June 10, 1952 W. T. LIVERMORE 2,599,927

SLIPPER PUMP

Filed Oct. 6, 1944 2 SHEETS—SHEET 1

Fig. 1.

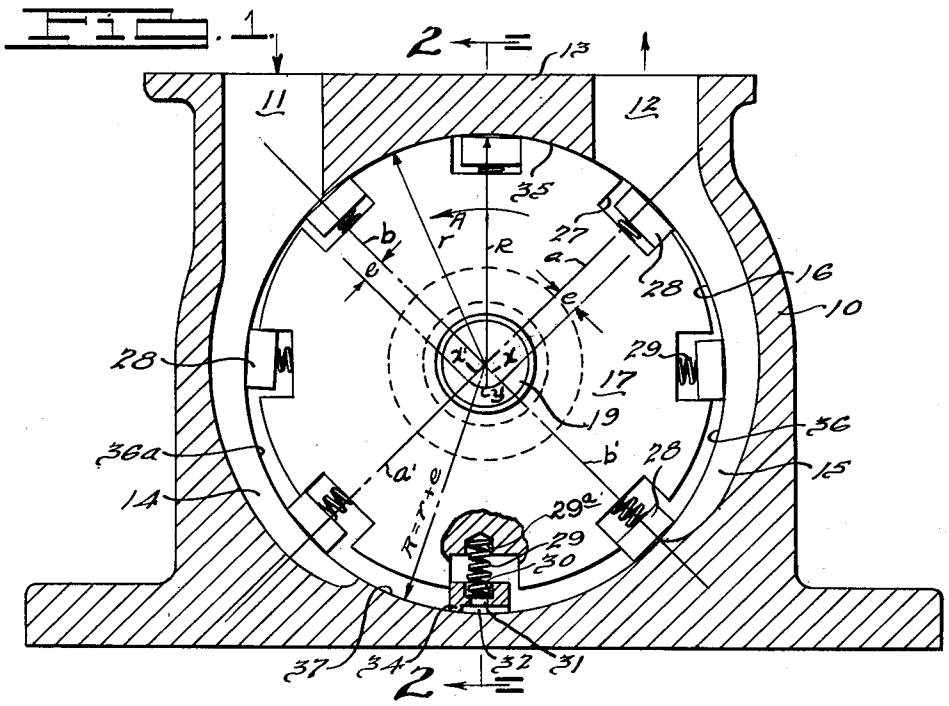
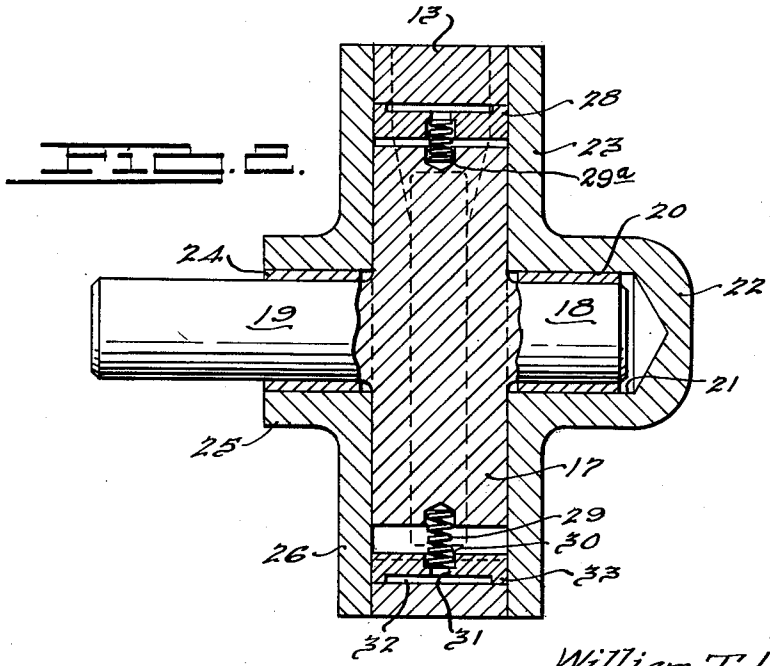


Fig. 2.



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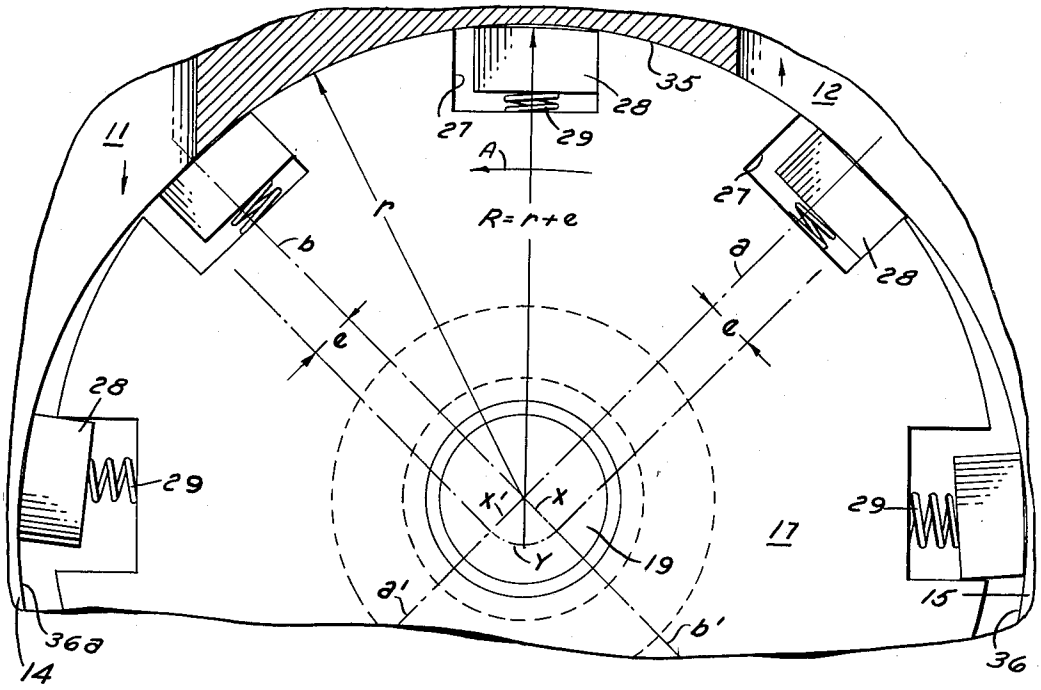


FIG. 3

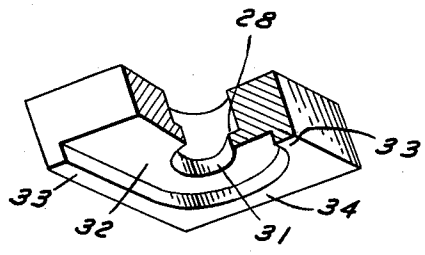


FIG. 4

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SLIPPER PUMP

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Application October 6, 1944, Serial No. 557,390

11 Claims. (Cl. 103—136)

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This invention relates to rotary pumps and specifically to that type thereof known as slipper pumps.

The rotary elongated vane type of pump is one wherein a rotor mounted for rotation in a pump casing or chamber carries a plurality of spaced vanes slidably arranged in rather deep radially extending slots which either extend nearly to the center of the rotor or extend diametrically entirely across said rotor. Although very many different types of constructions for the vane types of pumps have been proposed such type of pumps are subject to many objections. Unless the vanes extend a very substantial distance into the slots of the rotor, difficulty is experienced in preventing the vanes from jamming or cocking. As it is necessary, therefore, to have the vanes extend quite a substantial distance into the slots of the rotor, the frictional drag of the movement of the vanes in the slot is quite appreciable. Again due to the distance which the vanes must extend into the rotor slots, the vanes must be of substantial length and, due therefore to their mass, are forced against the bore of the pump chamber by centrifugal force with sufficient pressure as to cause marked wear upon the surface of the pump chamber.

Because of the above and other disadvantages of the rotary elongated vane type of pump, the so-called slipper type of pump is frequently employed. By a slipper pump is meant one in which the fluid propelling members instead of being of appreciable length, considered radially of the pump, are small block-like members, the thickness of which, that is the dimension considered radially, is usually no greater than and preferably is considerably smaller than the width of the notch or slot in the rotor in which said slipper is carried. By width is meant the dimension considered circumferentially, or in the direction of rotation of the rotor.

Both the elongated vane and slipper types of pumps are characterized by the rotor being mounted in a casing either having a pump chamber with a true cylindrical contour that is eccentric with respect to the axis of rotation of the rotor thereby to provide a crescent-shaped working space, or the inner surface of the pump chamber is in the form of a developed contour usually consisting of a plurality of cylindrical arcs which merge together to form a smooth contour with which the outer faces of propelling members, namely, vanes or slippers engage. When the inner surface of the pump chamber is formed as a developed surface of non-cylindrical contour, the machining of such surface is usually quite expensive.

One of the objects of the present invention is to provide a new and improved construction for the pump chamber of non-cylindrical contour which can be very simply and inexpensively machined in an ordinary standard milling machine.

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Another object is to provide a new and improved construction for a slipper type of pump wherein a portion of the pump chamber is in the form of a cylindrical arc concentric with the cylindrical surface of the rotor and, but very slightly greater than the radius of the rotor thereby to form a seal having a large surface area between the rotor and the inner wall of the pump chamber and located between the outlet and inlet ports of the pump.

A further object is to provide the pump chamber of the pump with a second cylindrical arc also concentric to the cylindrical surface of the rotor through the entire working arc between the inlet and outlet ports whereby the surface area of contact of the leading face of any one of the slippers against the fluid being pumped thereby will be uniform throughout the entire travel of the slipper through the effective working arc of the pump.

Another object of the invention is to form the contour of the surface of the pump chamber thereof adjacent to the inlet port and to so locate the port relative thereto that the formation of a vacuum pocket behind a slipper as such slipper enters the inlet port opening will be obviated.

A further object is to form the contour of the pump chamber in the area adjacent to the cut-off edge of the outlet port and to so locate the outlet port relative thereto that no fluid will be trapped in advance of a slipper as it passes through the non-working arc of the pump from the outlet towards the inlet of the pump.

Another object is to provide a new and improved construction for the slippers of a slipper type pump of the type wherein the slippers are seated in notches of much greater width than the slipper, whereby fluid will be admitted under pressure to the underside of the slipper and also to provide the slipper with a cut away portion on its outer face thereby to permit the pressure of the fluid to be exerted on the outer face of the slipper and thus counter-balance a portion of the fluid pressure on the underface thereof to reduce the frictional drag between the slipper and the inner surface of the pump chamber while at the same time maintaining effective sealing contact between the slipper and the surface of the pump chamber.

A further object is to provide an orifice or opening extending between the outer and inner faces of a slipper so as to insure that the pressure of the fluid being pumped will be equal on both faces of such slipper.

Another object is to provide a slipper type of pump in which the inner surfaces of the pump chamber are so constructed and arranged that the outer working faces of the slippers will be formed upon an arc having the same radius of curvature as the inner surfaces of the pump chamber throughout the working arc of the pump and upon a radius greater than the inner surface

of the pump chamber between the outlet and inlet whereby sealing contact of the slippers along the following edge thereof with the last-mentioned surface of the pump chamber will be secured.

As a result of considerable experimental and development work, I have found that the best efficiency for a slipper type pump is secured if the notches in which the slippers are mounted in the rotor are wider than the width of the slipper in order to permit the fluid being pumped by a slipper in the working arc of the pump to flow past the leading edge of the slipper and under the bottom surface thereof, thereby to employ the pressure of the fluid for forcing or holding the outer face of the slipper against the inner surface of the pump chamber with an effective seal. I have found that if the surface of the rotor of the pump contacts with the inner surface of the pump chamber at the point of tangency between these two members with a line contact in accordance with the usual construction of a slipper pump, the pressure of the fluid in the delivery or outlet side of the pump is exerted upon the rear or following edge of the slipper, while suction is exerted on the leading or forward edge of the slipper as the slipper is passing through the line of tangency. This tends to cause the slippers to be pulled forwardly so that the forward edge or leading edge contacts with the front wall of the notch and as the slipper passes into the working arc, the slipper is then shifted rearwardly to contact with the rear edge of the notch. Consequently, a more or less continuous shifting of the slippers from the forward to the rearward edge of the notch occurs, which produces fluctuations in the fluid pressure line that tends to produce an objectionable hydraulic hammer in the pressure line and also the shifting of the slippers tends to produce mechanical clicking noises which are highly objectionable. In accordance with the present invention, the pump is so constructed that a substantial sealing area is formed between the rotor and pump chamber at the non-working side of the pump which completely obviates these objectionable features because of the large area of the seal formed directly between the outer surface of the rotor and the cylindrical inner surface of the pump which is concentric with the cylindrical surface of the rotor and curved upon a radius that is substantially equal to the radius of curvature of the rotor.

The above and other objects of the invention, such as providing a pump of marked efficiency, low manufacturing and maintenance costs will appear more fully from the following more detailed description and by reference to the accompanying drawings forming a part hereof and wherein:

Fig. 1 is a central vertical section through the pump constructed in accordance with the principles of the present invention,

Fig. 2 is a vertical section taken substantially on the line 2—2 of Fig. 1,

Fig. 3 is an enlarged fragmentary view of the upper portion of the pump rotor shown in Fig. 1, and

Fig. 4 is a perspective view of an individual slipper element showing particularly the recess in the outer face thereof.

As shown in the drawings, the numeral **10** indicates the outer casing of the pump which is provided with an inlet **11** and an outlet **12** separated by a wall **13**. As clearly shown in Fig. 1, the inlet conduit terminates in an inlet port **14** while the outlet conduit terminates in similar port **15**.

The casing **10** is provided with a pump chamber indicated generally by the reference character **16** in which is rotatably mounted a rotor **17** having a pair of trunnions **18** and **19** integral therewith. The trunnion **18** is mounted in a suitable bearing bushing **20** seated within a bore **21** formed in a boss **22**, formed integral with the head **23**. The trunnion **19** is similarly journaled in a bushing **24** seated within an open ended boss **25** formed integral with the head **26**, the heads **23**, **26** being suitably secured to the pump casing **10** in the usual manner by bolts (not shown).

The rotor **17** is provided with a plurality of spaced notches **27** in each of which is seated a slipper **28** presently to be more fully described.

Each of the slippers **28** is normally urged in yielding contact with the wall **16** of the pump chamber by a compression spring **29**, one end of which is seated within a small hole **29**–*a* drilled in the base of each notch **27**. The other end of the spring **29** seats within a similar hole **30** drilled in the bottom face of its respective slipper **28**. As shown in Fig. 1 of the drawings, each slipper **28** is substantially narrower than the width of the notch **27** within which it is seated so that when the slippers are passing through the working arc of the pump chamber, the fluid under pressure within such working arc may pass into the notch to exert its pressure on the underside of the slipper and hold the same with a firm sealing contact against the wall of the pump chamber. For the purpose of reducing the pressure exerted by the slipper against the wall of the pump chamber, a small through hole **31** is drilled through the slipper in alignment with the hole or recess **30** so as to permit the pressure of the fluid within the notch below the slipper to be communicated to and equalized with fluid within a U-shaped recess **32** formed in the outer face of the slipper. This recess is bounded by a pair of side walls or ribs **33** and a rear wall or rib **34**, as shown in Figs. 1 and 2 of the drawings. It will be seen from the foregoing description that when a slipper is passing through the working arc of the pump with the rotor **17** rotating in the direction of the arrow A in Fig. 1, the fluid trapped in advance of the slipper will be prevented from flowing past the outer face of the slipper by the sealing of the outer surfaces of the two side ribs **33** and the rear rib **34** of each slipper; that the pressure of the fluid in advance of the slipper will be communicated directly to the recess **32** through the open front thereof and also through the notch **27** and holes **30** and **31** to the underside of the slipper so that the pressure both below the underface of the slipper and within the recess **32** on the top face thereof will be equalized.

The pump of the present invention has been particularly designed for use with automotive vehicles wherein smoothness and quietness of operation is absolutely imperative. If the surface of the rotor of the pump contacts with the inner surface of the pump chamber at the point of tangency between these two members with a line contact in accordance with the usual construction of a slipper pump, I have found that the pressure of the fluid in the delivery or outlet side of the pump is exerted upon the rear or following edge of the slipper, while suction is exerted on the leading or forward edge of the slipper as the slipper is passing through the line of tangency. This tends to cause the slippers to be pulled forwardly so that the forward edge or leading edge contacts

with the front wall of the notch and as the slipper passes into the working arc, the slipper is then shifted rearwardly to contact with the rear edge of the notch. Consequently, a more or less continuous shifting of the slippers from the forward to the rearward edge of each notch occurs, which not only causes fluctuations in the fluid pressure line that tends to produce an objectionable hydraulic hammer in the pressure line, but the shifting of the slippers also tends to produce mechanical clicking noises which are highly objectionable. I have also found that a smoother, quieter and more efficient operation of a slipper type pump is obtained if the cross sectional area of the space between the outer surface of the rotor and the inner surface of the pump chamber is uniform throughout the entire working arc of the pump between the inlet and outlet thereof.

The objectionable shifting of the slippers above described is obviated in the present invention by forming that portion of the surface of the pump chamber **16**, indicated by the reference character **25**, and located on the inner side of the wall **13** as a cylindrical arc having a radius r substantially equal to the radius of the rotor **17**, it being, of course, understood that the radius r of the surface **35** would be in the neighborhood of a thousandth of an inch larger than the radius of the rotor so that there is a neat running fit between the rotor and pump chamber at this point, while at the same time being of sufficiently close fit to maintain an effective seal between the inlet **11** and outlet **12** of the pump. The uniform cross sectional area of the pump in the working arc thereof is obtained by forming that portion of the pump chamber **16** indicated by the reference character **37** also as a cylindrical arc by having a radius R, which is equal to $r+e$, wherein e indicates the linear distance between the outer face of the rotor **17** and the cylindrical arc **37**.

As a matter of manufacturing simplicity and low manufacturing cost, the pump chamber is preferably fabricated by the use of an ordinary round or cylindrical milling cutter having a radius r, the axis of the cutter being held in substantially exact alignment with the axis upon which the rotor **17** is to be rotated, while the cutter is rotated to machine the cylindrical surface **35** to finished size. The milling cutter is then preferably fed so that its axis travels in a straight line, for example, along the line x, which will result in the formation of the surface **36** located between the radial lines a and b'. Next the cutter is then fed so that its axis traverses the circular arc y having a radius equal to the distance e indicated in the drawing. This will result in the formation of the cylindrical surface **37** having a radius R equal to $r+e$, and located between the radial lines b' and a'. Finally the cutter is fed backwardly to its starting point along the line x' which results in the formation of the surface **36**–a located between the radial lines a' and b.

As will be seen from the foregoing, the method of fabricating the walls of the pump chamber **16** is of marked simplicity as it can be performed with an ordinary stock or standard type of cylindrical milling cutter and by the simple manipulation of the carriage of a standard milling machine within the skill of an ordinary machinist. It will, of course, be understood that the contour of the pump chamber could be formed by the use of a special broach if the pumps were to be constructed in large quantities on a production basis.

In the operation of the pump with the rotor **17** rotating in a counterclockwise direction, as indicated by the arrow A in Fig. 1, it will be seen that fluid will be drawn in through the inlet **11** and the port **14**. The extreme lower end of the port **14** preferably terminates at a distance from the line a' that is slightly greater than or at least equal to, the width of the slipper. The purpose of this construction is to insure that when the leading or forward edge of the slipper reaches the cut-off position for the port **14**, the slipper will be in its outermost radial position from the axis of rotation, and so that there will be no possibility of any fluid being trapped as it were between the outer face of the slipper and the working arc **37** of the pump chamber **16**; such trapping would tend to prevent the rear edge or rib **34** of the slipper from forming a tight sealing contact with the wall **37**.

By reference to Fig. 1, it will be seen that the distance between the two slippers **28** through which the radial lines a' and b' pass is such that when the rear or following end of the slipper **28** at the lower right reaches the line b' at which the leading edge of outlet port **15** terminates, the leading edge of the slipper **28** at lower left simultaneously reaches the cut-off end of the inlet port **14**, as a result of this construction there will always be two succeeding slippers taking up the pumping function as soon as the slipper immediately ahead of them ceases its pumping action. Consequently, with the arrangement disclosed, the pump functions as a multi-stage pump and pump slip is reduced to a minimum. It will also be obvious that as the distance between the periphery of the rotor **17** and the cylindrical surface **37** is uniform throughout the pump's working arc, the delivery of the pump will at all times be uniform.

An important feature of the pump of the present invention is that the outer contact surface of each slipper is curved on an arc equal to the radius R of the cylindrical surface **37**; therefore the leading and following edges of the slippers will contact with the surface **35** of smaller radius. Surface, as distinguished from line, seals are thereby effected between outlet and inlet ports, by the slippers across the working arc and by the rotor itself across the non-working arc.

The springs **29** act to assist the centrifugal force in keeping the slippers snugly seated against the working arc **37** of the working chamber at low speeds and also tend to prevent the slippers from sticking to the bottom of the notches after they have passed the point of tangency between the rotor and working chamber.

The provision of the recess **32** in the outer working face of the slippers together with the communication provided through the hole **31** and counterbore **30** for fluid between the outer and underfaces of the slippers will result, as hereinbefore described, in a reduction of the force or pressure with which the slipper is forced against the surface of the working chamber of the pump by the fluid pressure.

It will be noted that the outlet port **15** terminates at the line b' so as to insure that the slippers will deliver fluid to the outlet port **15** and outlet **12**, while the slippers are still in their outermost radial position, and, therefore, delivering the full volume of fluid from the working chamber. As the slippers sweep upwardly from the right hand side of the pump, as shown in Fig. 1, and through the discharge arc of the pump, the configuration of the working face of the bore **16** is such that the outer faces of the slippers pass into engagement with the concentric arc **35** be-

fore they pass out of communication with the outlet port 15 and outlet 12, as is clearly indicated by the position of line *a*. It will likewise be noted that the end of the arc 35, as indicated by the position of line *b*, is slightly beyond the upper end of the inlet port 11. This results, as hereinbefore explained, in the sealing of the pump in the non-working arc between the inlet 11 and the outlet 12 being effected between the periphery of the rotor 17 and the concentric arc 35 of the bore 16. As a result, the slippers are not subjected to any suction or pressure effects from either the inlet or outlet of the pump, with the resultant tendency of the slippers, as hereinbefore described, to move backward and forward in their respective notches. It will be noted that the distance between the line *a* and the cut-off point of the outlet port 15 is greater than the width of the slipper so that there will be no possibility of any fluid being trapped ahead of the slippers as they pass through the concentric non-working arc 35 of the working chamber 16.

Although I have described a satisfactory constructional example embodying these various principles of invention, it will, of course, be understood that any changes, variations and modifications thereof may be resorted to without departing from the spirit of the present invention, as set forth in the claims hereunto appended.

I claim:

1. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches, the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber being provided with an arcuate sealing surface concentric with the axis of rotation of said rotor located between said outlet and inlet ports, and the radius of said arcuate sealing surface being substantially equal to the radius of said rotor thereby to form a fluid tight seal of relatively large area between the periphery of said rotor and said arcuate sealing surface between said inlet and outlet ports, the arc having said radius extending circumferentially into said outlet port a distance at least equal to the width of a slipper.

2. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber being provided with an arcuate sealing surface concentric with the axis of rotation of said rotor located between said outlet and inlet ports having substantially the same radius as said rotor, the arcuate surface having said radius extending into said outlet port a distance equal to at least the width of a slipper and extending at least to the beginning of said inlet port thereby to prevent the production of suction and pressure effects upon said slippers as they pass through the non-working zone of the pump between outlet and inlet ports thereof.

3. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber having an arcuate sealing surface concentric with the axis of rotation of said rotor extending entirely across said working chamber between the inlet and outlet of said pump and the radius of which is substantially equal to the radius of said rotor to form a fluid tight seal of relatively large area between said inlet and said outlet, and said working chamber having an arcuate working surface concentric with said rotor, diametrically opposite to said arcuate sealing surface and the radius of said second surface being greater than the radius of said rotor to form a working arc between said inlet and outlet ports of uniform cross sectional area, said slippers having an arcuate outer surface with a radius substantially equal to that of said working arc in order to establish a surface seal across the entire outside area of said slippers through said working arc.

4. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber having an arcuate sealing surface concentric with the axis of rotation of said rotor extending entirely across said working chamber between the outlet and inlet of said pump and the radius of which is substantially equal to the radius of said rotor to form a fluid tight seal of relatively large area between said inlet and said outlet and said working chamber having an arcuate working surface concentric with said rotor diametrically opposite to said sealing surface to form a working arc between said inlet and outlet ports of uniform cross sectional area, the concentric arc including said working arc extending into said inlet port a distance at least equal to the width of a slipper.

5. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber having an arcuate sealing surface concentric with the axis of rotation of said rotor extending entirely across said working chamber between the outlet and the inlet of said pump and the radius of which is substantially equal to the radius of said rotor to form a fluid tight seal of relatively large area between said inlet and said outlet and said working chamber having an arcuate working surface concentric with said rotor, diametrically opposite to said sealing surface to form a working arc between said inlet and outlet ports of uniform cross sectional area, the concentric arc including said working arc extending into said inlet port a distance at least equal to the width of a slipper and extending at least to the beginning of said outlet port.

6. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber having an arcuate working surface concentric to the axis of rotation of said rotor and having a radius greater than the radius of said rotor to form a working arc between said inlet and outlet ports of uniform cross sectional area, the concentric arc including said working arc extending into said inlet port a distance at least equal to the width of a slipper.

7. In a slipper type pump, a pump casing having a working chamber and a rotor rotatably mounted therein, said rotor being provided with a plurality of spaced notches, a slipper mounted in each of said notches, each of said slippers having a width and thickness and substantially less than the width and depth of its respective notch, the outer working face of said slipper being provided with an open ended U-shaped contact rib to reduce the cross sectional area of contact between the outer face of said slipper and the working chamber of said pump while retaining the stability characteristics of a full contact surface.

8. In a slipper type pump, a pump casing having a working chamber and a rotor rotatably mounted therein, said rotor being provided with a plurality of spaced notches, a slipper mounted in each of said notches, each of said slippers having a width and thickness substantially less than the width and depth of its respective notch, the outer working face of said slipper being provided along the side edges and the rear edge thereof with a projecting U-shaped rib to form a recess in said outer face open at the front end thereof for the admission of fluid under pressure to the outer face of said slipper as said slipper is passing through the working arc of said pump thereby to reduce the area of surface contact between said slipper and the surface of the working chamber of said pump as said slipper passes through said working arc while retaining the stability characteristics of a full contact surface.

9. In a slipper type pump, a pump casing having a working chamber, an inlet and an outlet terminating in an inlet and an outlet port respectively and communicating with said working chamber, a rotor having a plurality of spaced notches rotatably mounted within said working chamber, a slipper within each of said notches, each of said slippers having a circumferential width and a radial thickness substantially less than the width and depth of its respective notch, said working chamber having a working or pumping arc located between said inlet and said outlet ports through which said slippers pass to pump fluid under pressure from said inlet port to said outlet port and which fluid because of the looseness of each of said slippers in its respective notch is communicated to the underside of each slipper as it passes through said working arc, the upper face of each slipper being provided with a U-shaped contact rib to reduce the area of surface contact between said slipper and the working surface of said working chamber and the surface of said chamber as said slipper passes through the working arc of said pump while retaining the stability characteristics of a full contact surface, and means for establishing communication between the outer and under-surfaces of said slipper to insure equalization of the fluid pressure on said under and outer surfaces as said slipper passes through said working arc.

10. In a slipper type pump, a rotor having a plurality of spaced notches therein, a slipper freely mounted in each of said notches, the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, said rotor having a cylindrical periphery of radius r, and said working chamber also having an arcuate sealing surface substantially equal to said radius r, concentric to the axis of rotation of said rotor and extending entirely across said working chamber between said outlet and inlet ports and said working chamber having an arcuate working surface diametrically opposite said first named surface extending entirely across said working chamber between said inlet and outlet ports and having a radius $R=r+e$ where e represents the distance across the working arc of the pump between the said second surface and the periphery of said rotor, said slippers having an arcuate outer surface with a radius $R=r+e$.

11. In a slipper type pump, a rotor having a plurality of equally spaced notches therein, a slipper freely mounted in each of said notches the width and thickness of each slipper being less than the width and depth of its respective notch, a pump casing having a working chamber in which said rotor is rotatably mounted and an inlet and an outlet terminating in inlet and outlet ports respectively communicating with said working chamber, and said working chamber having a cylindrical working surface concentric to the axis of rotation of said rotor and having a radius greater than the radius of said rotor to form a working arc between said inlet and outlet ports of uniform cross sectional area the distance between the leading sealing edge of any one slipper to the following sealing edge of the second adjacent leading slipper being at least equal to the circumferential distance between said inlet port and said outlet port across said working arc.

WILLIAM T. LIVERMORE.

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