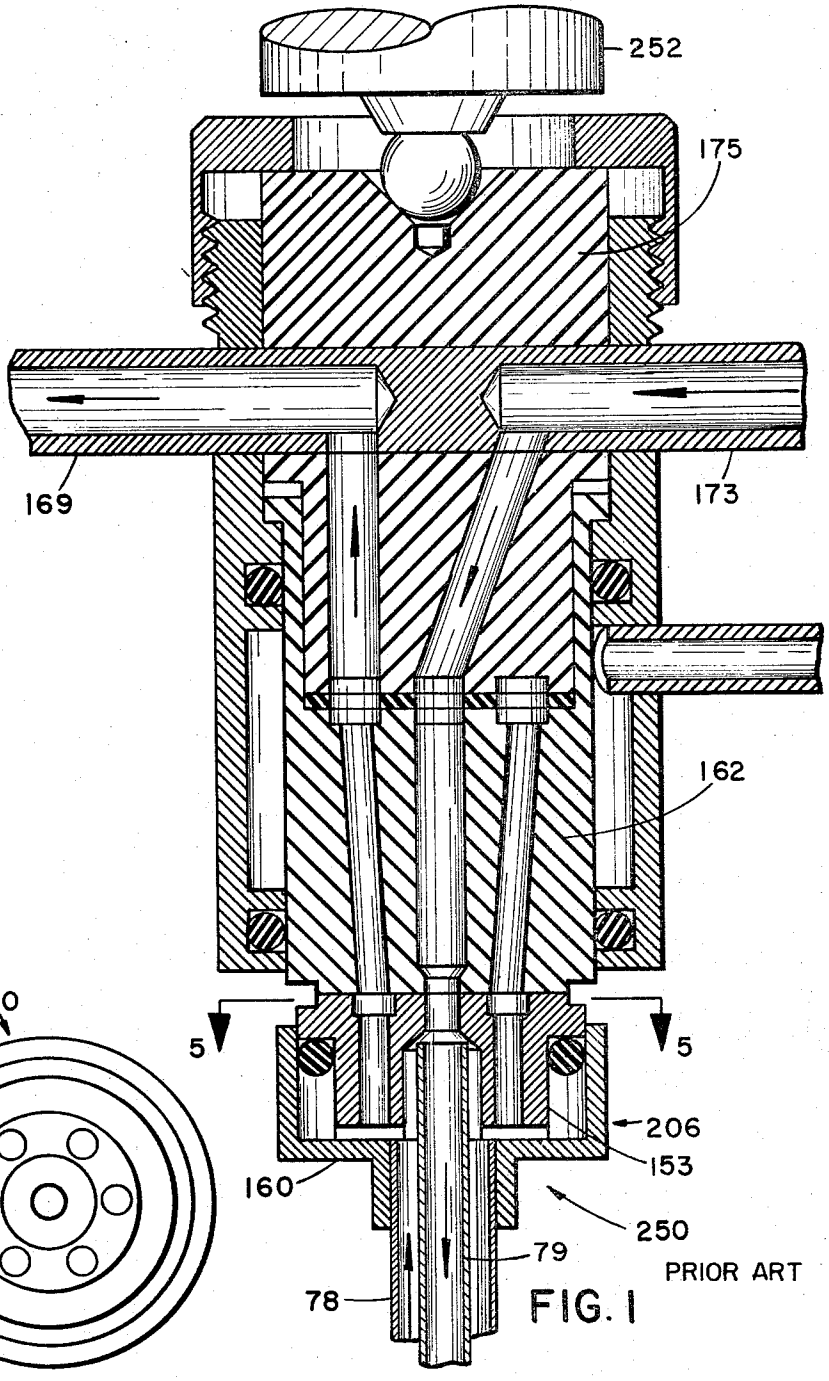
Dec. 20, 1966 C. E. NUNLEY 3,292,937

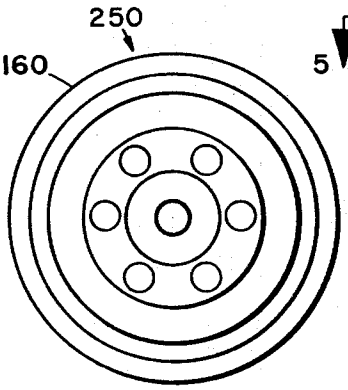
SHAFT SEAL FOR LIQUID CENTRIFUGES

Filed April 3, 1964 4 Sheets-Sheet 1



PRIOR ART

FIG. 1



PRIOR ART

FIG. 5

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SHAFT SEAL FOR LIQUID CENTRIFUGES

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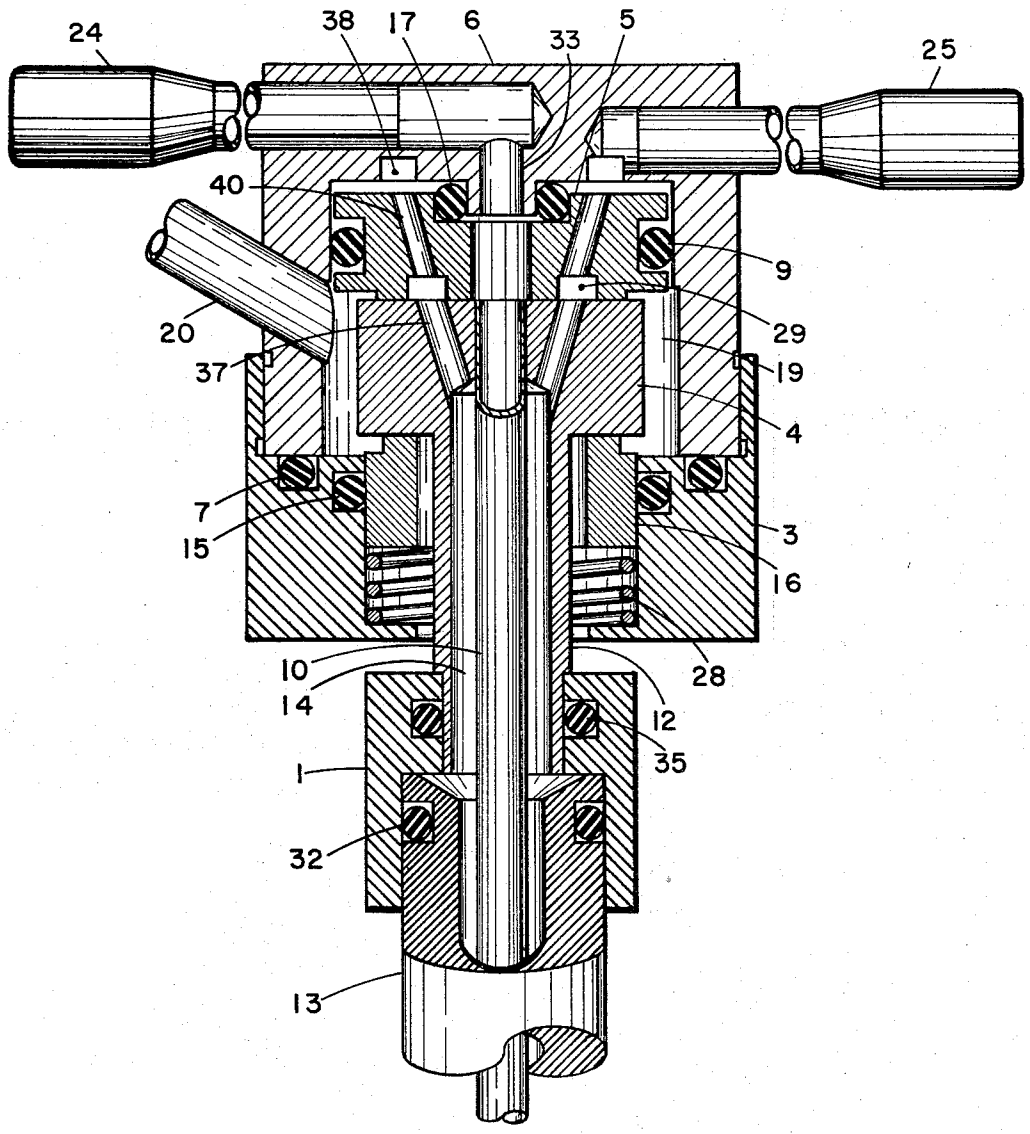

FIG. 2

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SHAFT SEAL FOR LIQUID CENTRIFUGES

Filed April 3, 1964 4 Sheets-Sheet 3

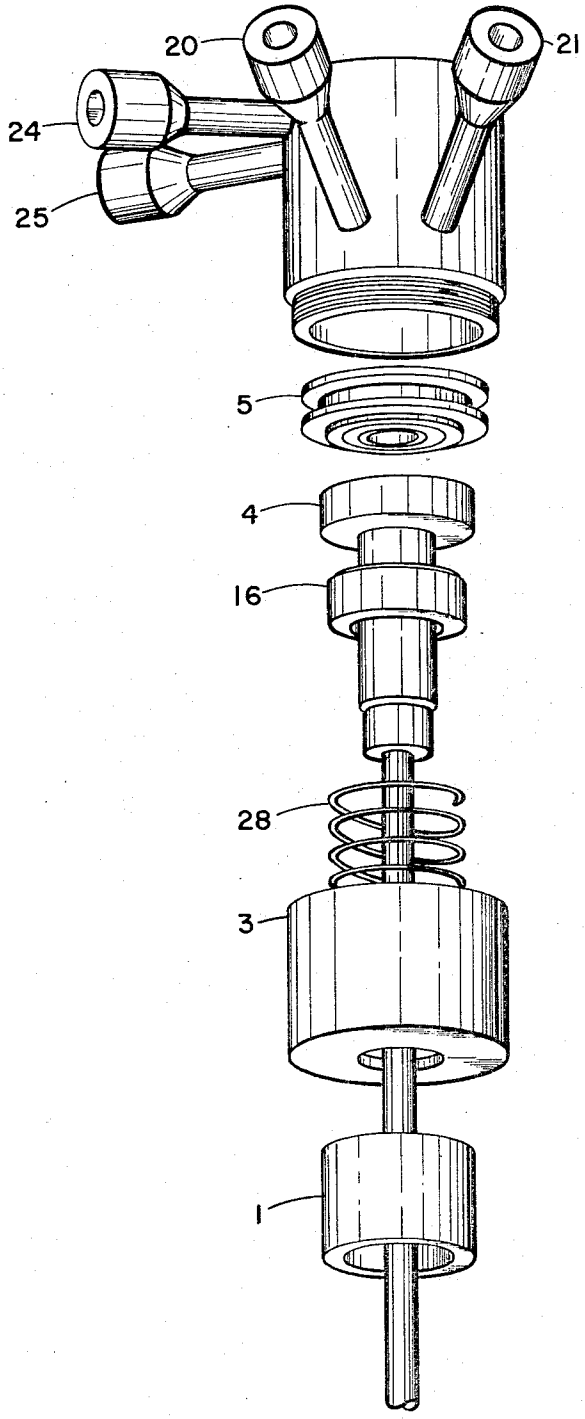

FIG. 3

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SHAFT SEAL FOR LIQUID CENTRIFUGES

Filed April 3, 1964 4 Sheets-Sheet 4

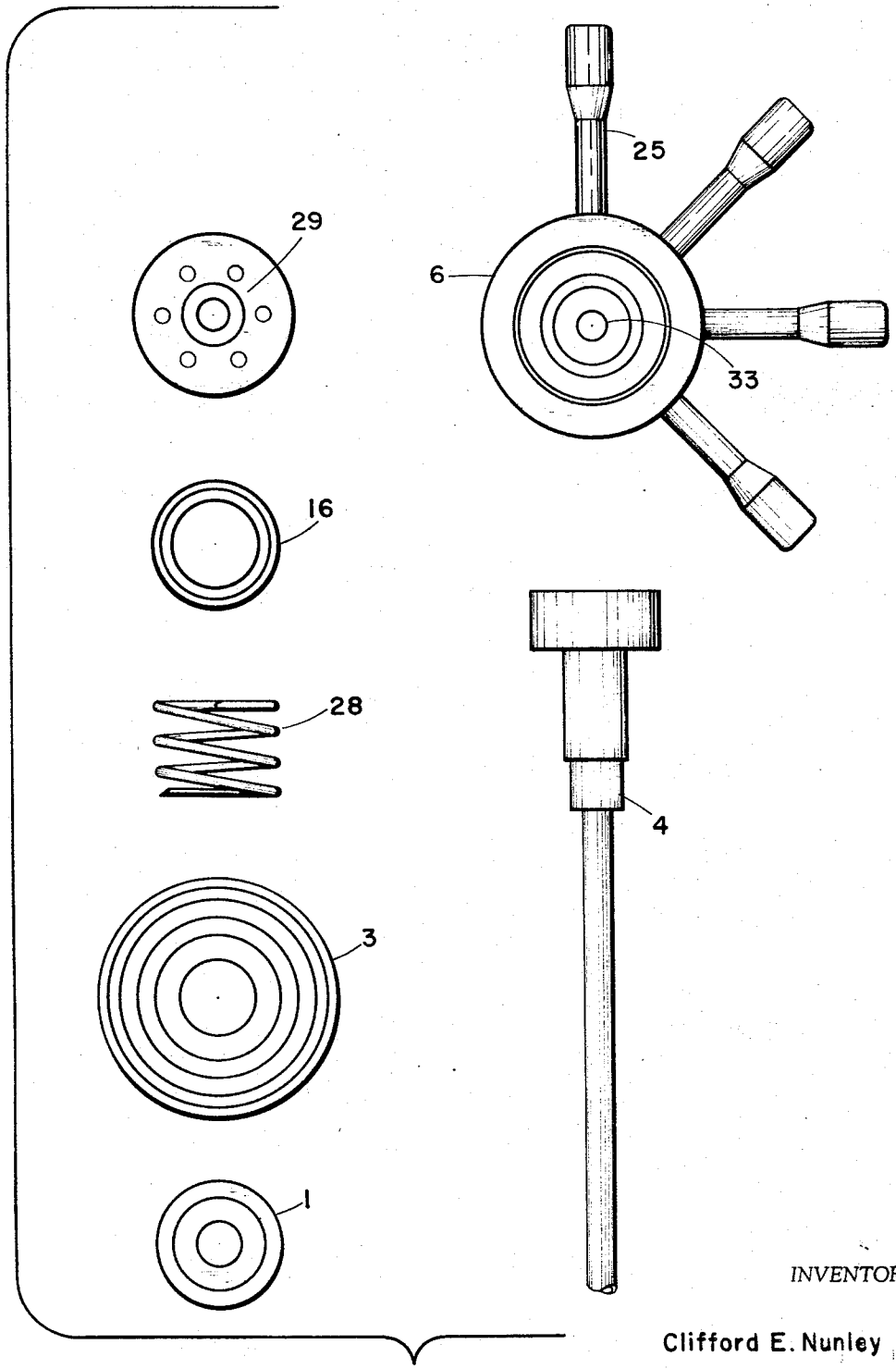

FIG. 4

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3,292,937

Patented Dec. 20, 1966

3,292,937

SHAFT SEAL FOR LIQUID CENTRIFUGES

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Filed Apr. 3, 1964, Ser. No. 357,338
2 Claims. (Cl. 277—59)

This invention relates to shaft seals and more particularly to a shaft seal for a liquid centrifuge to permit leak-free transfer of liquid between a rotary tubular shaft and a stationary manifold.

The present invention is particularly suited for use with an intermediate speed zonal type centrifuge rotor commonly referred to as a B-II rotor, made by Spinco Division of Beckman Instruments, Inc. The B-II rotor is designed for the liquid phase separation of biological materials; liquid can be admitted to and withdrawn from the rotor during operation. The construction and operation of the B-II rotor is described in a special report, ORNL–3415, dated March 4, 1963, pages 39–48.

In the prior art of shaft seals of centrifuges for processing pathogenic viruses, it has been the practice to employ a single face seal with proper contact at the seal face accomplished by loading, and by employing open jet spraying of coolant of the bearing housing near the point of rotation. Such an arrangement with external loading requires relatively close shaft alignment and does not permit a prior assembly. Because the solution employed as a coolant at the joint may be contaminated with outleaking process fluid containing pathogenic viruses or the like, there is a hazard and a problem of confining it to a limited area and disposing of it.

Applicant with a knowledge of these problems of the prior art has for an object of his invention the provision of a shaft seal for a liquid centrifuge which contemplates positive containment of a solution serving both as a seal coolant and as a seal disinfectant.

Applicant has as another object of his invention the provision of a double face seal for a liquid centrifuge which is simple in construction and may be preassembled as a single unit prior to installation on the rotor shaft.

Applicant has as a further object of his invention the provision of a shaft seal for a liquid centrifuge which will accommodate some shaft misalignment and operate satisfactorily.

Applicant has as a still further object of his invention the provision of a shaft seal for a liquid centrifuge which eliminates the need for external load to permit proper functioning.

Other objects and advantages of my invention will appear from the following specification and accompanying drawings, and the novel features thereof will be particularly pointed out in the annexed claims.

In the drawings, FIG. 1 is a sectional elevation of a conventional shaft seal for a liquid centrifuge. FIG. 2 is a sectional elevation of my improved shaft seal for a liquid centrifuge. FIG. 3 is a side elevation of the various elements, in disassembled relation, of my improved shaft seal. FIG. 4 is a plan view of the elements of my improved shaft seal in disassembled relation. FIG. 5 is a cross section of a conventional centrifuge shaft seal taken along the line 5—5 of FIG. 1.

A conventional prior art liquid centrifuge seal is shown in FIGS. 1 and 5. The assembly **250** includes a metal cup **160** which is rigidly secured to the outer tube **78** of the coaxial shaft **78–79** of the centrifuge rotor. A perforated disc **153**, composed of polytetrafluoethylene (Teflon) filled with iron oxide, is sealably mounted within the cup and is in facial contact with a stationary perforated disc **162**, which is composed of aluminum, its

mating surface being plated with tungsten carbide. Mounted on the disc **162** is a stationary perforated disc **175**. As indicated in FIG. 1, the perforations in the stationary discs **162** and **175** and in the rotatable disc **153** align to connect the inner tube **79** of the rotor shaft with an external inlet line **173**, and to connect the outer tube **78** with an external outlet line **169**. Also, as indicated in FIG. 1, a chamber is provided about stationary disc **162** for the circulation of liquid coolant. A jet of liquid coolant (not shown) is provided at point **206** to cool the rotatable assembly **250**. The jetted coolant drains toward the bottom of the centrifuge assembly and is removed through an outlet line (not shown). Also, in the seal of FIG. 1, an adjustable cartridge assembly **252** is provided to bear on the top of stationary disc **175** and urge the sealing face of disc **162** into engagement with that of the rotary disc **153**.

Applicant's improved seal is employed not only to accomplish the objectives of the seal of FIG. 1, but also to provide for positive containment of a solution serving both as a seal coolant and as a seal disinfectant. Because the solution may contain outleaking process fluid containing pathogenic viruses or the like, it is desired that the solution be confined to the relatively small annular region encompassing the sealing surfaces. In the seal of FIG. 1, the liquid jet **206** is permitted to drain over a substantial part of the centrifuge assembly. Thus, unlike the prior art seal, the applicant's improved seal is provided with two face-type seals.

Applicant's improved seal also differs from that of FIG. 1 in being simpler in construction, in being able to accommodate some misalignment of the rotor shaft and the seal assembly, and in being able to operate satisfactorily without the use of a relatively complicated seal-loading device such as that shown at **252** in FIG. 1. In addition, the seal can be assembled as a single unit and sterilized prior to installation on the rotor shaft, thus simplifying installation. The assembly of the seal and the operation of the centrifuge normally are conducted in a dry box.

Referring to FIGS. 2, 3 and 4, applicant's improved seal assembly includes a tubular metal runner comprising a stem **12** and a cylindrical head **4**. The lower end of stem **12** is fitted into, and secured frictionally to, a sleeve **1** and sealed thereto by O ring **35** which seats in an annular groove therein. Sleeve **1** frictionally engages the upper end of a centrifuge rotor shaft **13**. Frictional engagement is affected by means of an O ring **32** fitted in a groove encircling the shaft. As indicated, the rotor shaft is tubular. Coaxially disposed within the metal runner **4, 12** is a tube **10** whose upper end is circumferentially secured to the head **4** in a leak-tight joint. The tube **10** extends downwardly through the stem **12**, into the tubular rotor shaft **13**, and thence into the interior of the centrifuge rotor (not shown). There, it communicates with passages leading to the rotor wall. The tube **10** is of relatively small outside diameter so that it defines, in combination with the stem **12** and the rotor shaft **13**, an annular passageway **14**. This passageway communicates, through the rotor shaft, with the central region of the centrifuge rotor. Cylindrical head **4** is provided with a series of circularly disposed bores or passages **37** which converge downwardly and provide communication through the head to the passageway **14**.

The outer margin of the lower face of the cylindrical head **4** rests upon an annular sealing ring **16**. In the arrangement shown in FIG. 2, this ring is composed of Rulon (Teflon impregnated with iron oxide), and is urged into sealing contact with the rotating head **4** by means of spiral coiled compression spring **28**. The ring **16** and the spring **28** are mounted within a cup-shaped housing **3**, and O ring **15** being interposed between the ring **16** and

the inner wall of the housing 3. In an alternative arrangement, the assembly 16, 28 can be replaced with a standard Gits sealing element consisting of a spring-loaded carbon ring (not shown). Wave washers springs can be used in place of a coil spring.

As shown most clearly in FIG. 2, a Rulon ring 5 is mounted on the top face of the rotating head 4. The ring 5 is provided with a circumferential groove containing an O ring 9. The O ring 9 sealably engages the inner wall of a seal assembly cap 6, which encompasses the Rulon ring 5 and the rotating head 4. The lip of cap 6 is threaded externally for engagement with the lip of the aforementioned housing 3. As indicated, an O ring 7 is interposed between the cap 6 and the housing 3, providing a leak-tight junction. Note that sufficient clearance is provided between the head 4 and the cap 6 to form an annular chamber 19. A cooling and disinfecting solution is circulated through this chamber by means of external tubes 20 and 21 (FIG. 3) communicating therewith. The aforementioned O rings 7, 9 and 15 are provided for positive containment of this solution. The solution cools the sealing elements 4, 5 and 16, thus reducing wear and also avoiding undue heating of liquids flowing through the seal assembly. The solution disinfects any outleaking process liquid.

Formed in the lower face of the Rulon disc 5, is an annular collector groove 29 which is in register with the aforementioned bores or passages 37 in the rotating head 4 and thus with passageway 14. The upper face of ring 5 is cut away to receive an O ring 17 which provides a leak-tight joint between the ring 5 and a tubular projection 33, FIGS. 2 and 4 of the cap 6. The central passageway in the ring 5 communicates directly with (a) the aforementioned tube 10 extending into the interior of the centrifuge rotor, and (b) with an external tube 24 extending into the cap 6. As indicated in FIG. 2, the top face of the ring 5 is provided with a series of circularly disposed bores 40 communicating directly with the collector groove 29 formed in the bottom face of the ring 5. An annular collector groove 38 is formed in the base of cap 6 to register with the bores 40 in the ring 5. An external tube 25 extends into the cap to communicate with the collector groove 38.

Applicant's improved seal has operated satisfactorily on the B–II rotor at design speed of 40,000 r.p.m. This is design speed of rotation for the present B–II rotor system. The seal also has operated satisfactorily up to 40,000 r.p.m. in tests conducted with a precision grinding motor. The grinding motor simulated a rotor having a very low amplitude of vibration. In the course of the tests with the grinding motor, the upper end of tube 10 was closed off, and a pressure of about 5 p.s.i. was applied to the liquid in line 25. Under these conditions, the outleakage through the seal interfaces was satisfactory—about 2 cc./hr. The spring loading on the seal was about two pounds. Essentially the same result was obtained with tube 24 subjected to the same amount of pressure.

It was noted that the O ring coupling 1, 32 shown in

FIG. 2, acts to some extent as a universal joint, permitting slight misalignments between the seal assembly and the rotor shaft. Balanced loading of the seal is provided through the use of the coil spring 28—that is, the spring urges the lower stationary sealing element 16 against the rotating element 4, and also acts through the housings 3, 6 to urge the upper stationary sealing element 5 against the rotating element 4. Thus, it is possible to eliminate the external loading cartridge 252, FIG. 1 of the prior art. Tests show that the annular wear pattern on the faces of the rotating element 4 are more nearly concentrically disposed than is the case with the seal of FIG. 1. This indicates that the improved seal assembly is less affected by annular misalignment of the rotor shaft and the static portions of the seal assembly. As mentioned, the leak rate through the subject seal is acceptable.

Having thus described my invention, I claim:

1. A shaft seal for a liquid centrifuge comprising a housing defining an open-ended chamber, channels for leading fluid into and removing it from the chamber, a head rotatably disposed in the chamber in spaced relation to the walls and having ducts for communication with the channels in the head, a sealing element disposed between the head and the housing for bringing the channels and ducts into communication, a shaft including concentrically positioned tubes joined to the head and extending into the open chamber, a closure for the chamber surrounding the shaft and resilient means engaged by the closure for yieldingly urging the head into tight engagement with the sealing element to provide a liquid-tight seal.

2. A shaft seal for a liquid centrifuge comprising a housing defining an open-ended chamber, channels for leading fluid into and removing it from the chamber, a head rotatably disposed in the chamber in spaced relation to the walls thereof and having ducts for communication with the channels in the head, a sealing element disposed between the head and the housing for bringing the channels and ducts into communication, a shaft including concentrically positioned tubes joined to the head and extending into the open chamber, a closure for the chamber surrounding the shaft, a resilient means engaged by the closure by yieldingly urging the head into tight sealing engagement with the sealing element to provide a liquid-tight seal, and means for feeding coolant to and removing it from the housing chamber.

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