June 29, 1965 E. G. PICKELS ETAL 3,191,856

CENTRIFUGE ROTOR

Filed March 27, 1962 3 Sheets-Sheet 1

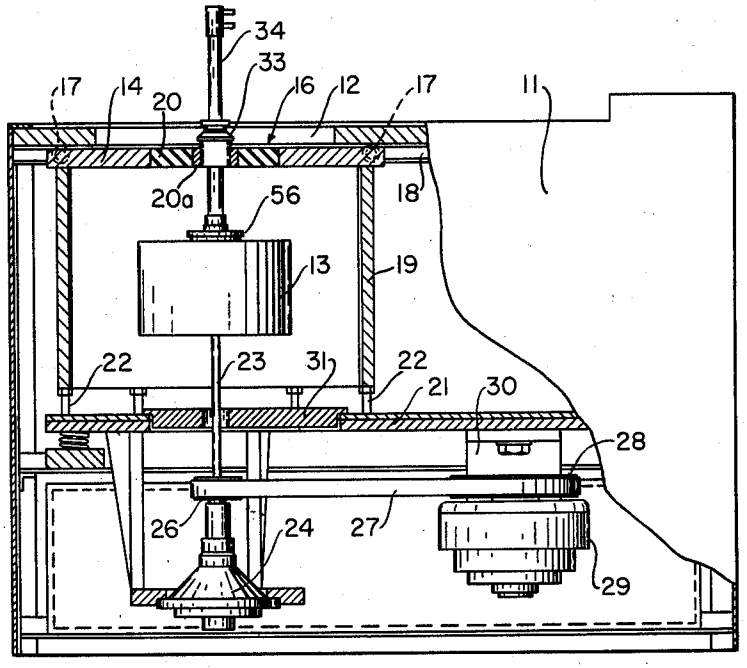


FIG. 1

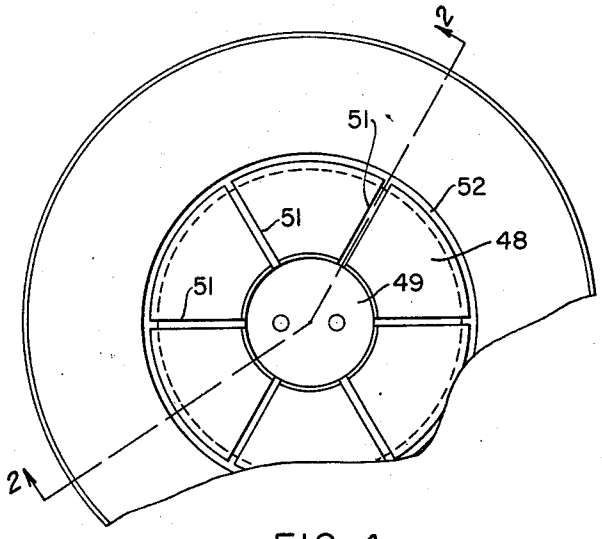


FIG. 4

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CENTRIFUGE ROTOR

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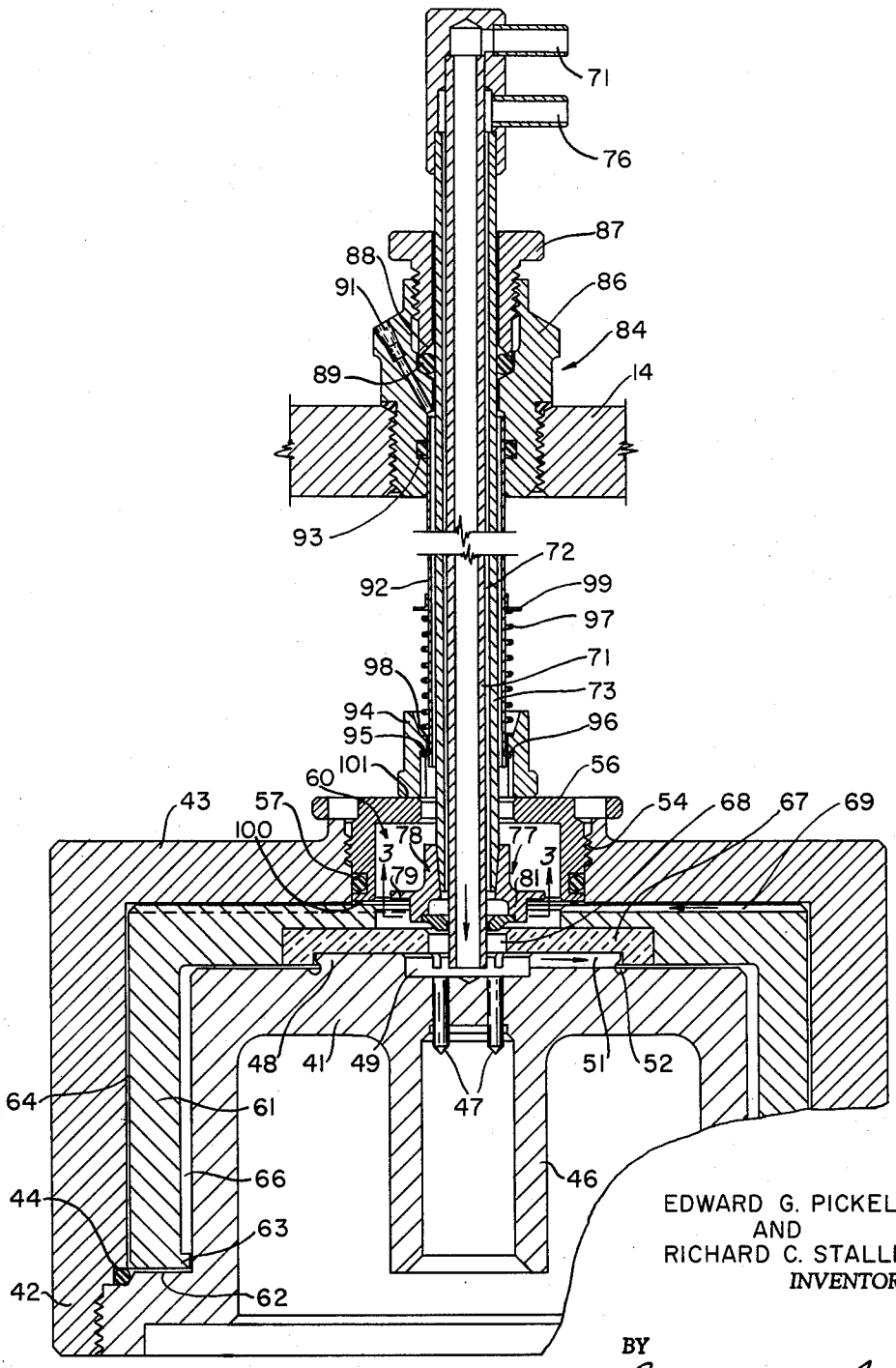


FIG. 2

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CENTRIFUGE ROTOR

Filed March 27, 1962 3 Sheets-Sheet 3

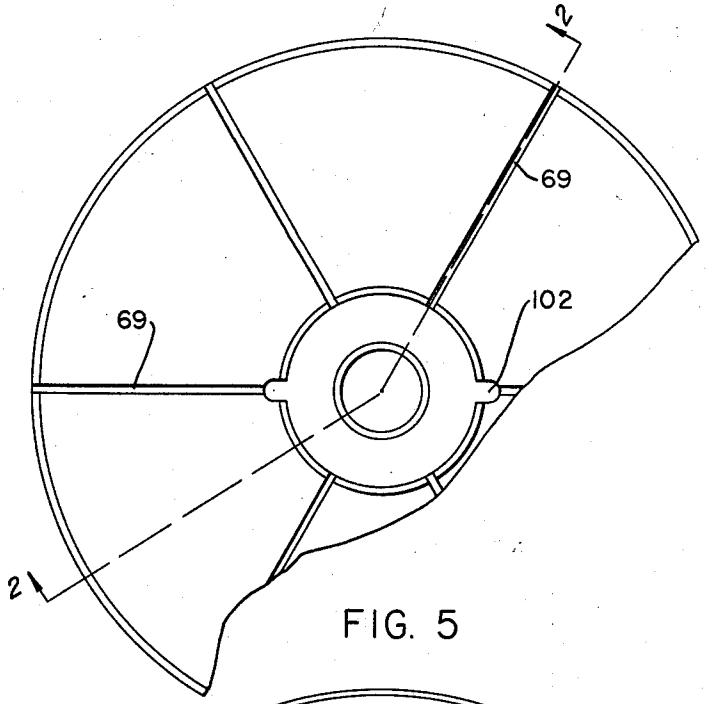


FIG. 5

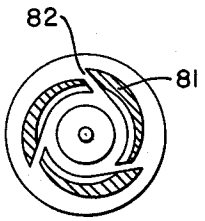


FIG. 3

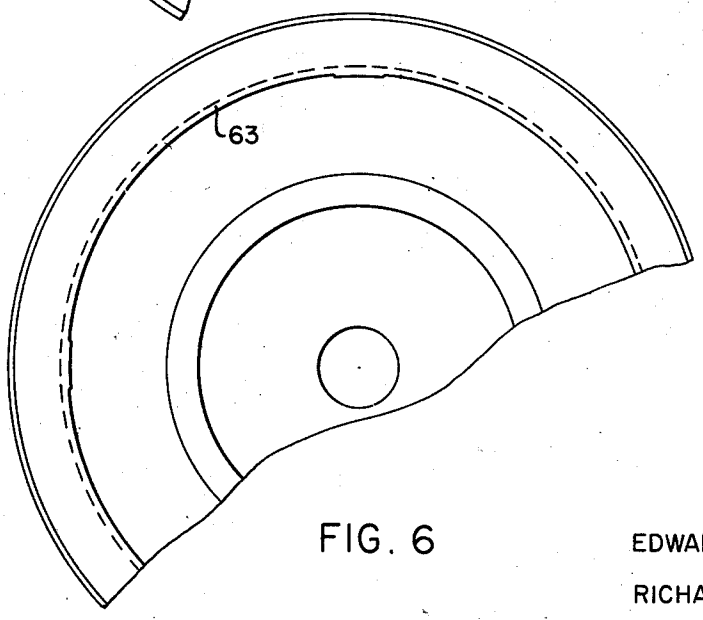


FIG. 6

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United States Patent Office 3,191,856 Patented June 29, 1965



3,191,856

# CENTRIFUGE ROTOR

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2 Claims. (Cl. 233—3)

This application is a continuation-in-part of our earlier filed copending application Serial No. 732,617, filed May 2, 1958, now abandoned.

The present invention relates generally to a centrifuge and more particularly to a centrifuge rotor.

Continuous flow centrifuge rotors of the prior art have some drawbacks when employed for laboratory use. For example, they have a relatively large hold-up volume and there are no satisfactory means for reconstituting the sediment which is collected on the walls of the rotor.

It is a general object of the present invention to provide an improved centrifuge rotor.

It is another object of the present invention to provide a continuous flow centrifuge having a relatively small hold-up volume.

It is another object of the invention to provide a centrifuge rotor having an inverted rotatable bowl-like member for reducing the hold-up volume and also providing means for reconstituting sediment.

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

Referring to the drawing:

FIGURE 1 is a side elevational view, partly in section, showing a complete centrifuge apparatus;

FIGURE 2 is an enlarged sectional view showing a continuous flow centrifuge rotor assembly and system;

FIGURE 3 is a sectional view along the line 3—3 of FIGURE 2;

FIGURE 4 is a top view of the inner bowl of a rotor assembly in accordance with the invention;

FIGURE 5 is a top view of the central bowl of a rotor assembly in accordance with the invention; and

FIGURE 6 is a bottom view of the central bowl of a rotor assembly in accordance with the invention.

Referring to FIGURE 1, a centrifuge apparatus having an outer housing 11 which encloses the working parts is illustrated. The top of the housing is provided with an opening 12 through which the rotor 13 may be installed and removed. A sliding door 14 having a louvered opening 16 provides access to the rotor 13. The door is provided with spaced rollers 17 which ride in the channels 18 secured to the sides of the housing 11. A latch mechanism (not shown) works in conjunction with the controls (not shown) to release the door whereby it may be opened. The louvered opening allows circulation of air through the rotor chamber, as will be presently described.

The rotor is disposed within a cylindrical chamber 19 which acts as a guard in the event of breakage or explosion of the rotor under the strains occasioned at the relatively high operating speeds at which it is operated. The louvers 20 are so slanted that if breakage should occur, none of the pieces will fly out.

The cylindrical chamber 19 is mounted on a base 21 by a plurality of pins 22 which are suitably secured to the bottom of the cylinder and to the base. The pins 22 serve to hold the bottom edge of the cylinder 19 spaced from the base 21 whereby air may circulate through the space between the cylinder 19 and the base 21. Thus, the air may circulate downward through the louvered opening in the door, past the rotor, and outwardly through



lower space. Circulation is caused by the air currents set up by the rapidly rotating rotor 13.

The rotor 13, to be presently described in detail, is mounted on the end of a flexible drive shaft 23. The bottom end of the shaft is journalled in the bearing assembly 24 which is filled with oil to continuously lubricate and cool the bearing as the rotor is driven. A replaceable gear 26 is adapted to drive the shaft 23. A drive belt 27 engages the gear 26 and a gear 28 driven by a motor 29 mounted on the base 21 by means of a bracket 30.

A removable plate 31 is carried at the bottom of the rotor chamber to permit changing the gear 26 for speed changes. Apparatus in accordance with the foregoing is described in detail in Patent No. 2,878,992.

A member 33 is threadably received by sleeve 20*a* carried by the louvers 20 formed in the cover 14. The member serves to slidably receive the assembly 34, to be presently described in detail, which feeds and removes sample material from the rotor.

Referring to FIGURE 2, a sectional view of a suitable rotor assembly and assembly 34 is shown. The rotor assembly shown comprises an inner bowl 41 which is threadably received by the lower end 42 of an outer bowl 43 to nest within the same in spaced relationship therewith. An O-ring 44 provides a suitable seal between the two bowls. The inner bowl includes a coaxial collar 46 which receives the upper end of the shaft 23. The pins 47 seat in accommodating recesses (not shown) formed in the shaft 23, whereby the rotor assembly is driven by the shaft.

The upper surface of the inner bowl 41 includes a boss 48 having a central recess 49. The boss is provided with a plurality of radially extending spaced slots 51 which terminate on a circular slot 52 (FIGURES 2 and 4).

The outer bowl is provided with a threaded opening 54 which is adapted to receive a nut 56. The lower end of the nut is suitably sealed to the member 43 by means of an O-ring seal 57. The bowls 41 and 43 cooperate to form a separating chamber. The central recess 49 of the inner bowl and the interior of the nut cooperate to form a sample supply and removal chamber 60 which, as will be presently described, receives the means for supplying and removing fluid from the rotor assembly. Within this chamber there is disposed a central bowl or core 61. The sides of the bowl 61 extend downwardly into the chamber and adjacent to the lower wall 62 of the same to thereby form two smaller separating chambers which are connected at their bottoms. The inner surface of the bowl is provided with a lip 63 for purposes to be presently described. The lip extends inwardly to the outer surface of the inner bowl. However, the lip is not circular, as shown in FIGURE 6, whereby liquid can flow past the lip. Preferably, the bowl or core is of such size that it occupies a large percentage of the volume of the chamber to form a relatively small chamber 64 between its outer surface and the outer bowl, and a relatively small chamber 66 between its inner surface and the adjacent outer surface of the inner bowl 41. A disk-like insert 67 is provided at the upper end of the bowl. It has an opening 68 which has a smaller diameter than the recess 49 previously described. Thus, the insert 67 acts as a dam subdividing the chamber 60 into two chambers so that one serves to receive the fluid feed means and the other accommodates a pump means. The member 67 is made of material which is self-lubricating whereby the central bowl rotates freely on the inner bowl. The upper surface of the central bowl is provided with slots 69 which extend radially outwardly as shown in FIGURE 5.

In operation, the liquid sample is fed into one portion of the sample chamber 60, passes down one of the cham-

bers 64 or 66 around the lower edge of the bowl 61, and up the other passage 66 or 64, into the other portion of the chamber 60 where it is removed by the pumping means.

Suitable means are provided for feeding the sample into one fluid chamber and removing the same from the other fluid chamber. As illustrated in FIGURE 2, the sample is fed through the tube 71 of the assembly 34 into the fluid chamber including recess 49 where it travels outwardly along the slots 51 and downwardly in the separating chamber 66. Sample material is removed through the annular passage 72 formed between the concentric tubes 71 and 73. The upper end of the annular passage is connected to an outlet tube 76, and the lower end is connected to a pump means designated generally by the reference numeral 77 disposed in the fluid removal chamber.

The pump means includes an upper portion 78 having a tapered passage adapted to receive the lower end of the tube 73. The pump includes a disk 79 and scoops 81 disposed below the same. The scoops 81 are provided with openings 82 (FIGURE 3) which communicate with the annular passage 72. The liquid is scooped up as it is rotated past the scoops and pumped upwardly in the annular passage to the outlet 76. In operation, the rotor is being spun at relatively high speeds and the scoop is stationary. The impact of the liquid in the scoops creates sufficient static pressure to cause pumping. It is, of course, apparent that the design of the scoops shown is merely illustrative.

Thus, in operation, liquid is continuously fed by the tube 71 into the fluid feed chamber including recess 49. The liquid then flows outwardly between the bowls 41 and 61 along the slots 51 into the chamber 66, downwardly past the lip 63, across the surface 62, and upwardly in the chamber 64, and thence between the central bowl 61 and the outer bowl 43 where it is collected (removed) by the pumping means in the fluid removal chamber. An explanation of the forces which cause the fluid to flow through the rotor will be presently given.

It is desirable for ease of assembly that the tube 73 be removable from the pump. As described and illustrated, the pump is removable whereby it may be dropped in the rotor and the nut 56 secured. The concentric tubes are then fed downwardly until the tapered end of the tube 73 engages the tapered opening formed in the pump. The tubes and pump are then lifted until the pump is free of the upper surface of bowl 61. Adjusting means 84 is adapted to receive and hold the outer tube 73 of the concentric tubes. The arrangement includes an outer sleeve 86 which is threadably received by the cover 14. The sleeve 86 slidably receives the tubes. A nut 87 is threaded into the sleeve 86 and has a lower tapered edge 88 which is adapted to engage the outer surface of an O-ring 89 and urge the same inwardly to lock the outer tube 73. Thus, by a turning movement of the nut 87, the outer tube may be locked in position. To open the cover 14, the adjusting means 84 is loosened and the pump means are disconnected from the tube 73. The concentric tubes are removed from the adjusting means 84 and the adjusting means unscrewed from the cover 14. The cover is then free to slide open for removal of the rotor.

In certain applications it is desirable to operate the rotor with the sample in an atmosphere of inert gas. For this purpose, an opening 91 formed in the sleeve 86 communicates with the space formed between a tube 92 and the outer tube 73. The tube 92 is held within the sleeve by means of an O-ring 93. A member 94 is carried by the lower end of the tube and is held thereon by the shoulder 95 which engages the flared lower portion 96 of the tube 92. Spring means 97 may be provided for urging the member 94 downwardly. The spring acts between the shoulder 98 formed in the member and the shoulder formed by the ring 99 which is suitably secured to the cylinder at a spaced interval along the same. The member 94 is preferably made of a low friction material and has its lower edge in engagement with the machined surface 101 formed in the upper surface of the nut 56. Thus, inert gas may be continuously fed downwardly into the rotor.

Operation of the apparatus as described is then as follows: An O-ring 100 of a relatively hard material is placed on the surface of the central bowl whereby the lower edge of the nut 56 locks the center bowl against rotation with respect to the outer bowl. The liquid is fed, as previously described, whereby it flows in the inner chamber 66 and the larger particles are collected by centrifugal force on the inner wall of the central bowl 61. The solute flows downwardly past the lip but the collected particles are trapped by the lip and held on the surface. The solute then flows upwardly in the chamber 64 where additional separation takes place and is then pumped upwardly to the outlet 76.

If the liquid is to be reconstituted, the rotor may be removed from the chamber 19 and the nut 56 loosened whereby the central bowl is allowed to rotate freely. Suitable driving means may then be placed into engagement with the central bowl at the notches 102 (FIGURE 5). The chambers are filled with liquid and the central bowl is rotated. The relative motion between the central bowl and the inner and outer bowls will agitate the liquid and the collected particles are reconstituted. The reconstituted liquid in the rotor may then be drained.

It is observed that the apparatus is a continuous apparatus wherein the fluid is continuously fed and removed at the top of the rotor. The hold-up volume, that is, the volume in the separating chamber, is relatively small and, therefore, small amounts of liquid may be separated. Further, means are provided for reconstituting the sediment.

We claim:

1. In a centrifuge, a rotor having inner and outer bowls secured together to form a cylindrical chamber therebetween, a central bowl disposed in said chamber, means formed to define a self-lubricated bearing interface between said inner and central bowls, said interface extending transversely of the axis of rotation of the rotor and disposed to support said central bowl upon said inner bowl and to permti relative rotation therebetween, means rotatable with and secured to the outer bowl and formed to be axially movable between advanced and retracted positions to respectively lock and unlock said outer bowl with respect to said central bowl, said central bowl being otherwise free to rotate in said chamber, the last named means including a nut threadedly engaging said outer bowl and an O-ring disposed to be pinched between said nut and said central bowl when said nut is in its advanced position to frictionally lock said outer and central bowls to provide conjoint rotation of all said bowls during a centrifugation and, when said nut is moved to its retracted position, to permit rotation of said central bowl in said chamber.

2. In a centrifuge, a rotor having inner and outer bowls secured together to form a cylindrical chamber therebetween, a central bowl disposed in said chamber, means formed to define a self-lubricated bearing interface between said inner and central bowls, said interface extending transversely of the axis of rotation of the rotor and disposed to support said central bowl upon said inner bowl and to permit relative rotation therebetween, and means rotatable with and secured to the outer bowl and formed to be axially movable between advanced and retracted positions to respectively lock and unlock said outer bowl with respect to said central bowl, said central bowl being otherwise free to rotate in said chamber.

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