Dec. 13, 1955 L. L. ASPELIN ET AL 2,726,604

MIXED FLOW MULTIPLE PUMP

Filed June 15, 1951 4 Sheets-Sheet 1

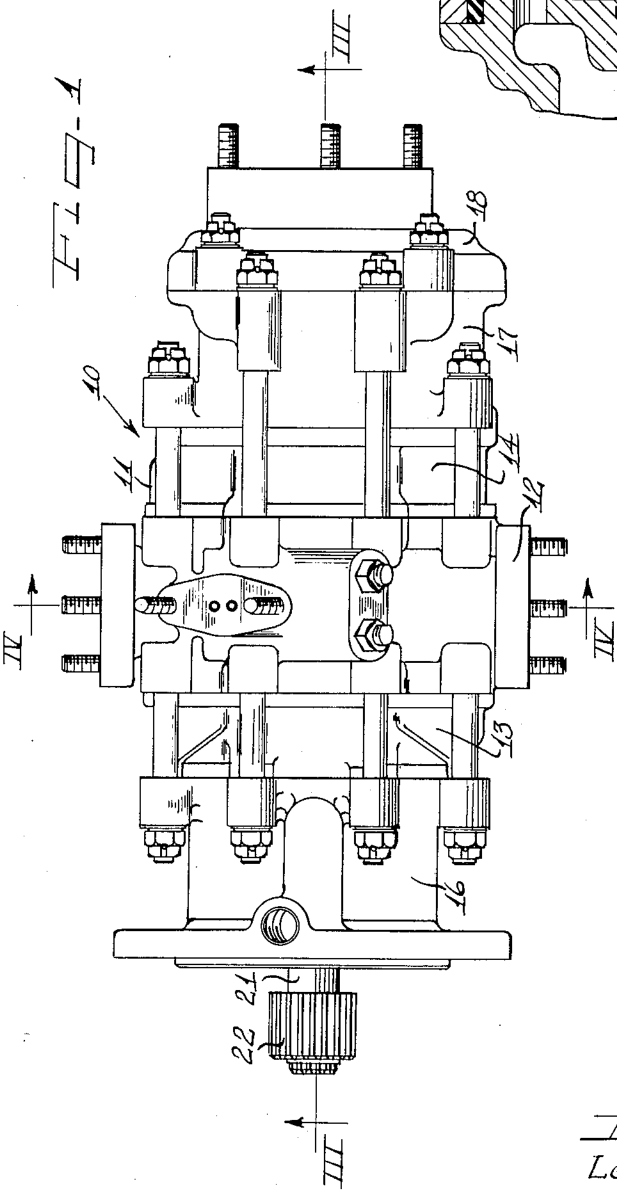

Fig-1

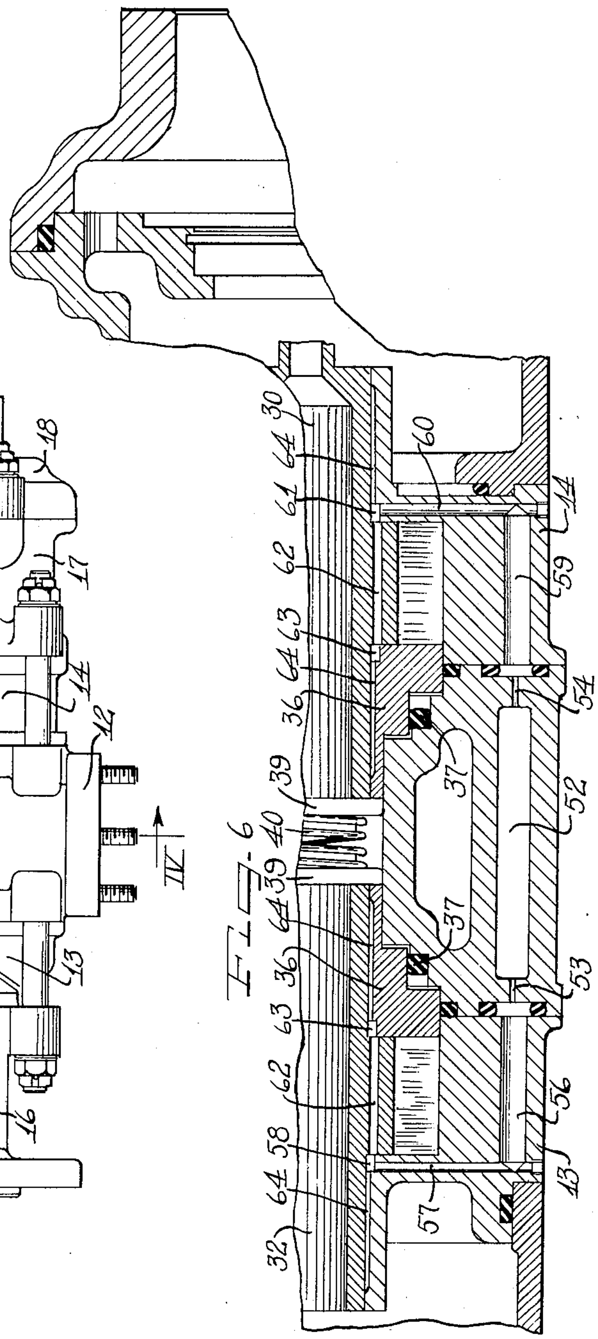

Fig-6

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Filed June 15, 1951 4 Sheets-Sheet 2

Fig-2

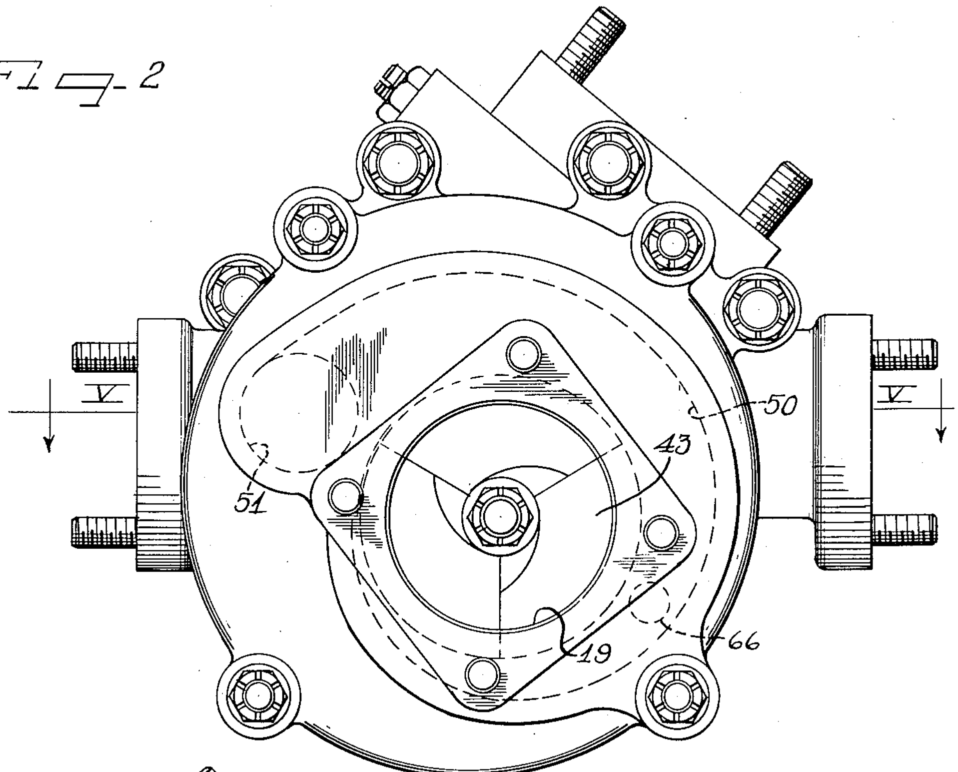
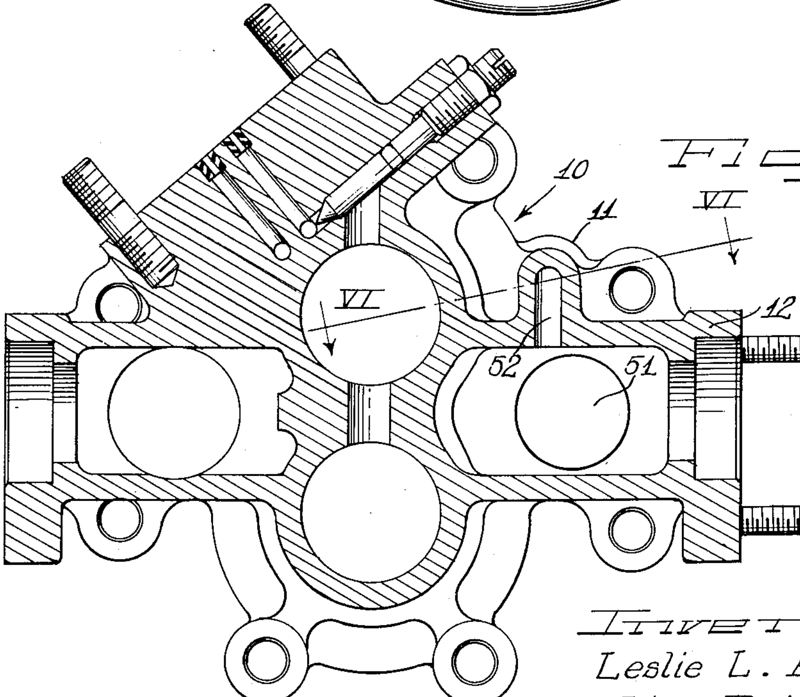


Fig-4



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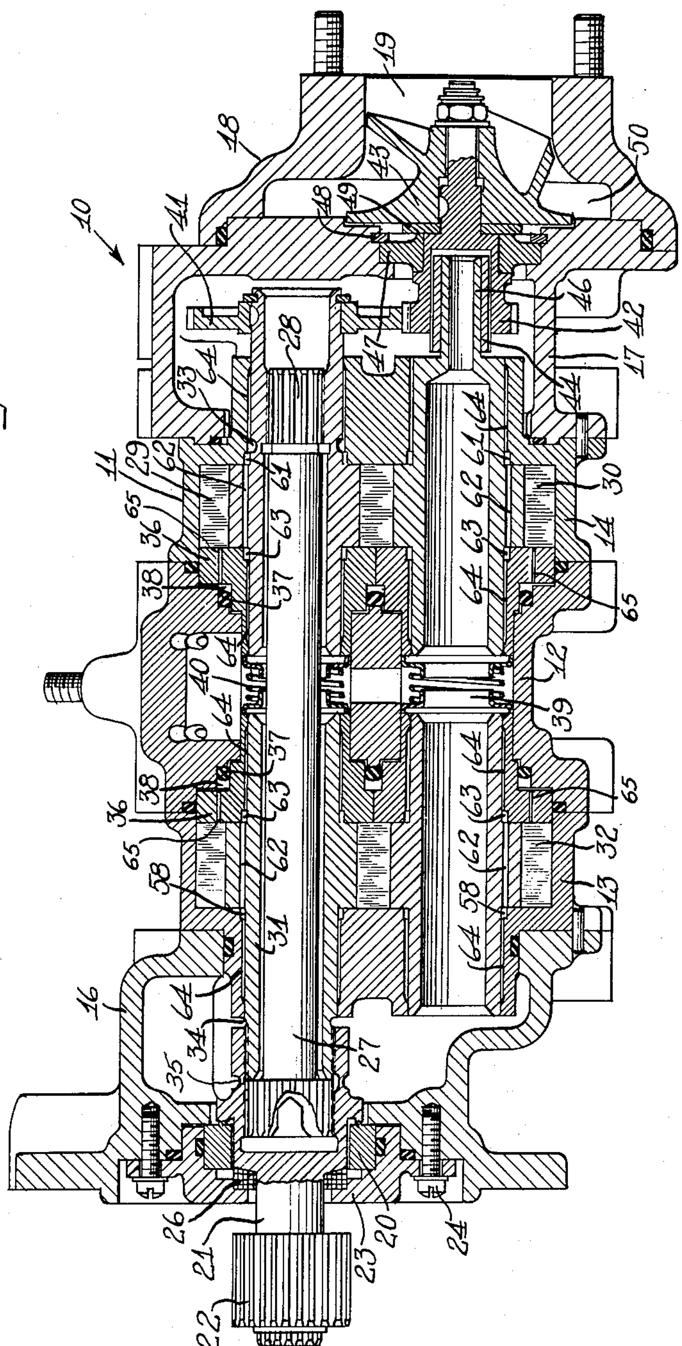
Filed June 15, 1951 4 Sheets-Sheet 3

Fig-3



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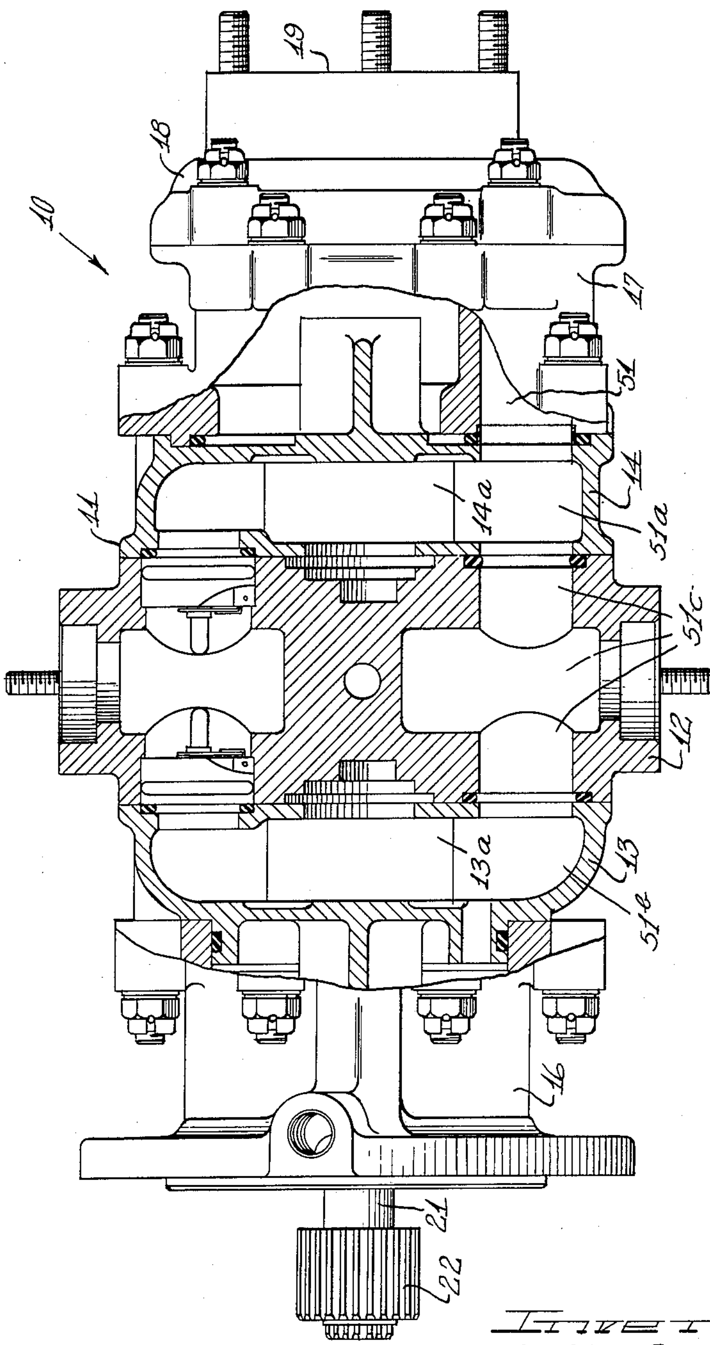
Filed June 15, 1951 4 Sheets-Sheet 4

FIG-5



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1

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MIXED FLOW MULTIPLE PUMP

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Application June 15, 1951, Serial No. 231,712

18 Claims. (Cl. 103—5)

This invention relates generally to pumps and more particularly to a mixed flow multiple pump of the type including a hydraulically loaded gear type rotor pump rotatably journaled in a bearing or bearings and arranged in line with a centrifugal impeller-type pump, the multiple unit being provided with means to divert a portion of the discharge flow of the centrifugal impeller type pump through the bearing or bearings of the hydraulically loaded gear type pump for the purpose of cooling and lubricating the bearing or bearings without necessitating an objectionable loss in volumetric efficiency of the composite pump.

Composite multiple pump units have been provided heretofore to supply pressurized fluids. In some applications, the required discharge pressures and speeds of the pump impellers have been so high as to seriously affect the capacity of the bearings to acceptably withstand the load imparted thereto.

This invention provides a multiple pump with a bearing arrangement that better withstands high loads by diverting a portion of the pump discharge flow of one pumping unit through the bearings.

According to the general principles of the present invention, a centrifugal pumping element is arranged in series with a dual gear type pumping unit. The centrifugal pumping element is selected to discharge a fluid flow greater than the pumping capacity of the dual gear type pumping unit and a proportionate amount of the discharge flow from the centrifugal impeller unit is diverted through the bearings of the gear impellers and returns to a point of lower pressure adjacent the inlet of the centrifugal unit. The centrifugal unit, therefore, develops the dual function of providing a pressurized fluid to the inlet of the gear type pumping unit and further providing a flow of fluid through the bearings which operates to cool and lubricate the bearings, particularly when the bearings are critically loaded at higher speeds.

It is an object of the present invention, therefore, to provide an improved composite multiple pump structure capable of operating at higher speeds and at higher capacities than have heretofore been possible.

Another object of the present invention is to provide a pump in which lubrication is improved at critical operating speeds.

Another object of the present invention is to provide a pumping unit structure in which a portion of the fluid pumped by the unit may be diverted for purposes of cooling and lubricating bearings without detracting from the volumetric efficiency of the pumping unit.

Many other features, advantages and additional objects of the present invention will become manifest to those versed in the art upon making reference to the detailed description which follows in the accompanying sheets of drawings in which a preferred structural embodiment incorporating the principles of the present invention is shown by way of illustrative example.

On the drawings:

Figure 1 is an elevational view of a composite multiple

2

pump provided in accordance with the principles of the present invention;

Figure 2 is an end elevational view of the pump shown in Figure 1;

Figure 3 is a cross-sectional view with parts shown in elevation, taken substantially on line III—III of Figure 1;

Figure 4 is a cross-sectional view with parts shown in elevation, taken substantially on line IV—IV of Figure 1;

Figure 5 is a cross-sectional view with parts shown in elevation and with parts broken away, taken substantially on line V—V of Figure 2; and

Figure 6 is a fragmentary cross-sectional view with parts shown in elevation taken substantially on line VI—VI of Figure 4.

As shown on the drawings:

The composite multiple pump structure of the present invention is indicated generally by the reference numeral **10** and includes a sectionalized casing **11**. The casing **11** includes a center portion **12** made as a casting of ordinary lightweight metal and sandwiched between a first pumping chamber member **13** and a second pumping chamber member **14** preferably made out of a suitable bearing material.

The pumping chamber members are respectively abutted by a cover **16** and by a cap member **17**. In addition, a second cover **18** is assembled with the cap member **17** and forms an inlet **19** for the pump **10**.

The cover **16** is suitably bored and counterbored to receive a seal assembly **20** to seal against internal leakage from the pump or external leakage into the pump. The seal face of this assembly mates with a seal face on an annular shoulder on the shaft **21**. The seal is retained by a cap **23** secured in assembly with the cover **16** by means of a plurality of fasteners **24**, the thrust cap also forming a seat for a thrust washer **26**.

The shaft **21** is provided with a splined recess at its inner end to effect a driving coupling connection with a drive shaft **27** which, in turn, is splined as at **28** to effect a driving connection with a rotary fluid displacement means comprising a driver gear **29** of a dual gear pump impeller further including a driven gear **30** and rotatable in a pumping chamber formed by the pumping chamber member **14**.

The shaft **21** is further splined to a driver gear **31** of a rotary fluid displacement means further including a driven gear **32** rotatable in the pumping chamber formed by the pumping chamber member **13**.

The driver gear **29** is provided with a conventional machining relief **33** and the driver gear **31** is provided with a conventional machining relief **34** to facilitate formation of splines on the shaft extensions. To insure continued operation of at least one of the gear pump units in the event of jamming within the respective rotary fluid displacement means, the splined portion of the shaft **21** is provided with a reduced section **35** providing a frangible coupling joint and the drive shaft **27** is reduced to form a shear section adjacent the splines **28**.

The center portion **12** of the casing **11** is suitably bored and counterbored to receive a rotor engaging hydraulically loaded sealing mechanism.

Each of the sealing mechanisms includes a pair of bushings **36** having a radially extending portion adapted to engage the sides of the gear teeth on the rotary fluid displacement means and further including an axially extending portion forming a bearing support to journal the shaft portions of the rotary fluid displacement means. Each of the bushings **36** further includes an eccentrically offset shoulder between the radially extending portion and the axially extending portion seating a sealing member **37**. A pressure control chamber **38** is formed between each of the bushings **36** and the center portion **12** which chamber may be placed in communication with discharge pressure to axially load the bushings 36 into pressure sealing engagement with the rotary fluid displacement means. In the present embodiment an aperture 65 (Figure 3) is drilled through the radially extending portion of each of the bushings 36 in the discharge area of the pump.

To initially load each of the bushings 36, a plurality of cap members 39 are provided, each pair of opposing cap members serving to seat a coil spring 40.

At the end of the driver gear 29 is located a spur gear 41 arranged to mesh with and drive a gear 42 arranged to rotate a centrifugal impeller 43 rotatable within the pumping chamber formed in the cap member 18.

To journal the gear 42, a recess is provided therein receiving a bearing bushing 44 carried on the end of a stub shaft 46 located on the end of the driven gear 30. It will be apparent that the stub shaft 46, being integral with the driven gear 30, rotates therewith and rotation will occur whenever the drive shaft 27 is rotated because driven gear 30 meshes with driver gear 29. The gear 42 also rotates upon rotation of the drive shaft 27, however, such rotation results from the meshing of the gear 42 with the spur gear 41. Since the gear combination 29, 30 is not necessarily the same as the gear combination 41, 42, it will be apparent that the rotational speeds of the stub shaft 46 and the gear 42 are likely to be unequal. The slippage occurring between the bushing 44 and the gear 42 fully accommodates the differences in rotational speed.

A thrust bearing 47 is retained in assembly with the member 17 by means of a retainer 48 and a thrust washer 49 is also interposed between the impeller 43 and the bearing 47.

As is clearly shown in Figures 2 and 3, the cap member 18 is provided with an inlet 19 and the centrifugal impeller 43 is rotatable in a volute chamber 50 to pressurize the incoming fuel whereupon a pressurized fuel is delivered to the volute chamber outlet 51.

As shown in Figure 5, the volute chamber outlet 51 constitutes a common inlet for both of the rotary fluid displacement means of the gear pump units, the pumping chamber in the pumping chamber member 14 being indicated at 14*a* and having inlet portion 51*a*, and the pumping chamber in the pumping chamber member 13 being indicated at 13*a* and having inlet portion 51*b*. Inlet portions 51*a* and 51*b* communicate with each other via the inlet portion indicated at 51*c*. The centrifugal impeller 43 is thus able to pressurize the fuel with a low inlet loss thereby to improve pumping performance of the pumping unit 10 at low atmospheric pressures, for example, if the pumping unit 10 is employed on a high altitude aircraft and it is necessary to provide a continuous flow of fluid at high pressure.

The centrifugal impeller 43 is preferably designed to produce a discharge flow greater than the pumping capacity of the dual gear rotary fluid displacement means and a proportioned amount of the discharge flow from the impeller 43 is diverted by taking a portion of such flow through a core passage 52 whereupon the flow is metered through suitably sized restrictions indicated at 53 and 54 and formed at the respective ends of the core passage 52 (Figure 6). A pair of intersecting openings 56 and 57 are formed in the pumping chamber member 13 to establish flow communication between the restriction 53 and an annular counterbore 58 formed at the bearing portion of the pumping chamber member 13 journaling one side of the driven gear 32 and the driver gear 31.

A pair of intersecting passages 59 and 60 are formed in the pumping chamber member 14 to establish flow communication between the restriction 54 and an annular counterbore 61 formed in the bearing portion of the pumping chamber member 14 journaling the driven gear 30 and the driver gear 29.

A plurality of axially extending apertures 62 are formed through each of the gears 29, 30, 31 and 32 and are arranged to be aligned in registry with the annular counterbores 58 and 61. Thus, the pressurized fluid in the annular counterbores 58 and 61 flows through the axially extending openings 62 to an annular counterbore 63 formed in the bearing face of each of the bushings 36.

The journaling portions of each of the pumping chamber members 13 and 14, as well as the axially extending portions of each of the bushings 36 are provided with axially extending lubrication grooves 64 and are constructed to supply a pressurized cooling and lubricating fluid throughout a substantial portion of the bearing engagement surface between the journaling elements and the gear type impeller elements.

Leakage of cooling and lubricating fluid through the bearings of the rotary fluid displacement means is referenced to a point of lower pressure, for example, a passageway 66 is provided (Figure 2) by means of which the fluid may be recirculated to a point adjacent the inlet of the centrifugal pumping unit.

It will be apparent that the structural arrangement provided in accordance with the principles set forth above permit the centrifugal pumping unit to develop the dual function of supplying fluid at positive pressure to the inlet of the gear type rotary fluid displacement means and to supply a flow of cooling and lubricating fluid through the bearings of the gear impellers.

It may be noted that the critical loading of bearings in a positive displacement pump of the type incorporating gear type impellers usually occurs at higher speeds. It is also well known that a centrifugal pumping unit develops increased pressures at higher speeds. In accordance with the principles of the present invention, therefore, the quantity of flow diverted through the bearings of the gear impellers is controlled as a function of pressure through the provision of the restrictions 53 and 54 operating as fixed orifices, thereby to increase the flow of cooling and lubricating fluid through the bearings at critical operating speed.

Although various minor structural modifications might be suggested to those versed in the art, it should be understood that we wish to embody within the scope of this patent all such modifications as reasonably and properly come within the scope of our contribution to the art.

We claim as our invention:

1. A mixed flow pump, comprising, a positive displacement pumping unit including rotary fluid displacement elements and bearings to rotatably journal said elements, a centrifugal pumping unit including an inlet and an outlet arranged to discharge a larger quantity of fluid at increased pressure to said positive displacement pumping unit than the pumping capacity of said positive displacement pumping unit, and by-pass means to divert a portion of the excess fluid supplied from said centrifugal pumping unit to said positive displacement pumping unit, said by-pass means including flow passages through said bearings to cool and lubricate same, said by-pass means having restricted flow passages therein to control the quantity of diverted flow as a function of pressure, thereby to provide increased fluid flow at critical speeds of said positive displacement pumping unit.

2. A pump comprising, a casing, a first stage pumping chamber and a second stage pumping chamber formed in said casing, rotary fluid pumping means in each of said chambers of different pumping capacities, respectively, larger and smaller, a common driving means to rotate each of said pumping means, an inlet in said casing for said first stage, an outlet in said casing for said first stage and constituting an inlet for said second stage, a diversion passageway in said casing from said outlet to said second inlet to divert the excess capacity of the first stage, said passageway having restrictions formed therein to meter a quantity of fluid in proportion to the pressure at said outlet, and bearings for said rotary fluid dis-

placement means having passages therethrough communicating with said diversion passageway for cooling and lubricating said bearings.

3. A pump comprising, a casing, a plurality of pumping chambers in said casing, rotary gear impellers in one of said chambers, a centrifugal impeller in another of said chambers, an inlet for said pump to said centrifugal impeller, a passage between said chambers to deliver the fluid discharged by the centrifugal impeller to the rotary gear impellers, bearings journaling said rotary gear impellers and having end faces engaging the side faces of said rotary gear impellers, an annular counterbore formed in said end faces of said bearings, axial holes through said rotary gear impellers in registry with said counterbore, and by-pass means between said passage and said inlet to divert a portion of the discharge from said centrifugal impeller, said annular counterbores being in flow passage communication with said by-pass means to provide a flow of cooling and lubricating fluid to said bearings.

4. A mixed flow pump comprising, gear type pumping elements, centrifugal pumping elements, bearing means to journal said gear type pumping elements, a common driving means for said pumping elements including speed proportioning coupling means between said gear and centrifugal elements to operate said centrifugal pumping elements at a speed greater than that of the gear pump elements to deliver fluid at increased pressure for further pressurization by said gear type pumping elements, and flow passage means to divert a portion of the fluid discharged by said centrifugal pumping elements through said bearing means to cool and lubricate said bearing means.

5. A mixed flow pump comprising, a first pressure stage and a second pressure stage, common driving means for both of said stages, said second pressure stage including bearing means and a rotor rotatably journaled in said bearing means, said first pressure stage including an inlet and a rotor adapted to deliver fluid at increased pressure for further pressurization in said second pressure stage and producing a discharge flow greater than the pumping capacity of said second pressure stage, and by-pass means from said first pressure stage to said inlet to divert the fluid discharged thereby in excess of the pumping capacity of said second stage, said by-pass means including flow passages through said bearing means to cool and lubricate said bearing means.

6. A pump comprising a casing, a plurality of longitudinally spaced pumping chambers in said casing, rotary gear impellers in one of said pumping chambers, a bushing in said casing to engage each rotary gear impeller in pressure sealing relationship, means to hydraulically load said bushings, a centrifugal pumping element in another of said pumping chambers, said casing having an inlet for said centrifugal impeller and an outlet for said centrifugal impeller further constituting an inlet for said rotary gear impellers, a core passageway in said casing in communication with the discharge from said centrifugal impeller, a restricted orifice at one end of said core passageway, an annular passageway in said casing adjacent the rotary gear impellers, passage means providing communication between said restricted orifice and said annular passageway to provide a supply of pressured fluid thereto, a plurality of axially extending openings formed through said rotary gear impellers and arranged in aligned registry with said annular passageway, an annular passageway in the face of each of said bushings in registry with said axially extending openings through said rotary gear impellers, a plurality of axially extending grooves in said bushings and in said casing in communication with said annular passageways in said bushings and in said casing to cool and lubricate the bearing surface at the rotary gear impellers, and means providing a return passage to conduct leakage through said bearings to the inlet of said centrifugal impeller.

7. A multiple pump comprising first and second pumps

in series flow relation, bearings for said second pump, means defining a passageway connecting the discharge side of the first pump with the inlet of the second pump, and additional means defining a by-pass passage from the discharge of the first pump to the inlet of the first pump, said by-pass passage including flow passage means through said bearings to supply said bearings with a pressurized flow of fluid to cool and lubricate said bearings.

8. A multiple pump comprising first and second pumps in series flow relation, bearings for said second pump, means defining a passageway connecting the discharge side of the first pump with the inlet of the second pump, and additional means defining a by-pass passage from the discharge of the first pump to the inlet of the first pump, said by-pass passage including flow passage means through said bearings to supply said bearings with a pressurized flow of fluid to cool and lubricate said bearings, said flow passage means including flow restriction means to meter only a predetermined portion of the fluid discharged by the first pump through the bearings.

9. A pump comprising, a casing, a plurality of pumping chambers in said casing, a rotary gear impeller in one of said chambers, a centrifugal impeller in another of said chambers, an inlet for said pump to said centrifugal impeller, a passage between said chambers to deliver the fluid discharged by the centrifugal impeller to the rotary gear impellers, bearings journaling said rotary gear impellers and having end faces engaging the side faces of said rotary gear impellers, means providing annular lubricating recesses between and radially inwardly of said side faces of said rotary gear impellers and said end faces, and by-pass means between said passage and said inlet to divert a portion of the discharge from said centrifugal impeller, said recesses being in flow passage communication with said by-pass means to provide a flow of cooling and lubricating fluid to said bearings.

10. A pump comprising, a casing, a plurality of pumping chambers in said casing, a rotary gear impeller in one of said chambers, a centrifugal impeller in another of said chambers, an inlet for said pump to said centrifugal impeller, a passage between said chambers to deliver the fluid discharged by the centrifugal impeller to the rotary gear impellers, bearings journaling said rotary gear impellers and having end faces engaging the side faces of said rotary gear impellers, means providing annular lubricating recesses between and radially inwardly of said side faces of said rotary gear impellers and said end faces, and by-pass means between said passage and said inlet to divert a portion of the discharge from said centrifugal impeller, said recesses being in flow passage communication with said by-pass means to provide a flow of cooling and lubricating fluid to said bearings, said bearings and said gear impellers having cooperating bearing surfaces characterized by the provision of axially extending grooves therein communicating with said recesses to flood the bearing surfaces with lubricant.

11. A pump comprising, a casing, a plurality of pumping chambers in said casing, a rotary gear impeller in one of said chambers, a centrifugal impeller in another of said chambers, an inlet for said pump to said centrifugal impeller, a passage between said chambers to deliver the fluid discharged by the centrifugal impeller to the rotary gear impellers, bearings journaling said rotary gear impellers and having end faces engaging the side faces of said rotary gear impellers and said end faces, and by-pass means between said passage and said inlet to divert a portion of the discharge from said centrifugal impeller, said recesses being in flow passage communication with said by-pass means to provide a flow of cooling and lubricating fluid to said bearings, said bearings and said gear impellers having cooperating bearing surfaces characterized by the provision of axially extending grooves therein communicating with said recesses to flood the bearing surfaces with lubricant, said grooves terminating short of the end of

said bearings to assist in maintaining a supply of lubricant at the bearing surfaces.

12. A pump comprising, a casing, a plurality of pumping chambers in said casing, a rotary gear impeller in one of said chambers, a centrifugal impeller in another of said chambers, an inlet for said pump to said centrifugal impeller, a passage between said chambers to deliver the fluid discharged by the centrifugal impeller to the rotary gear impellers, bearings journaling said rotary gear impellers and having end faces engaging the side faces of said rotary gear impellers and said end faces, and by-pass means between said passage and said inlet to divert a portion of the discharge from said centrifugal impeller, said recesses being in flow passage communication with said by-pass means to provide a flow of cooling and lubricating fluid to said bearings, said bearings and said gear impellers having cooperating bearing surfaces characterized by the provision of axially extending grooves therein communicating with said recesses to flood the bearing surfaces with lubricant, said grooves terminating short of the end of said bearings to assist in maintaining a supply of lubricant at the bearing surfaces, and means at the ends of said bearings providing a return passage to conduct leakage through said bearings to said inlet.

13. A pump comprising, a casing, a plurality of pumping chambers in said casing, a rotary gear impeller in one of said chambers, a centrifugal impeller in another of said chambers, an inlet for said pump to said centrifugal impeller, a passage between said chambers to deliver the fluid discharged by the centrifugal impeller to the rotary gear impellers, bearings journaling said rotary gear impellers and having end faces engaging the side faces of said rotary gear impellers, means providing annular lubricating recesses between and radially inwardly of said side faces of said rotary gear impellers and said end faces, and by-pass means between said passage and said inlet to divert a portion of the discharge from said centrifugal impeller, said recesses being in flow passage communication with said by-pass means to provide a flow of cooling and lubricating fluid to said bearings, said bearings and said gear impellers having cooperating bearing surfaces characterized by the provision of axially extending grooves therein communicating with said recesses to flood the bearing surfaces with lubricant, and means at the ends of said bearings providing a return passage to conduct leakage through said bearings to said inlet.

14. In a pump, a casing having an inlet and an outlet, rotary gears in said casing for moving fluid from said inlet to said outlet, bushings journaling said gears and having end faces engaging corresponding side faces of said gears, means providing annular recesses between and radially inwardly of said side and end faces, and passages formed in and through said gears and extending between the opposite side faces thereof to intercommunicate said annular recesses.

15. In a pump, a casing having an inlet and an outlet, rotary gears in said casing for moving fluid from said inlet to said outlet, bushings journaling said gears and having end faces engaging corresponding side faces of

said gears, means providing annular recesses between and radially inwardly of said side and end faces, and passages formed in and through said gears and extending between the opposite side faces thereof to intercommunicate said annular recesses, said bushings and said gears having cooperating bearing surfaces, means communicating fluid at increased pressure to said recesses at one end of each respective one of said bearing surfaces, and said casing having passage means formed at the opposite end of each respective one of said bearing surfaces communicating with a zone of lower pressure to produce forced flow of lubricant over said bearing surfaces.

16. A mixed flow pump comprising a positive displacement stage having gear type pumping elements, a centrifugal stage having a centrifugal impeller, bearing means to journal said gear type pumping elements, said centrifugal impeller arranged to deliver fluid at increased pressure for further pressurization by said gear type pumping elements, a casing common to both stages, speed proportioning means interconnecting said pumping elements and said impeller to rotate said impeller at proportionately faster speeds than said pumping elements, whereby said centrifugal impeller will discharge a larger quantity of fluid at increased pressure to said gear type pumping elements than the pumping capacity of said gear type pumping elements, and flow passage means to divert a portion of the fluid discharged by said centrifugal impeller through said bearing means to cool and lubricate said bearing means.

17. In a rotary gear pump, rotary gear impellers having radially extending side faces, bushing means to journal said impellers and having radially extending sealing faces engaging said side faces, means providing annular passageways between said side and sealing faces, a plurality of axially extending openings through the impellers intercommunicating said annular passageways, said journaling means having axially extending grooves in communication with said annular passageways, and means to provide a pressured fluid to said annular passageways to cool and lubricate the bearing surfaces of said impellers.

18. A multiple pump comprising first and second pumps in series flow relation, bearings providing bearing surfaces for said second pump, means providing a passage connecting the pressure side of the first pump with one end of each of said bearing surfaces for flow of pressured fluid to the bearing surfaces, and additional passage means connecting the other end of said bearing surfaces with the inlet side of the first pump for feeding the fluid through the bearing surfaces.

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