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Tabacchi

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[54] **HYDRAULIC MULTICELLULAR SEALING DEVICE FOR CENTRIFUGAL PUMPS**

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[52] **U.S. Cl.** **277/14**

[51] **Int. Cl.** **F16j 15/40**

[58] **Field of Search** ..... 277/13, 14 R, 14 V, 17, 277/135

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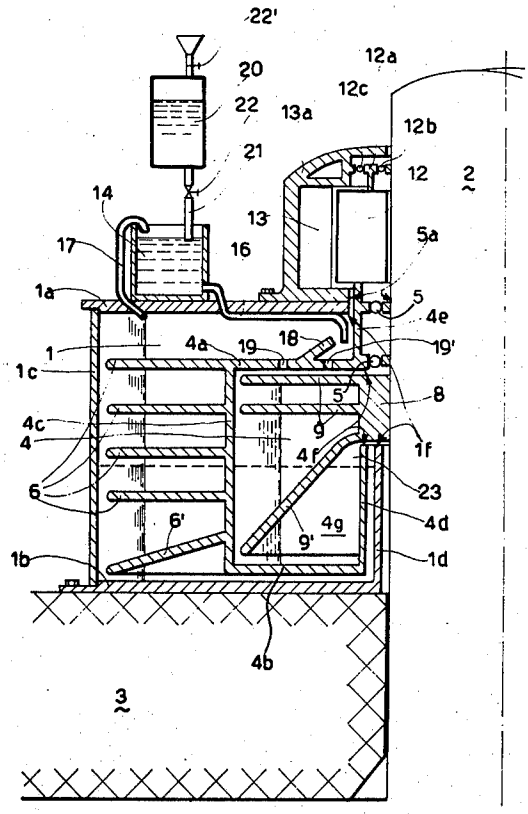
Primary Examiner—Robert I. Smith

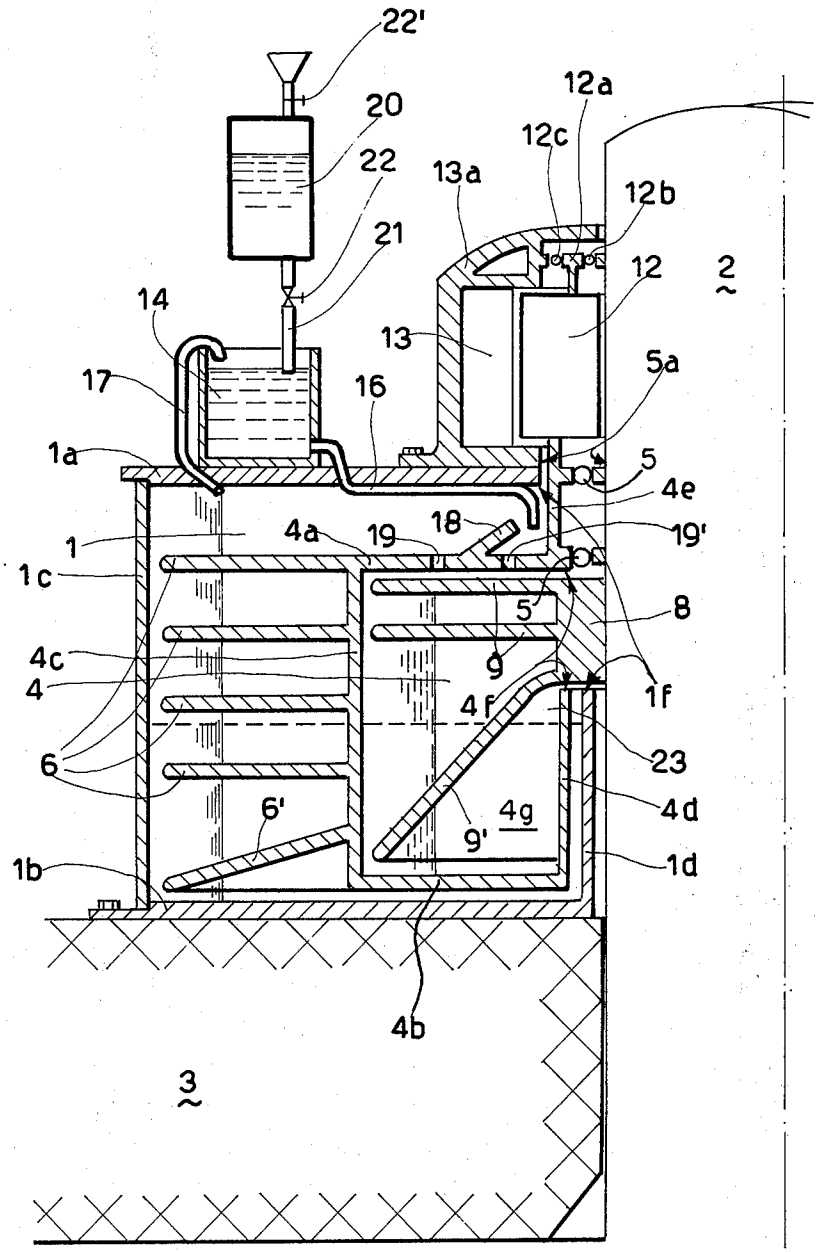
Attorney, Agent, or Firm—Stevens, Davis, Miller & Mosher

[57] **ABSTRACT**

A sealing device is provided around a vertical shaft where it passes through a wall by which two spaces at different pressures are separated. The shaft is provided with an array of circular fins which extend outwardly into an annular rotatable drum coaxial with the shaft to nearly touch the wall of the drum farthest from the shaft. The drum also is provided with another array of circular fins which extend from the outer wall thereof into a stationary annular chamber to nearly touch the wall of the chamber farthest from the shaft. The drum can be rotated independently on the shaft by means of an annular electric motor surrounding the shaft. A layer of fluid is obtained by centrifugation against said walls respectively of the chamber and of the drum, when said motor is running. A seal is thus ensured by said fins penetrating said layers with their outer edges. The lowermost fin of said arrays is bent downward to provide a seal when neither the motor nor the pump are running.

6 Claims, 1 Drawing Figure




22'
20
22
21
14
17
16
1a
1
1c
4a
19
18
19'
5
8
4c
4
9
1f
4f
6
23
6'
4g
9'
4d
1b
1d
4b
3
2
12a
12c
13a
12b
12
13
5a
5
4e

HYDRAULIC MULTICELLULAR SEALING DEVICE FOR CENTRIFUGAL PUMPS

In general solid contact sealing devices are used with centrifugal pumps of nuclear plants which devices are based on the concept of reducing to a minimum the clearance between the two elements of the pump of which one rotates with respect to the other.

In order to reduce the friction between the contact surfaces of said devices to a minimum these are machined with care and the surfaces are finished for instace by plating; various kinds of particular oils greases and graphites being used for lubricating them. Such seals however suffer from the following defects:

- they are not positively reliable for long uninterrupted operation: actually a six months at least continuous operation is specified for the coolant pumps of nuclear plants, this being the time period between two successive servicing at the reactor core, while the reactor shut down is required whenever a failure of the pump sealing occurs;
- the lubricating oils and greases used with solid contact sealing devices could contaminate the coolant with consequent serious inconveniencies.

In order to overcome the above drawbacks, a hydraulic sealing has been developed for vertical shaft pumps which meets the following requirements:

- there is no metal rubbing between the two pump elements of which one rotates with respect to the other;
- the seal operates also when the pump is not running; that is the seal is not driven by the pump shaft;
- the seal comprises several in series elements, each element being effective for counteracting the differential pressure across the seal;
- the seal life is practically indefinite and it is substantially free from failures.

Specifically the hydraulic seal of this invention comprises a series of thin annular elements of which one is conical and the others are flat, which elements are attached to the pump shaft by means of a hub and project radially to penetrate with their peripheral rim into a liquid layer produced by centrifugation against a vertical cylindrical wall. A hydraulic seal is so obtained across each of said elements. When more than one element is used a space is formed between each pair of adjacent elements which space is called cell and from this the name of pluricellular seal is used to signify a seal with multiple sealing elements.

In the device of this invention the vertical wall of the seal, against which the sealing liquid is centrifuged, comprises the peripheral wall of an annular drum coaxial with the pump shaft.

According to an important feature of the invention, the drum is not attached to the pump casing but is is made to rotate with respect to the pump shaft and as a consequence with respect to the pump casing. From this the requirement ensues of preventing any leakage between the drum and the pump casing. In order to eliminate the leakage the drum is provided on the outer surface of its peripheral wall with one or more sealing elements similar to those already described which penetrate with their peripheral rim into a second liquid layer which is produced by centrifugation against the peripheral cylindrical wall of a stationary annular chamber coaxial with the pump shaft and attached to the pump casing.

An hydraulic seal is thus achieved similar to the seal between the drum and the shaft as already described.

According to another important aspect of the invention, a sealing system is provided which can operate also when the pump is not running in as much as the above mentioned two vertical liquid layers whereby the hydraulic seal is ensured between the pump shaft and the drum and between this in the pump casing, are set up and maintained by simply rotating the drum.

According to a further aspect of the invention, a sealing system is provided which effectively operates also when both the pump and the drum are stationary, that is not rotating and this because of the conical sealing elements with which both the hub and drum are provided, which elements in addition to projecting outwards as the other sealing elements, project also downwards and penetrate the liquid layers which collects at the bottom of said drum and chamber when neither the pump nor the drum are running.

Additional objects and advantages of this invention will become apparent from the following description and attached drawing which illustrate a preferred embodiment of the invention as a non limitative example thereof.

A vertical radial cross section of the seal of this invention is illustrated by the drawing. With reference to the drawing the seal of this invention comprises an annular chamber **1** with rectangular vertical radial cross section which chamber is defined by a vertical cylindrical circular wall **1***c*, two horizontal walls, that is a top wall **1***a* and a bottom wall **1***b* both in the form of an annulus, and a vertical cylindrical circular wall **1***d* — coaxial with wall **1***c* — which extends from the bottom wall **1***b* and reaches to a certain distance from the top wall **1***a* whereby a constant height window is defined between the upper rim of wall **1***d* and wall **1***a*.

Wall **1***d* encloses shaft **2** with a large clearance while an annular gap of considerable height is left open between the inner rim of wall **1***a* and shaft **2.**

Within chamber **1** an annular drum **4** is enclosed which is made up of two horizontal walls that is a top wall **4***a* and a bottom wall **4***b* with annular form, of a vertical cylindrical circular wall **4***c* and a second vertical cylindrical circular wall **4***d* which extends from the bottom wall **4***b* up to the same height as wall **1***d* of chamber **1,** said walls defining within drum **4** an annular space with a vertical radial cross section generally rectangular.

A series of circular fins — five in the case of the example illustrated in the drawing — are provided at the outer surface of drum **4** which fins are integral or attached to the vertical outer wall of the drum and are regularly spaced vertically from one another. Such fins extend radially from the drum to nearly reach the vertical cylindrical outer wall **1***c* of said annular chamber **1.**

As can be seen in the drawing, four of said fins indicated by reference number **6,** are horizontal, while the lower one indicated by **6′** is bent downwardly to form a conical surface.

Drum **4** is rotatably mounted coaxially with shaft **2** by means of two bearings **5** inserted between the shaft and the sleeve **4***e* which extends from the top wall **4***a* of the drum upwards. On shaft **2** a hub **8** is firmly mounted which on its outer surface is provided with a series of fins (three are shown in the drawing) which are vertically spaced from one another and which pass through windows **4***f* and through the corresponding portion of

window 1*f* and extend radially to nearly touch the vertical cylindrical outer wall 4*c* of drum 4.

As shown in the drawing, two of said fins indicated by 9 are horizontal while the lowest one, indicated by 9', is bent downwardly from hub 8 whereby a conical bell is formed opening downwardly. Thus the lowest fin attains the lower portion of drum 4. From the top wall of drum 4 sleeve 4*e* projects through the annular gap 5*a* between the inner edge of wall 1*a* of casing 1 and shaft 2 and is connected at its upper end to an annular rotor 12 of an electric motor of which the stator 13 annularly surrounds said rotor 12 and is firmly mounted within a bell-shaped housing 13*a* which is mounted on top of chamber 1. Both components 12 and 13 are coaxial with shaft 2. Rotor 12 is provided at the top thereof with a ring-like extension 12*a* which is inserted between two coplanar rolling bearings 12*b*, 12*c*. Rotor 12 and drum 4, mounted on shaft 2 by means of bearings 12*b*, 12*c* and 5, are free to rotate with respect to said shaft, chamber 1 and housing 13*a*.

On top of chamber 1 a fluid reservoir 14 is mounted for partially filling chamber 1 and drum 4. Reservoir 14 is provided at a position close to its bottom with a pipe 16 which penetrates into chamber 1 and terminates within this chamber at a position close to sleeve 4*e*.

In this area wall 4*a* is provided with a range of through holes 19' and with a conical baffle 18 which extends upwardly and inwardly from wall 4*a*. The same wall is also provided with another range of holes 19 along a circle outside of said baffle which holes are at a distance from the vertical outer wall of drum 4 equal to the thickness of the liquid layer which is to be obtained within drum 4 when drum 4 is driven to rotate by motor 12, 13.

A second pipe 17 connects the space above the liquid surface within reservoir 14 with the inside of chamber 1 at a distance from the vertical outer wall of it equal to the thickness of the liquid layer which is to be obtained during the dynamic operation of the seal as will be explained later on.

The level in reservoir 14 is maintained automatically constant by means of tank 20 which is provided with inlet valve 22' and outlet valve 22, the latter being actuated through an automatic control — not shown — interconnected with the control switch of motor 12, 13. Tank 20 is filled with liquid through valve 22'; when this is closed and valve 22 is open, the liquid will pass from tank 20 into reservoir 14 whenever the liquid level within reservoir 14 will be lower than the level of the lower end of pipe 21.

In operation of the seal of this invention the following three cases may occur:

a. The pump and the seal are stationary that is not rotating. Valves 22 and 22' are closed and reservoir 14 is empty. Casing 1 and drum 4 are full of fluid approximately up to the level indicated by a dashed line in the drawing. The fluid within the pump casing, that is the pressurized fluid of which the leakage towards the inside of the pump is to be prevented by the sealing of this invention, escapes through the clearance between the pump shaft 2 and the wall 3 of the pump casing and through the clearance between the same shaft and the inner wall 4*d* of drum 4 and reaches space 23 and the space between the inner wall 1*d* of casing 1 and the inner wall 4*d* of drum 4; however it cannot escape therefrom due to the presence of sealing fluid within the lower portion 4*g* of space 23 which is defined by conical fin 9' and wall 4*d* and within the space defined by wall 1*d* and wall 4*d*.

b. The pump stationary and drum 4 is rotating. Motor 12, 13 rotates drum 4 whereby the fluid within drum 4 and the fluid within casing 1 are centrifuged, the first one by friction between the fluid in drum 4 and the wall thereof, the second one by friction between the fluid in chamber 1 and the outer surface of drum 4 plus the surface of fins 6,5'. By opening valve 22 sealing fluid is first admitted to reservoir 14 and then into drum 4 through pipe 16; however the thickness of the centrifuged fluid layer against wall 4*c* cannot increase beyond the limit as set up by holes 19; any fluid exceeding this limit is discharged into casing 1 through holes 19. Here again a limit to the thickness of the centrifuged fluid layer is set up by the open end of pipe 17. Any fluid exceeding this limit is returned back to reservoir 14 through pipe 17.

c. Both the pump and the drum 4 are rotating. This case is similar to case (b); however the centrifuged fluid force on the fluid within drum 4 is not hindered but enhanced by the action of rotating fins 9,9' which rotate in the same direction as drum 4.

What is claimed is:

1. A sealing device of the centrifugal multicellular type for preventing any leakage of fluid around a vertical rotatable shaft where it passes through a wall by which two spaces at different pressures are separated, which device comprises:

a first stationary annular chamber coaxial with said shaft, which chamber in vertical radial cross-section has the shape of a C with the C opening directed toward the shaft;

a second annular chamber within the first one and coaxial with said shaft which chamber has also the shape of a C in vertical radial cross section with the C opening directed toward said shaft the openings of the two chambers being made to coincide at least partially, said second chamber being surrounded by the first chamber and rot-atably mounted with respect thereto and coupled to a motor for being rotated thereby;

a hub tightly mounted on a shaft and provided with a series of circular fins vertically spaced which project outward from the shaft and pass through said two corresponding openings of said chambers into the inside of the said second chamber to nearly touch the wall thereof opposite to the chamber opening; said second chamber being provided on its surface facing outward with respect to said shaft with a series of vertically spaced circular fins which project outwards to nearly touch the inner surface of the outer wall of the first chamber; said chambers being partially filled with sealing fluid; one of the two spaces which are separated by said wall through which said shaft passes being open into the space underlying the lowest fin in both chambers while the other space communicates with the space within both said chambers above the highest of the respective fins.

2. A sealing device of the centrifugal multicellular type for preventing any leakage of fluid around a vertical rotatable shaft where it passes through a wall by which an upper space at lower pressure is separated from a lower space of higher pressure which device comprises:

a stationary annular chamber coaxial with said shaft and having cylindrical vertical walls and horizontal top and bottom walls;

an annular drum with cylindrical vertical walls and horizontal top and bottom walls the inner diameter of said drum being greater than said chamber inner diameter and the outer diameter being smaller than said chamber outer diameter; said drum being enclosed within said casing and coaxial therewith; which drum on its outer vertical surface is provided with a series of vertically spaced circular fins which project outwards to nearly touch the vertical outer wall of said chamber; said drum being rotatably mounted with respect to said shaft and said chamber and coupled with a motor for being rotated thereby;

a hub tightly mounted around said shaft and provided at its outer surface with a series of vertically spaced circular fins which project into said drum to nearly touch the outer vertical wall thereof, a circular horizontal window being provided through said casing and through said drum at a distance from the respective bottoms for permitting said fins to enter said drum; said fins of each series being all flat and horizontal except for the lowest one which is bent downward from said drum and said hub to form a downwardly open conical bell; the lowest one of said spaces to be sealed one from the other being in communication with the spaces in said drum and in said chamber underlying the lowest fin respectively while the upper space is made to communicate with the spaces in said drum and chamber overlying the highest fin respectively said chamber and drum being partially filled with sealing fluid.

3. A sealing device as per claim **2** wherein the motor which rotates said drum comprises an annular electric rotor attached to said drum which rotor is mounted around said shaft by means of roller bearings and an annular stator around said rotor which stator is mounted within a bell-shaped housing mounted on top of said chamber and provided with a central bore for said shaft; a further roller bearing coplanar with the first one being inserted between an annular extension of said stator and a circular rib integral with said bell-shaped housing; said rotor being connected to said drum by means of a cylindrical sleeve coaxial with said shaft which sleeve extends downwardly from said stator into said chamber through an annular opening of which the top wall of the chamber is provided; two roller bearings being inserted between said sleeve and said shaft.

4. A sealing device as described in claim **2** wherein the top wall of said drum is provided with a first range of through holes spaced along a circle coaxial with said shaft for inletting the sealing fluid thereinto from a reservoir through a first pipe the outlet of which is at a distance from said shaft less than said range of holes and less than a circular baffle of which said top wall is provided for preventing said fluid from being centrifuged away from said holes; with a second range of through holes regularly spaced along a circle coaxial with said shaft at a distance therefrom greater than said first range and said baffle; with a second pipe which connects the inside of said chamber at a position thereof closer to said shaft than the outer wall of said chamber with the top of the sealing fluid reservoir, whereby the sealing fluid introduced into the drum is centrifuged in operation against the outer wall of the drum to form a layer of which the radial thickness is equal to the distance between the latter wall and said row of holes while the fluid exceeding said layer is discharged through the latter holes into said chamber wherein is centrifuged — when the said drum rotates — against the outer wall of said chamber to form a layer of which the radial thickness is equal to the distance between the last recited wall and the open end of said second pipe while the fluid exceeding said layer is returned to said reservoir through said second pipe.

5. A sealing device as described in claim **4** which device is further provided with a filling system of the sealing fluid reservoir for keeping it at a constant level which system comprises a sealed receptacle provided with a filling valve on top of it and with a pipe at its bottom which terminates with an open end into said reservoir at the same level to be attained by the sealing fluid therein; which pipe is provided with a valve to be closed when said receptacle is to be refilled through said filling valve.

6. In a motor driven centrifugal pump provided with an impeller and a shaft for connecting said impeller to said motor a sealing device as claimed in claim **1** provided about said shaft.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 3,910,585

DATED : October 7, 1975

INVENTOR(S) : Giuseppe TABACCHI

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

[73] Assignee, second line, cancel "& Chen" and insert -- -CNEN --.

Signed and Sealed this

twenty-seventh Day of April 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

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Commissioner of Patents and Trademarks