United States Patent

Bass

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[54] OSCILLATING SPINDLE SEAL

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[21] Appl. No.: **24,188**

[52] **U.S. Cl.**.....**277/174**, 277/212 F

[51] **Int. Cl.**.....**F16j 15/00**

[58] **Field of Search**.....277/174, 97, 177, 176, 212 F, 277/58, 173

[56] **References Cited**

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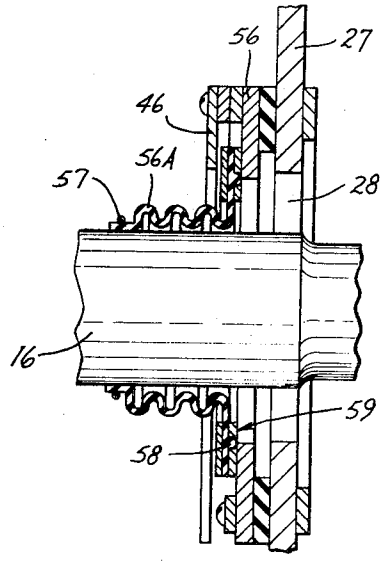
[57] **ABSTRACT**

A sealing assembly, particularly adapted for use with an electrochemical grinding machine, for permitting relative radial oscillation and/or axial reciprocation between a spindle housing and a hood. The hood is provided with an elongated opening therein through which passes the spindle housing, the elongated opening permitting the spindle housing to radially oscillate. The seal assembly comprises a stationary seal means which is in sealing engagement with the hood and surrounds the opening therein. A movable seal means is in surrounding sealing engagement with the spindle housing. Said stationary and movable seal means are slidingly and sealingly interconnected.

11 Claims, 6 Drawing Figures



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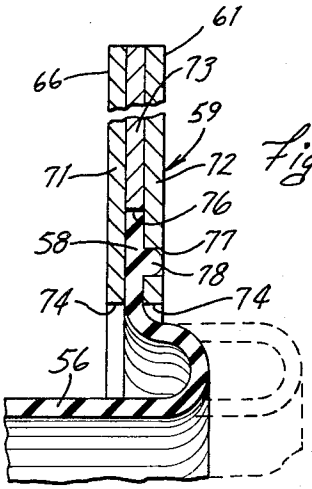

Fig. 5

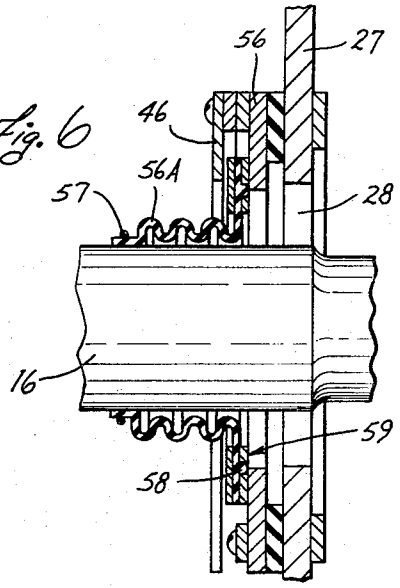

Fig. 6

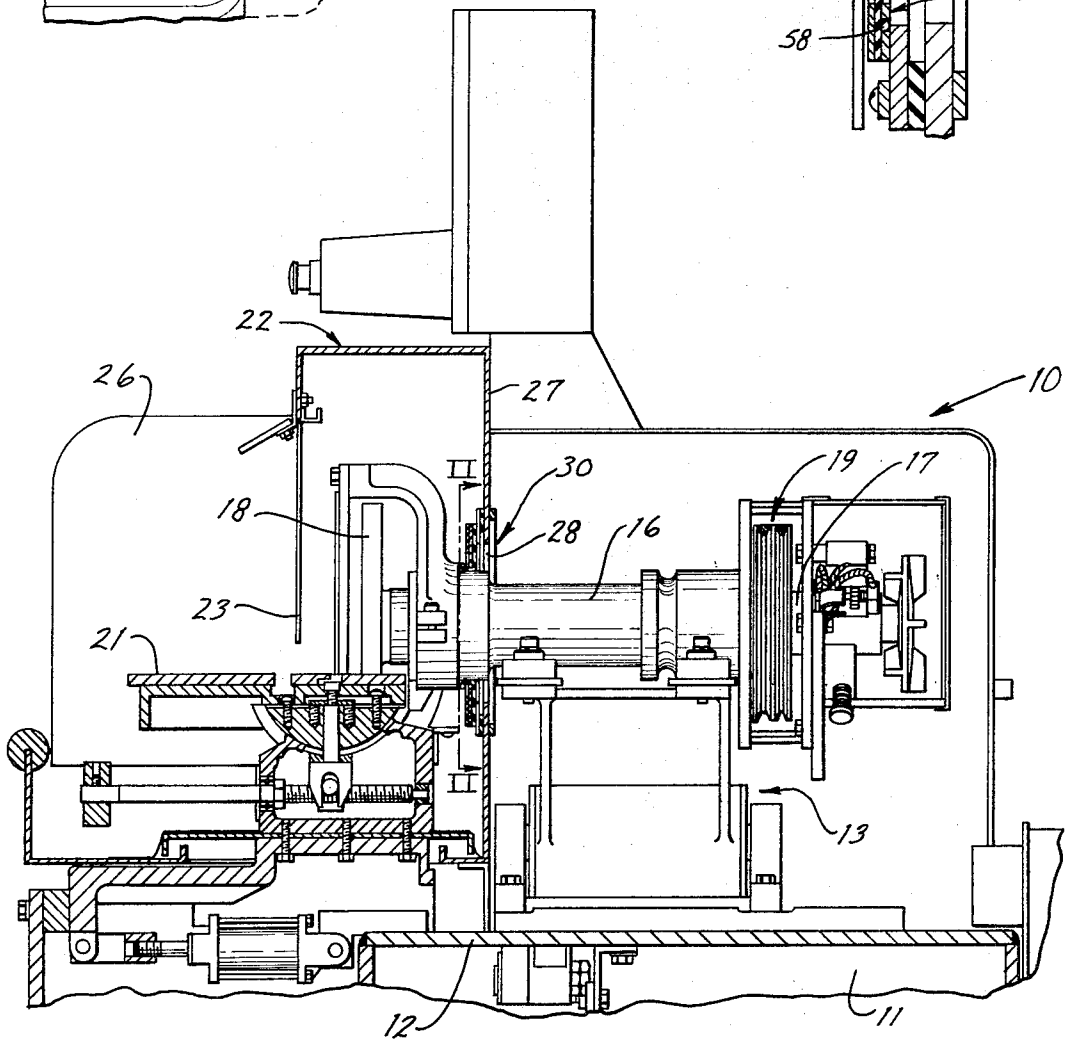

Fig. 1

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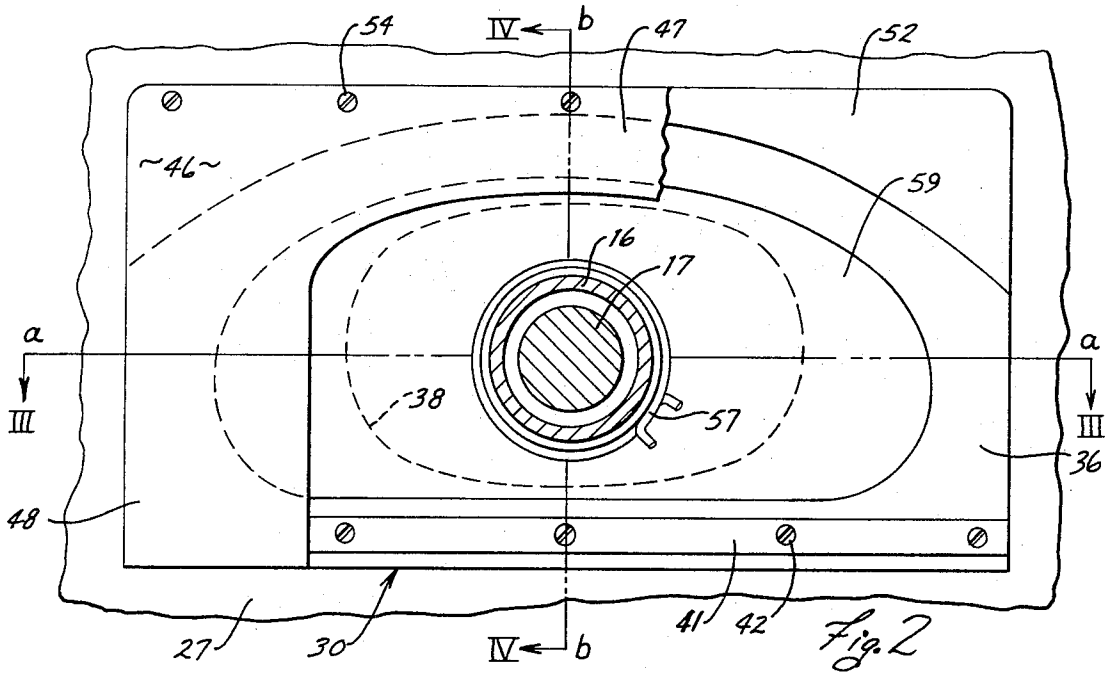

Fig. 2

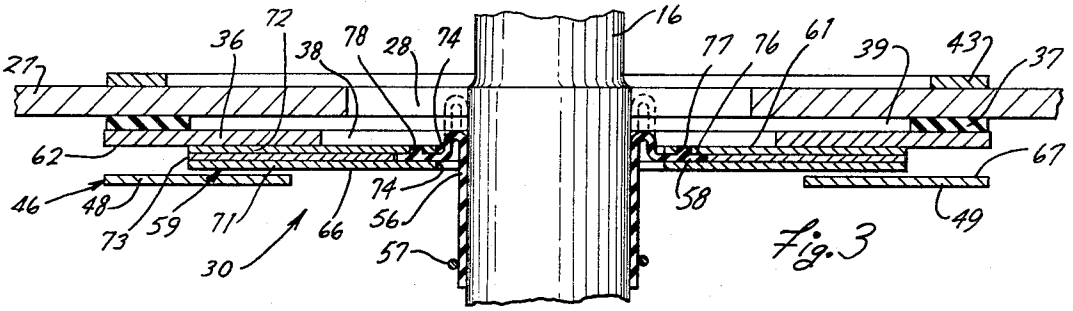

Fig. 3

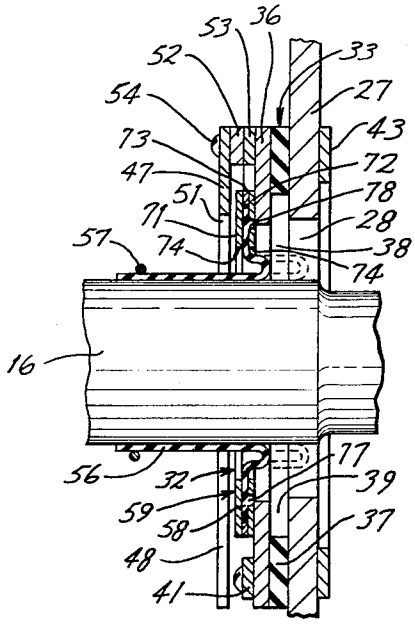

Fig. 4

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OSCILLATING SPINDLE SEAL

1. Field of the Invention

This invention relates to a new and improved seal assembly and, in particular, to a seal assembly adapted for use on an electrochemical grinding machine for permitting relative radial oscillation and/or axial reciprocation between a spindle housing and a hood. The seal assembly includes a first seal means fixedly secured to the hood in surrounding relationship to the spindle housing and a second seal means fixedly secured to the spindle housing. The first seal means surrounds the second seal means while permitting the latter to slide laterally within the first seal means.

2. Description of the Prior Art

In electrochemical grinding machines, such as that described in the U.S. patent to Keeleric, U.S. Pat. No. 2,826,540, the grinding operation is performed by supplying an electrolytic fluid (electrolyte) at the interface between the grinding tool and the workpiece. The electrolyte permits electrical current to be transferred between the grinding wheel and the workpiece whereby particles are removed from the workpiece. However, most electrolytes are highly corrosive and thus it becomes necessary to isolate or substantially enclose the grinding area and the electrolytic fluid to prevent it from contaminating and corroding the associated grinding machine structure. In particular, this fluid must not be allowed to come into contact with the bearings or other elements associated with the grinding wheel drive mechanisms since its highly corrosive nature seriously deteriorates and shortens the life of bearings and associated moving parts.

The problem of isolating the grinding area is further complicated in electrochemical grinding machines wherein the spindle assembly is subject to oscillation in a direction substantially transverse to the spindle axis during the grinding operation. To permit such operation to occur, the frame structure, such as a hood, surrounding the grinding wheel and the grinding area must be provided with a substantially large elongated spindle opening to permit such oscillation to take place. Since the spindle oscillatory movement is of appreciable magnitude, the elongated opening must be of sufficient size that a seal means must be provided between the hood and the spindle housing to prevent the passage of electrolyte through said opening whereby the same could come into contact with the remainder of the grinding machine and contaminate the same.

The problem of isolating the grinding area is still further complicated by the fact that the hood and table assembly in many electrochemical grinding machines is mounted for movement or reciprocation in a direction parallel to the spindle axis. This combined spindle radial oscillation and permissible hood axial displacement thus makes isolation of the grinding area and confinement of the electrolytic fluid extremely difficult.

Various types of sealing means have been tried in an attempt to find an effective seal between the frame structure, particularly the hood, and the oscillating spindle housing. Attempts have been made to utilize flexible diaphragms or boots of nonmetallic materials, such as both synthetic and natural rubber, with the inner and outer edges being fixedly connected to and in sealing engagement with the spindle housing and the frame structure, respectively. However, the continual and substantial flexing of the diaphragm due to the large relative movement between the spindle and the frame structure, or hood, results in rapid deterioration and breakdown of the diaphragm.

Thus, the use of flexible diaphragms or boots as a seal for the oscillating spindle, wherein the seal member is fixedly connected at opposite ends thereof to the frame structure, or hood, and the spindle housing, has proven unsuccessful for the reasons above stated. However, since nothing better was available, the situation has been tolerated and commercial machines have been constructed with flexible seals.

SUMMARY OF THE INVENTION

This invention provides a sealing device between a spindle housing and an associated member, as a hood, in an electrochemical grinding machine, wherein the spindle projects through an opening in such hood and both radially oscillating and axially reciprocating relative motion exists between said spindle and said hood.

The seal assembly is positioned between the spindle housing and the hood structure to prevent corrosive electrolytic fluid from passing through the opening. Specifically, in one embodiment the seal comprises a first seal plate in sealing engagement with the hood and surrounding the opening therein, the seal plate additionally having an opening therein aligned with and of substantially the same size as the hood opening. A sealing panel surrounds and is secured to the spindle housing in sealing engagement therewith by a rolling boot or sleeve to permit relative axial movement therebetween, said panel being larger than the opening in said first seal plate and further being in slideable sealing engagement therewith whereby said opening is substantially closed at all times. A second substantially U-shaped seal plate is fixedly connected to the first seal plate and is laterally spaced therefrom by means of an intermediate spacer member, the sealing panel mounted on said spindle being positioned in said space between the first and second seal plates. The edges of said U-shaped plate extend inwardly and radially overlap the edges of the seal panel to prevent electrolytic fluid from splashing around the edges of the panel into the region of the sliding seal between the panel and the first seal plate. The sealing plates and the sealing panel are preferably formed of materials having high resistivity to the corrosive electrolytes.

Accordingly, it is an object of the present invention to provide:

1. A new and improved seal arrangement for use with a movable spindle assembly.

2. A seal assembly, as aforesaid, particularly adapted for use with an electrochemical grinding machine.

3. A seal arrangement, as aforesaid, for use between a frame structure, such as a hood, and a spindle passing through an elongated opening in said hood wherein relative movement occurs between said spindle and said hood in either or both of radial and axial directions.

4. A seal arrangement, as aforesaid, wherein a first seal plate surrounds the spindle opening and is in sealing engagement with the hood, a second seal plate is fixedly secured to and in sealing engagement with the spindle housing, the second seal plate being slideably engaged with said first seal plate and completely covering the spindle opening formed therein while permitting said relative motion to occur.

5. A seal arrangement, as aforesaid, further including a third seal plate fixedly secured to said first seal plate and laterally spaced therefrom to define a clearance chamber or space between said first and third seal plates, said second seal plate being positioned within said space.

6. A seal arrangement, as aforesaid, further including a spacer member interconnecting the upper edges of said first and third seal plates to prevent electrolytic fluid from entering said space.

7. A seal arrangement, as aforesaid, wherein said third seal plate is of a generally U-shaped construction with the edges thereof extending radially inwardly so as to radially overlap the outer edges of said second seal plate and thus prevent fluid from splashing axially around the edges of said second seal plate into the seal region between said first and second seal plates.

8. A seal arrangement, as aforesaid, which permits relative axial reciprocation between the hood and the spindle housing by means of a rolling resilient sleeve.

9. A seal arrangement, as aforesaid, which is effective to prevent the flow of fluid therethrough and further possesses a long seal life even when used in combination with a corrosive fluid or environment.

10. A seal arrangement, as aforesaid, which is economical to manufacture, install and maintain.

Other objects and purposes of the invention will be apparent to persons acquainted with apparatus of this general type upon reading the specification and inspecting the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a fragmentary side elevational view, partially in cross section, of the machine on which the present invention is preferably used.

FIG. 2 is a front view of the seal arrangement according to the present invention taken on the line II—II of FIG. 1, a portion of the front sealing plate being broken away for illustrative purposes.

FIG. 3 is a sectional view taken along the line III—III of FIG. 2.

FIG. 4 is a sectional view taken on the line IV—IV of FIG. 2.

FIG. 5 is an enlarged fragmentary sectional view illustrating the manner in which the resilient sleeve is secured to the seal panel.

FIG. 6 illustrates a modification of the present invention.

Certain terminology will be used in the following description for reference only and will not be limiting. The words "upwardly," "downwardly," "rightwardly," and "leftwardly" will designate directions in the drawings to which reference is made. The words "forwardly" and "rearwardly" will refer to positions relative to the grinding area and the enclosed region surrounding the grinding area and containing the electrolytic fluid therein, "forwardly" being the position nearest or facing said grinding area. The words "inwardly" and "outwardly" will refer to directions toward and away from, respectively, the geometric center of the device and designated parts thereof. Said terminology will include the words above specifically mentioned, derivatives thereof, and words of similar import.

DETAILED DESCRIPTION

In general, the seal apparatus of the present invention is normally, though not necessarily, embodied in an electrolytic grinding machine having a radially reciprocating or oscillating grinding wheel of the type set forth in U.S. Pat. Nos. 2,922,258, 2,988,857 or 3,450,618. Specifically, FIG. 1 illustrates a portion of the grinding machine into which the present invention is preferably incorporated, with only those portions of the machine being illustrated which are directly related or in close proximity to the specific seal arrangement of the present invention.

In particular, the tool grinding machine **10** is provided with a support frame **11** having a top plate **12** upon which is supported the pivot structure **13**, which structure pivotally and rotatably supports the spindle **17**. The spindle **17** is rotatably mounted in and supported by a tubular spindle housing **16** which is mounted on the pivot structure **13**. A grinding wheel **18** is mounted on the front end of the spindle **17**, the grinding wheel and the spindle assembly being radially oscillated in a substantially horizontal direction along the axis *a—a* (FIG. 2) by the pivot structure **13**. A pulley assembly **19** is mounted on the opposite end of the spindle **17** and is driven by a motor means (not shown) whereby the spindle and its associated grinding wheel is also rotated. The pivot structure **13**, the grinding wheel **18** and the drive mechanism within the frame **11** for effecting controlled oscillation and rotation of the grinding wheel **18** through the pivot structure **13** are completely disclosed and discussed in U.S. Pat. No. 2,922,258. Thus, further detailed description of these elements of the grinding machine **10** is not believed necessary.

The grinding machine is further provided with a worktable **21** which is positioned adjacent to the grinding wheel **18** whereby a workpiece is positioned on the worktable in close proximity to the grinding wheel and electrolytic fluid is then permitted to flow into the grinding or interface region between the grinding wheel and the workpiece. Since the electrolytic fluid is highly corrosive, suitable frame structure, as a hood **22**, is provided on the machine in surrounding relationship to the grinding wheel **18** so as to localize or retain the corrosive electrolyte in the immediate vicinity of the grinding wheel. The worktable **21** and hood **22** are often mounted for limited linear displacement or reciprocation in a direction parallel to the axis of spindle **17**.

The front surface of the hood **22** is provided with an opening **23** therein directly above the worktable **21** so as to permit access to the grinding wheel. However, the hood **22** is provided with side shields **26** connected thereto and positioned on opposite sides on the worktable **21** so as to retain the electrolytic fluid in the grinding region. The back panel **27** of the hood **22** is provided with a spindle opening **28** therein to permit the spindle housing member **16** to pass therethrough. A spindle seal assembly **30**, which seal assembly represents the present invention, interconnects the back panel **27** and the spindle housing **16** to prevent the leakage of electrolytic fluid through the opening **28** whereby the fluid would be able to come into contact with and contaminate the spindle drive mechanisms and other related components.

The spindle seal assembly **30** of the present invention is illustrated in detail in FIGS. **2–4** and comprises a movable seal means indicated generally at **32** (FIG. **4**) which is fixed to the spindle housing **16** and a stationary or fixed seal means indicated generally at **33** fixed to the rear panel **27** of the hood. The movable seal means **32** is positioned within and in sliding engagement with the stationary seal means **33** to prevent the electrolytic fluid within the hood **22** from escaping through the opening **28**.

More specifically, the fixed seal means **33** comprises a first generally rectangular seal member or plate **36** in surrounding relationship to the opening **28** and in sealing engagement with the back panel **27** by means of a gasket **37** positioned therebetween. The first seal plate **36** is provided with an opening **38** therein which is aligned with and of substantially the same size as the opening **28**. The openings **28** and **38** are, due to the reciprocal movement of the spindle approximately along the axis *a—a*, preferably elongated in one direction so as to approach a generally elliptical shape as illustrated in FIG. **2**. However, the openings can be of any desired shape. The gasket **37** is also provided with a central opening **39** therein so as to permit direct communication between the openings **28** and **38**, respectively.

A clamping strip **41** is positioned adjacent the front side of the first seal plate **36** along the lower edge thereof. A similar thin clamping ring **43** is positioned on the rear side of the back panel **27** in surrounding relationship to the spindle housing **16**. A plurality of screws **42** pass through the clamping strip **41**, the lower edge of the first seal plate **36**, the gasket **37** and the back panel **27** and are threadedly received into the clamping ring **43**, whereby the gasket **37** is tightly compressed between the first seal plate **36** and the back panel **27** so as to prevent leakage therebetween.

The stationary seal means **33** further comprises a second seal member or plate **46** which is fixedly secured to but laterally spaced from the first seal plate **36**. As shown in FIG. **2**, the second seal plate **46** is preferably U-shaped and has a base portion **47** positioned along the upper edge thereof with a pair of parallel legs **48, 49** integrally connected thereto and extending downwardly on opposite sides of the spindle housing **16**. The parallel legs **48, 49** thus define an opening **51** therebetween in which is received the spindle housing **16**. A pair of spacer strips **52, 53** are positioned between the base portion **47** and the upper edge of the first seal plate **36** with the upper edge of the stationary seal means **33** being secured together by means of a plurality of screws **54** which pass through the second seal plate **46**, the spacer strips **52, 53**, the first seal plate **36**, the gasket **37** and the back panel **27** and are threadedly received into the clamping ring **43**. The screws **54** thus maintain the upper edge of the first seal plate in tight seal-

ing engagement with the back panel **27** and further maintain the first and second seal plates **36** and **46**, respectively, in tight clamping engagement so as to prevent any leakage of fluid therebetween.

As illustrated in FIG. **4**, the spacers **52, 53** axially separate the first and second seal plates **36** and **46**, respectively, so as to define a clearance space or channel therebetween into which is received the movable seal means **32**. More specifically, the movable seal means **32** comprises a flexible nonmetallic boot, preferably of rubber, which has an elongated tubular portion **56** which surrounds the spindle housing **16** and is held in tight sealing engagement therewith by means of a retainer or snap ring **57**. The leading or forward edge of the tubular portion is positioned so as to face inwardly toward the grinding area to prevent fluid from travelling axially along the spindle housing **16** (rightwardly in FIG. **4**) and escaping through the opening **28**.

The flexible boot is further provided with a flange portion **58** which is integrally connected to the tubular portion **56** and extends substantially radially outward therefrom. The flange portion **58** is fixedly connected to a movable panel **59**, which panel **59** is preferably of a shape similar to the opening **38** and is, in this example, of a generally elongated elliptical shape. However, as illustrated in FIGS. **3** and **4**, the panel **59** is larger than the opening **38** and extends radially beyond the opening in all directions so as to substantially radially overlap the seal plate **36**.

The movable panel **59** is, as illustrated in FIG. **5**, preferably of a laminated construction and includes front and rear plates **71** and **72** having an intermediate spacer plate **73** therebetween. The front and rear plates **71** and **72** each have coaxially aligned openings **74** therein, which openings **74** are slightly larger than the external diameter of the spindle housing **16** to permit the tubular boot portion **56** to freely pass therethrough. The intermediate spacer plate **73** is provided with a larger opening **76** for permitting the resilient flange **58** to be positioned therein, whereby the resilient flange **58** is thus clampingly held between the front and rear plates **71** and **72**. The flange **58** is securely held between the plates by means of a plurality of circumferentially spaced projections **78**, which projections extend through suitable openings **77** formed in the rear plate **72**. The projections **78** are preferably integrally molded on the flange **58** during fabrication of the resilient boot structure.

The thickness of the movable panel **59** is sightly less than the clearance space which exists between the first and second seal plates **36** and **46**, respectively. Thus, the panel **59** fits and is movable within the clearance space. The spacer strips **52, 53** are preferably formed with a concave configuration on the lower edge thereof (FIG. **2**) since such a configuration permits the movable seal means **32** to oscillate substantially along the axis *a—a* while still providing the necessary support and rigidity for interconnecting the first and second seal plates **36** and **46**, respectively. Further, the concave configuration permits the opposite ends of the spacer strips to extend downwardly along the vertical edges of the seal plates so as to prevent electrolytic fluid from splashing between the seal plates **36, 46** whereby the fluid could then run or drain downwardly between the seal plate **36** and the rear plate **72**.

With the seal arrangement assembled substantially as illustrated in FIGS. **3** and **4**, the rear sealing face **61** of the panel **59** is preferably positioned on the spindle housing **16** so as to be in sliding contact with the front sealing face **62** of the first seal plate **36**. Further, the front surface **66** of the panel **59** is generally slightly spaced from the rear surface **67** of the second seal plate **46** so as to provide a small clearance space therebetween.

OPERATION

Although the operation of the device embodying the invention has been indicated above, said operation will be described in detail hereinbelow to assure a complete understanding of the invention.

During operation of the grinding machine, the spindle housing **16** is subjected to oscillatory movement in a substantially horizontal direction along the axis *a—a*, with the housing also being simultaneously subjected to a small vertical component of motion substantially parallel to the axis *b—b* During this oscillatory movement, the movable panel **59** fixed to the spindle housing **16** remains in sliding engagement with the front face **62** of the first seal plate **36**. Due to the radial overlap which exists between the panel **59** and the first seal plate **36**, the amount of which depends upon the magnitude of the oscillatory movement, the opening **38** remains completely covered by the movable panel **59** at all times during operation of the machine.

The seal assembly **30** is effective in preventing the electrolyte from escaping through the opening **28** into the remainder of the machine. For example, any fluid which splashes against the back panel **27** is prevented from escaping through the opening **28** by means of the gasket **37**. Further, fluid which splashes through the opening **51** of the second seal plate **46** comes into contact with the front surface **66** of the panel **59** whereby the fluid thus runs down the face of the panel and drips back into the interior of the hood. While a small amount of fluid may be successful in travelling around the edges of the panel **59**, the majority of this fluid will be prevented from reaching the opening **28** due to the sliding sealing engagement which exists between the front face **62** of the first seal member **36** and the rear face **61** of the panel **59**. Further, the spacer strips **52, 53** which extend across the top of the upper sides of the seal assembly prevent fluid from reaching the sliding seal region between the first seal plate **36** and the rear face **61** of the panel **59**. Still further, while some fluid may run along the periphery of the spindle housing **16**, this fluid will be effectively stopped from passing through the opening **28** by means of the resilient tubular portion **56** which is maintained in snug sealing engagement at its outer end with the periphery of the spindle housing by means of the retainer ring **57**.

In situations where the position of hood **22** is axially adjusted or displaced relative to the spindle housing **16**, the axial displacement is accommodated by a rolling action of the tubular boot portion **56**, which boot portion axially rolls substantially as illustrated by dotted lines in FIGS. **3** and **4** so as to permit limited axial movement of the panel **59** relative to the spindle housing **16**, thereby maintaining panel **59** in contact with seal plate **36**.

FIG. **6** illustrates therein a modification of the invention wherein the rolling cylindrical boot portion **56** is replaced by a bellows-type boot portion **56A** for permitting the panel **59** to have limited axial movement relative to the spindle housing **16**. As in the above-described embodiment, the bellows portion **56A** is maintained in snug sealing engagement with the spindle housing **16** by means of a retainer ring **57**, the other end of the resilient bellows **56A** having an annular flange **58** thereon fixedly secured to and clamped within the laminated movable panel **59**. The operation of this embodiment of the invention is the same as described above except that relative axial movement between the spindle housing **16** and panel **59** is accommodated due to collapsing and/or expanding of the bellows portion **56A**.

Thus, the above seal arrangements are very effective in preventing leakage of electrolytic fluid from the hood region. This effectiveness is in part due to the fact that the major seal components between the hood and the movable spindle assembly are substantially stationary relative to their respective mounting structures. Further, due to the design of the seal assembly, the sliding seal between seal plate **36** and panel **59** is enclosed and protected by the other seal assembly components such that only a small quantity of fluid is permitted to reach the region of this sliding seal and thus leakage through the seal assembly is effectively prevented.

Further it will be recognized that in the seal assembly described above the relative axial movement between the spindle housing and the panel **59** is easily absorbed by the rolling of the boot and that such flexing thereof will not substantially reduce the overall life of the seal assembly.

Instead, since the flexible boot comprising the portions **56** (or **56A**) and **58** is affixed solely to the spindle housing **16** and moves therewith, it is not subjected to excessive relative movement or flexing and thus possesses a long seal life.

In the above-described seal assembly, most of the components thereof are preferably of a nonmetallic material, such as plastic, in order to resist the highly corrosive electrolytic fluid. In particular, the gasket **37** and the flexible boot **56, 58** are preferably of a seal material, such as rubber or the like. On the other hand, the first seal plate **36** is preferably of a synthetic material having a low coefficient of friction, such as Teflon, in order to permit a free-sliding engagement between the front surface **62** thereof and the panel **59**. However, the second seal plate **46**, the spacer strips **52, 53**, and the panel member **59** can be effectively formed from a phenolic laminated plastic, an epoxy resin or any other material which resists deterioration when subjected to the corrosive electrolytic liquid. Alternately, the plates **71, 72** and **73** comprising the movable panel **59** can be constructed from stainless steel.

While the seal assembly as described above has been used in combination with a spindle which moves radially relative to a radially stationary frame or hood structure and the hood moves axially relative to an axially stationary spindle, it will be obvious from the foregoing that the above-described seal assembly would also be very effective if these relative motions are reversed.

Further, while the openings utilized in the present seal assembly as discussed above have been generally of elongated elliptical shape, it will be appreciated that the openings can be of any desired shape so as to accommodate whatever relative motion is desired, the only essential requirement being that the plate members forming the sliding seal overlap to a sufficient extent so as to accommodate the desired relative movement without uncovering the opening therein.

Still further, while the above seal assembly has been described as being well suited for use with corrosive fluids, it is also usable with noncorrosive fluids, in which case the components of the seal assembly can be fabricated from any materials desired, the seal being well adapted for use on any machine or apparatus wherein a large amount of relative movement occurs between a spindle and associated frame means.

Although a particular preferred embodiment of the invention has been disclosed above for illustrative purposes, it will be understood that the variations or modifications thereof which lie within the scope of the invention are fully contemplated.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A seal assembly for a shaft passing through an opening in a frame, said shaft and said frame being subjected to relative oscillation therebetween in a direction substantially transverse to the shaft axis, said seal assembly comprising:

first seal means fixed to said frame in surrounding relationship to said opening and second seal means mounted on said shaft in surrounding relationship thereto, said second seal means being positioned sealingly adjacent said first seal means for relative movement therebetween;

said first seal means comprising means substantially surrounding said frame opening and having an opening therein which is substantially aligned with the frame opening and which is large enough to permit both relative radial and axial movement between said shaft and said frame;

said second seal means including plate-like means surrounding and substantially transverse to said shaft, said plate-like means being larger than the opening in said first seal means and being disposed in slidable sealing engagement with said first seal means; and

said second seal means further including resilient sleeve means surrounding said shaft and connected between said plate-like means and said shaft for permitting limited axial movement therebetween, one end of said resilient sleeve means being fixedly and sealingly secured to said shaft and the other end of said resilient sleeve means being fixedly and sealingly secured to said plate-like means.

2. A seal assembly for a spindle housing wherein said spindle housing passes through an opening in a frame member, said spindle housing and said frame member being subjected to relative oscillation therebetween in a direction substantially transverse of the spindle axis, said seal assembly comprising:

first seal means fixed to said frame member in surrounding relationship to said opening and second seal means mounted on said spindle housing in surrounding relationship thereto, said second seal means being positioned sealingly adjacent said first seal means for relative movement therebetween;

said first seal means comprising plate means surrounding said frame member and having a central opening therein substantially aligned with said frame opening, said central opening being large enough to permit relative radial movement between said spindle housing and said frame;

said second seal means including panel means surrounding and substantially transverse to said spindle housing, said panel means being larger than said central opening and being disposed in slideable sealing engagement with said plate means; and

said second seal means further including resilient sleeve means surrounding said spindle housing and connected between said panel means and said spindle housing, one end of said resilient sleeve means being fixedly and sealingly secured to said spindle housing and the other end of said resilient sleeve means being fixedly and sealing secured to said panel means.

3. A seal assembly according to claim **2**, wherein said plate means includes a first seal member completely surrounding said frame opening and having a central opening therein substantially aligned with said frame opening and large enough to permit relative radial movement to occur between said spindle housing and said frame;

said plate means further including a second seal member fixedly connected to said first seal member in parallel relation therewith and spaced therefrom to define a clearance space therebetween, said first and second seal members being constructed of a plastic material;

said plate means further including spacer plate means fixedly connected between and interconnecting said first and second seal members to define said clearance space therebetween, said spacer plate means being in tight sealing engagement with said first and second seal members, respectively; and

the outer edges of said panel means extending into the clearance space defined between said first and second seal members to permit relative sliding movement between said panel means and said first and second seal members.

4. A seal assembly for a spindle housing wherein said spindle housing passes through an opening in a frame member, said spindle housing and said frame member being subjected to relative oscillation therebetween in a direction substantially transverse to the spindle axis, said seal assembly comprising;

first seal means fixed to said frame member in surrounding relationship to said opening and second seal means mounted on said spindle housing in surrounding relationship thereto, said second seal means being positioned sealingly adjacent said first seal means for relative movement therebetween;

said first seal means comprising plate means surrounding said frame opening and having a central opening therein substantially aligned with said frame opening, said central opening being large enough to permit both relative radial and axial movement between said spindle housing and said frame member;

said second seal means including panel means surrounding and substantially transverse to said spindle housing, said

panel means being larger than said central opening and being disposed in slideable sealing engagement with said plate means;

said second seal means further including resilient sleeve means surrounding said spindle housing and connected between and in sealing engagement with said panel means and said spindle housing for permitting limited relative axial movement between said spindle housing and said panel means, one end of said resilient sleeve means being fixedly and sealingly secured to said spindle housing and the other end of said resilient sleeve means being fixedly and sealingly secured to said panel means.

5. A seal assembly according to claim 4, wherein:

said first seal means further includes a nonmetallic resilient gasket surrounding said frame opening and positioned between and in tight sealing engagement with said plate means and said frame member.

6. A seal assembly according to claim 4, wherein:

said plate means includes a first seal member completely surrounding said frame opening and having a central opening therein substantially aligned with said frame opening, said central opening being large enough to permit relative movement to occur;

said plate means further including a second seal member fixedly connected to said first seal member in parallel relation therewith and spaced therefrom so as to define a clearance space therebetween; and

said panel means being positioned in said clearance space between said first and second seal members so as to permit relative sliding movement to occur between said panel means and said first and second seal members.

7. A seal assembly according to claim 6, wherein:

said first seal means further includes spacer plate means fixedly positioned between and interconnecting said first and second seal members so as to define said clearance space therebetween, said spacer plate means being in tight sealing engagement with said first and second seal members, respectively.

8. A seal assembly according to claim 7, wherein:

said second seal member is of a generally U-shape having a base portion and a pair of parallel leg portions extending thereform;

said base portion being positioned above said spindle housing and fixedly connected to said spacer plate means;

said leg portions being integrally connected to said base portion and extending downwardly therefrom on opposite sides of said spindle housing; and

said base portion and said leg portions extending radially inwardly toward said spindle housing so as to radially overlap said panel means.

9. A seal assembly according to claim 8, wherein:

said first seal member and said second seal member are of a plastic material.

10. A seal assembly according to claim 4, wherein:

said panel means is of a laminated construction and includes a plurality of thin plate-like members fixedly connected together; and

said other end of said resilient sleeve means comprising an annular flange fixedly and clampingly disposed between a pair of said plate-like members.

11. A seal assembly according to claim 10, wherein:

said annular flange has a plurality of circumferentially spaced projections fixedly secured thereto; and

one of said plate-like members has a plurality of circumferentially spaced openings therein with the projections on said flange extending into said openings for fixedly securing said flange relative to said panel means.

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