,753	Wallgren	Sept. 17, 1946
2,599,507	Wyckoff	June 3, 1952
2,640,423	Boyer	June 2, 1953
2,688,925	Thoren et al.	Sept. 14, 1954
2,714,857	Albright	Aug. 9, 1955
2,726,604	Aspelin et al.	Dec. 13, 1955
2,761,387	Gaubatz	Sept. 4, 1956
2,823,518	Murray	Feb. 18, 1958

FOREIGN PATENTS

788,955	France	Aug. 5, 1935

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,955,537 October 11, 1960

Arthur W. Gaubatz

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 1, line 44, for "casaulty" read -- casualty --; line 67, after "cut" insert -- out --; column 6, lines 17 and 27, for "and", each occurrence, read -- an --.

Signed and sealed this 11th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

ARTHUR W. CROCKER
Acting Commissioner of Patents