

[54] **SEALING ARRANGEMENT FOR A CENTRIFUGE**

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[51] **Int. Cl.**..... **B04b 1/00**

[58] **Field of Search** **233/31, 15, 37, 43, 233/46, 47 R, 27, 28, 1 A; 285/DIG. 10, 331, 285/350, 373**

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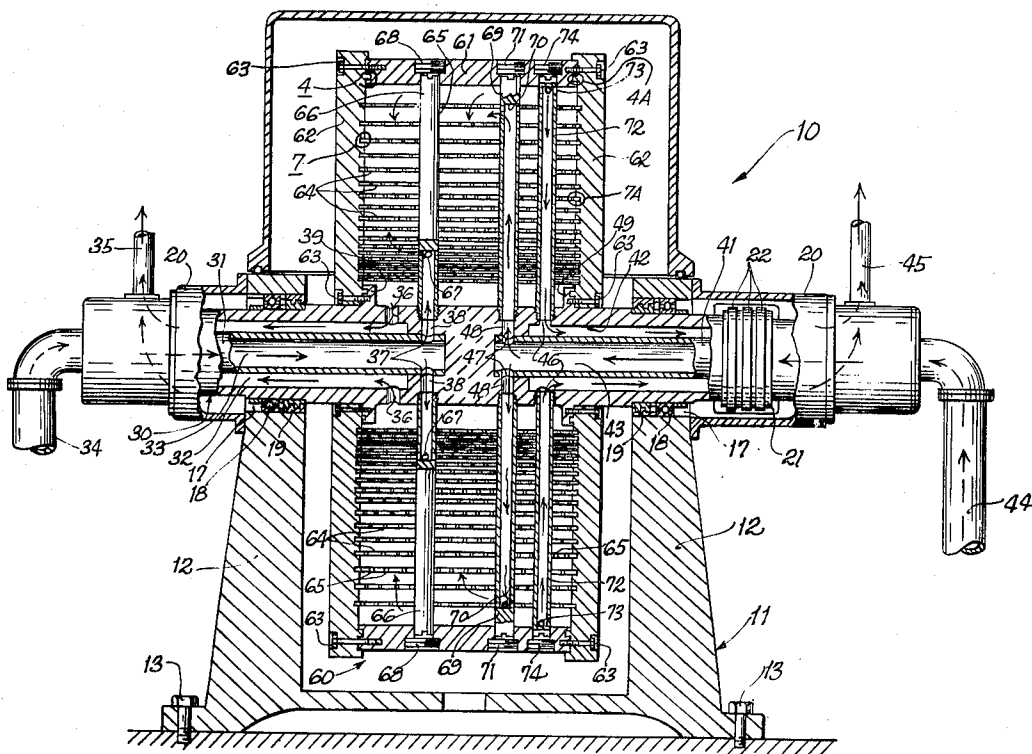
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[57] **ABSTRACT**

A centrifuge has a shell and a pair of plates for attachment to the ends of the shell. An annular channel is formed in at least one of the plates or in the shell adjacent an end thereof, for receiving a transversely deformable cord. When the shell and the plate are assembled and suitable fastening means are tightened, the cord deforms to provide a very effective seal which is so thin as to be able to withstand the high pressures developed in the centrifuge. The other end plate may be secured in a similar fashion. Also, when the centrifuge is constructed to be of the countercurrent exchange variety, the end plates respectively have pluralities of axially aligned grooves within which are disposed transversely deformable cords. Cylindrical, apertured separator bands are respectively disposed in axially aligned pairs of the grooves. The cords are deformed when the end plates are drawn together by tightening the fastening means.

14 Claims, 9 Drawing Figures



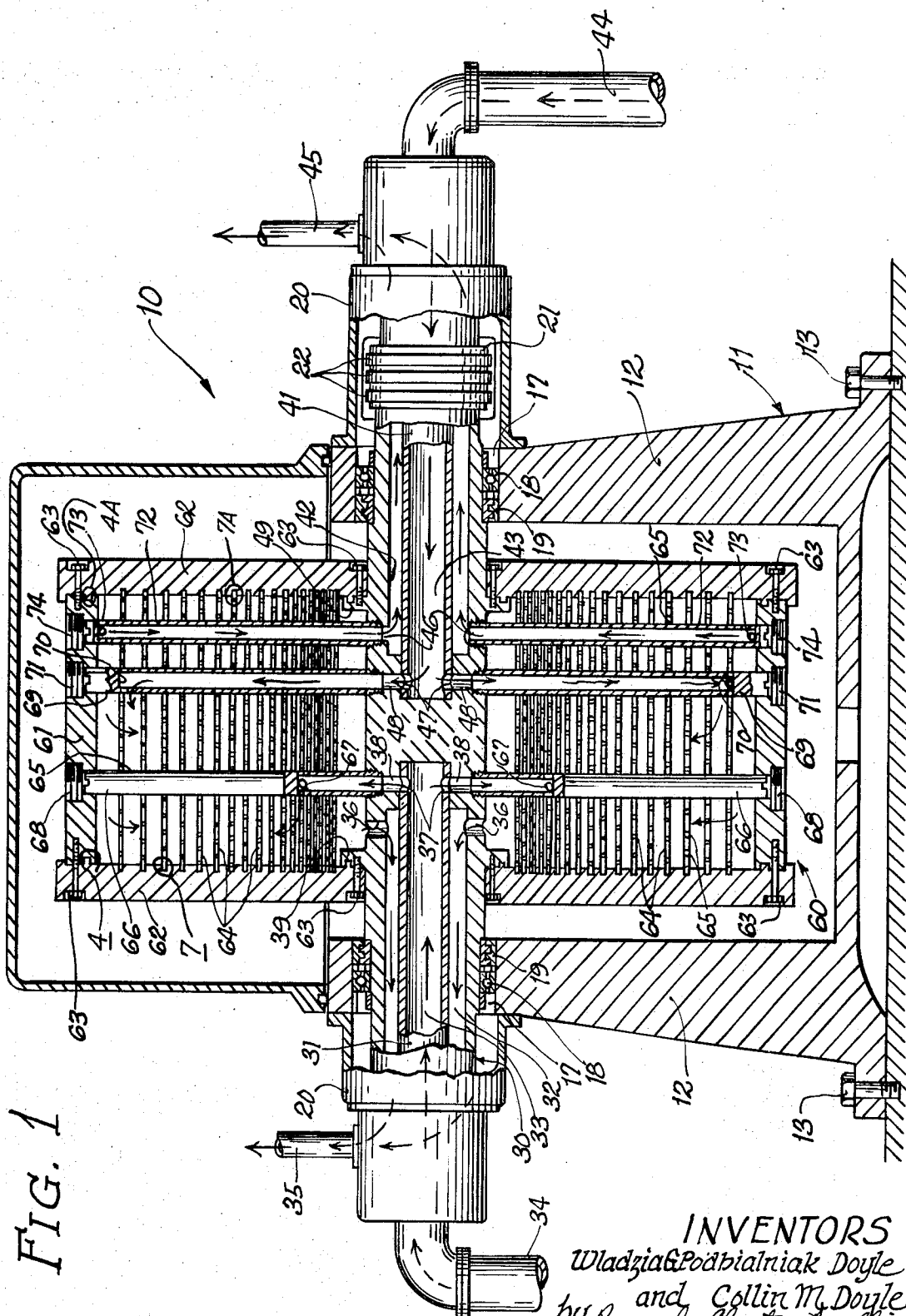


FIG. 1

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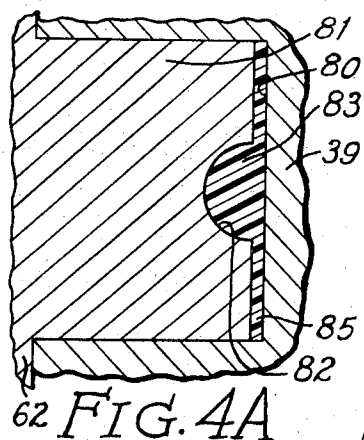
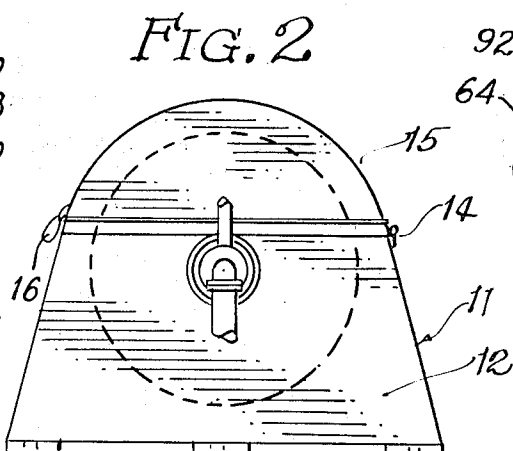
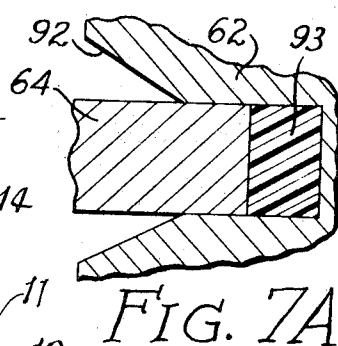
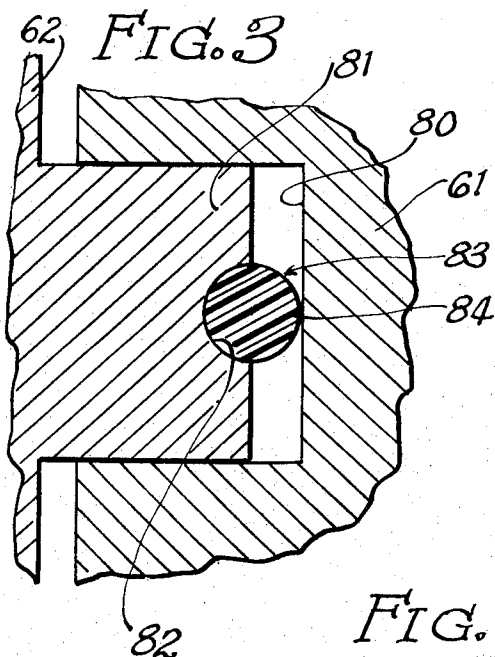
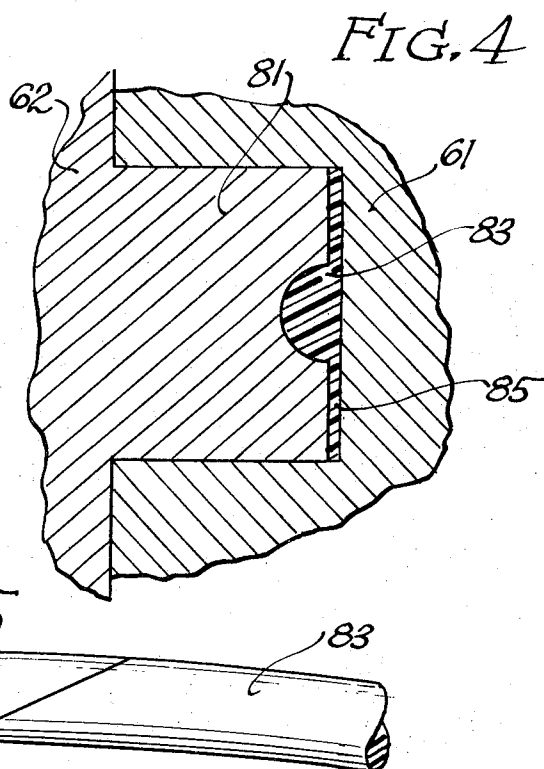
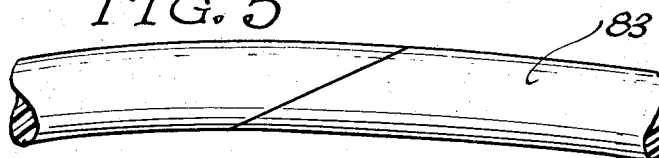
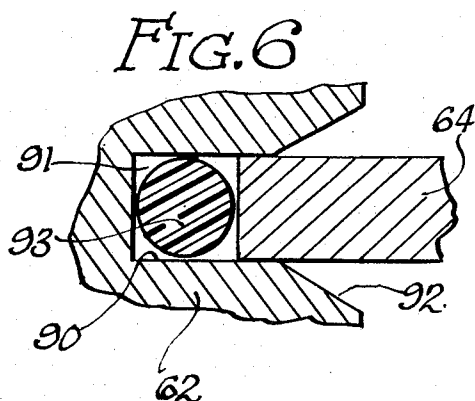
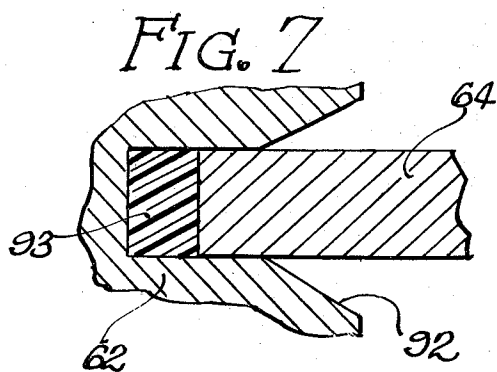


FIG. 5



SEALING ARRANGEMENT FOR A CENTRIFUGE

It is an important object of the present invention to provide a centrifuge having inexpensive seals therein, yet capable of withstanding the high pressures of 10,000 pounds per square inch generated during use.

Another object is to provide cords at the juncture points between the end plates, the outer shell and the shaft of a centrifuge, which cords are transversely deformed when assembled to seal the centrifuge.

Still another object of the present invention is to provide a seal for use in a centrifuge which is constructed of material capable of withstanding the corrosive tendencies of liquids which may be used.

Yet another object is to provide a sealing arrangement for mounting the separator bands of a centrifugal countercurrent exchange device into the end plates thereof, such that liquid flow around the ends of the bands is prevented.

Further features of the invention pertain to the particular arrangement of the parts of the centrifuge and sealing arrangement used therein whereby the above outlined and additional features are attained.

The invention both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification when taken in connection with the accompanying drawings in which:

FIG. 1 is a view in vertical section of a centrifugal countercurrent exchange device embodying the invention, with portions thereof being cut away and other portions being shown in elevation;

FIG. 2 is an end view on a smaller scale of the device of FIG. 1;

FIG. 3 is a view in vertical section on a greatly enlarged scale of the portion of FIG. 1 shown in the circle labeled "3," prior to assembly;

FIG. 4 is a view like FIG. 3 after assembly;

FIG. 4A is a view in vertical section on a greatly-enlarged scale of the portion of FIG. 1 shown in the circle labeled "4A";

FIG. 5 is a fragmentary view of the juncture of the ends of the cord shown in FIGS. 3 and 4;

FIG. 6 is a greatly enlarged view in vertical cross section of the portion of FIG. 1 in the circle labeled "6," prior to assembly;

FIG. 7 is a view like that of FIG. 6 after assembly; and

FIG. 7A is a greatly-enlarged view in vertical cross section of the portion of FIG. 1 in the circle labeled "7A."

Referring now to the drawings, and more particularly to FIGS. 1 and 2 thereof, there is shown a countercurrent exchange device 10. The device 10 comprises a base 11 which may be secured to the floor by means of bolts 13. Attached to the base 11 by means of hinges 14 is a part-cylindrical cover 15 which, in turn, carries a handle 16. Formed respectively in the side walls 12 of the base 11 are axially-aligned openings 17 within which is mounted the outer race of a pair of bearing units 18. The inner race of each of the bearing units 18 is affixed to a shaft 30 which passes through the openings 17. The shaft 30 is maintained in a fixed axial position by means of a pair of key members 19. Encircling the shaft 30 adjacent the ends thereof and aligned respectively with the openings 17 are caps 20. One side of the shaft 30 is provided with a sheave 21 upon which is mounted a plurality of drive belts 22. Each of the drive belts 22 may be connected to a motor of different oper-

ational speed, so that the speed of rotation of the shaft 30 may be selected, depending upon the particular use of the device 10.

The shaft 30 is provided with a longitudinal bore on the left, as viewed in FIG. 1, within which is mounted a tube 31. The annular space between the tube 31 and the shaft 30 defines a passageway 32 for the flow of light liquid out of the device 10. The space within the tube 31 defines a passageway 33 for the flow of heavy liquid into the device 10. The tube 31 communicates with an inlet pipe 34 which is, in turn, coupled to a source of heavy liquid. An outlet pipe 35 communicates with the passageway 32 and is coupled to a container or the like to collect the light liquid effluent discharged from the device 10. The passageway 32 communicates, adjacent its inner end, with a set of openings 36, and the passageway 33 communicates, at its inner end, with a set of openings 37 formed in the tube 31. The openings 37, in turn, communicate respectively with threaded bores 38 in the side wall of the shaft 30. The shaft 30 further includes an annular, radially-extending flange 39 disposed outwardly (to the left, as viewed in FIG. 1) of the openings 36.

Similarly, formed in the right side of the shaft 30 is a longitudinally-extending bore within which is mounted a tube 41. The annular space between the tube 41 and the shaft 30 defines a passageway 42 for the heavy liquid to flow out of the device 10. The space within the tube 41 defines a passageway 43 for the flow of light liquid into the device 10. The tube 41 communicates with an inlet pipe 44 which is, in turn, coupled to a source of light liquid. An outlet pipe 45 communicates with the passageway 42 and is coupled to a container or the like to collect the heavy liquid effluent discharged from the device 10. The passageway 42 communicates, adjacent its inner end, with a set of threaded openings 46; and the passageway 43 communicates, at its inner end, with a set of openings 47 formed in the tube 41. The openings 47, in turn, communicate respectively with threaded bores 48 in the side wall of the shaft 30. The shaft 30 further includes an annular, radially-extending flange 49 disposed outwardly (to the right, as viewed in FIG. 1) of the openings 46.

The countercurrent exchange device 10 also includes a rotor 60, which rotor 60 is defined by a cylindrical outer shell 61 and a pair of annular end plates 62 secured at the outer ends thereof to the outer shell 61 by means of bolts 63. Formed centrally in each of the end plates 62 is an opening through which passes the shaft 30. The annular regions of the end plates 62 near the shaft 30 are secured respectively to the outwardly-facing surfaces of the flanges 39 and 49 by means of bolts 63. The details of connection between the end plates 62 and the shell 61 and between the end plates 62 and the shaft 30 will be described hereinafter.

A plurality of concentric separator bands 64 is positioned in annular grooves formed in the end plates 62 in a manner presently described, each band 64 being formed with a plurality of apertures 65. In the form illustrated, the bands 64 are arranged with the spacing between any pair thereof increasing as the radius increases. Although this is the preferred form of construction, it is not necessary to the invention hereinafter described.

Positioned in radially-aligned openings in the separator bands 64 is a supply tube 66, which is threaded at one end thereof to mate with a threaded opening 38 in

the shaft 30. Additional sets of radially-aligned openings in the separator bands 64 accommodate additional supply tubes 66, all of which are, in the form shown, in axial alignment. Each of the tubes 66 has an opening 67 nearer the end thereof that is adjacent to the shaft 30. The outer end of each of the supply tubes 66 is located within a suitable opening in the shell 61, each of which openings has an enlarged, threaded portion to receive a plug 68. The plug 68 may be unscrewed to enable removal of the tube 66, for cleaning or replacement. A supply tube 69 passes through a second set of radially-aligned openings in the separator bands 64. Additional sets of openings in the bands 64 accommodate further tubes 69. Each supply tube 69 is threaded at one end thereof to mate with a threaded opening 48 in the shaft 30. Each tube 69 has an opening 70 near the outer end thereof. The outer end of each of the supply tubes 69 is located within a suitable opening in the shell 61, each of which has an enlarged threaded portion to receive a plug 71. A discharge tube 72 passes through a third set of radially-aligned openings in the separator bands 64. Other discharge tubes are provided, each of which is threaded at one end thereof to mate with the threaded openings 46 in the shaft 30. Each of the tubes 72 has an opening 73 at its outer end, that is, adjacent to the shell 61. The outer end of each of the tubes 72 is located within a suitable opening in the shell 61, which is enlarged and threaded to receive a plug 74. Although two of each of the tubes 66, 69 and 72 are shown, it is to be understood that any number of such tubes may be provided.

In operation, heavy liquid from the source thereof is supplied through the inlet pipe 34, through the passageway 33, through the openings 37 and 38 into the liquid supply tubes 66. The rotation of the rotor 60 causes the heavy liquid to flow outwardly through the tubes 66 and through the openings 67 into the interior of the rotor 60. The heavy liquid flows outwardly through the apertures 65 in the separator bands 64 by centrifugal force. Similarly, light liquid from a source thereof flows through the inlet pipe 44 and is supplied through the passageway 43, the openings 47 and 48, and into the supply tube 69, all as indicated by the arrows. The centrifugal force of the revolving rotor 60 causes the light liquid to flow outwardly through the tubes 69, as indicated by the arrows, and into the space between the two outermost separator bands 64. The pressurized light liquid flows inwardly through the apertures 65 in the separator bands 64 and mixes with the heavy liquid in countercurrent fashion. As the liquids pass through a band 64, they are broken up into droplets by the apertures 65. A violent and intimate mixing of both droplet-dispersed liquids then takes place in the areas between each pair of bands 64. After both liquids have passed through all of the mixing stages, the same continue on through the preset nonmixing or clarification areas. The heavy liquid which arrives in the space near the outer shell 61 flows into the discharge tubes 72 by means of the openings 73. The heavy liquid flows back down the tubes 72, as indicated by the arrows, through the openings 46, the passageway 42, through the outlet pipe 54 to a container for the effluent. The light liquid which reaches the shaft 30 flows through the openings 36, through the passageway 32, through the outlet pipe 35, as indicated by the arrows, and to a container for the light liquid effluent.

Generally, both liquids travel concurrently or in the same direction as they pass through the rotor 60. This direction of travel is of course the same as the direction of rotation of the rotor itself. However, as a liquid passes from one band 64 to the next, this liquid is either accelerated or decelerated as above described. Since the passage of a liquid from one band 64 to the next takes but a short moment of time, the described acceleration or deceleration thus imparts a violent or jolting action to that liquid. In the case of the decelerating lighter liquid, the jolting action is in a direction opposed to the general direction of the liquid's travel. On the other hand, the jolting action of the accelerating heavy liquid is in the same direction as the general direction of the liquid's travel. There thus occurs a violent cross collision between the two liquids in the area between any two bands 64.

Referring now to FIGS. 3, 4 and 5, the details of construction of the novel interconnection between one of the end plates 62 and the outer shell 61 will be described. Formed in each end of the shell 61 in an annular groove 80 having a generally-rectangular cross section. Formed adjacent the periphery of each end plate 62 is an annular tongue 81 which also has a substantially square cross section and is constructed to mate with the groove 80 in the shell 61. Formed in the tongue 81 is an annular channel 82 in which is press-fitted a core 83 constructed of a suitable, transversely deformable material such as polytetrafluoroethylene. The ends of the cord 83 are scarfed as shown in FIG. 5 to inhibit any tendency to separate in use. Although the cord 83 is shown to be round in cross section and the channel 82 is shown to have a part-circular cross section, other shapes such as rectangular or the like will be satisfactory. Also, the angular extent of the channel may be more or less than the 180° shown. In the illustrated embodiment, the cross-sectional radius of the cord 83 is about equal to the radius of curvature of the channel 82 or perhaps slightly greater to achieve a secure connection therebetween. Thus, a portion 84 which encompasses about one half of the cross-sectional area of the cord 83 protrudes from the channel 82. Of course, a deeper groove will allow less of the cord 83 to protrude. Each end plate 62 is then positioned to align its tongue 81 with the associated groove 80 and is inserted therein to enable the protruding portion 84 to contact the outwardly facing surface of the groove 80. The bolts 63 are then inserted and turned to draw the end plate 62 against the end of the outer shell 61 to flatten, at 85, the cord 83 to the condition shown in FIG. 4.

The diameter of the cord 83 and the radius of curvature (or depth) of the channel 82 are selected to enable the thickness of the flattened portion 85 to be no greater than about 0.065 inch and preferably between 0.001 and 0.005 inch. The minimizing of this thickness is extremely important if the gasket thereby formed is to withstand the extreme pressures of 10,000 pounds per square inch or more which may be exerted at the in the rotor 60. As can be appreciated, reducing the area of the seal or gasket presented to the rotor interior reduces the force to which the seal or gasket is subjected, and thus lengthens its useful life. The type of construction above described is highly advantageous, in that a relatively inexpensive piece of transversely-deformable material such as polytetrafluoroethylene cord may be installed with a minimum of effort, yet providing a gas-

ket of high quality and long life. Moreover, the particular construction above described simplifies the assembly of parts. More specifically, the cord 83 may be press-fitted into its channel 82 wherein it will be retained simply by the resiliency of the cord. Of the various deformable materials usable to construct the cord 83, polytetrafluoroethylene is preferable by virtue of its strength and ability to withstand the corrosive tendencies of certain liquids which may be used.

It is to be understood that various modifications in the sealing arrangement may be made. For example, the channel 82, instead of being formed in the tongue 81, may be formed in the outwardly-facing surface of the groove 80. Also, the groove 80, instead of being formed in the end of the shell 61, may be formed in the end plate 62; of course, the tongue 81 would then be formed in the end of the shell 61. Alternatively, the end plate 62 may have a diameter such that they will fit within the shell 61 so as to be secured to the inner surface thereof. In that case, the sealing elements would be provided on the interior surface of the shell 61 and on the annular end of each end plate 62. Moreover, in certain designs, it may be desirable for one end plate to be welded or otherwise permanently attached to the shell 61. In that case, the other end plate will have one of the sealing arrangements above described.

Although the above description was directed to the mounting of the periphery of each end plate 62 to the outer shell 61, it is to be understood that a similar design is intended in attaching the interior of the end plate 62 to the shaft flanges 39 and 49. It should be appreciated that forces of 10,000 pounds per square inch are also present adjacent to the shaft 30.

Referring now to FIGS. 6 and 7, the details of mounting the separator bands 64 in the rotor 60 will be described. Formed in each end plate 62 is a plurality of concentric, annular grooves 90. The grooves 90 have an interior portion 91 which is square in cross section and an exterior portion 92 which is funnel-shaped. Positioned within the portion 91 is a transversely-deformable cord 93 which, in the form shown, is round in cross section. The preferred material for the cord 93 is polytetrafluoroethylene by virtue of its strength and corrosion resistance characteristics. The grooves 90 in one end plate 62 are axially aligned with similarly-shaped grooves in the other end plate 62. Each end of each separator band 64 has a thickness approximately equal to the height of the portion 91 of the groove 90. The funnel portion 92 is used for guiding the end of a separator band 64 into the portion 91. When the bolts 63 are turned to draw the end plates 62 toward each other, the cords 93 deform until they fill substantially the spaces between the band 64 and the end plate 62. In this manner, liquid is prevented from undesirably flowing around the end plates 62 to reduce efficiency of the device 10.

While a preferred embodiment of the invention has been shown and described for illustrative purposes, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A centrifuge comprising a shaft member having an annular flange protruding radially therefrom, said flange member having a first surface region which faces outwardly, a shell member encircling said shaft mem-

ber having one end sealed, said shell member having a second surface region in the end thereof opposite to said sealed end, a plate member having an opening therein for receiving therethrough said shaft member, said plate member having a third surface region adjacent said opening for mating with said first surface region, said plate member having a fourth surface region adjacent its periphery for mating with said second surface portion, said first or said third surface regions having therein a first annular channel, said second or said fourth surface regions having therein a second annular channel, two transversely deformable cords respectively in said channels and having portions protruding therefrom, said plate member being positioned to place said protruding portions respectively in contact with the ones of said surface regions which do not have channels therein, means drawing said end plate toward said shell member and toward said flange member to flatten said cords to thicknesses no greater than about 0.065 inch, thereby effectively to seal the junction of said shell member and said plate member and the junction of said flange member and said plate member despite the existence of pressures of 10,000 pounds per square inch in said centrifuge.

2. The centrifuge set forth in claim 1, wherein said first annular channel is formed in said third surface region and said second annular channel is formed in said fourth surface region.

3. A centrifuge comprising a shaft member having a pair of axially spaced apart annular flanges protruding radially therefrom, each of said flange members having a first surface region which faces outwardly, a shell member encircling said shaft member, said shell member having a second surface region in each of the ends thereof, a pair of plate members each having an opening therein for receiving therethrough said shaft member, each of said plate members having a third surface region adjacent said openings for mating with said first surface portion, each of said plate members having a fourth surface region adjacent its periphery for mating with said second surface portion, said first or said third surface regions each having therein a first annular channel, said second or said fourth surface regions each having therein a second annular channel, four transversely deformable cords respectively in said channels and having portions protruding therefrom, said plate members being positioned to place said protruding portions respectively in contact with the ones of said surface regions which do not have channels therein, means drawing said end plate toward said shell member and toward said flange member to flatten said cords to thicknesses no greater than about 0.065 inch, thereby effectively to seal the junction of said shell member and said plate member and the junction of said flange member and said plate member despite the existence of pressures of 10,000 pounds per square inch in said centrifuge.

4. The centrifuge set forth in claim 3, wherein said first annular channels are respectively formed in said third surface regions and said second annular channels are respectively formed in said fourth surface regions.

5. A centrifuge comprising a cylindrical shell member having one end thereof sealed, a plate member, one of said members having therein an annular groove with a first sealing surface, the other of said members having therein an annular tongue with a second sealing surface thereon, one of said sealing surfaces having therein an

annular channel, an elongated transversely deformable cord in said channel and having a portion protruding therefrom, said one member being positioned to place said tongue in said groove and said protruding portion in contact with the other of said sealing surfaces, means 5 drawing said members together to flatten said cord to a thickness no greater than about 0.065 inch, thereby effectively to seal the junction of said shell member and said plate member despite the existence of pressures of 10,000 pounds per square inch in said centrifuge.

6. The centrifuge set forth in claim 5, wherein said annular tongue is formed on said plate member.

7. The centrifuge set forth in claim 5, wherein said annular groove is formed in said shell member.

8. The centrifuge set forth in claim 5, wherein the inner surface of said groove and the outer surface of said tongue are substantially flat, whereby said cord when flattened is rectangular in cross section.

9. The centrifuge set forth in claim 5, wherein said plate member has a diameter exceeding the diameter of said shell member and is secured to the outer end thereof.

10. The centrifuge set forth in claim 5, wherein said annular channel is formed in the sealing surface of said plate member.

11. A centrifugal countercurrent exchange device comprising a cylindrical shell and a pair of end plates said end plates, respectively having pluralities of axially-aligned grooves formed therein, a plurality of elongated transversely deformable cords having diameters less than the depths of said grooves and being disposed respectively therein, a plurality of cylindrical apertured separator bands respectively in axially aligned pairs of said grooves, means drawing said end plates toward each other to deform said cords substantially to fill the space in the grooves, thereby to prevent liquids from flowing around the ends of said separator bands, and means securing said end plates to the ends of said shell to retain said cords in the deformed condition thereof.

12. The centrifugal countercurrent exchange device set forth in claim 11, wherein each of said cords is circular in transverse cross section.

13. The centrifugal countercurrent exchange device set forth in claim 11, wherein each of said grooves has a funnel-shaped entry portion to facilitate insertion of the end of the associated separator band.

14. The centrifugal countercurrent exchange device set forth in claim 11, wherein each of said cords is fabricated of polytetrafluoroethylene.

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