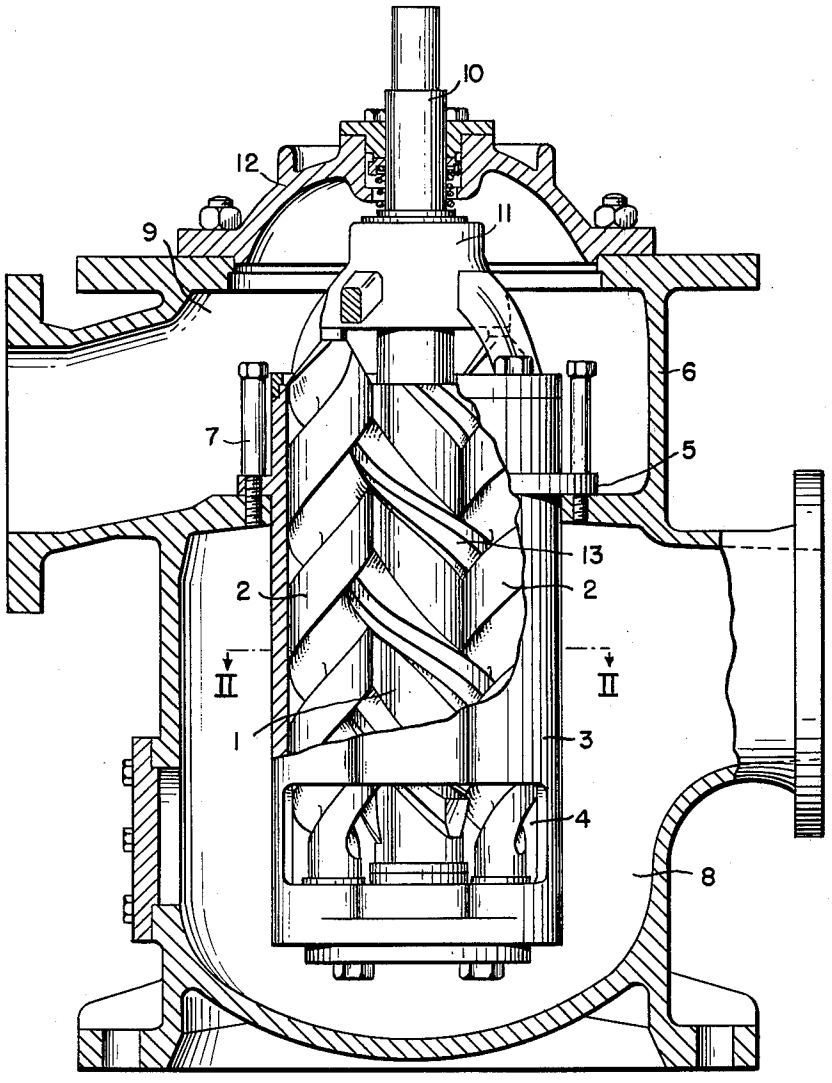
Sept. 17, 1963 M. B. SENNET 3,103,894

SCREW PUMP

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Fig. 1.



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SCREW PUMP

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Fig. 2.

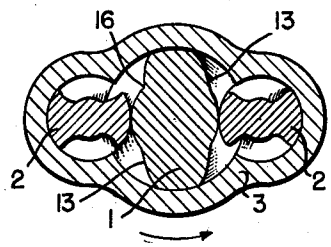


Fig. 5.

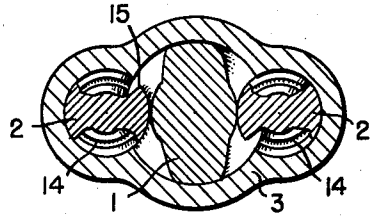
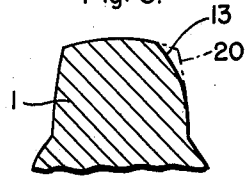


Fig. 3.



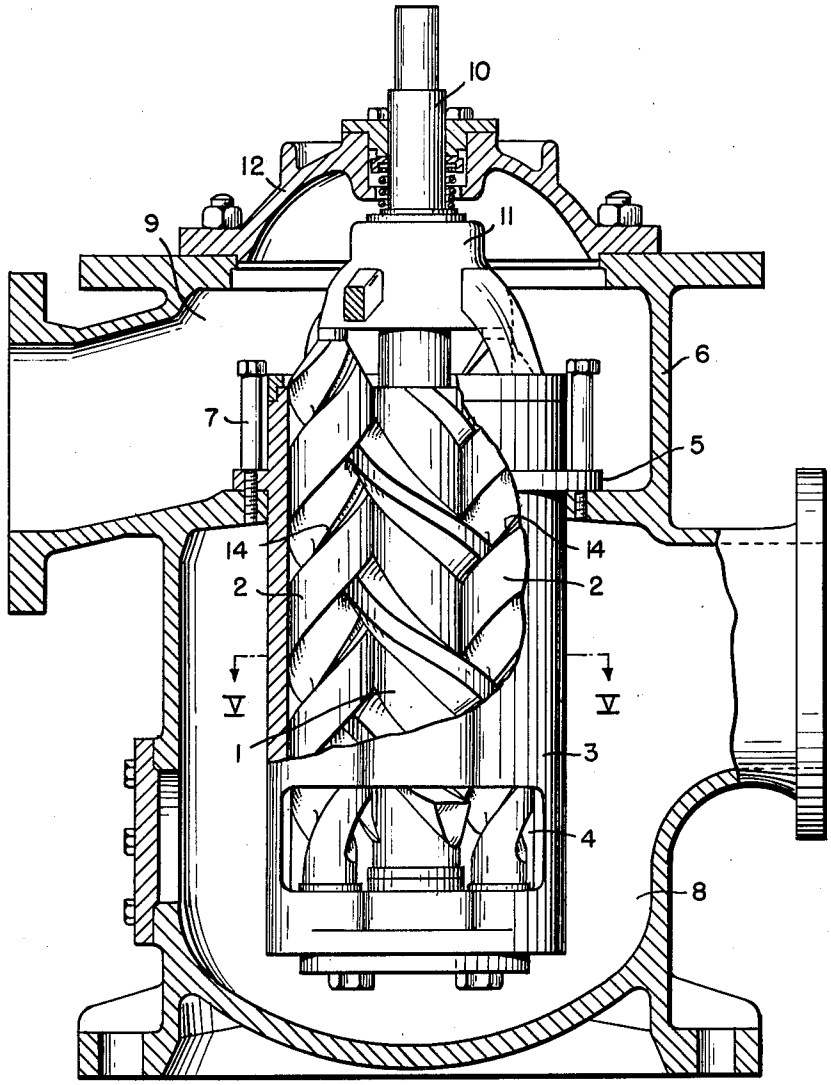
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Fig. 4.



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3,103,894

SCREW PUMP

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This invention relates to screw pumps of the type comprising an assemblage of screws including a middle power screw with convex thread flanks and one or more side or idler screws meshing with the middle screw and having concave thread flanks, the threads being of such configuration that they seal against the circumferences of cooperating screws, all said screws being sealingly enclosed in a casing.

In the operation of such a pump, the liquid being pumped is progressed axially from the inlet end or suction side of the screw assemblage to the outlet end or pressure side thereof in essentially closed chambers formed by the thread flanks and bottoms of the screws and the enclosing casing. Such a chamber is formed at the suction-side of the screw assemblage when the screws are rotated and is filled with liquid while it is formed. When the chamber is fully formed, it is closed toward the suction side and on continued rotation of the screws it travels axially along the screw assebmlage toward the outlet end of the screw assemblage where it is opened and the liquid is discharged. The volume of the chamber is unchanged while it progresses from the inlet to the outlet end, and provided that the pump is ideally tight, the liquid in the chamber is throughout this travel subjected to the pressure prevailing at the inlet end to be subjected to the higher pressure prevailing at the outlet end only when the chamber is opened at the outlet end. In an actual pump of this type, of course, a certain amount of leakage will occur on account of unavoidable tolerances in the manufacture which result in a certain amount of play as between the screws and as between the screws and the casing, wherefore a small increase in the pressure on the liquid will occur during travel along the screw assemblage. With a sufficient accuracy in manufacture, however, this increase in pressure will be so small that substantially the entire increase in pressure occurs at the outlet end.

When the chamber is being formed, a vacuum is developed in the chamber, which causes the chamber to be filled with the liquid. If rotation takes place at a rate of speed which is below a certain critical value, the chamber will be filled completely with liquid. That critical value depends on a number of factors, namely, the dimensions and geometrical configuration of the screws, the shape of the inlet, the characteristics of the liquid being pumped, such as its viscosity, vapor pressure and its content of dissolved gases, and the particular height of suction. When the speed exceeds the critical value, the chamber will not be completely filled during the period of time before it is closed toward the suction side, but cavitation results, i.e., there are formed cavities in the liquid which are filled with gas or air given off by the liquid being pumped. These gas or air bubbles accompany the liquid in its travel along the screw assemblage from the inlet to the outlet end. When the chamber is opened toward the outlet end and the liquid is suddenly subjected to the higher pressure prevailing there the gas and air bubbles will be rapidly compressed, i.e. they implode. This results in noise and vibration which may be very annoying and also cause damage to the pump or other components of the installation.

The present invention relates to means for minimizing these effects of cavitation so that it will be possible to operate the pump at speeds exceeding the critical speed

where cavitation normally occurs. To achieve this result, the invention contemplates providing at least one passage through the screw assemblage from its pressure side to its suction side so as to achieve during travel of the chamber from the inlet end to the outlet end a continuous increase in pressure in each chamber from the value at the inlet end to the value at the outlet end. This gives the result that the gas and air bubbles are progressively compressed, thus avoiding the sudden implosion of the bubbles at the outlet end whereby the pump can operate quietly even at high rates of speed. Of course, this arrangement will increase the leakage in the pump, and the increase in speed of rotation which depends on the size of the passage will thus take place at the expense of the tightness. In spite of this fact it may sometimes be advantageous to be able to operate the pump at a higher speed of rotation. When using short-circuited alternating current motors to drive the screws, the steps between the motor speeds available are great. It may then be advantageous to be able to select a higher speed when the next lower speed in the motor series would yield an essentially larger pump (and also motor). The advantage of a higher speed may then more than compensate for the disadvantage of a reduced sealing in the pump.

According to the invention this effect is achieved in that at least in one of the screws a recess is provided in the thread flank, said recess forming a helical passage through the entire screw assemblage. This recess may be provided in the thread flank of the middle screw and then preferably on the rear flank of the thread, i.e. the flank which forms the trailing side in the intended direction of rotation of the middle screw. However, the recess may also be provided in one or more threads of one or more of the side screws.

The invention will be described more in detail below with reference to the accompanying drawings which illustrate two embodiments of the invention, and in which:

FIGURES 1 and 2 illustrate one embodiment in elevation, partly in section, and in cross-section taken along line II—II of FIGURE 1;

FIGURE 3 shows a detail view of FIGURE 2 on an enlarged scale; and

FIGURES 4 and 5 show the other embodiment in elevation and in cross-section taken along line V—V in FIGURE 4.

The screw pump illustrated in FIGURES 1 and 2 is of the type comprising a driven middle screw **1** and two side-screws **2**, the middle screw **1** having two threads with convex flanks and the side screws also having two threads each but with concave flanks, the threads being formed in a known manner so as to be in sealing relationship with each other. The screw assemblage comprising the middle screw **1** and the side-screws **2** is enclosed in a casing **3** which sealingly surrounds the screw assemblage, said casing having at its lower end two symmetrical ports **4** through which the entrance of fluid to the screw assemblage takes place. The casing **3** has an attachment flange **5** for positioning the casing with the screw assemblage in a pump housing **6** by means of screws **7** so that the lower end of the casing **3** with the ports **4** is disposed in the inlet chamber **8** of the pump housing, while the upper, axially open end which forms the outlet from the screw assemblage is disposed in the discharge chamber **9** of the pump housing.

The middle screw **1** is adapted to be driven and for this purpose it is formed integral with a driving shaft **10** which is journaled in a bearing **11** attached to the top end of the casing **3** and extends through a cover **12** attached to the pump housing for connection to a motor (not shown). The lower ends of the screws are journaled in a suitable manner in the bottom end wall of the casing **3**.

To achieve the result contemplated by this invention,

i.e. a progressive compression of gas bubbles formed when the critical speed is exceeded, the threads of the middle screw **1** are milled off on the flank which is at the trailing side of the thread when the main screw rotates in the direction indicated by the arrow in FIGURE 2. The milled portions are designated **13**. FIGURE 3 shows more in detail the configuration of the milled portion **13** as compared to the original thread profile which is shown by the dot-and-dash line **20**. On account of the milled portions the sealing in the screw assemblage will not be complete, i.e. the pump will not be positive, but helical passages are formed through the screw assemblage. Thereby the above-mentioned action is obtained in that the fluid chambers are progressively brought from the pressure at the inlet end to the pressure at the outlet end, whereby the gas bubbles are progressively compressed and no imposion with resultant noise and vibration occurs at the outlet end. Therefore, the speed of rotation can without disadvantages be maintained above the critical value at which cavitation occurs. The possible increase in speed depends on the size of the milled portions **13**. The greater these are selected, the more can the speed be increased, but at the same time the leakage in the pump increases which of course limits the size of the passages. The dimensions in a given case will of course depend on the conditions under which the pump is to be used. In order that each chamber during each portion of each revolution shall communicate with the passage such a passage should be provided in one flank of each thread of the middle screw.

The embodiment according to FIGURES 4 and 5 differs from the embodiment according to FIGURES 1 and 2 only in that the passage is formed by providing grooves **14** in the concave thread flanks of the side-screws. Otherwise this embodiment is similar to the embodiment of FIGURES 1 and 2 and the members have been provided with the same designations as in FIGURES 1 and 2. These members need not be described once more. It will be readily understood that the effect with this embodiment will be the same as in the first embodiment.

It will be understood that the invention is not restricted to the embodiments shown comprising a driven two-threaded middle screw and two two-threaded side-screws, but is generally applicable to other screw-pumps having a different number of side-screws and a different number of threads, the shape of the threads and the number of side-screws as well as the number of threads of the screws being so selected in relation to each other, in a manner known per se, that in each position of the screws there is at least one essentially closed chamber in the screw assemblage except for the provision of the leakage passage, i.e. the pump except for the leakage passage would be positive. It is known to those skilled in the art that this can be realized if the threads obtain a certain mathematically defined geometrical shape, and if the condition $G-ng+n=0$ is satisfied, where G is the number of threads of the middle screw, n is the number of side-screws and g is the number of threads of each side-screw. The invention is applicable to all screw pumps of this type, including such screw pumps of this type where not only the middle screw but also that side-screws are driven. Furthermore the passages through the screw assemblage need not be provided in the positions shown but may be provided in other positions in the thread flanks. However, as regards the side-screws, the grooves should not be provided in the thread edge portion designated **14** in FIGURE 5 and which is flattened or rounded, and as regards the middle screw not in the thread portion cooperating with said flattened or rounded portion and designated **16** in FIGURE 2.

What is claimed is:

1. A liquid screw pump of the type comprising an assemblage of intermeshing rotary screws including a middle screw having at least one thread with convex flanks having peripheral edge portions at junctions with cylindrical outermost portions of said thread, and having at least one side screw having threads with concave flanks having peripheral edge portions at junctions with cylindrical outermost portions of the last mentioned threads, the respective threads being arranged to approximately seal against the cooperating screws, and the assemblage of screws being sealingly enclosed by cylindrical walls of a casing substantially contacting said cylindrical outermost portions of the threads of said screws, which casing provides free continuous liquid communication between the ends of the casing and the ends of said screws, the screws and the assemblage being such that in every position of said screws at least one substantially closed chamber is formed by the threads, the troughs between the threads, and the cyclindrical walls of the casing, which chamber during rotation of the screws travels axially with maintenance of a substantially constant volume from the inlet to the outlet of the screw assemblage, characterized in that each of said thread flanks is essentially of a form geometrically generated, except for running clearances, by the peripheral edge portions of the flank of an adjacent screw with the exception that a portion of one flank of a thread of one of the screws lies slightly inwardly of the surface that would theoretically be so generated providing a helical clearance slightly greater than that provided by the other flank of the same thread with respect to the peripheral edge portion of the flank of the adjacent screw, said helical clearance providing a helical passage through the entire screw assemblage.

2. A screw pump according to claim 1 in which the last mentioned inwardly lying portion occurs in the rear flank of said thread of the middle screw.

3. A screw pump according to claim 1 in which the last mentioned inwardly lying portion occurs in a concave flank of a thread of one of said side screws.

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