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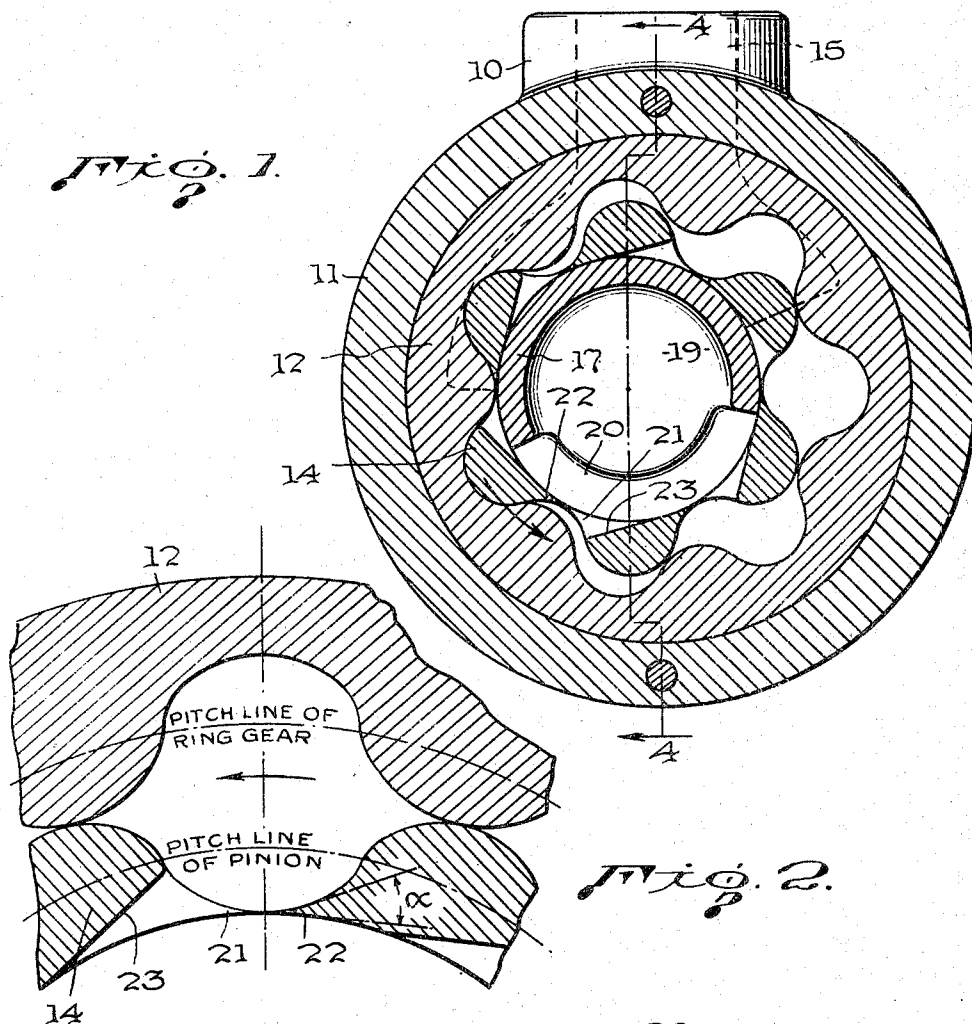
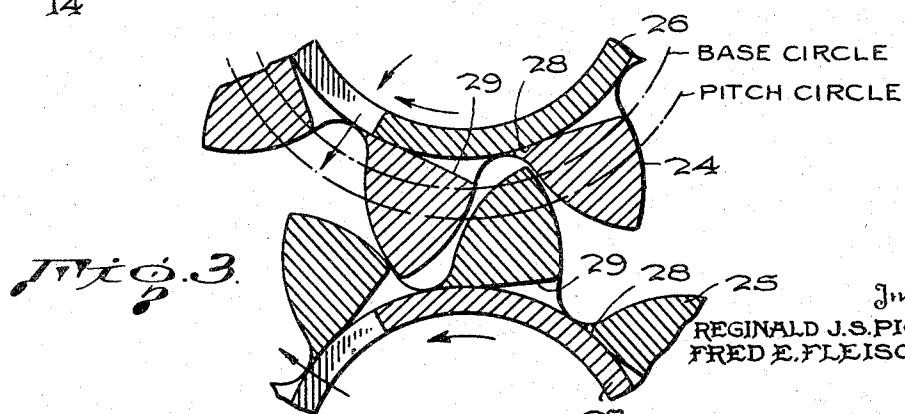
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ROTARY GEAR PUMP

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ROTARY GEAR PUMP

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This invention relates to rotary gear pumps and more particularly to an inlet port construction therefor which reduces shock loss and in general improves volumetric and mechanical efficiency at high speeds and especially under low inlet absolute pressures of the order of those encountered in the flight of aircraft.

Although our invention is not of limited applicability, as will be evident from the following description, it is especially adapted to pumps of the rotary positive displacement type the interengaging teeth of which are generated from a basic rack formed of two logarithmic spirals, as disclosed in the patent to R. J. S. Pigott, No. 1,909,117. These have an internally toothed ring gear meshing with a driving pinion of one tooth difference, the arrangement being such that the tooth spaces constitute chambers which expand and contract as the gears rotate, the expanding chambers communicating with an inlet port from which they draw liquid, while those which are contracting discharge the pumped liquid through an outlet passage.

Pumps of this type are designed for high speed operation and may be directly driven by electric motors at speeds of about 1200 R. P. M. or higher. The periphery of the pinion runs at a rather high rate and if liquid entering the tooth spaces is suddenly accelerated to the peripheral speed of the pinion a drop in pressure occurs at the inlet. If the liquid being pumped is saturated with gas or if it carries entrained air bubbles, a condition which is frequently encountered in aircraft engine lubrication systems, the resulting pressure drop at the inlet causes the gaseous fluid to expand and partially fill the tooth spaces. When this occurs the pump must assume the additional work of compressing the gas, thus not only reducing the liquid delivery of the pump but also giving rise to other objectionable results. Bubbles of air or evolved gas in the liquid entering at the inlet expand, due to reduced pressure at that point, and are then abruptly compressed and collapsed, producing vibrations in the column of oil discharged from the pump. These vibrations may be so severe as to cause mechanical failure and, even if more moderate, they cause rattle and noisy operation of the pump.

The present invention is an improvement upon that described and claimed in the copending application of Fred E. Fleischer, Serial No. 476,440, now Patent No. 2,416,987, wherein radial inlet ports open outwardly into the tooth spaces and the resistance to entry due to centrifugal force is eliminated. The internally ported construction

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permits the inlet ports to be shallow, thereby reducing inactive pump volume. According to the present invention the inlet ports also open outwardly but, instead of extending radially they are axially offset from the center line of the tooth spaces and are inclined to provide a wedge-shaped pick-up lip. This construction avoids sudden acceleration of the entering liquid to the speed of the rapidly rotating pinion, for the wall of each inclined port merges into the contour of its associated tooth space and the liquid, which in effect is scooped by the pick-up lip, rolls up along that contour into the chamber defined by the teeth in open mesh and is carried along by rotation of the pinion without abrupt change in the direction of its flow. The shock loss due to sudden acceleration is thereby reduced without sacrificing the advantages of the aforesaid radial port construction in keeping clearance volume to a minimum.

The improved construction preserves the advantage of shallow radial ports in that clearance volume is minimized (by "clearance volume" is meant the volume in the port which is now swept by the teeth of the meshing gear). With either the radial or inclined form of port a certain absolute radial velocity obtains, due to the tooth port area ratio to the volume of liquid flowing per second. In order to reduce unnecessary acceleration in tangential velocity components and thus avoid shock, this absolute radial velocity is preferably kept constant. Thus, in the case of the inclined port, its area perpendicular to the radial velocity (i. e., tangential to the circle at the base of the tooth) must remain substantially the same as if a radial port were employed. The transverse width of the port perpendicular to its own sides, however, will be narrowed proportionally to the tangent of the inclination angle. Although relative velocity of flow through the port is increased in the case of the inclined port, the absolute radial velocity of flow is unchanged.

An added advantage is that the inclined port permits the entry to be faired, so that a vena contracta is not formed in the liquid stream entering each tooth space.

One of the outstanding objects of the invention is to provide rotary gear pumps with an inlet passage which extends internally of one of the gears and which communicates with angularly inclined ports leading into the tooth spaces of such gear, whereby sudden acceleration of entering liquid, and accompanying pressure drop at the inlet causing shock loss, are minimized.

Another object of our invention is to provide one of the gears of a rotary gear pump with in-

ternal ports which are successively presented to an axial inlet and which open outwardly into the tooth spaces of such gear, the ports being so inclined that entering liquid is directed in smooth flow along the surface of each advancing tooth and is accelerated to the speed of the rotating gears without detrimental pressure drop at the inlet.

A further object of our invention is to provide a rotary gear pump with inclined ports opening outwardly into the tooth spaces, thereby constituting by means of the relatively thin edge at the entrance of each port, a pick-up lip whose contour merges with that of the advancing tooth, the opposed edge of the port being so shaped by cutting or fairing away the bottom of the tooth on a long slope, leaving only a narrow land at the lip, that the opening is in the form of a modified bell mouth converging from the port entry toward the tooth space, which suppresses the formation of a vena contracta in the stream of liquid entering each tooth space.

Other and further objects and advantages of the invention will be apparent from the accompanying description and drawings, in which

Figure 1 is a vertical cross-sectional view through a rotary positive displacement pump embodying the improved inlet port arrangement;

Figure 2 is an enlarged detail view of a part of the pump shown in Figure 1;

Figure 3 is a fragmentary cross-sectional view showing the port arrangement as embodied in a spur gear type of pump;

Figure 4 is a sectional view, taken along line 4-4 of Figure 1, and

Figure 5 is a perspective view of the driving pinion as employed in the rotary positive displacement pump of Figures 1 and 4.

Referring to the drawings and in particular to Figures 1 and 4, the pump casing 10 is formed with a cup-like cavity bounded by an annular wall 11 within which a rotatable ring gear 12 is retained by a cover 13. A pinion 14 which has one tooth less than the ring gear is eccentrically mounted so that as it drives the ring gear in the direction of the arrow, Figure 1, the pinion teeth will enter into full mesh with those of the ring gear at a point adjacent the discharge port 15 of the pump. In continued rotation of the gears, their contacting teeth will form expanding chambers in the tooth spaces of the ring gear as the same rotates past the pump inlet, and contracting chambers therebeyond where they communicate with the discharge port. The pinion 14 is mounted on a shaft 16 journaled in the pump casing and adapted to be coupled to an electric motor or other prime mover, not shown.

A cylindrical boss 17 on the cover 13 extends into the cored face of pinion 14, the face of the pinion being cut away to the root circle so that the projecting teeth 18, which are spaced apart, as shown in Figure 5, engage over the boss and are in close contact with it during their rotation. The boss is formed with an internal passageway 19 terminating in a slot 20 which is presented to the openings or ports 21 between the pinion teeth. Thus, as the gears rotate and the pinion teeth pass the inlet 20, the fluid to be pumped enters the expanding chambers in the tooth spaces without material change of velocity or direction and not opposed by centrifugal force.

The ports 21 are offset from the center lines of each respective tooth space, thereby providing a tapered pick-up lip 22, the surface contour of which is the unaltered contour of the tooth shape.

This materially aids in filling the tooth spaces at high speed by reducing shock loss. The angle α at the entering edge (Figure 2) can be varied to give best results, the tangent of the angle being equal to the mean radial velocity of the fluid through the port divided by the tangential velocity at the diameter of the port, or

$$\tan \alpha = \frac{v_r}{v_t}$$

Entering fluid is not suddenly accelerated in the direction of the rotating teeth, but keeps the same direction and velocity of flow and rolls up along the surface of the advancing tooth of the pinion. Thus, an abrupt pressure drop at the pump inlet, and the detrimental effects produced by such pressure drop, are avoided.

The bottom of each tooth is faired away on a long slope as at 23 to form the leading edge of a modified bell mouth opening which is defined by the outwardly converging surfaces of the wall 23 and the opposed pick-up lip 22, and, leaving only a very narrow land at the lip. This also aids in filling the tooth spaces by reducing resistance to flow. In effect, it increases the value of the orifice coefficient, providing a larger flow for the same pressure drop across the port and suppressing the formation of a vena contracta in the liquid stream flowing through the port.

Our invention is also applicable to an internal ported spur gear type of pump, as shown in Figure 3, wherein spur gears 24 and 25, which are cut away at their centers, are mounted on hollow bosses 26 and 27 or other suitable inlet means. In this construction, the contour of the lip 28 will be limited by the curve generated by the tip of the mating tooth, so as not to interfere with the natural tooth action, and both the pick-up edge and the beveled side 29 must be kept below the base circle of the gear.

From the foregoing it will be apparent that our invention provides an inlet port construction for gear pumps of either the internal-external gear type or the spur gear type, which port not only opens outwardly into the tooth spaces to eliminate centrifugal force as a resistance in filling the tooth spaces but, as well, is offset and inclined to provide a tapered pick-up edge for promoting smooth flow into the tooth space while avoiding sudden acceleration of the liquid picked up in rotation of the gears, and which, further, provides a modified bell-mouth opening adapted to suppress the formation of a vena contracta in the stream of liquid entering the tooth space and thereby to reduce resistance to flow.

What we claim is:

1. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, at least one of said gears being formed with an axial cavity and having inclined ports extending outwardly from said cavity to the spaces between adjacent teeth of such gear, a fixed inlet passage means extending from the pump inlet into the gear cavity and having an outwardly directed opening to which said ports are successively presented in rotation of the gear, said inlet passage means constituting an abutment between the inlet and outlet of the pump.

2. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, at least one of said gears being formed with an axial cav-

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ity and having inclined ports extending outwardly from said cavity to the spaces between adjacent teeth of such gear, a tapered pick-up lip at the advancing edge of each said port and an opposed port wall inclined in the direction of slope of the tapered pick-up lip and extending from the gear cavity to the communicating tooth space, a fixed inlet passage means projecting from the casing inlet into the gear cavity and having an outwardly directed opening to which said ports are successively presented in rotation of the gear, said inlet passage means constituting an abutment between the inlet and outlet of the pump.

3. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, at least one of said gears being formed with an axial cavity and having inclined ports extending outwardly from said cavity to the spaces between adjacent teeth of such gear, each port having its center offset from the center line of its associated tooth space, a tapered pick-up lip at the edge of said port nearest the center line of the associated tooth space, and an opposed port wall inclined in the direction of slope of the tapered pick-up lip and extending from the gear cavity to the communicating tooth space, a fixed inlet passage means extending from the casing inlet into the gear cavity and having an outwardly directed opening to which said ports are successively presented in rotation of the gear, said inlet passage means constituting an abutment between the inlet and outlet of the pump.

4. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, at least one of said gears being formed with an axial cavity and having inclined ports extending outwardly from said cavity to the spaces between adjacent teeth of such gear, each port being angularly related to the radial center line of its communicating tooth space, a tapered pick-up lip at one edge of each said port and an opposed inclined wall extending from the gear cavity to the tooth space with which each port communicates, a fixed inlet passage means extending from the casing inlet into the gear cavity and having an outwardly directed opening to which said ports are successively presented in rotation of the gear, said inlet passage means constituting an abutment between the inlet and outlet of the pump.

5. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, at least one of said gears being formed with a cavity of substantially the same diameter as the diameter of the root circle of such gear and having inclined ports extending outwardly from said cavity to the spaces between adjacent teeth of such gear, one edge of each port lying closely adjacent to the center line of the communicating tooth space, thereby providing a tapered pick-up lip on said edge, the port wall opposite to said pick-up lip being formed by cutting away a portion of the flank and base of the next adjacent tooth, a fixed inlet passage means extending from the casing inlet into the gear cavity and having an outwardly directed opening to which said ports are successively presented in rotation of the gear, said inlet passage means constituting an abutment between the inlet and outlet of the pump.

6. In a rotary gear pump having a chambered

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casing provided with an inlet and an outlet, meshing gears in said casing serving as pumping members, at least one of said gears having a cavity therein of a diameter substantially the same as that of the root circle of such gear, inclined ports in such gear extending from the cavity therein to the spaces between adjacent teeth thereof, an inlet passage means projecting from the casing inlet into the cavity of such gear and providing an abutment between the pump inlet and outlet, said means having an opening through which fluid enters the said ports as the same are presented thereto in rotation of the gear, the entry of each port being centrally displaced from alignment with the center line of its communicating tooth space, thereby constituting the advancing flank of each tooth a tapered pick-up lip having as its tapered surface a portion of the contour of its associated tooth, and a spaced inclined wall forming the wall of the port opposed to said pick-up lip.

7. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, inlet passage means extending into an axial cavity in one of the meshing gears and providing an abutment between the pump inlet and outlet, said cavity being substantially of the same size as the root circle of said gear, inclined ports in said gear extending outwardly from the axial cavity therein to the spaces between the teeth thereof, each port entry being offset from the center line of its communicating tooth space to provide a wedge-shaped pick-up lip at the base of one of the adjacent teeth defining such space and having a surface contour which merges with that of its associated tooth, the wall of port opposite said pick-up lip being inclined in the same direction as the slope of the pick-up lip.

8. In a rotary gear pump having a chambered casing provided with an inlet and an outlet, meshing gears in said casing serving as pumping members, at least one of said gears being formed with an axial cavity extending substantially to the root circle of such gear, a series of inclined ports in such gear extending outwardly from the cavity therein to the spaces between adjacent teeth of the gear, each said port having a tapered pick-up lip at its advancing edge and an opposed inclined wall of sufficiently long slope to leave only a narrow land adjacent the pick-up lip of the next port in the series, and an inlet passage means projecting from the casing inlet into the cavity of said gear and providing an abutment between the inlet and outlet, said inlet passage means having an opening through which fluid enters the said ports as the same are presented thereto in rotation of the gear.

9. In a rotary gear pump having a chambered casing provided with an inlet and an outlet, meshing gears in said casing serving as pumping members, at least one of said gears being formed with an axial cavity extending substantially to the root circle of such gear, a series of inclined ports in such gear extending outwardly from the cavity therein to the spaces between adjacent teeth of the gear, each said port having a tapered pick-up lip at its advancing edge formed by the contour of one of the adjacent teeth and an inclined wall spaced therefrom formed in the next adjacent tooth, the opposed surfaces of said pick-up lip and wall converging in outward direction from the port entry, and an inlet passage means projecting from the pump inlet into the cavity

of said gear and providing an abutment between the pump inlet and outlet, said means having an opening through which fluid enters the said ports as the same are presented thereto in rotation of the gear.

10. In a rotary gear pump having a chambered casing provided with an inlet and an outlet, meshing gears in said casing serving as pumping members, at least one of said gears being formed with an axial cavity of a size substantially the same as that of the root circle of such gear and further being formed with inclined ports extending outwardly from said cavity to the spaces between adjacent teeth of such gear, each said port having a pick-up lip at its advancing edge formed in one of each pair of teeth defining a tooth space, each said pick-up lip comprising a section of the wall of the central cavity which provides a narrow land and the intersecting sloping surface of the advancing flank of the tooth from which said pick-up lip is formed, each port further having a spaced inclined wall opposed to said pick-up lip and of more gradual slope than that of the pick-up lip, the center of each port being displaced from the center line of its communicating tooth space, an inlet passage means projecting from the pump inlet into the cavity of said gear and providing an abutment between the pump inlet and outlet, said means having an outwardly directed opening through which fluid from the pump inlet enters said ports as the same are presented thereto in rotation of the gear.

11. In a rotary pump having a casing provided with an inlet and an outlet, the combination of meshing rotary gears in said casing for transferring fluid from the inlet to the outlet, at least one of said gears being formed with an axial cavity, inlet passage means projecting into said gear cavity and constituting an abutment between the inlet and outlet of the pump, inclined ports in such gear extending outwardly from said cavity to the spaces between adjacent teeth of the gear, said inclined ports being located off center with respect to their associated tooth spaces to define a tapered pick-up lip at one edge of each port entry and an opposed inclined wall which joins the tooth space at a point not outwardly of the base circle of the gear.

12. A pump of the rotary positive displacement type having a chambered casing provided with an inlet and an outlet and containing an internally toothed ring gear and a pinion of one tooth difference meshing therewith, the pinion being formed with a cavity in one side extending substantially to the root circle thereof, a drive shaft extending from the other side of said pinion and journaled in the wall of said casing, inlet passage means fitting within said pinion cavity, said inlet passage means being open to the inlet of the pump but providing an abutment between the inlet and outlet, inclined ports in said pinion opening outwardly from the cavity therein into the spaces between adjacent teeth thereof, the center of each said port being displaced from the center line of its communicating tooth space to provide a wedge-shaped pick-up lip in one of each pair of teeth defining a tooth space at one edge of the port entry, the surfaces of which pick-up lip comprise a section of the wall of the pinion cavity and the contour of the pinion adjacent to said edge of the port entry, and an inclined wall extending from the opposite entry edge of the port to such tooth space.

13. A pump of the rotary positive displacement

type having chambered casing provided with an inlet and an outlet and containing an internally toothed ring gear and a pinion of one tooth difference meshing therewith, the pinion being formed with a cavity in one side extending substantially to the root circle thereof, a drive shaft extending from the other side of said pinion and journaled in the wall of said casing, inlet passage means fitting within said pinion cavity, said inlet passage means being open to the inlet side of the pump but providing an abutment between the inlet and outlet, inclined ports in said pinion opening outwardly from the cavity therein into the spaces between adjacent teeth thereof, the center of each port entry being offset from the center line of its associated tooth space to provide a pick-up lip substantially at the root of one of the adjacent teeth defining each tooth space, the tangent of the angle of said pick-up lip being equal to the mean radial velocity of the fluid through the port divided by the tangential velocity at the diameter of the port, and an opposed inclined wall extending from the opposite entry edge of the port to the tooth space.

14. A pump of the rotary positive displacement type comprising a casing body formed with an internal chamber for receiving meshing gears and having an abutment therein for preventing lateral shifting of the gears in one direction, an internally toothed ring gear received in the internal chamber and a meshing pinion of one tooth difference also mounted in the chamber and rotatable on an axis spaced from that of the ring gear, a drive shaft extending from one side of said pinion and journaled in said casing body, and a fluid passageway in said casing body extending from the exterior to the chamber therein, a circular cavity in the pinion of substantially the same size as the root circle of the pinion, a cover for said casing body confining the ring gear and pinion within the chamber, said cover being provided with a projecting boss which extends into the pinion cavity and closely fits the same, the said boss having a fluid passageway directed outwardly within the pinion cavity, the wall of said boss providing an abutment between the inlet and outlet of the pump, shallow ports extending outwardly from the said cavity to the spaces between adjacent teeth of the pinion, each said port being offset from its respective communicating tooth space, a tapered pick-up lip at one edge of the port entry, formed in the tooth adjacent said edge by intersection of the tooth surface with the surface of said cavity, and a spaced inclined surface extending from the pinion cavity outwardly to the tooth space and joining the tooth space within the base circle of said pinion, said inclined wall defining the opposite side of the port.

REGINALD J. S. FIGOTT.
FRED E. FLEISCHER.

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