

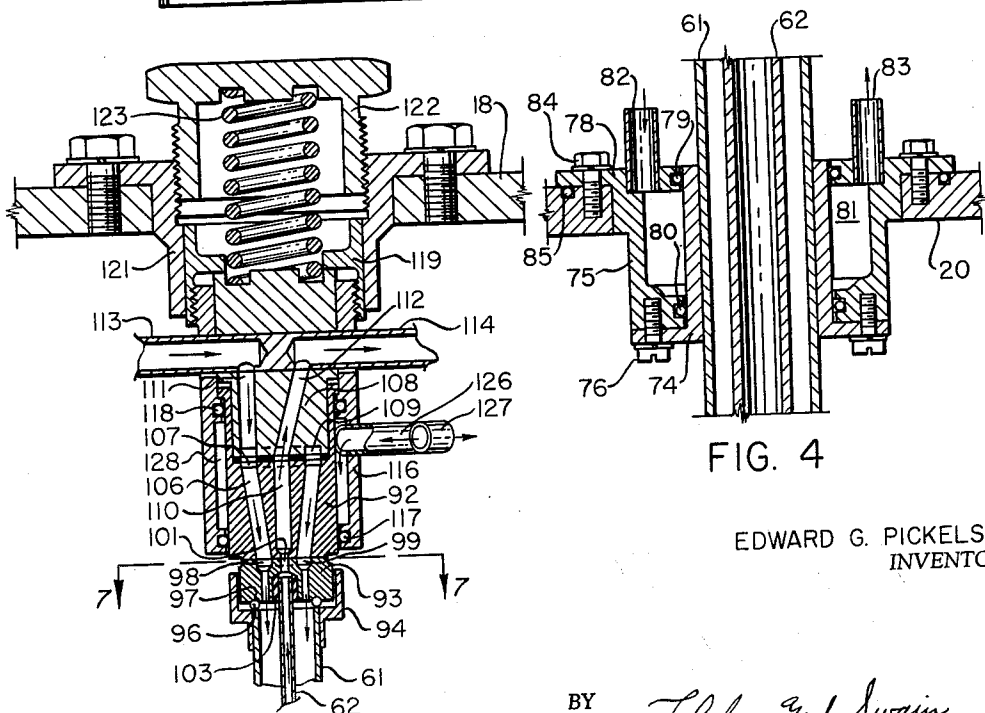
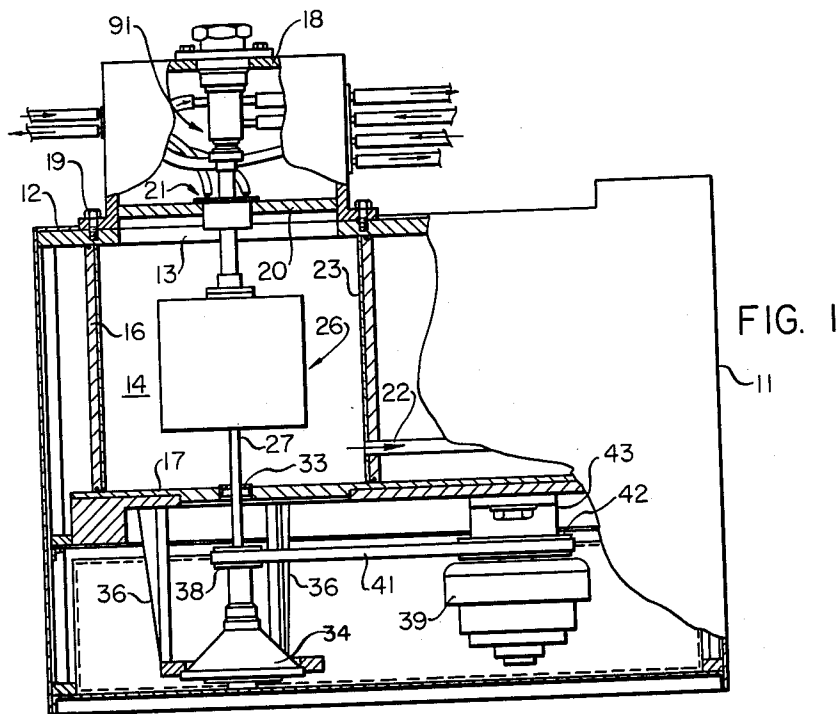
Sept. 10, 1963

E. G. PICKELS
CONTINUOUS FLOW ULTRACENTRIFUGE APPARATUS
AND ROTARY FLUID CONNECTION

3,103,489

Filed March 9, 1961

2 Sheets-Sheet 1



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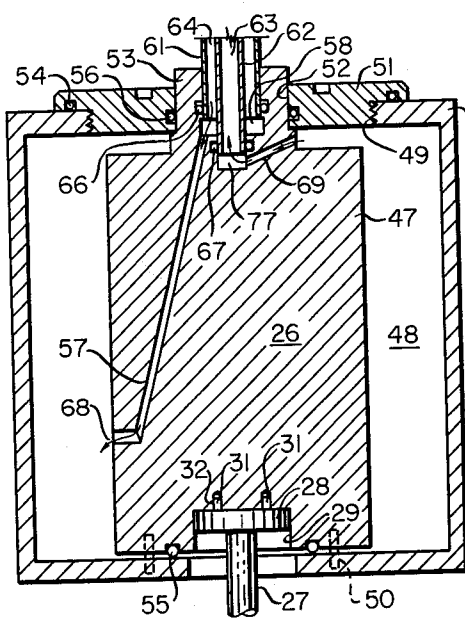


FIG. 5

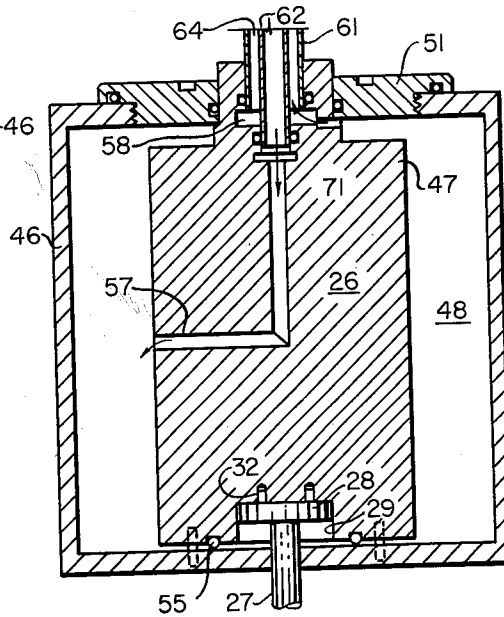


FIG. 6

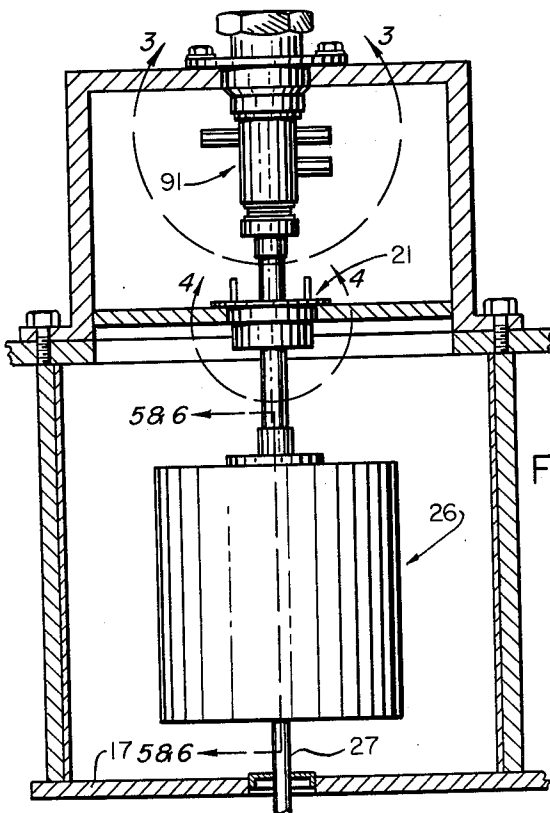


FIG. 2

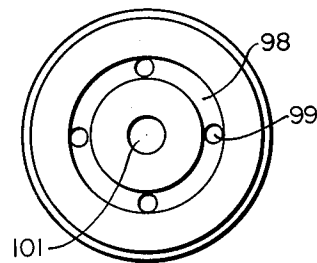


FIG. 7

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1

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CONTINUOUS FLOW ULTRACENTRIFUGE APPARATUS AND ROTARY FLUID CONNECTION

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2 Claims. (Cl. 233-21)

This invention relates generally to centrifuge apparatus, and more particularly to a continuous flow ultracentrifuge apparatus and rotary fluid connection therefor.

Generally, in ultracentrifuge apparatus, the rotor is enclosed in an evacuated chamber. This reduces the frictional forces between the rotor and the enveloping atmosphere and permits achieving relatively high speeds with minimum power input and temperature rise of the rotor. Ultracentrifuge apparatus of the prior art has been of the batch type; that is, the samples are placed in sample vessels which are disposed in wells formed in the rotor. The vessels are sealed whereby the sample is isolated from the vacuum chamber. The liquid is not subjected to the relatively low pressures in the rotor chamber. Evaporation and boiling of the sample is substantially eliminated.

Continuous flow centrifuge apparatus of the prior art has been limited to apparatus in which the rotor is operated at atmospheric pressure. Thus, the sample can be continuously fed into the rotor separating chamber and removed therefrom without the necessity of sealing the rotor to isolate the sample from the chamber. However, when operating such a system at reduced pressures, means are required to maintain the sample at substantially atmospheric pressure while the rotor is in an atmosphere of reduced pressure.

One way that the sample can be isolated from the reduced pressure within the rotor chamber is to permanently attach feed and removal tubes to the rotor and then provide a rotary vacuum seal between the tubes and the stationary parts of the apparatus. However, there is still a problem of feeding the sample from the stationary parts of the apparatus to the rapidly rotating feed and removal tubes. In general, this must be accomplished by some type of rotary seal. The seal should be self compensating for wear, it should have low friction whereby loading and heating is minimized, it should accommodate motion of the tubes due to flutter of the rotor and it should present a minimum of metal to the fluid sample.

It is a general object of the present invention to provide a continuous flow ultracentrifuge apparatus.

It is another object of the present invention to provide a rotary joint or connection for feeding liquids between a rapidly rotating fluid path and a stationary fluid path.

It is another object of the present invention to provide a rotary joint or connection for continuously feeding a liquid from a reservoir into a rapidly rotating rotor which automatically accommodates for wear of the co-operating seal parts.

It is a further object of the present invention to provide a liquid-cooled high speed rotary joint or connection.

It is still a further object of the present invention to provide a rotary fluid joint or connection having minimum frictional losses.

It is another object of the present invention to provide a rotary joint for conveying fluids coaxially in two directions between a stationary and rotating part with minimum communication between the two fluid paths.

It is still a further object of the present invention to provide an ultracentrifuge apparatus in which the rotor operates in a vacuum chamber with a rotary seal provid-

2

ing a fluid connection between the rotor and a stationary fluid source.

These and other objects of the invention will become more clearly apparent from the following description when taken in conjunction with the accompanying drawing.

Referring to the drawing:

FIGURE 1 is an elevational view, partly in section, illustrating a centrifuge apparatus in accordance with the invention;

FIGURE 2 is an enlarged view of the rotor chamber and rotary joint or connection;

FIGURE 3 is an enlarged sectional view of the rotary joint delineated by the line 3-3 of FIGURE 2;

FIGURE 4 is an enlarged sectional view of the portion delineated by the line 4-4 of FIGURE 2;

FIGURE 5 is an enlarged view of a suitable rotor;

FIGURE 6 is an enlarged view of another suitable rotor; and

FIGURE 7 is a view taken along the line 7-7 of FIGURE 3.

Referring to FIGURE 1, the apparatus includes an outer housing 11 which serves to enclose the working parts. The housing 11 includes an upper wall 12 which is provided with an opening 13 through which the rotor may be inserted into the rotor chamber 14. The chamber 14 is formed by a portion of the wall 12, the cylindrical wall 16 and the bottom 17.

A bell-shaped housing or support 18 is suitably secured to the upper wall 12 as, for example, by means of bolts 19. The support is adapted to house and support the rotary seal. A plate 20 is secured near the bottom of the housing. The plate 20 receives a rotary vacuum seal assembly 21, to be presently described.

A vacuum chamber is formed by the rotor chamber and the plate 20. The chamber may be evacuated through a tube 22 which is suitably attached to a vacuum system (not shown).

The cylindrical wall 16 may be lined with suitable material 23 or may be provided with refrigeration cooling coils (not shown) to cool the chamber.

The rotor 26 is carried on a spindle 27. For example, the spindle 27 may carry a disc-shaped member 28, FIGURES 5 and 6. The disc is adapted to fit within the well 29 formed in the rotor. The upper surface of the disc is provided with spaced driving pins 31 which ride into accommodating recesses 32 formed in the rotor.

Preferably, the spindle is made of flexible material to accommodate any flutter of the rotor. The spindle extends downwardly through a vacuum seal 33 formed in the bottom wall. Its lower end is journaled in an oil-filled bearing 34. The bearing 34 is supported from the bottom wall 17 by downwardly extending spaced brackets 36. A driven pulley 38 is carried by the spindle. A variable speed drive motor 39 is provided for driving the belt 41 which engages the drive pulley 42 and the driven pulley 38 to impart a rotative force to the spindle. The motor 39 may be mounted to the bottom wall 17 by means of bracket 43.

Suitable rotors 26 are illustrated in FIGURES 5 and 6. In each instance, the rotor includes an outer shell 46 and a coaxial core 47 having its sides spaced from the shell to provide a separating chamber 48. The upper wall of the shell includes an opening 49 which threadably receives a cap 51. The cap 51 has a central opening 52 which fits over the neck 53 of the core 47. The lower end of the core is driven by the spaced pin 50 and sealed by the O-ring 55. The core is provided with one or more passages 57 which communicate between the separating chamber 48 and the chamber 58. Suitable O-rings 54 and 56 are provided to form a vacuum joint between the

cap 51 and rotor shell 46 and the neck 53 and core 47, respectively.

A pair of concentric tubes 61 and 62 extend downwardly into the neck. The tubes form axial and annular fluid or sample passages 63 and 64, respectively. The outer tube 61 engages an O-ring 66 to seal the annular passage 64 from the surrounds. The tube 62 engages O-ring 67 which isolates the passages. During a separation, sample fluid flows down into the annulus 64 into chamber 58 and outwardly from the connecting tubes 57 as indicated by the arrow 68. The fluid is then subjected to centrifugal forces. The pressure causes the supernate to flow through passages 69 formed in the core neck 53 into the chamber 71. The fluid or sample then travels from the chamber 77 upwardly through the tube 62.

It may be desirable in certain instances to feed the sample into the rotor through the inner tube 62 and remove the fluid through the annulus passage 64. The rotor shown in FIGURE 6 is adapted to provide the foregoing flow. Like reference numerals are used for like parts.

It is, of course, to be understood that the rotors shown in FIGURES 5 and 6 are merely illustrative and that other types of rotors may be employed as, for example, rotors of the type illustrated generally in copending patent applications Serial No. 804,609, filed April 7, 1959, now Patent Number 3,073,517, and Serial No. 732,617, filed May 2, 1958, now abandoned.

The concentric tubes 61 and 62 rotate with the rotor and extend upwardly through a vacuum seal assembly designated generally by the reference numeral 21, FIGURES 1 and 2, and illustrated in detail in FIGURE 4. The seal assembly is carried by plate 20 suitably secured to the walls of the housing 18.

The seal may be formed as shown in FIGURE 4 with a sleeve 74 suitably secured to an outer sleeve 75, as for example, by a bolt 76 and sealed by means of O-ring 80. The upper end of the sleeve 75 may include a flange 78. An O-ring 79 provides a seal between the inner edge of the flange 78 and sleeve 74. The space 81 between the inner and outer sleeves 74 and 75 has communicating therewith inlet and outlet tubes 82 and 83, respectively, through which a cooling fluid may be circulated to cool the bearing formed by inner sleeve 74. The complete assembly may be suitably attached to the plate 20 by means of bolts 84 extending through the flange. An O-ring 85 provides a seal. Thus, there is provided a fluid cooled rotary vacuum seal. Generally, rotary seal bearings also include means for supplying lubricant to the bearing. Since this is conventional and such showing would only complicate the drawing, no showing is made in the drawings.

The concentric tubes extend upwardly and are attached to the rotating portion of the rotary seal designated generally by the reference numeral 91, FIGURES 1 and 2, and shown in detail in FIGURE 3.

The rotary seal includes a stationary seal member 92 and a rotating seal member 93. The rotating member 93 is carried within the cup-shaped housing 94 secured to the upper end of the outer tube 61. An O-ring 96 is disposed in the annular groove 97 formed on the lower surface of the seal member 93 and is adapted to provide a seal between the upper end of the tube 61 and the surrounds. The O-ring also serves to provide for cushioning of the seal member 93 so that its face is always in contact with the adjacent face of the stationary seal member 92. The seal member 93 includes an annular groove 98, FIGURE 7, which is provided with a plurality of spaced openings 99 to communicate with the annular passage 64. An axial passage 101 communicates with the axial passage 63. The inner tube 62 extends upwardly into the member 93 and is suitably sealed as, for example, by the packing 103.

The stationary portion of the seal assembly includes

the seal member 92 which is provided with a plurality of spaced openings 106 which communicate with the annular groove 98. The upper end of the openings 106 communicate with an annular groove 107 formed in the seal member 92. A cooperating plug 108 is received by the cup-shaped portion of the member 92. It also includes an annular groove 109 which cooperates with the groove 107. An axial passage 110 is formed in the member 92 and it communicates with the opening 101 of member 93. Suitable inlet and outlet passages 111 and 12 are formed in the plug 108 to communicate between the inlet and outlet tubes 113 and 114 and the passages 106 and 110.

The seal member 92 is slidably received within the housing 116 and retained therein by the O-rings 117 and 118. The upper end of the housing 116 is threadably received by guide 119 which, in turn, is slidably received in the collar 121.

The collar 121 threadably receives an end plug 122. A spring 123 is disposed between the end plug and the plug 108 and serves to urge the plug 108 and associated seal member 92 downwardly into pressure contact with the upper face of the member 93. Thus, a pressure face seal is formed between the faces of the seal members 92 and 93. The seal is maintained under predetermined adjustable pressure by the spring 123.

It is observed that any wear of the seal faces will continuously be compensated by the forces bringing the faces together and that the amount of friction can be adjusted by adjusting the spring forces applied between the same. Any flexure of the tubes 61 and 62 is accommodated by the flexible mounting of the member 93.

The space between the outer housing 116 and the seal member 92 is provided with inlets and outlets 126 and 127, FIGURE 3. Fluid is circulated in the jacket 128 to cool the seal member 92.

The seal member 93 is preferably constructed of a material, for example, modified Teflon, which has a relatively low coefficient of friction, while the member 92 may be made of copper or other high conducting metal which serves to provide good heat conduction so that the heat generated by friction is conducted to the cooling fluid in jacket 128. The fluid being separated may form a film between the adjacent faces of the seal member and aid in lubricating the seal.

In the feed arrangement shown in FIGURE 3, the fluid to be processed is fed down through the annulus. Any leakage of fluid at the seal faces will flow outwardly due to the centrifugal forces. Leakage from the inner tube will be outwardly and will flow into the annular groove 98. However, this does not contaminate the supernate and it is re-subjected to a separation.

It is observed that centrifugal forces do not affect the seal. The effect of wear is minimized since the face seals are continuously urged against one another. The relative velocity between the sealing parts is minimized and is dependent only upon the diameter of the seal. It is observed that at the center of the seal, the relative velocity is low while at the outer periphery, it is greater.

Thus, it is seen that there is provided an improved ultracentrifuge apparatus which can be operated in a vacuum and which includes a water-cooled rotary face seal for transferring fluid into and out of the rotor. The sample is circulated through a closed path never being exposed to the surrounding atmosphere. There is no need for release on centrifugal faces for moving the sample since the closed system can employ a forced feed system. In collecting the supernate there is no frothing or aeration of the sample as is present in systems which employ a spill over for collecting the supernate.

I claim:

1. An ultracentrifuge apparatus including a rotor adapted to be driven at relatively high rotative velocities, means for supplying a liquid to the interior of said rotor and removing liquid therefrom, said last named means

5

including an outer and an inner concentric tube each having one end secured for rotation with the rotor and in cooperation defining an annular and an axial passage communicating with the interior of the rotor, a rotary sealing member having passages at least one of which communicates with the axial passage and at least another one of which communicates with the annular passage, cup-shaped housing means carried at the other end of said outer tube for supporting the rotary sealing member, means cooperating between said cup-shaped housing means and said rotary sealing member for resiliently mounting said rotary sealing member, said last named means serving additionally to form a seal between said supporting means and said rotary sealing member, said rotary sealing member including means for receiving the other end of the inner concentric tube, said rotary sealing member including a seal face disposed at substantially right angles with respect to the axis of said concentric tubes, a stationary sealing member including a seal face adapted to cooperate with the seal face of said rotary sealing member, said stationary sealing member including passages communicating with the axial and annular passages through the rotary sealing member passages, and means for urging

6

said stationary sealing member into sealing contact with the sealing face of the rotary sealing member.

2. Apparatus as in claim 1 in which said stationary sealing member is supported in a housing, said stationary member and housing cooperating to form a jacket for the reception of a coolant to cool the stationary member.

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