Dec. 4, 1951 L. J. WEBER 2,577,292

SHAFT SEAL MECHANISM

Filed Jan. 2, 1948 3 Sheets-Sheet 1

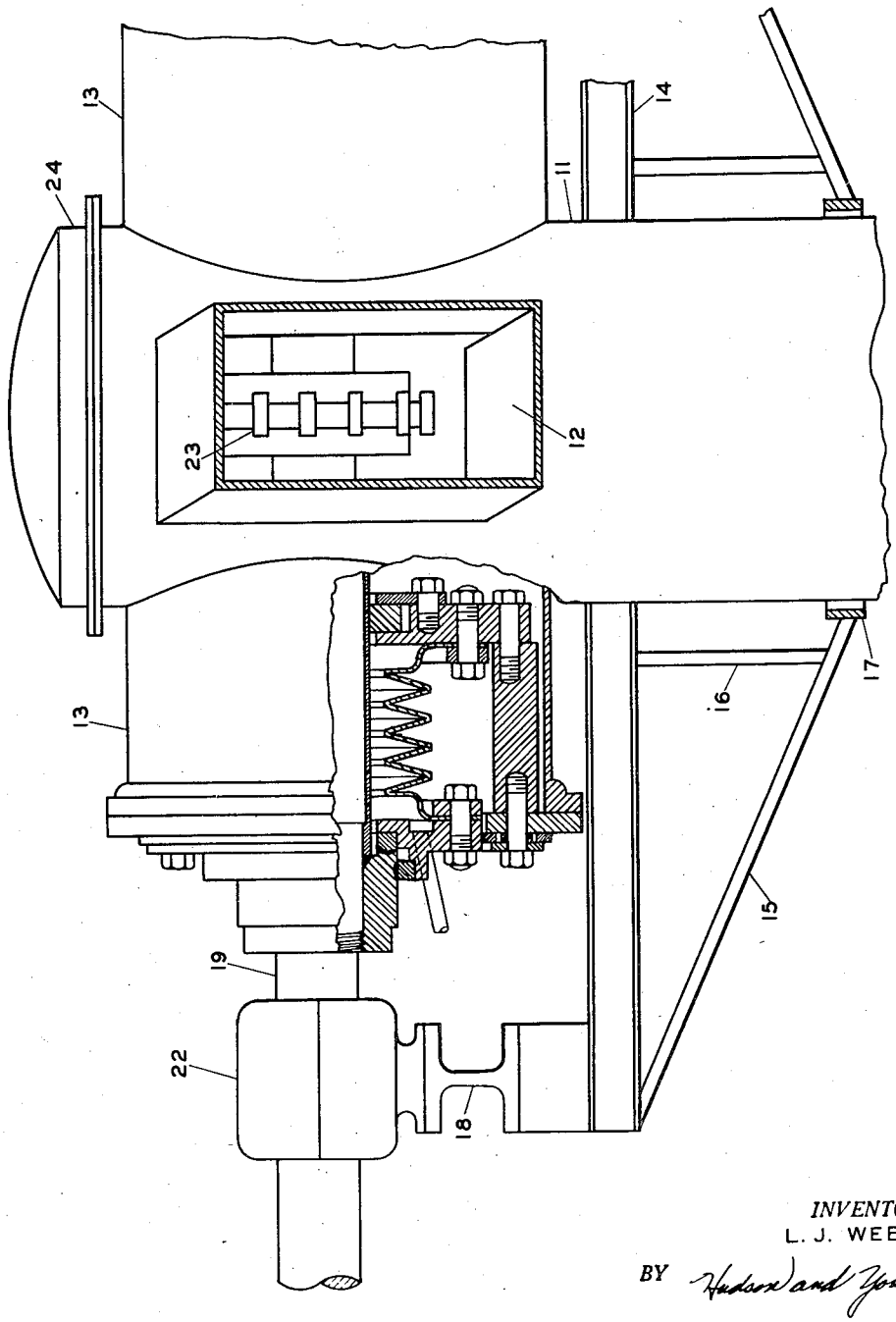


FIG. 1

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SHAFT SEAL MECHANISM

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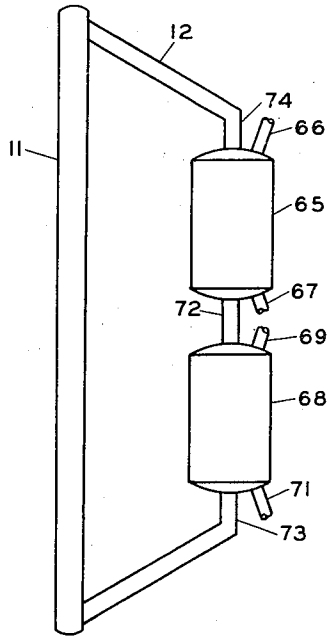


FIG. 4

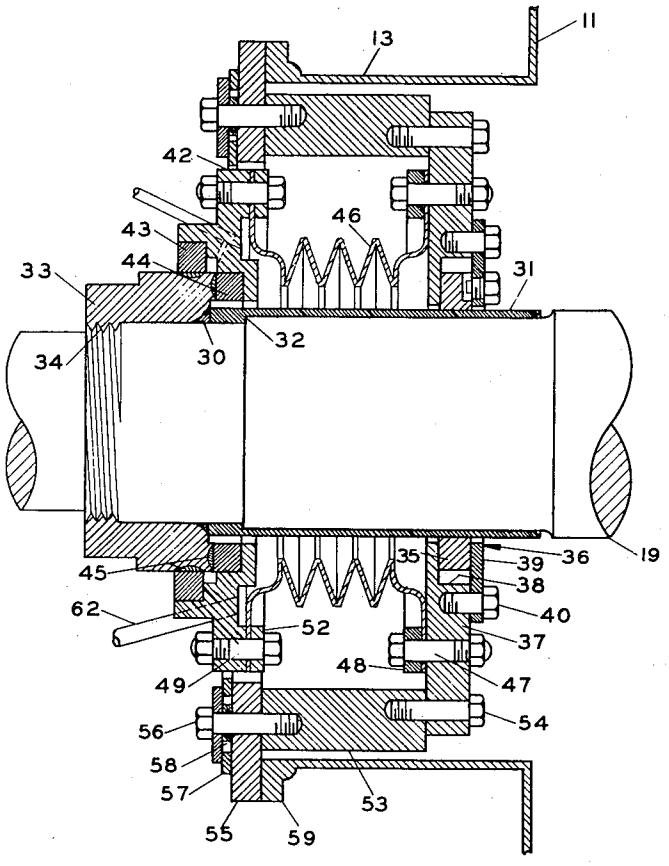


FIG. 2

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SHAFT SEAL MECHANISM

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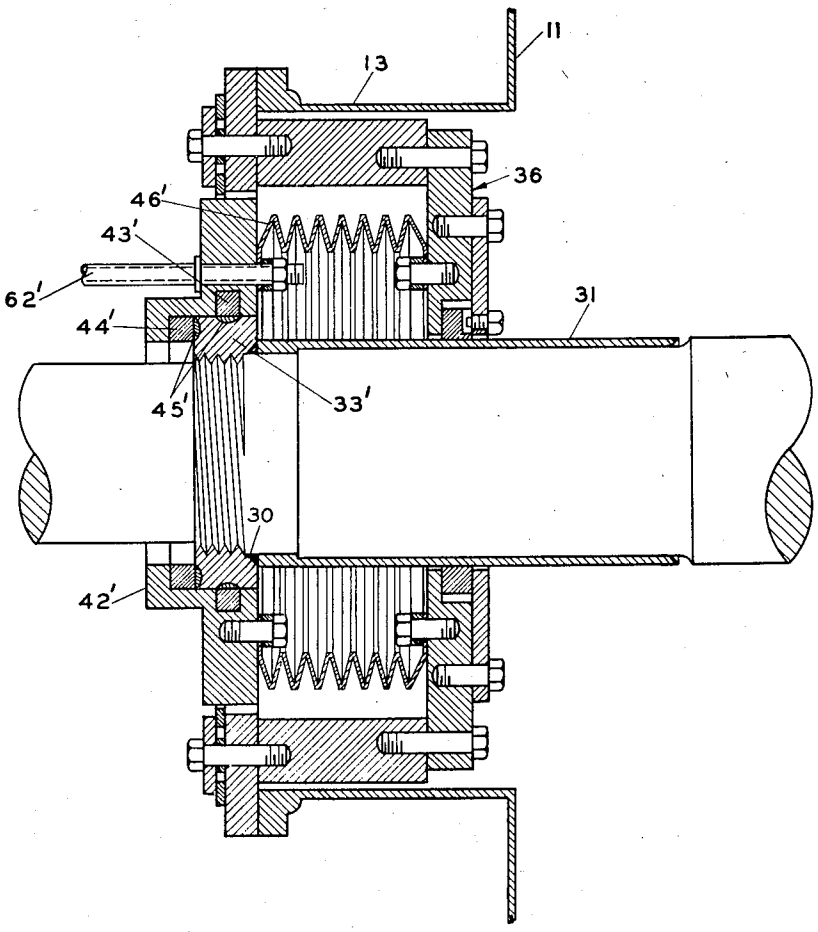


FIG. 3

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UNITED STATES PATENT OFFICE

2,577,292

SHAFT SEAL MECHANISM

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7 Claims. (Cl. 286—9)

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This invention relates to high temperature apparatus. In one of its more specific aspects it relates to means for sealing displaceable shafts in apparatus casings. In another of its more specific aspects it relates to means for compensating for displacement of shafts in high temperature apparatus. In another of its more specific aspects it relates to means for sealing head-shafts in elevator apparatus operating at relatively high temperatures.

Many apparatus have been developed for operation with processes utilizing high temperatures wherein shafts protrude through the casing for such apparatus and are supported on bearings outside the casing. In such a situation trouble is often encountered in maintaining a seal between the casing and the shaft.

In recent years many processes have been devised for hydrocarbon conversion which involve the circulation of solid materials such as catalyst pellets or beads or material such as ceramic pebbles. One of these process developments involves the use of the so-called pebble heater for high temperature treatment or conversion of gaseous materials by means of direct heat exchange with a continuously moving bed of ceramic pebbles. A pebble heater unit normally comprises two or more chambers in substantially vertical alignment with the uppermost chamber being known as the pebble heating chamber or zone. The gas heating chamber is usually positioned immediately below the pebble heater chamber with solid material communication means extending between the two chambers. The heat necessary for the gas heating step is supplied by the ceramic pebbles which are continuously circulated from the outlet of the conversion chamber to the top of the pebble heating chamber. This transfer of pebbles may be efficiently accomplished by elevating means, such as a bucket type elevator which comprises an endless chain to which is attached a plurality of buckets or pockets. The entire elevator assembly is encased in a suitable housing such as a cylindrical casing.

The elevator is operated or driven by means of a motor or turbine supplying power to a shaft which projects through the sides of the elevator casing. This shaft is fitted with a traction wheel which is suitably adapted so as to move or rotate the elevator mechanism. The shaft just described is frequently called a head-shaft. It is readily apparent that a portion of the shaft within the elevator casing will be exposed to a relatively high temperature and possibly a dust

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laden atmosphere. In such a pebble heater apparatus the temperature within the elevator casing may range from about 400° F. to about 2000° F. but will usually range from about 700° F. to about 1200° F. A gaseous atmosphere comprising flue gas, steam, hydrocarbon reactants or reaction products may exist within the elevator casing during operation of the apparatus. Usually the gaseous material will exist within the casing under a relatively low pressure, in the order of about ¼ to about 10 p. s. i. g. The head-shaft is subject to longitudinal expansion as the unit is brought on stream and the temperature within the elevator casings rises from approximately atmospheric to an operating temperature of about 1000° F. Furthermore, as operating temperatures are reached, the elevator casing which cases a portion of the head-shaft will itself tend to expand laterally and longitudinally whereas neither the prime mover, its support or the head-shaft will ordinarily be subject to the same expansion. The head-shaft is thus subjected to vertical displacement.

An object of the invention is to provide a means for sealing a casing from which a shaft extends when such shaft is subject to vertical, lateral and/or longitudinal displacement. Another object is to provide a method for sealing a casing from which a shaft extends when such shaft is subject to vertical, lateral and/or longitudinal displacement. Another object is to provide a means for continuously effecting a uniform seal of a casing from which projects a rotating shaft. Another object is to exclude a dust laden atmosphere from a shaft seal. Other and further objects and advantages of the invention will be apparent upon examination of the accompanying discussion, the diagrammatic drawings and the claims.

More complete understanding of the invention will be facilitated upon reference to the schematic drawings in which Figure 1 is a vertical plan view partially in section of an elevator casing showing the mounted head-shaft. Figure 2 is a sectional view of a shaft seal embodying a preferred form of the invention. Figure 3 is a sectional view of a shaft seal embodying a modification of the invention. Figure 4 is a diagrammatic view of a pebble heater apparatus showing the relative position of the pebble heater chamber, the gas heating chamber and the elevator assembly.

In the apparatus shown in Figure 1, elevator casing 11 is provided with pebble chute 12 which communicates between the interior of the ele-

vator casing and the upper portion of the pebble heating chamber. Protruding from elevator casing 11 are two casing extensions or nozzles 13 which are positioned in substantially the same horizontal plane as chute 12. Support members 14 are rigidly affixed to casing 11 and are supported at their outer ends by a framework comprising secondary support members 15 and 16 which are rigidly affixed to collar member 17 which is slidably mounted around the circumference of casing 11. Bearing support members 18 are carried by support members 14. Shaft 19 extends through nozzles 13 and is rotatably mounted in bearings 22 which are rigidly supported by bearing support members 14. Traction wheel 23 is mounted on shaft 19 within casing 11 so as to elevate buckets to a position adjacent chute 12. Access to the interior of casing 11 is obtained through closure member 24. A relatively complete description of the shaft seal chamber shown in the cutaway portion of Figure 1 will be found in the description of Figure 2 of the drawings.

The preferred modification of the invention is shown in Figure 2 in which sleeve member 31 is slidably mounted on shaft 19 and fits at its outer end against shoulder 32 on said shaft, thus forming a part of the shaft surface. Sleeve member 31 is rigidly affixed on shaft 19 by collar member 33 which is removably mounted by means of threaded portion 34 on shaft 19. When collar member 33 is drawn up tight against gasket member 30 and sleeve member 31 a substantially gas tight seal is effected between shaft 19, sleeve 31 and collar member 33. Closure ring 35 is rotatably mounted on and closely encircles sleeve member 31 adjacent its end opposite collar member 33. Closure ring 35 may be made of any suitable form retaining material consistent with the operating temperature, such as carbon or felt. It is preferred to construct ring 35 of carbon, however, inasmuch as it will be more easily retained in position by a stud extending through the side of casing ring 36 and also has some of the lubricating qualities of graphite. Casing ring 36 preferably comprises base ring 37 which is substantially larger of inner diameter than the outer diameter of sleeve 31 and smaller than the outer diameter of ring 35. Laterally extending from base ring 37 is shoulder 38 which is of a larger inner diameter than the outer diameter of closure ring 35. Ring plate 39 has an inner diameter which is larger than the outer diameter of sleeve member 31 and which inner diameter is smaller than the outer diameter of closure ring 35. Closure ring 35 is fitted against base ring 37 within the space formed within shoulder 38 and is fastened in an enclosed position by securing ring plate 39 to the shouldered base ring by means of bolts 40. In this construction, casing ring 36 has a substantially U-shaped cross-section which encompasses closure ring 35 in such a manner that the interior lateral sides of base ring 37 and plate ring 39 form a slip-joint with the lateral sides of closure ring 35. Casing ring 36, being of larger inner diameter than the inner diameter of closure ring 35 and being enlarged intermediate its lateral sides so as to be interiorly larger than the outer diameter of closure ring 35, forms a slip-joint which will allow movement of closure ring 35 within casing ring 36 while maintaining it in a plane established by casing ring 36 which is retained in a substantially fixed relation with shell 11.

Seal-bearing member 42, provided with a bearing surface ring 43 and sealing surface ring 44, is mounted on collar member 33 so that bearing surface ring 43 bears against the circumference of collar member 33 and sealing surface ring 44 bears against a substantially perpendicular shoulder formed by the collar. Bearing surface ring 43 is preferably a replaceable carbon or bronze stationary ring which is removably secured in the framework of seal-bearing member 42. Sealing surface ring 44 may also be a replaceable carbon or bronze stationary ring mounted in the framework of member 42. Hard metal alloy surfaces 45 may be provided on the shoulder and circumference of collar member 33 so as to reduce the wear on such collar member by the bearing and the sealing surface rings. It will be seen that in such construction when wear occurs the collar member may be removed and replaced or repaired with little or no inconvenience and, at the same time, the bearing and sealing surface rings of the seal-bearing member may also be replaced. Flexible expansible-contractible closure means, such as circular spring bellows 46, is mounted between casing ring 36 and seal-bearing member 42 and encompasses that portion of sleeve member 31 between ring 36 and member 42. The sealing surface ring of member 42 may be maintained against the collar shoulder in any conventional manner, but it is preferred to accomplish the function by pressure from bellows member 46. Bellows 46 is attached at one of its ends by a gas-tight seal to casing ring 36, preferably by bolts 47 which may extend through clamping ring 48, bellows 46 and through base ring 37. Bellows 46 is attached at its other end, by a gas-tight seal, to seal-bearing member 42. The gas-tight seal is preferably made by bolts 49 which extend through clamping ring 52, bellows 46 and seal-bearing member 42. Casing ring 36 is affixed to elevator casing 11, preferably by a rigid connection which may substantially close off the greater portion of atmospheric flow about the exterior of bellows 46. The connecting means may comprise spacer ring 53 which is preferably rigidly secured to base ring 37 by bolts 54. Spacer ring 53 extends around bellows 46 and is preferably rigidly secured to connecting flange 55 by bolts 56. Reducing ring 57 is slidably affixed to flange 55 by bolts 56. The interior diameter of reducing ring which, as mounted, preferably encircles seal-bearing member 42 may be of any desired size greater than the outer diameter of member 42. By thus enclosing the shaft seal means a substantially dead air space is provided around the seal. Temperature of bellows member 46 will in this manner substantially depend on the temperature of fluid within the shaft seal. Holes 58, in reducing ring 57, through which bolts 56 extend, are substantially larger in diameter than the diameter of the bolts and spacer bushings about the bolts. Washer members provide the clamping means against which bolts 56 may be tightened. The washer members are tightened down on the spacer bushings which extend around bolts 56 and through holes 58 so as to clamp flange 55 in place and slidably retain ring 57. Ring 57 substantially reduces the opening between seal-bearing member 42 and flange 55. It is at the same time attached by means of the bolts extending through the enlarged holes therein so as to be shifted in its attachment by pressure from seal-bearing member 42 upon its interior diameter. Flange 55 is preferably rigidly affixed in fluid tight relationship to flange 59, which is a part of the elevator casing extension or nozzle 13. A plurality

of conduit means, such as conduits 62 is preferably provided so as to extend through seal-bearing member 42 so as to communicate between the closed area within the space formed between sleeve 31 and bellows 46 and the exterior of the seal. These conduits may be adapted for the injection and withdrawal of sealing fluid, or for the measurement of pressure within the seal. The inner end of at least one of the conduits may be plugged and another conduit extend between conduit 62 and the interior of seal-bearing member 42 from a point between the bearing ring and the sealing ring. The latter construction may be utilized if the sealing ring and/or bearing ring is made of material other than carbon. A lubricating material may then be supplied to the sealing and bearing rings through the conduit so adapted.

In the device shown in Figure 3, sleeve 31 is affixed in place by a collar member 33' which may be provided with hard metal alloy surfaces 45' which will bear against bearing surface ring 43' and sealing surface ring 44' of seal-bearing member 42'. The seal device shown in Figure 3 is similar to that of Figure 2 with a few exceptions. The shoulder on collar member 33' which is used for sealing is provided at the end of collar member 33' opposite sleeve member 31 rather than adjacent it. Seal-bearing member 42' is mounted on collar member 33' in such manner as to bear on the circumference of collar 33' and seal against the seal shoulder provided by collar 33'. Flexible closure means, such as bellows 46', is in this case a tension rather than an expansion spring type bellows. Bellows 46' is affixed by a gas-tight seal at one of its two ends to casing ring 36 and by a gas-tight seal at its other end to seal-bearing member 42'.

Casing 65 shown in Figure 4 encloses a pebble heating chamber therein and is provided in its upper portion with an effluent outlet 66 and in its lower portion with a heating fluid inlet means, such as conduit 67. Shell 68 encloses a gas heating chamber therein and is provided in its upper portion with effluent outlet means, such as conduit 69, and in its lower portion with a reactant inlet means, such as conduit 71. Communication means, such as pebble conduit 72, connects the lower portion of shell 65 with the upper portion of shell 68. Pebble outlet 73 is provided in the lower portion of shell 68 and communicates between shell 68 and the elevator means contained within elevator casing 11. Pebble chute 12 communicates between elevator casing 11 and pebble inlet 74 in the upper portion of shell 65.

In the operation of the device diagrammatically shown in Figures 1 to 4, inclusive, pebbles are inserted into shell 65 and thus into shell 68 forming a substantially continuous bed therethrough. It is to be understood that the continuity of the pebble bed within the pebble and gas heating chambers is not to limit the scope of the invention. Pebbles within shell 65 are heated to a temperature which may range between about 1500° F. and about 3500° F. by passing combustion gas or combustible materials through conduit 67, burning the combustible materials within the combustion zone and passing the combustion gases upwardly in direct heat exchange with the pebbles in the chamber. The pebbles are circulated through the two heating chambers and are recycled by means of the elevator means within casing 11 which draws pebbles from the bottom of shell 68 and elevates them to the top of shell 65. Gaseous materials are fed through conduit 71 into the chamber within shell 68 and pass upwardly in direct heat exchange with downwardly flowing pebbles in the gas heating chamber and escape from the chamber through effluent outlet 69. As pebbles are passed upwardly through the elevator casing, they tend to heat the atmosphere therein, raising the temperature of the elevator casing from substantially atmospheric to a temperature ranging between about 400° F. and about 2000° F. but preferably between about 700° F. and about 1200° F. The atmosphere within the elevator casing may, as pointed out above, comprise flue gases, steam, hydrocarbon reactants, or reaction products and may at the same time be dust laden. As the elevator casing is heated it tends to expand longitudinally. This expansion would cause a prohibitive displacement of the head shaft within the elevator casing if the head shaft were supported from the ground. Means have been devised for supporting the head shaft on the elevator casing, but at the same time there still exists a portion of the casing between the point to which the shaft support is attached to the elevator casing and the plane passing through the longitudinal center of the shaft. Displacement caused by the difference in expansion between that portion of the elevator casing and the shaft support member is often times sufficient to either crack the seal around the shaft or place the shaft under such stress as would cause it to fracture. This is prevented by the instant invention because of the fact that the seal is flexible enough to retain the closed communication between the shaft and the elevator casing despite displacement. A sealing fluid, such as steam, is injected through conduits 62 or 62' into a plenum chamber formed within the bellows 46 or 46', and a portion of the gas is withdrawn therefrom through conduits 62 or 62', which conduit and chamber form injection and withdrawal zones. The sealing fluid is maintained at a pressure equal to or slightly greater than the pressure within the elevator casing. Bellows 46 forces sealing surface rings 44 or 44' against the shoulder of collar members 33 or 33' in such a manner as to maintain a substantially gas tight friction seal therebetween. It will be seen that as a substantially fluid tight seal is established between the sealing surfaces of the collar and seal-bearing members, any sealing fluid within the plenum chamber will be caused to seek another exit. The fit of closure ring 35 on sleeve 31 is not ordinarily fluid-tight. The sealing fluid will thus tend to escape between the surfaces of the sleeve and the closure ring and any other openings into the casing. Such openings into the elevator casing form a choking zone. Seepage of the sealing fluids into the elevator casing excludes in that manner, seepage of dust laden atmosphere into the shaft seal. As the elevator casing expands or contracts casing ring 36 moves about closure ring 35 and may move in any direction without affecting the position of the sleeve or shaft. At the same time, bearing surface rings 43 or 43' will maintain the seal-bearing members in a fixed relation with collar members 33 and 33' and thus with shaft 19.

Under the high temperatures within the elevator casing the head shaft will tend to expand longitudinally in a direction substantially perpendicular to the longitudinal expansion of the elevator casing. The spring bellows is of such

design as to maintain a relatively constant pressure against seal-bearing ring members 42 and 42' within a limited range of expansion despite the lengthening or shortening of the head shaft or of the elevator casing. It will thus be seen that when a shaft is horizontally mounted in a vertically disposed casing a shaft seal of this invention may be utilized to compensate for positive vertical and horizontal displacement of the shaft while maintaining a substantially fluid tight connection therebetween.

The bellows materials used in this seal may be any spring type material such as silicon bronze, Phosphor bronze or stainless steel, which materials are weldable. The tension or compression of the bellows member may be varied by varying the length of the spacer ring 53, thus extending the bellows member to a different zone of expansion or tension.

The atmosphere within elevator casing 11 exists at a relatively low pressure ordinarily in the order of about ¼ to about 10 p. s. i. g. The pressure under which the sealing fluid is maintained will ordinarily range between about 5 and about 18 p. s. i. g.

Use of the shaft seal chamber of this invention should not be limited to use in apparatus in which the shaft is provided with a sleeve and/or collar member or sleeve-collar member. Such construction will, however, enable one to make economical replacement of worn parts. It is obvious that good results may be obtained by merely adapting the shaft with a shoulder and using the modification of the seal shown in Figure 3 or providing the shaft with a replaceable collar member and using either the preferred embodiment of the invention shown in Figure 2 or the modification shown in Figure 3. The shoulder of the sleeve or collar member on which the seal-bearing member seats to make a substantially gas-tight seal may be chamfered, perpeidicular or of any desired shape.

It will be noted that with the device of this invention a constant seal is maintained despite vertical, lateral, or longitudinal displacement of the shaft. The sealing surfaces of ring 44 and collar 33 are maintained in congruity regardless of the direction of shift. The sealing surfaces of collar 33 and ring 44 are coaxially maintained at all times.

Though the invention has been described in considerable detail, many additional modifications and advantages will be apparent to those skilled in the art without departing from the scope and intent of the invention, upon examination of the discussion, the attached drawings and of the claims.

I claim:

1. In high temperature apparatus having a shouldered shaft extending from the case therefor, the improvement of a shaft seal chamber adapted so as to offset displacement of said shaft in said case, said seal chamber comprising in combination a closure ring slidably mounted on said shaft; a casing ring having a substantially U-shaped cross-section affixed to said apparatus case and encompassing said closure ring in such manner that a slip-joint is made between the lateral sides of said closure ring and the adjacent interior lateral sides of said casing ring, said casing ring being enlarged interiorly so as to be of substantially larger interior diameter than the outer diameter of said shaft and intermediate its lateral sides being interiorly larger than the outer diameter of said closure ring; flexible expansible-contractible closure means surrounding a short portion of said shaft and affixed at one of its two ends by a substantially gas-tight seal to said casing ring to form a sealing chamber therein; a seal-bearing member provided interiorly with a bearing surface bearing on the circumference of said shaft and a sealing surface bearing on said shaft shoulder so as to form a substantially gas-tight seal therebetween, said seal-bearing member being mounted on said shaft so as to move longitudinally and coaxially with said shaft and being affixed to the otherwise unaffixed end of said flexible closure member by a substantially gas-tight seal, thereby substantially closing said sealing chamber; and conduit means for injecting a fluid into said sealing chamber at a pressure at least as great as the pressure maintained within said apparatus, communicating between the interior of said sealing chamber and a sealing fluid supply source exterior of said sealing chamber.

2. In high temperature apparatus having a shouldered shaft extending from the case therefor, the improvement of a shaft seal chamber adapted so as to offset displacement of said shaft in said case, said seal comprising in combination a closure ring slidably mounted on and closely encircling said shaft at a point closely adjacent the plane of a lateral wall of said apparatus case; a casing ring having a substantially U-shaped cross-section, rigidly affixed to said apparatus case, encompassing said closure ring in such manner that a slip-joint is made between the lateral sides of said closure ring and the adjacent interior lateral sides of said casing ring, said casing ring being enlarged interiorly so as to be of substantially larger interior diameter than the outer diameter of said shaft and intermediate its lateral sides being interiorly substantially larger than the outer diameter of said closure ring; flexible expansible-contractible closure means affixed at one of its two ends by a substantially gas-tight seal to said casing ring and surrounding a short portion of said shaft, extending outwardly from said apparatus casing to form a sealing chamber therein; a seal-bearing member provided interiorly with a bearing surface bearing on the circumference of said shaft and a sealing surface bearing on said shaft shoulder so as to form a substantially gas-tight seal therebetween, said seal-bearing member being mounted on said shaft so as to move longitudinally and coaxially with said shaft and being affixed to the second end of said flexible closure member by a substantially gas-tight seal, thereby substantially closing said sealing chamber; and open conduit means for injecting a fluid into said sealing chamber at a pressure at least as great as the pressure maintained within said apparatus, communicating between the interior of said sealing chamber and a sealing fluid supply source exterior of said sealing chamber.

3. In high temperature apparatus having a shaft extending from the case for said apparatus, the improvement of a shaft seal chamber adapted so as to offset displacement of said shaft in said case, said seal chamber comprising in combination a seal-bearing member provided with a bearing surface bearing on the circumference of a shouldered member rigidly affixed on the circumference of said shaft and a sealing surface bearing on a lateral side of said shouldered member so as to form a substantially gas tight seal therebetween, rotatably mounted

on and encircling said shouldered member so as to move longitudinally and coaxially with said shaft; a spring-like flexible expansible-contractible closure member, surrounding a short section of said shaft, attached at one of its two ends by a substantially gas-tight seal to said seal-bearing member; a closure ring slidably mounted on said shaft adjacent the unaffixed end of said flexible closure member; a casing ring having a substantially U-shaped cross-section encompassing said closure ring in such manner that a slip-joint is made between the lateral sides of said closure ring and the adjacent interior lateral sides of said casing ring, said casing ring being enlarged interiorly so as to be substantially larger of interior diameter than the outer diameter of said shaft and intermediate its lateral sides being interiorly larger than the outer diameter of said closure ring, said casing ring being affixed by a substantially gas-tight seal to the otherwise unaffixed end of said flexible closure member, said flexible closure member being adapted so as to force said seal-bearing member against said lateral side of said shouldered member; connecting means rigidly securing said casing ring to said apparatus case; and conduit means for injecting a fluid into said sealing chamber at a pressure at least as great as the pressure maintained within said apparatus, communicating between the space within said seal chamber and a sealing fluid supply source exterior of said sealing chamber.

4. The shaft seal chamber of claim 3, wherein said spring-like flexible expansible-contractible closure member is a tension member, adapted so as to maintain a substantially constant pressure on said seal-bearing member by tension.

5. The shaft seal chamber of claim 3, wherein said flexible expansible-contractible closure member is a spring bellows; and said connecting means surrounds at least a portion of said shaft seal chamber so as to restrict the flow of atmosphere about said shaft seal chamber.

6. The shaft seal chamber of claim 3, wherein said spring-like flexible expansible-contractible closure member is a compression member, adapted so as to maintain a substantially constant pressure on said seal-bearing member by compression.

7. In high temperature apparatus having a

rotatable shaft extending from the case for said apparatus, the improvement of a shaft seal chamber adapted so as to seal said shaft at projections through said apparatus case and to offset displacement of said shaft in said case, each said seal chamber comprising in combination a seal-bearing member mounted on said shaft, having an interior bearing surface and a lateral sealing surface, said sealing surface bearing on a lateral side of a shoulder extending around said shaft so as to form a substantially gas-tight seal therebetween and so as to move longitudinally and coaxially with said shaft; a spring-like flexible expansible-contractible closure member, surrounding a short section of said shaft, attached at one of its two ends by a substantially gas-tight seal to said seal-bearing member; a closure ring slidably mounted on said shaft adjacent the unaffixed end of said flexible closure member; a casing ring rigidly affixed to said case for said apparatus by a gas-tight seal, said casing ring enclosing said closure ring so as to form a slip-joint therebetween extending in a direction lateral to said shaft and being affixed by a substantially gas-tight seal to the otherwise unaffixed end of said flexible closure member; and conduit means for introducing a fluid into and removing said fluid from said sealing chamber at a pressure at least as great as the pressure maintained within said apparatus, communicating between the space within said seal chamber and a sealing fluid supply source exterior of said sealing chamber.

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