June 11, 1963 C. S. TARIFA ETAL 3,093,080

HYDRAULIC PUMPS

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FIG. 1

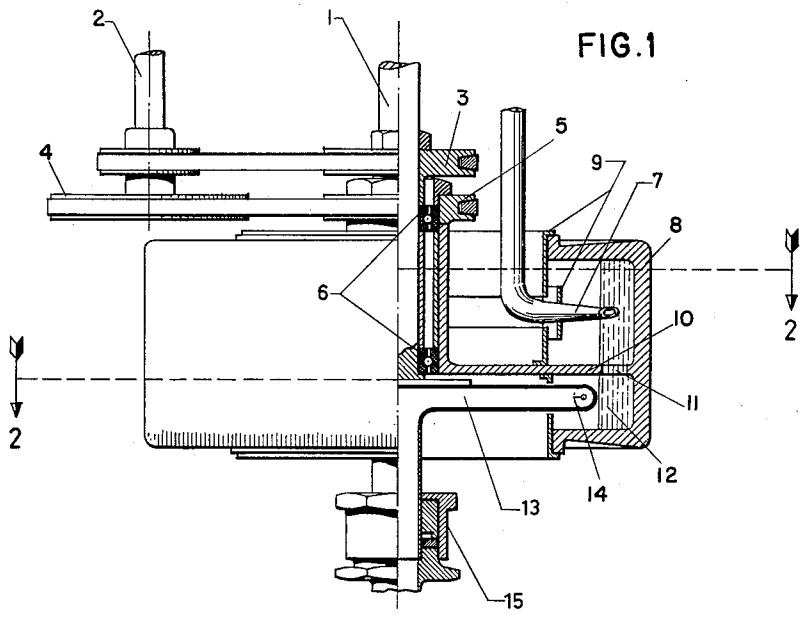
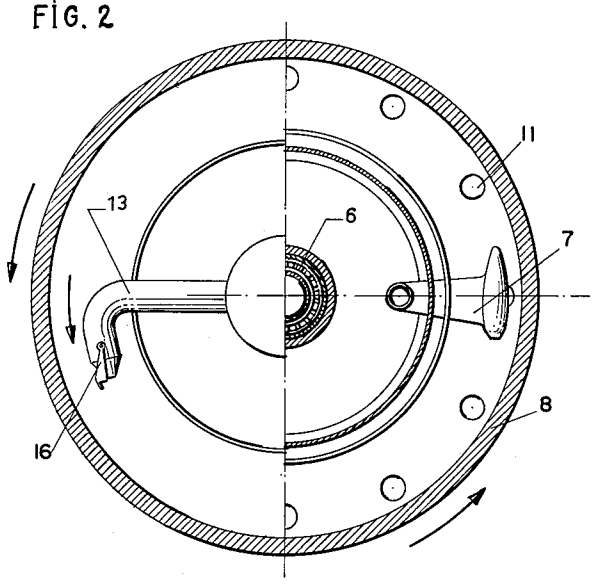


FIG. 2



INVENTORS
Carlos Sanchez Tarifa &
Jacobo Valdés Pedrosa

FIG. 3

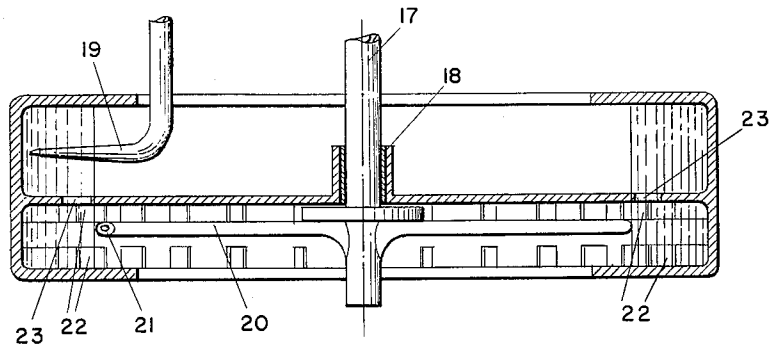


FIG. 4

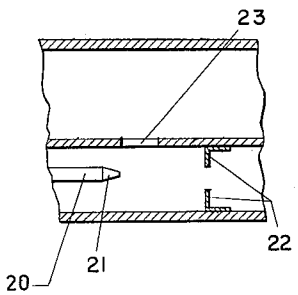
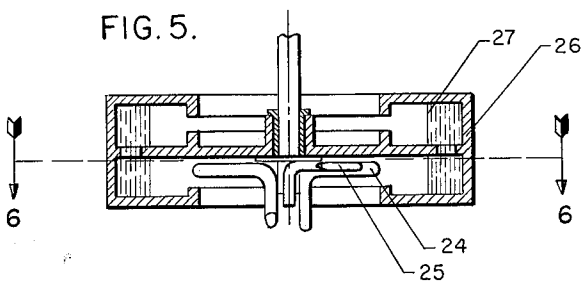


FIG. 5.



INVENTORS
Carlos Sanchez Tarifa &
Jacobo Valdés Pedrosa

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FIG. 6

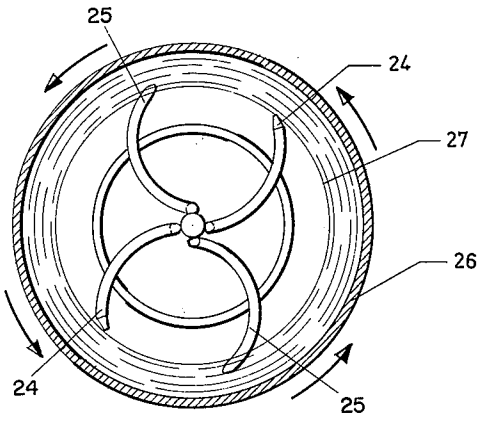


FIG. 7

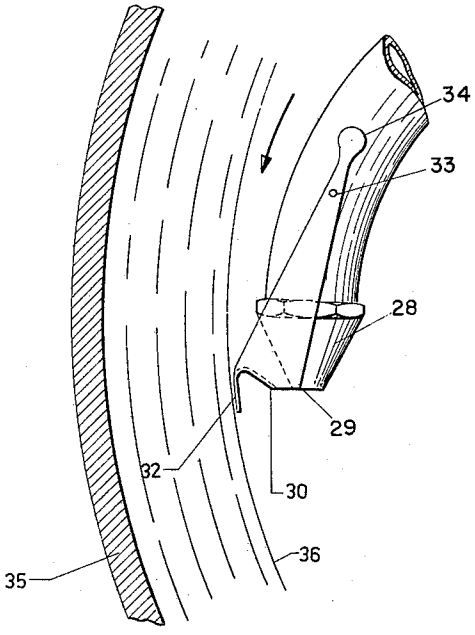
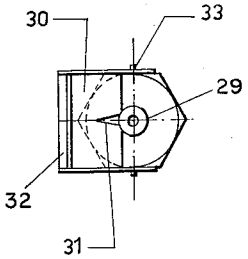


FIG. 8



INVENTORS
Carlos Sanchez Tarifa &
Jacobo Valdés Pedrosa

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FIG. 9

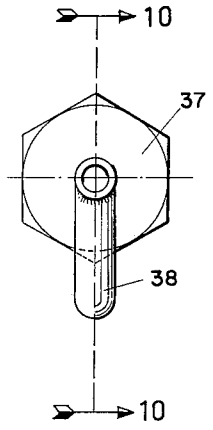


FIG. 10

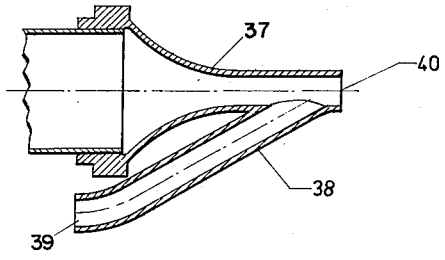


FIG. 13

FIG. 11

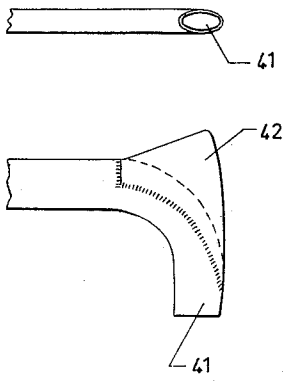


FIG. 12

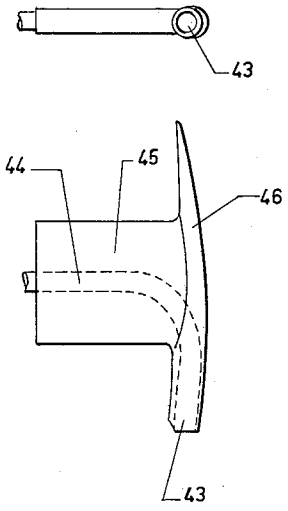


FIG. 14

FIG. 15

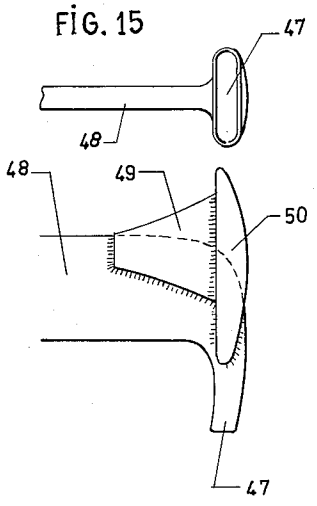


FIG. 16

INVENTORS
Carlos Sanchez Tarifa &
Jacobo Valdes Pedrosa

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3,093,080

HYDRAULIC PUMPS

Carlos Sanchez Tarifa, Avda. de America 4, and Jacobo Valdés Pedrosa, Ayala 75, both of Madrid, Spain

Filed Mar. 15, 1961, Ser. No. 95,999
7 Claims. (Cl. 103—5)

This invention relates to hydraulic pumps. More particularly, the invention relates to rotary type hydraulic pumps having an annular container forming a collection chamber which is rotated to impart a high tangential velocity to liquid introduced therein, and which liquid may then be removed from the rotating chamber by a suitable eduction pipe at high pressures. Rotary pumps of this type are relatively simple in structure, and they offer the important advantage of not requiring high pressure liquid seals or of requiring precision adjustments of any moving parts.

An object of the present invention is to provide a new and improved hydraulic pump.

Another object of the invention is to provide a new and improved rotary type hydraulic pump having higher efficiency and capable of developing higher pumping pressures than any of such pumps known heretofore.

In accordance with certain features of the invention, pumps embodying the invention comprise a rotatable annular container forming a collection chamber adapted to impart a high tangential velocity to liquid introduced therein, one or more inlet pipes for supplying liquid to the chamber, and one or more outlet pipes for removing the liquid therefrom at high pressures. The inlet pipes are positively rotated in the same direction as that in which the annular chamber is rotated by a separate driving means, while the outlet pipes are held stationary relative thereto. A primary feature of the invention is the rotation of the annular chamber at a speed substantially higher than that of the inlet pipes and preferably at about twice the speed of inlet pipes, thereby producing higher efficiencies and pressures than any such pumps known heretofore.

Other objects and advantages of the invention will become evident in the following detailed description of specific embodiments thereof, when read in conjunction with the accompanying drawings, wherein:

FIG. 1 is a partially sectional elevation view of a pump embodying the invention;

FIG. 2 is a plan elevation view and partial section taken on the line 2—2 of FIG. 1;

FIG. 3 is a partially sectional elevation view of another pump embodying the invention;

FIG. 4 is a fragmentary vertical section of a detail portion of FIG. 3;

FIG. 5 is a partially sectional elevation view of a pump constituting a third embodiment of the invention;

FIG. 6 is a horizontal section taken on the line 6—6 of FIG. 5;

FIG. 7 is a fragmentary partially sectional plan view of a portion of a pump embodying the invention, showing one means for automatically controlling the supply rate of liquid introduced into the annular collection chamber;

FIG. 8 is an end elevation view of a portion of the controlling means shown in FIG. 7;

FIG. 9 is an end elevation view of another form of such controlling means;

FIG. 10 is a vertical section taken on the line 10—10 of FIG. 9;

FIG. 11 is a side elevation view of an outlet pipe having an eduction orifice of oval cross-section;

FIG. 12 is a plan elevation view of the outlet pipe and orifice shown in FIG. 11;

FIG. 13 is a view corresponding to that of FIG. 11 showing an eduction orifice of circular cross-section;

FIG. 14 is a plan elevation view of the outlet pipe and orifice of FIG. 13;

FIG. 15 is a view corresponding with those of FIGS. 11 and 13 showing an eduction orifice flattened to extend vertically; and

FIG. 16 is a plan elevation view of the outlet pipe orifice of FIG. 15.

Referring to FIGS. 1 and 2, in this embodiment of the invention a rotary pump shaft 1 is driven from a motor shaft 2 through a suitable V-belt transmission extending from a small pulley on the shaft 2 to a pulley 3 secured to the shaft 1. A large pulley 4 also mounted on the motor shaft 2 transmits rotary motion through another suitable V-belt transmission to a pulley 5 rotatable freely on the shaft 1 and separated therefrom by ball bearings 6. A pair of oppositely extending radial feed arms constituting liquid inlet pipes are joined to and are rotatable with the rotary shaft 1.

Liquid supplied to the pump flows upwardly through a low pressure stuffing box 15, and thence radially outwardly through the feed arms 13 and through expansion nozzles 14 at the ends of the arms 13, into a surrounding rotatable annular container constituting a collection chamber 8. Due to the rotary motion of the feed arms 13, the liquid is sucked upwardly and centrifuged outwardly, so as to give it firstly an increase in its static pressure and thereafter a high tangential velocity.

The rotary feed arms 13 are connected centrally to a conduit coaxial with the shaft 1 and with the axis of rotation of the pump. This conduit and the arms 13 are connected to the pump shaft 1 by means of a suitable intermediate flange member, the shape of which may vary according to the number of arms and variations in the detailed structure of the pump.

The feed arms 13 may extend directly radially and thereby be perfectly straight, or they may curve gradually in the direction of rotation and terminate in an approximately tangential direction. The cross-sectional area of the flow passage through the arms may be constant or variable, but it must be sufficiently large for the frictional losses to be of small value. The shape of the cross-section of the arms does not substantially affect the operation thereof, but circular shapes are preferable because of their greater simplicity and because they entail smaller frictional losses than other shapes having a larger perimeter to area ratio. However, in some cases streamlined oval shapes may be suitable for the purpose of reducing the exterior aerodynamic resistance of the arms. Likewise, it is possible to arrange a plurality of such arms within a single fairing forming a hollow disc enclosing all of the arms.

The outer end of each of the radial arms 13 curves into a tangentially extending portion terminating in one of the expansion nozzles 14 and facing in the direction of rotation of the arms. The nozzles 14 have a flow passage of decreasing cross-section, and they are each equipped with an automatic flow rate control means 16, which will be described in detail subsequently in connection with FIGS. 7 and 8. The liquid discharged from the nozzles 14 is expanded from the pressure resulting from the effect of centrifugal force to the atmospheric pressure of the annular collection chamber 8 into which it is discharged. With this arrangement, the absolute speed of discharge is on the order of twice the peripheral speed (product of the angular speed and the radius) of the outer ends of the rotary feed arms 13.

The annular collection chamber 8 is preferably rotated at a speed of about twice the speed of rotation of the feed arms 13, and as indicated by the arrows in FIG. 2

the arms 13 and the chamber 8 are rotated in the same direction. By this arrangement the mean peripheral speed of the annular chamber 8 is approximately equal to its absolute speed of the liquid thrown by the rotary arms 13, and the collection of the liquid in the chamber is effected at zero speed or a very small relative speed, whereby frictional losses and splashing of the liquid are eliminated or substantially reduced.

As is shown in FIG. 1, the annular chamber 8 is generally U-shaped in cross-section, with the open side of the U facing inwardly toward the axis of rotation, and during rotation of the chamber 8 the collected liquid is held by centrifugal force against the outer or bottom wall of its U-shaped configuration. It should also be observed that the free surface 12 of the liquid in the chamber 8 is disposed vertically at a radius slightly greater than that of the outer ends of the feed arms 13.

The annular chamber 8 is divided intermediate its upper and lower ends, which correspond to the side walls of its U-shaped configuration, into two separate vertically spaced portions separated by a radial supporting disc 10 having a plurality of peripherally spaced apertures 11 through which the liquid flows from the lower portion to the upper portion. The rotary feed arms 13 are located in said lower portion, while a plurality of stationary outlet ducts 7 are positioned in said upper portion. Both portions of the chamber are open to the atmosphere on the side thereof facing the axis of rotation, but a pair of peripherally slotted annular plates 9 disposed vertically on opposite sides of the disc 10 function as splash shields for said upper and lower portions of the chamber, with the arms 13 and the outlet ducts 7 projecting through the slots in said plates 9. The division of the chamber 8 into an upper discharge portion and a lower collection portion by the disc 10 is convenient but not essential to the operation of the pump. The disc 10 could be omitted, whereupon the U-shaped chamber 8 could be supported by having one of its side walls attached to a suitable disc or to radial arms mounted rotatably on the pump shaft 1.

The stationary outlet ducts 7 may be attached to any fixed part of the pump or its support. These ducts penetrate the collected liquid in the upper portion of the annular chamber 8, entering in a generally radial direction they may curve gradually in a direction opposite to that of the centrifugally whirling liquid, and terminate in tangentially located pick-up orifices. These terminal orifices of the ducts 7 are designed to pick up the collected liquid at the stagnation pressure, which is equal to the static pressure plus the dynamic pressure corresponding to the tangential or peripheral velocity of the collected liquid. The discharge pressure of its pump therefore depends essentially on the tangential velocity of the collected liquid, and is proportional to the square thereof.

The outlet ducts 7 may vary in shape, from simple structures as above-described to complex forms designed to reduce the external hydrodynamic drag, as illustrated in detail in FIGS. 11 through 16. In FIGS. 11 and 12 an outlet orifice 41 is oval in shape, and a streamlined or low-drag profile fin 42 is attached to the duct 7 where the tangentially directed orifice 41 curves into the radially directed portion of the duct 7. FIGS. 13 and 14 show a corresponding orifice 43 of circular shape, and a streamlined fin 45 for a radial pipe portion 44 of oval cross-section, with an elongated streamlined fin 46 trailing the orifice 43. In FIGS. 15 and 16 a corresponding eduction orifice 47 is flattened into an oval shape having its major axis extending vertically, that is perpendicular to the plane of rotation of the pump. This orifice 47 leads to a radial pipe portion 48 of oval cross-section having a streamlined fin 49, and an elongated streamlined fin 50 trails from the orifice 47. The structure shown in FIGS. 15 and 16 is designed to enable the orifice to project deeply into the collected liquid to where the pressure is highest. In this respect, the depth to which the eduction orifices are introduced into the liquid depends upon the effect desired, since the total or stagnation pressure increases with the depth, while the hydrodynamic resistance of the duct also increases when a greater length thereof is projected into the flowing liquid.

In the embodiment of the invention illustrated in FIGS. 3 and 4, the rotation of the annular collection chamber is effected hydraulically by the momentum of the incoming liquid, in place of a mechanical drive, such as the two belt transmissions shown in FIGS. 1 and 2. Both the annular collection chamber and the rotary feed arms, such as arms 20, may be mounted directly on a single driving shaft 17, with the arms 20 rotated by said shaft 17 while the chamber body is freely rotatable thereon by means of a bearing 18. The chamber body is provided with a plurality of vanes 22 against which incoming liquid is thrown from ejection nozzles 21 located at the terminal ends of the feed arms 20, thereby propelling the chamber body rotatably. The liquid flows through orifices 23, which correspond to the orifices 11 of FIGS. 1 and 2, into the upper portion of the annular chamber, where the excess collected liquid is scooped out by stationary outlet ducts 19. The resulting maximum speed of rotation achieved by the annular chamber will be substantially higher than that of the rotary feed arms 20, but somewhat less than twice that speed.

FIGS. 5 and 6 show an embodiment wherein the eduction pipes are rotatable instead of being held stationary as in the two previously described embodiments. To this end, a pair of inlet feed arms 24 and a pair of outlet scoop arms 25 are secured centrally to a common rotatable shaft extending axially through an annular chamber 26. The arms 24 and 25 are rotated in the same direction, but they curve in opposite directions as they extend radially outwardly and approach tangential relationship with the surface 27 of the collected liquid. The inlet arms 24 terminate in nozzles facing on the direction of rotation and located slightly radially inward of the surface 27 of the collected liquid, while the outlet arms 25 have nozzles facing opposite to the rotation direction and radially beyond the liquid surface 27 so as to exert a scooping action. The annular chamber body being freely rotatable on the axial shaft, said body is propelled rotatably by the momentum of the incoming liquid.

It is evident that the amount of liquid collected and being centrifugally whirled within its annular rotatable chamber must be maintained between predetermined limits. Thus, an excessive quantity of liquid may merely overflow and be lost, while an inadequate quantity may result in a liquid level too low for the scooping action of the eduction pipes to be effective. These eduction pipes provide by themselves a certain margin of automatic regulation, since an increase in the quantity of liquid collected causes a reduction in the radius of its free surface and a corresponding increase in the static pressure, which results in increasing the volume of liquid pumped.

Additional means for automatically controlling the supply rate of the liquid being fed into the annular chamber may be advantageously provided, to maintain a constant radius of the surface of the collected liquid. One such control means is depicted in FIGS. 7 and 8, wherein an inlet expansion nozzle 28 has a terminal orifice 29 which is covered partially and uncovered to varying degrees by a transversely extending plate 30 having a V-shaped notch 31, best shown in FIG. 8. The plate 30 is joined to a tangentially extending tab 32 and is adapted to ride on the surface 36 of the collected liquid, and thereby move the plate 30 transversely across the orifice 29 about a pivot 33 as the depth of the liquid relative to the side wall 35 of the annular chamber increases or decreases. A balancing counterweight 34 is provided on the opposite side of the pivot 33. Thus, the uncovered area of the orifice 29 is effectively controlled automatically in proportion to the quantity of collected liquid present in the chamber.

It is also possible to regulate the flow supplied to the rotary feed arms by causing a back pressure in the expansion nozzles, as illustrated in FIGS. 9 and 10. To this end, an expansion nozzle **37** having a terminal orifice **40** is provided with a generally laterally extending regulating tube **38**, having an inlet orifice **39** directed rearwardly relative to the orifice **40**, whereby some of the collected liquid is allowed to enter laterally into the nozzle **37**. This laterally entering liquid is at a stagnation pressure dependent upon the relative speed of movement of the centrifugally whirling collected liquid. Thus, at greater speeds correspondingly greater back pressures are created in the nozzle **37**, thereby regulating the flow therethrough.

Pumps embodying the invention operate at high efficiencies, and are capable of pumping at pressures several times greater than can be done by an ordinary single rotor centrifugal pump. Furthermore, the pumps contemplated within the scope of the invention are simple and inexpensive to construct, they are capable of operating over a wide range of flow rates and pressures, and can pump a variety of different liquids, including muddy waters.

What we claim is:

1. A hydraulic pump comprising an annular container forming a collection chamber of U-shaped cross-section rotatable on a shaft and adapted to retain a quantity of collected liquid at its outer periphery by centrifugal force, means for rotating said container at a high speed to impart a high tangential velocity to liquid injected therein, at least one liquid inlet pipe mounted rotatably with said shaft and extending radially into said container, said means rotating said inlet pipe in the same direction as that of the container, said inlet pipe terminating in an injection nozzle disposed substantially tangentially with respect to said outer periphery and facing in its direction of rotation, at least one fixed liquid outlet pipe extending radially into said container to a point near its outer periphery so as to scoop collected liquid therefrom, said container being rotated at a speed substantially higher than the speed of the inlet pipe, whereby high pumping pressures are created, and means for maintaining the quantity of liquid retained in the container between maximum and minimum limits.

2. A hydraulic pump, comprising an annular container forming a collection chamber of U-shaped cross-section rotatable on a shaft and adapted to retain a quantity of collected liquid at its outer periphery by centrifugal force, means for rotating said container at a high speed to impart a high tangential velocity to liquid injected therein, a fixed liquid inlet duct extending into the container and communicating with a plurality of tubular branch arms extending radially towards the periphery of the container, said radial arms being rotatably mounted on the fixed inlet duct, means for rotating said arms in the same direction as that in which the container is rotated, each of said arms terminating in an injection nozzle disposed substantially tangentially with respect to said outer periphery and facing its direction of rotation, at least one fixed liquid outlet pipe extending radially into said container to a point near its outer periphery so as to scoop collected liquid therefrom, said container being rotated at a speed substantially higher than the speed of the inlet arms to create high pumping pressures, and means for maintaining the quantity of liquid retained in the container between maximum and minimum limits.

3. A hydraulic pump, comprising an annular container forming a collection chamber of U-shaped cross-section rotatable on a shaft and adapted to retain a quantity of liquid at its outer periphery by centrifugal force, means for rotating said container at a high speed to impart a high tangential velocity to liquid injected therein, a disc extending radially into the container from the shaft and dividing said container intermediately into an upper discharge chamber portion and a lower collection chamber portion, said disc having a plurality of peripherally spaced apertures adjacent said outer periphery allowing free flow of liquid from said lower collection chamber portion to said upper discharge chamber portion, a fixed liquid inlet duct extending into a low pressure stuffing box and communicating through said box with a plurality of tubular branch arms extending radially through said lower collection chamber portion of the container towards the periphery thereof, said radial arms being rotatably mounted on the fixed inlet duct, means for rotating said arms in the same direction as that in which the container is rotated, each of said arms terminating in an expansion ejection nozzle disposed substantially tangentially with respect to said outer periphery and facing its direction of rotation, a plurality of fixed liquid eduction pipes extending radially onto the upper discharge chamber portion of the container to near its outer periphery so as to scoop collected liquid therefrom, said container being rotated at a speed of about twice the speed of said inlet arms to create high pumping pressures, and means for maintaining the quantity of liquid retained in the container between maximum and minimum limits.

4. A hydraulic pump as defined by claim 3, wherein the means for maintaining the collected liquid between maximum and minimum limits is a transversely movable cover plate mounted pivotally on each of the injection nozzles, said plate being movable to control the area of the injection orifice uncovered, and an actuating tab secured to the plate and adapted to ride on the surface of the collected liquid, whereby the orifice area uncovered is responsive to the quantity of collected liquid present.

5. A hydraulic pump as defined by claim 3, wherein the means for maintaining the collected liquid between maximum and minimum limits is a duct allowing back pressure to be introduced into each injection nozzle, said duct extending laterally and rearwardly from the injection orifice to allow collected liquid to enter the nozzle at the stagnation pressure in the collection chamber, whereby the back pressure created is responsive to the quantity of collected liquid present.

6. A hydraulic pump, comprising an annular container of U-shaped cross-section forming a collection chamber rotatable on a shaft and adapted to retain a quantity of collected liquid at its outer periphery by centrifugal force, a radial disc secured to and dividing said container intermediately into an upper discharge chamber portion and a lower collection chamber portion, said disc having a plurality of spaced apertures adjacent said outer periphery allowing free flow of liquid from said lower collection chamber portion to said upper discharge chamber portion, a fixed liquid inlet duct extending into the container and communicating with a plurality of tubular branch arms mounted rotatably and extending radially through said lower collection chamber portion of the container towards the outer periphery thereof, means for rotating said arms in one direction, each of said arms terminating in an expansion injection nozzle disposed substantially tangentially with respect to said outer periphery and facing its direction of rotation, said periphery of the lower collection chamber portion of the container having a plurality of vanes against which the injected liquid impinges thereby rotatably propelling the container at a speed substantially higher than the speed of the arms, a plurality of fixed liquid eduction pipes extending radially into the upper discharge chamber portion of the container to near its outer periphery so as to scoop collected liquid therefrom, and means for maintaining the quantity of liquid retained in the container between maximum and minimum limits.

7. A hydraulic pump, comprising an annular container of U-shaped cross-section forming a collection chamber rotatable on a shaft, and adapted to retain a quantity of collected liquid at its outer periphery by centrifugal force, a fixed liquid inlet duct extending into the container and communicating with a plurality of tubular branch inlet arms mounted rotatably on said duct and extending ra-

dially towards the outer periphery of the container, means for rotating said inlet arms in one direction, each of said inlet arms terminating in an expansion injection nozzle disposed substantially tangentially with respect to said outer periphery and facing its direction of rotation at a predetermined radial distance from said periphery, a plurality of tubular outlet arms mounted for rotation with the inlet arms and extending radially towards said periphery, each of said outlet arms terminating in an eduction orifice disposed substantially tangentially with respect to said periphery and facing opposite to its direction of rotation at a radial distance less than that of the inlet arms from said outer periphery, means for rotating the collection chamber at a speed of about twice the speed of said arms, whereby high pumping pressures are created, and means for maintaining the quantity of liquid retained in the container between maximum and minimum limits.

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