

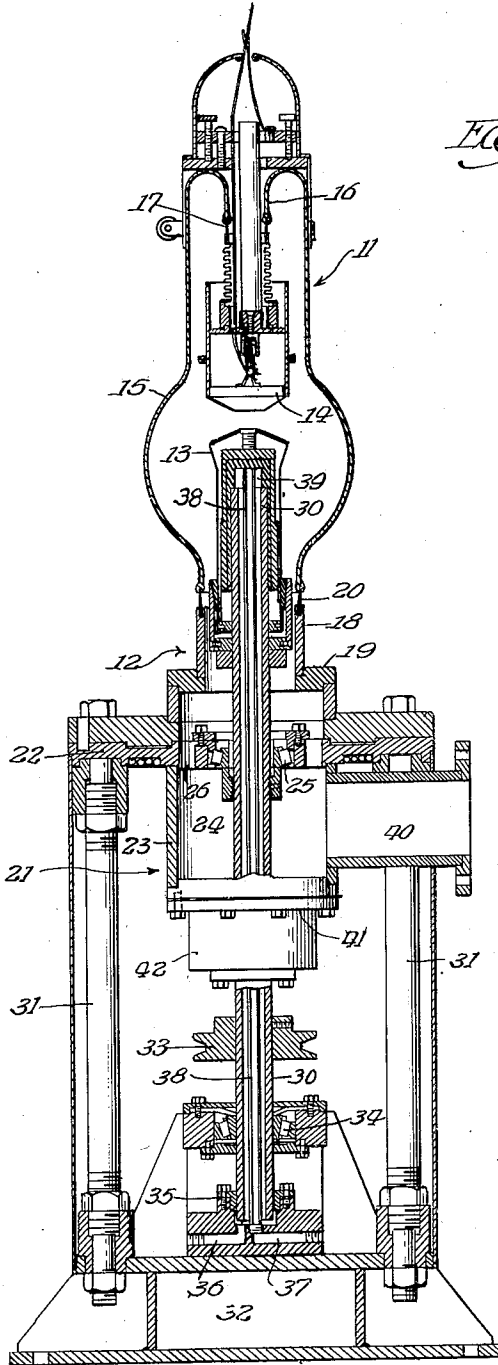
Feb. 14, 1950

J. J. VLACH  
ROTATING VACUUM SEAL

2,497,479

Filed June 7, 1946

2 Sheets-Sheet 1



*FIG. 1*

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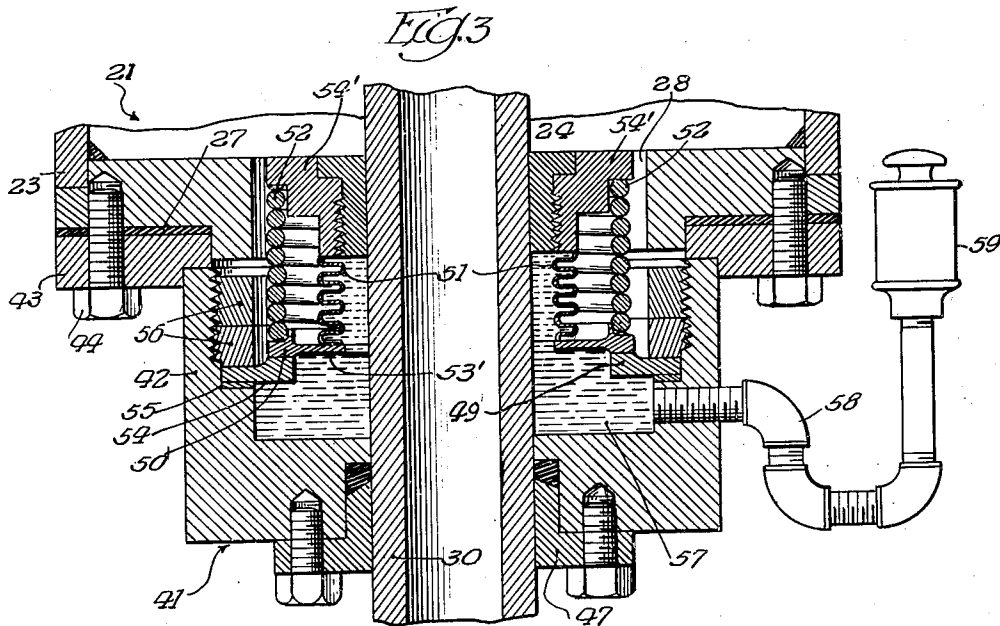
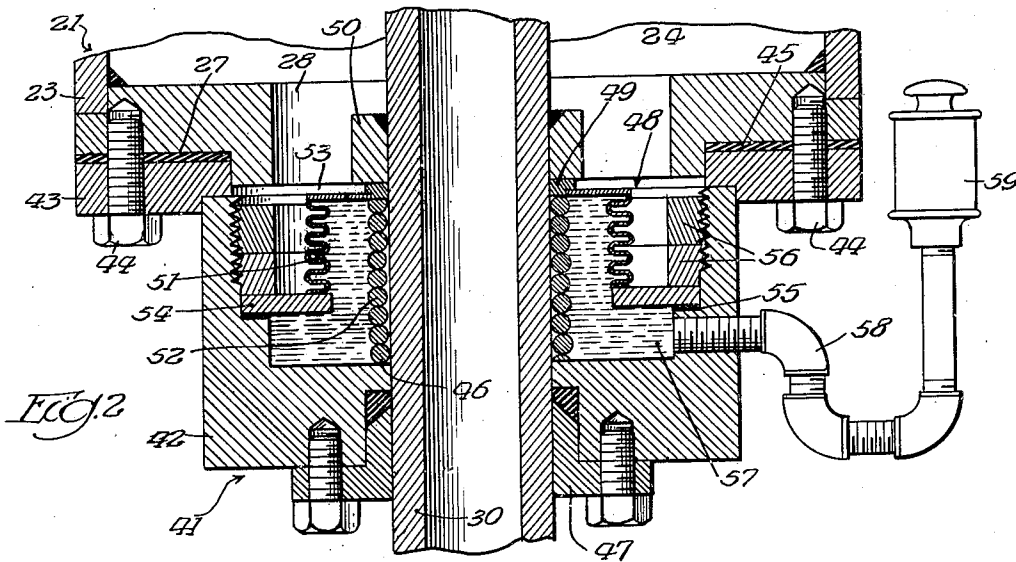
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# UNITED STATES PATENT OFFICE

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## ROTATING VACUUM SEAL

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10 Claims. (Cl. 250—148)

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The present invention relates in general to seals and sealing, and has more particular reference to the provision of means for sealing rotating, shaft-like members to prevent fluid leakage along the member through a wall or journal in which the shaft extends; the invention especially relating to the sealing of low pressure vessels, such as the envelopes of X-ray generators, particularly X-ray generators having rotating anodes driven by motive means disposed outwardly of the envelope, wherein the anode and motive means are drivingly connected by a shaft-like member extending through a wall portion of the envelope.

X-ray generators commonly comprise an electron emitting cathode, and a cooperative anode forming a target for receiving impingement of electrons emitted from the cathode, X-rays being generated by such electron impingement on the anode target. The anode and cathode are commonly enclosed within a sealed and exhausted envelope, whereby the anode and cathode elements may operate substantially in vacuo. In certain circumstances, particularly in heavy duty generators, it is desirable to utilize a rotating anode positioned to receive electrons, at any instant, upon a portion only of the anode target, said target being of annular configuration, whereby, when rotated, the target may be continuously moved to progressively shift the portions thereof under electron bombardment, and, thus, prevent any target area from becoming overheated, it being understood that electron bombardment results in the generation of excessive heat in the target element.

An important object of the present invention is to provide an improved X-ray generator having a rotating anode mounted within a sealed and evacuated envelope, together with facilities for driving the anode, from outwardly of the envelope, by shaft-like means drivingly connected with the anode and extending outwardly of the envelope through a novel and effective shaft seal forming a portion of the envelope.

Another important object is to provide improved means for mounting the anode for rotation within a sealed envelope, including an improved seal structure for vacuum sealing an envelope opening, through which an anode connected drive shaft extends.

Another important object is to provide an improved shaft seal structure, particularly for vacuum or low pressure vessels; a further object being to utilize a liquid sealing medium as a component part of the seal arrangement.

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Another important object is to provide a shaft seal embodying an expansible bellows element, carrying a seal ring adapted to form a ground joint with a cooperating seal seat, whereby said ring and seat may provide a vacuum seal when in relative rotation; a further object being to provide for the retention of a liquid sealing medium at, and on one side of, said ground joint; a further object being to utilize the expansible bellows as a means for retaining the liquid sealing medium at said ground joint.

Another important object is to provide reservoir means for insuring the maintenance of liquid sealing medium at, and on one side of, the ground joint; a further object being to regulate the supply of liquid sealing medium to prevent leakage thereof through the ground joint and into the evacuated vessel.

Another important object is to provide a shaft seal utilizing a liquid seal medium in conjunction with a seal ring and cooperating seat forming a running ground joint, including the novel arrangement of parts whereby the seal may be formed as a separate assembly unit, adapted for application upon an envelope or housing at a shaft opening therein, in position to sealingly cooperate with a shaft-like member extending in said opening, the particular arrangement of the seal making it adaptable for use as a replacement unit, said unit, when mounted, forming a part of the envelope or housing on which it is assembled.

Another important object is to provide a shaft seal for the rotating anode of an X-ray generator, including sealed means for circulating a cooling medium through the shaft to and from the anode of the generator, for the purpose of continuously cooling the same while the generator is in operation.

The foregoing and numerous other important objects, advantages, and inherent functions of the invention will become apparent as the same is more fully understood from the following description, which, taken in connection with the accompanying drawings, discloses a preferred embodiment of the invention.

Referring to the drawings:

Fig. 1 is a sectional view through an X-ray generator embodying the present invention;

Fig. 2 is an enlarged sectional view of a seal structure forming a part of the device shown in Fig. 1; and

Fig. 3 is a modified seal arrangement embodying the invention.

To illustrate the invention, the drawings show an electronic device comprising an X-ray gener-

ator 11, although it will be understood that the invention is not necessarily limited, in all of its aspects, to X-ray generators, some of the features of the present invention having general application wherever effective shaft sealing functions are required. As shown on the drawings, however, the generator 11 may comprise sealed envelope means 12 containing an anode 13 and a cooperating cathode 14 of any suitable or preferred construction.

The envelope 12 may be formed in any convenient or preferred manner, and may comprise any suitable envelope material. As shown, the envelope may comprise a tubular glass sleeve 15, having a re-entrant neck 16, at one end, upon which neck the cathode structure 14 may be supported and sealed in any suitable fashion, as by means of the seal ring 17, making an annular glass-to-metal seal with the re-entrant neck 16. The opposite end of the envelope sleeve 15 may, likewise, be sealed upon the upstanding neck portion 18 of an annular flanged structure 19, the end of the sleeves 15 being sealed to the neck portion 18, as by means of a ring 20, similar to the ring 17, and forming a glass-to-metal seal with the end of the sleeve 15.

The envelope 12 may, also, include closure means 21, adapted for application to the flanged member 19 for sealing the opening therethrough into the sleeve 15, said closure means 21 being preferably formed to turnably support the anode 13. To this end, the closure means 21 may include a preferably annular structure, comprising a plate portion 22 formed with a central opening and adapted to be clamped sealingly with the flange structure 19, and a housing portion 23 of preferably sleeve-like configuration adapted to form, with the plate 22 and the flanged structure 19, a bearing cavity 24 extending axially of, and forming a continuation of, the space enclosed by the envelope sleeve 15.

The closure means 21 carries a bearing structure 25 within the chamber 24, said structure being preferably mounted on a support spider 26 disposed within the central opening of the plate portion 22. This spider may conveniently be formed as an integral part of the plate portion 22. The housing portion 23 may extend outwardly of the plate portion 22, and may be formed with a seal seat 27 at the end thereof remote from the plate portion 22. This seal seat preferably defines a central opening 28 through which the shaft member 30 extends. The flanged structure 19 and, also, the closure means 21 may be made of any suitable, preferably metallic material, and may comprise tubular and plate-like sections welded, brazed, or otherwise sealingly secured together, as shown, to provide the required envelope parts.

The anode 13, which may be of any suitable or preferred structure, is supported within the envelope sleeve 15 on a shaft-like element 30, said element preferably comprising a tube which extends from the anode through the chamber 24 and outwardly thereof through the opening 28, said tubular shaft member being journaled for rotation in the bearing means 25.

The entire structure may conveniently be supported in operating position on pedestals 31, comprising rods mounted on, and extending upwardly of, a suitable supporting base 32, the rods 31 carrying the flange structure 19 with closure means 21 sealingly clamped thereto.

The end of the shaft sleeve 30, which projects outwardly of the closure means 21, may be driv-

ingly connected with any suitable or preferred shaft turning mechanism. As shown, the projecting portions of the sleeve 30 carry a driving pulley 33 fixed thereto, whereby the member 30 may be turned by a suitable motor belted to the pulley. Obviously, any other suitable driving connection may be employed.

The projecting end of the tubular member 30 may, also, be journaled, if desired, in suitable bearing means 34 supported on the base 32, which is also preferably formed with a packing gland 35 for turnably receiving the terminal end of the member 30, the gland 35 providing a liquid seal for connecting the open end of the member 30 with conduit means 36. The base 32 may, also, be formed with a liquid conduit 37 connected with one end of a tube 38, which extends concentrically within the tubular member 30, the tube 38 opening, at its remote end, into a cavity 39 formed within the body of the anode 13, said cavity communicating, also, with the anode connected end of the member 30. By circulating a cooling medium, such as water, through the cavity 39 by way of the conduits 36 and 37 and the concentric tubes 30 and 38, the operating temperature of the anode may be held within safe limits.

In order to maintain desired low pressure, substantially vacuum conditions within the envelope, during operation of the generator, the closure means 21 may be provided with a conduit 40 adapted for connection with suitable exhaust means, such as a vacuum pump.

The present invention provides novel and improved means for sealing the envelope against vacuum leakage along the shaft, at the place where it extends through the envelope structure, that is to say, through the opening 28. To this end, the present invention contemplates the provision of novel vacuum seal means 41, preferably arranged as a replaceable unit adapted to be mounted on, and to form a part of, the envelope structure. As shown, the seal means 41 comprises a housing 42 of preferably cup-shaped configuration, having flange means 43 at the lip of the cup member, said flange being adapted to sealingly engage in the seat 27 formed on the closure means 21. To this end, the flange 43 may be secured on the seat 27, as by means of clamping studs 44, a suitable sealing gasket 45 being applied and clampingly received between the flange 43 and the seat 27. The bottom of the cup-like housing 42 is formed with a central opening 46, sized to snugly, yet turnably, receive the shaft member 30, said opening being preferably fitted with a packing gland 47 around the shaft. The housing member 42 is preferably made of metal.

The cup-shaped housing 42 is, thus, adapted to define a chamber 48 around the shaft member 30 at, and communicating with, the opening 28, and, thus, when mounted, comprises a part of the envelope itself. The seal comprises a pair of cooperating, preferably metal rings 49 and 50, one of which is mounted, or formed, on the shaft member 30 in position providing an annular sealing surface facing into the chamber 48, and the other of which is mounted on the cup-shaped housing 42 in position providing an annular sealing surface adapted to engage and form a running seal with the sealing surface of the cooperating ring. One of the ring elements preferably comprises relatively hard material, such as steel, while the other may comprise a relatively softer metal, such as bronze. The more

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readily replaceable ring 49 is preferably made of the softer material to take the wear. One of the ring elements, also, is yieldingly supported, as on a metal bellows 51, whereby the resilience of said bellows may serve to hold the ring element in yielding engagement with the cooperating ring element. If desired, spring means 52 may be employed to aid in holding the ring elements yieldingly in mutual sealing engagement.

If desired, the shaft mounted ring 50 may be, thus, yieldingly supported on the shaft in the manner shown in Fig. 3, wherein the shaft mounted ring comprises an element 50' supported on the shaft by means of the bellows 51 and urged by the spring 52 into engagement with the seat element 49' on the housing 42. It is preferable, however, as a matter of manufacturing convenience, to mount the ring 50 rigidly and sealingly on the shaft member 30, as shown in Fig. 2, as by welding, or brazing, or otherwise integrally fastening the ring 50 upon the shaft, preferably in position extending in the opening 28. If desired, the shaft 30 may be integrally formed with a shoulder in the opening 28, in position to cooperatively engage the seal ring 49. In either case, the cooperating annular surfaces of the ring or shoulder 50 and the seal ring 49 are finished accurately, to provide smooth, highly polished annular sealing surfaces. The ring 49, also, is sealed, as by brazing the same in a central opening formed in a metal plate 53, the plate, in turn, being sealed, outwardly of the ring 49, to one end of the bellows element 51. The other end of the bellows is sealed on a metal mounting ring 54, adapted to sealingly engage in an annular seat 55 formed in the cup-shaped housing 42, the mounting ring being retained in its seat as by means of clamping rings 56, which may be threadingly secured in the housing. The spring means 52 may comprise a helical spring element encircling the shaft, and, as shown in Fig. 2, bearing at one end on the seal ring 49, the other end of the spring seating upon the bottom of the cup-shaped housing around the opening 46. As shown in Fig. 3, however, the spring 52 may bear at one end on the shaft mounted seal ring 50, the other end of the spring engaging a shoulder formed on the shaft. In this connection, the arrangement, as shown in Fig. 3, embodies a removable mounting nut 54' adapted for threaded, sealing engagement on the shaft, said nut providing an annular spring seat and a concentric annular rib, to which one end of the bellows element is sealingly secured, the other end of the bellows element carrying the disk 53' on which the shaft supported seal ring 50' is sealingly mounted. In the Fig. 3 embodiment, the cooperating seal ring 49' is sealed directly on the mounting ring 54.

When the shaft 30 is rotating, the rings 49 and 50 will turn, one with respect to the other, to form a running ground joint between the cooperating seal faces of the rings, the rings being, at all times, maintained in tight sealing engagement by the action of the spring 52. The envelope will, thus, be sealed against fluid leakage around the shaft at the opening 28, since the ring 50 is sealed around the shaft, the ring 49 is sealed to the bellows, which, in turn, is sealed to the housing 42, the housing 42, in turn, being sealed to the envelope closure member 21, and the running ground joint sealing against leakage between the rings 49 and 50, as shown in Fig. 2. In the Fig. 3 embodiment, the envelope is sealed against fluid leakage since the ring 50' is sealed

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to the bellows, which in turn is sealed to the shaft, while the ring 49' is sealed to the housing 42, the running ground joint sealing against leakage between the members 49' and 50'.

In order to enhance the efficacy of the seal, means is provided for maintaining a supply of a liquid sealing medium, such as oil, around the shaft 30 at, and outwardly of, the seal ring 49, said supply of liquid preferably being contained within the space 57 defined around the shaft between the bottom of the housing 42 and the ring supporting means, comprising the disk 54, bellows 51, and disk 53. To this end, the housing 42 is provided with conduit means 58 connecting with an oil reservoir 59, whereby oil may be supplied to, and held in, the space 57 to completely fill the same up to the ring 49. In this connection, it is desirable, also, though not absolutely essential, to connect the reservoir 59 with suitable exhausting means, so that the sealing liquid in the reservoir 59 and the space 57 may be held under reduced pressure, to thus minimize any tendency for the liquid sealing medium to leak through the ground joint into the evacuated envelope.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the forms herein disclosed being preferred embodiments for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. An X-ray generator comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a cathode and a cooperating rotatable anode mounted within the main chamber, a shaft member drivingly connected with said anode and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising a running seal and flexible partition means supporting the same in position forming a liquid chamber in said sleeve-like extension, at the end thereof remote from said main chamber, and around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said liquid chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

2. An X-ray generator comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a cathode and a cooperating rotatable anode mounted within the main chamber, a shaft member drivingly connected with said anode and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means defining a liquid chamber in said sleeve-like extension, at the end thereof remote from said main chamber, and around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said liquid chamber under substantial pressure of the order of atmospheric pressure, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers to maintain low pres-

sure conditions therein of the order approaching an absolute vacuum.

3. An X-ray generator comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a cathode and a co-operating rotatable anode mounted within the main chamber, a shaft member drivingly connected with said anode and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means forming annular abutments on said shaft and on said envelope extension adjacent said opening, one of said abutments providing an annular running seal seat, an extensible bellows sealed at one end on the other of said abutments, a seal ring sealingly secured on said bellows at the opposite end thereof in position to form running engagement with said seat, whereby to define a liquid chamber in said sleeve-like extension around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

4. An X-ray generator comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a cathode and a co-operating rotatable anode mounted within the main chamber, a shaft member drivingly connected with said anode and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means forming an annular running seal seat on said shaft and an annular mounting abutment on said envelope extension adjacent said opening, an extensible bellows sealed at one end on the mounting abutment, a seal ring sealingly secured on said bellows at the opposite end thereof in position to form running engagement with said seal seat, whereby to define a liquid chamber in said sleeve-like extension around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

5. An X-ray generator comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a cathode and a co-operating rotatable anode mounted within the main chamber, a shaft member drivingly connected with said anode and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means forming an annular mounting abutment on said shaft and an annular running seal seat on said envelope extension adjacent said opening, an extensible bellows sealed at one end on the mounting, a seal ring sealingly secured on said bellows at the opposite end thereof in position to form running engagement with said seat, whereby to define a liquid chamber in said sleeve-like extension around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

6. A low pressure device comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a rotatable

element in said main chamber; a shaft member drivingly connected with said element and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising a running seal and flexible partition means supporting the same in position forming a liquid chamber in said sleeve-like extension, at the end thereof remote from said main chamber, and around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said liquid chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

7. A low pressure device comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a rotatable element in said main chamber, a shaft member drivingly connected with said element and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means defining a liquid chamber in said sleeve-like extension, at the end thereof remote from said main chamber, and around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said liquid chamber under substantial pressure of the order of atmospheric pressure, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers to maintain low pressure conditions therein of the order approaching an absolute vacuum.

8. A low pressure device comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a rotatable element in said main chamber, a shaft member drivingly connected with said element and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means forming annular abutments on said shaft and on said envelope extension adjacent said opening, one of said abutments providing an annular running seal seat, an extensible bellows sealed at one end on the other of said abutments, a seal ring sealingly secured on said bellows at the opposite end thereof in position to form running engagement with said seat, whereby to define a liquid chamber in said sleeve-like extension around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

9. A low pressure device comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a rotatable element in said main chamber, a shaft member drivingly connected with said element and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means forming an annular running seal seat on said shaft and an annular mounting abutment on said envelope extension adjacent said opening, an extensible bellows sealed at one end on the mounting abutment, a seal ring sealingly secured on said bellows at the opposite end thereof in position to form running engagement with said seal seat, whereby to define a

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liquid chamber in said sleeve-like extension around said shaft at said opening, means for maintaining a supply of liquid sealing medium in said chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers. 5

10. A low pressure device comprising means forming a sealed envelope providing a main chamber and a sleeve-like extension, a rotatable element in said main chamber, a shaft member 10 drivingly connected with said element and extending in said sleeve-like extension and outwardly thereof through a shaft opening in said extension, means for sealing said opening against fluid leakage therethrough along said shaft member, comprising means forming an annular mounting abutment on said shaft and an annular running seal seat on said envelope extension adjacent said opening, an extensible bellows sealed at one end on the mounting, a seal 20 ring sealingly secured on said bellows at the opposite end thereof in position to form running engagement with said seat, whereby to define a liquid chamber in said sleeve-like extension around said shaft at said opening, means for 25

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maintaining a supply of liquid sealing medium in said chamber, and exhaust conduit means connected to said sleeve-like extension between said main and liquid chambers.

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