

[72] Inventor **Pieter F. Hoos**
Greensburg, Pa.
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[73] Assignee **Aloyco Incorporated**
Linden, N.J.
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This application Mar. 17, 1970, Ser. No. 20,234

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Primary Examiner—Henry T. Klinksiek
Attorney—Melvin R. Stidham

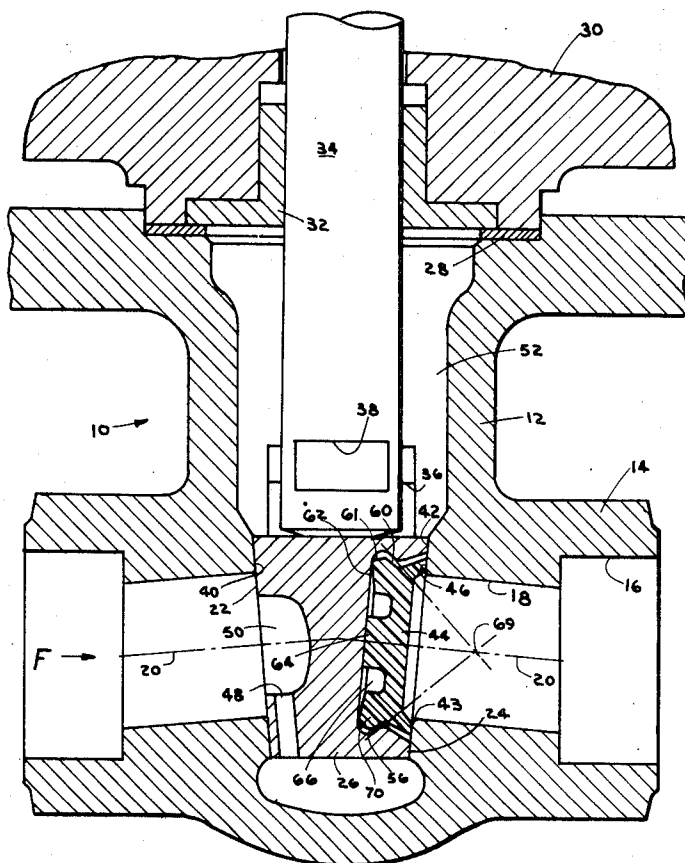
[54] **TEMPERATURE COMPENSATED PRELOADED SEAL**
7 Claims, 8 Drawing Figs.

[52] U.S. Cl..... 251/326
[51] Int. Cl..... F16k 3/30
[50] Field of Search..... 251/84, 85,
86, 88, 203, 326-328, 333, 357

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ABSTRACT: A valve seal assembly wherein a circular recess in the valve closure member accommodates a normally resilient circular seal member with a relatively narrow annular ridge around the outside of the front face to seal against the opposing working surface. Because of a central axial protuberance, the back of the seal engages the bottom of the recess only at the central portion in absence of distortion. However, an internal shoulder in the recess engages a radial shoulder around the seal member to rotate the sealing ridge about the protuberance toward the back of the seal recess so as to preload the seal in the nature of a Belleville spring washer. The internal shoulder in the recess is frustoconical with its projected apex located on the recess centerline and on, or outside of, the valve closure surface.



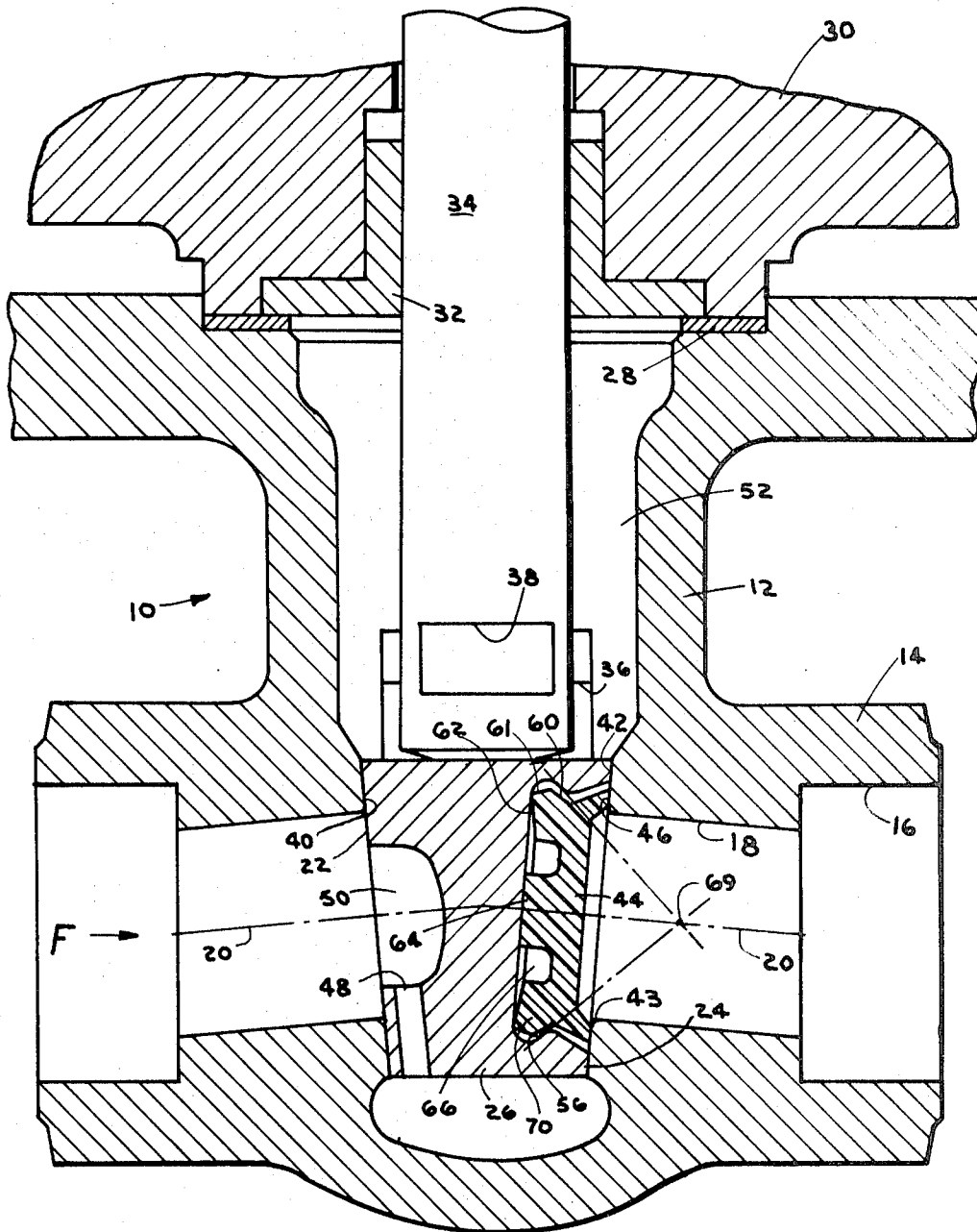
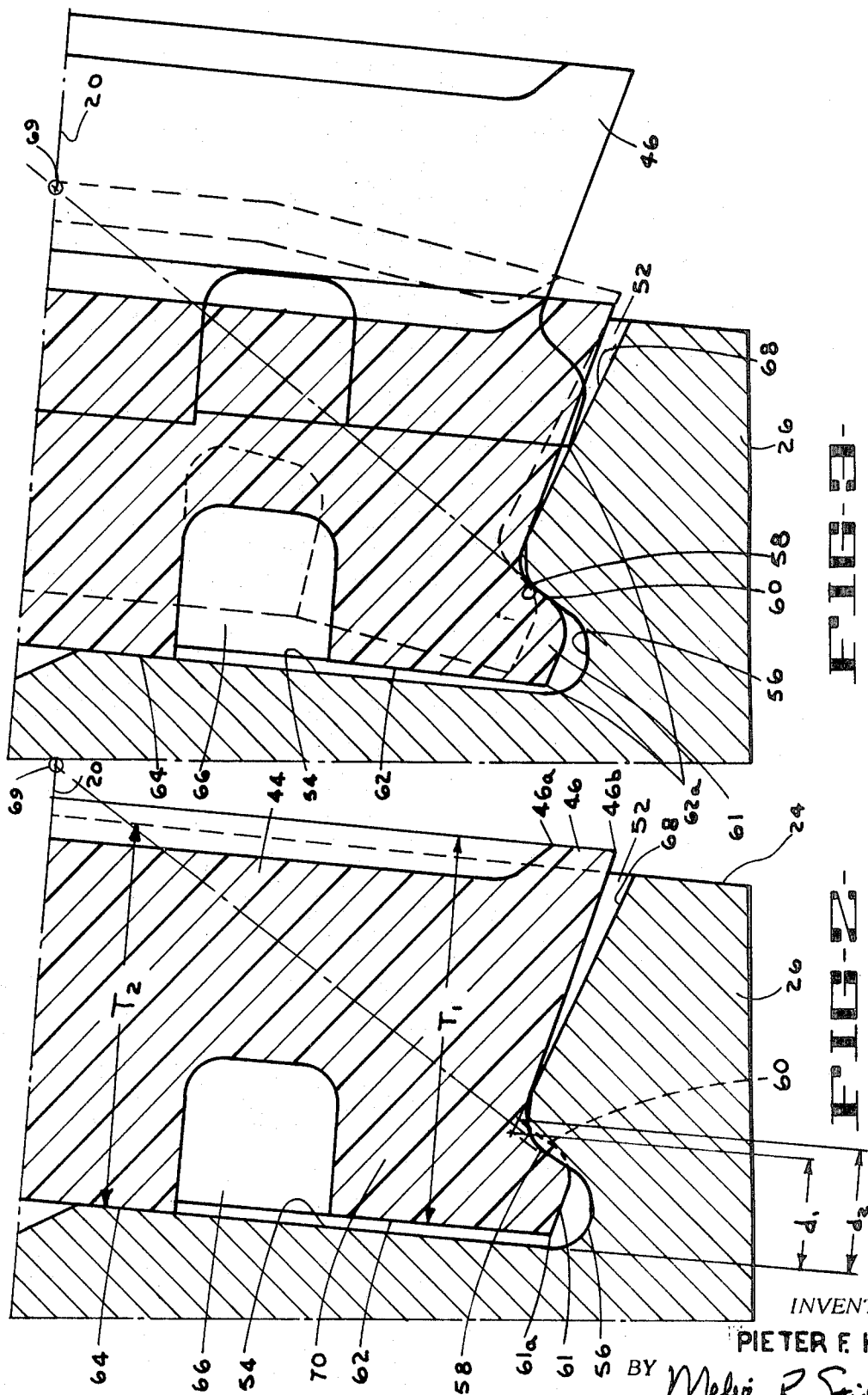


FIG-1-

INVENTOR,
PIETER. F. HOOS

BY Melvin R. Stidham

ATTORNEY



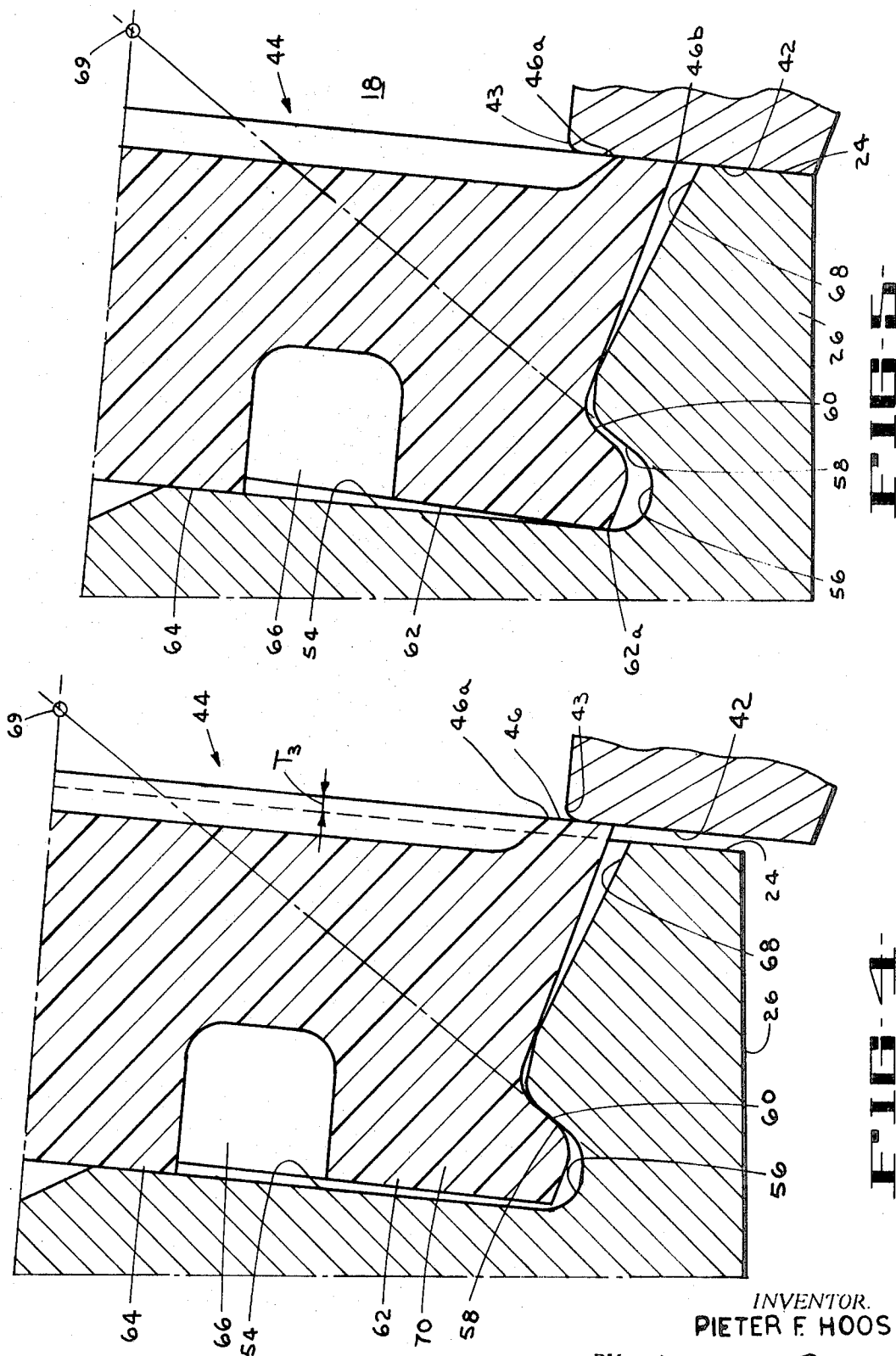


FIG. 5

FIG. 4

INVENTOR.
PIETER F. HOOS

BY *Melvin R. Stidha*

ATTORNEY

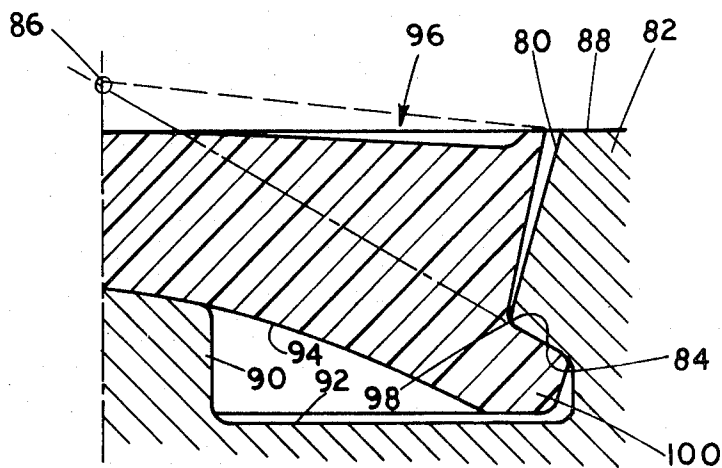


FIG. 6-

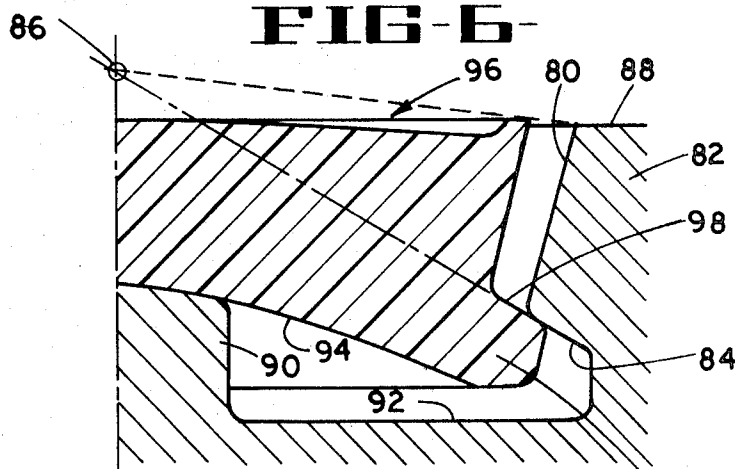


FIG. 7-

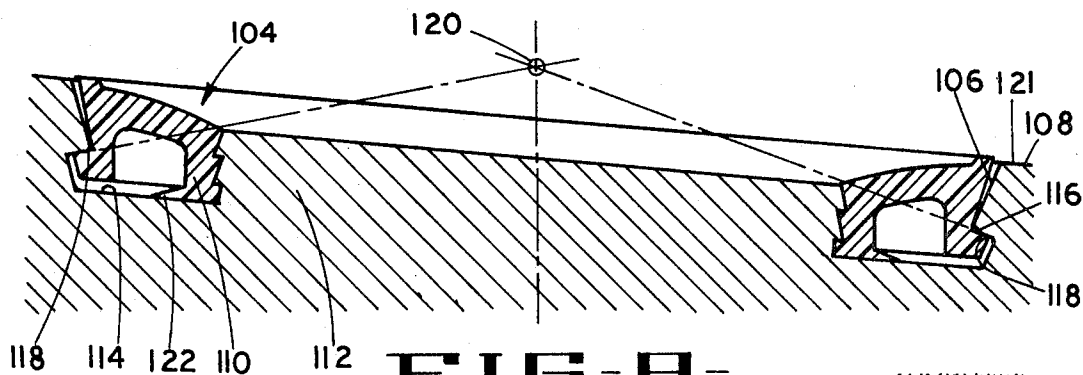


FIG. 8-

INVENTOR.
PIETER F. HOOS

BY *Melvin R. Friedman*

ATTORNEY

TEMPERATURE COMPENSATED PRELOADED SEAL

CONTINUATION-IN-PART

This application is a continuation-in-part of my copending application Ser. No. 758,462 filed Sept. 9, 1968 for "Pre-Loaded Valve Seal Assembly" now abandoned,

FIELD OF THE INVENTION

This invention relates to a preloaded seal assembly and, more particularly, to a valve seal assembly which is temperature compensated for use in a cryogenic system.

BACKGROUND OF THE INVENTION

Considerable difficulty has been encountered in attempting to utilize resilient seals in valves which are installed in cryogenic systems because such seals tend to lose their resiliency and become hard and brittle at the extremely low temperatures to which they are subjected in cryogenic use. This results in a loss of the characteristic ability of elastomeric materials to adjust to surface irregularities which require the materials to release stored energy under all pressures. The need for flexible pressure seals is intensified by reason of the thermal stresses, as well as those seat deformations which result from pipe shrinkage at the low cryogenic temperatures. Such stresses distort the seat sealing surfaces and render necessary a seal member which is capable of adapting to surface irregularities, particularly at low system pressure, where the pressure level is not high enough to load the seal over the complete annular area onto the opposite seat working area.

A cryogenic valve has to function over a very wide temperature range, preferably from high temperatures up to +160° F. to cryogenic temperatures as low as -450° F., e.g., liquid helium. To create a bubbletight seal, we force a relatively soft and yieldable material onto a hard seating surface. The natural or synthetic elastomeric materials cannot be used as they become too hard and brittle at temperatures below -175° F. We can use some of the fluoroplastic materials and make use of their cold flow properties in lieu of the loss of resiliency. At high temperatures the material will regain its resiliency and restore the deformation which was produced by cold flow. This can be regarded as elasticity with delayed action.

To yield this plastic material onto the seat requires high material stresses and because stress is the product of load and the inverse of area, the seal contact area should be as small as possible to require a small seal loading.

At cryogenic temperatures, the seal material requires much higher stresses to deform and yield than at room temperature, which means that a particular seal area can carry a much higher load at cryogenic temperature than it can at room temperature. The seal loading however is due to system pressure which can be the same at any temperature level.

OBJECTS OF THE INVENTION

It is, therefore, an object of this invention to provide a valve seal assembly which is temperature compensated to provide an effective seal under all temperatures using a plastic seal material with an inherent high coefficient of expansion in lieu of the conventional elastomeric materials.

It is a further object of this invention to provide a particularly configured valve seal member and accommodating recess which cooperate to retract the seal member at high temperatures and extend it at low temperatures.

It is a further object of this invention to provide a valve seal assembly wherein loading is transferred from a seal retention shoulder to the working seat area of the body with engagement of the valve sealing members.

It is a further object of this invention to provide a particularly configured valve seal member and accommodating recess which provide protection to the seal due to retraction at high temperature and increased extrusion at lower temperature.

SUMMARY OF THE INVENTION

In carrying out this invention, the valve closure member has a circular recess to accommodate a complementary circular seal member of a material which is resilient with respect to the valve seat at all temperatures. The seal member has an outer axial extension or ridge which extends beyond the face of the valve disc to function as the main sealing surface. A small central circular protuberance extends from either the bottom of the recess or the back of the seal to engage the seal member and the bottom of the recess in the center, while providing a clearance with the recess bottom radially outward of the protuberance. Complementary engaging internal and external shoulders on the circumferences of the recess and the seal member, respectively, are disposed relatively so that the radially outer portion of the seal member is pulled back toward the recess bottom, being rotated about the central protuberance. Hence, the seal member in normal condition in place in the closure member is preloaded in the nature of a Belleville spring. Even when so distorted, the sealing lip extends outside of the recess to provide a yieldable seal adapted to engage the annular working surface on the valve body. When the valve closure member is in firm sealing engagement in metal-to-metal contact with the opposing working surface, the outer sealing rim is rotated even further about the rearward protuberance to insure in addition to the metal-to-metal seal, a yieldable seal which is preloaded onto the annular working surface of the valve body.

At low temperature, the seal transfers the initial preload as well as the full line-pressure loading onto the working body-seat area, to create high material stresses in the sealing edge and yield or cold-flow the seal onto the seat. In order to make the seal extend further out of the disc recess at low temperatures than at high temperatures and thus preserve the sharp sealing ridge, the differential between the coefficients of expansion of the plastic seal material and the ferrous valve disc material is used to advantage in the geometry of the seal assembly. Specifically, the complementary engaging shoulders on the seal and in the recess are of frustoconical configuration with the projected apex on the seal centerline and beyond the valve closure surface. Hence, as the seal contracts relative to the closure the seal will slide up the conical retention shoulder toward the apex, extending the seal ridge further beyond the valve closure disc surface.

Other objects and advantages of this invention will become more apparent from the description following when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a partial section view of a wedge-type gate valve embodying features of this invention;

FIG. 2 is an enlarged section view of a seal embodying features of this invention superimposed on the cross section of the gate recess in which it is to be placed;

FIG. 3 is an enlarged section view showing steps in placement of the seal within its accommodating recess;

FIG. 4 is an enlarged section view of the seal in place before the gate is fully closed;

FIG. 5 is an enlarged section view showing the seal in place and deflected with the gate in metal-to-metal contact with the body seat;

FIGS. 6 and 7 are enlarged partial section views of another seal assembly embodiment; and

FIG. 8 is a section view of a third embodiment of the invention.

Referring now more particularly to FIG. 1 there is illustrated a wedge type of gate valve 10 the body of which 12 may be of cast construction with integral hubs 14. Bored into the hubs are pipe-communicating flow passages 16 which are generally coaxial with the pipeline (not shown) in which the valve 10 is to be connected. Continuing flow passages 18 are counterbored in the hubs with their axes 20 generally normal to the wedge faces 22 and 24 of the valve gate 26.

Sealed at the upper end of the body, as by means of a gasket ring 28 of resilient material is the valve bonnet 30 in which is carried a bonnet valve stem bushing 32 of bronze or the like which slidably receives the valve stem 34. On the lower end of the valve stem is carried the valve gate 26 as by a slidable connection of a C-coupling 36 with slots 38 in the sides of the stem 34. The slidable coupling permits limited axial movement of the gate 26 in order that it may accommodate itself to the wedging surfaces 40 and 42 of the valve body on the upstream and downstream side of the valve, respectively, the direction of flow being indicated by arrow F. The valve seal member 44 is preferably carried on the downstream side of the gate, and the downstream valve body wedging surface 42 which forms the annular body seat or working surface is preferably rounded at 43 around the flow passages 18 in order to eliminate any sharp edges which might cut or otherwise damage the resilient seal. The body working surface 42 is of sufficient internal diameter and at sufficient slope that the sealing ridge 46 of the seal member always engages within the area of the working surface 24 as it is lowered into closed position. Otherwise engagement of the periphery of the seal against the inner surface of the flow passage at 18 or 43 may cause a leak producing deformation of the seal ring periphery.

On the upstream side of the gate a vent passageway 48 is provided to open into a pocket 50 in order to prevent the entrapment of fluid within the valve body space 52. Unless so relieved, trapped fluid can cause severe damage to the valve body 12 as a result of thermal expansion. For example, a valve which is filled with fluid and then exposed to warm external temperatures may increase in pressure by several hundred pounds and cause considerable damage.

The seal of this invention 44 is particularly designed for sealing under cryogenic conditions, and therefore, the seal which is normally resilient at or near room temperature, is designed to provide a bubbletight pressure seal even though it may become extremely hard at cryogenic temperature. The manner in which this is achieved will now be described in greater detail.

Referring now to FIG. 2 there is shown an enlarged partial section view of the seal 44 superimposed upon a cross section of the gate 26 and its recess 52 in which the seal is to be contained. The recess has a circular bottom surface 54 which merges into an annular radial extension 56 forming an internal shoulder 58 adapted to receive a shoulder 60 on a substantially complementary radial extension 61 on the seal. The small flat portion of this shoulder 58 is of a frustoconical configuration with its projected apex 69 located in the center line 20 of the recess 52 and well beyond the plane of the wedge face 24 outside and away from the plane in which the seal ridge 46 will be located when assembled in the recess. The thickness T_1 of the outer annular portions 70 of the seal ring 44 measured from the outer sealing ridge 46 around the front of the seal to the backface 62 is equal to or slightly more than the depth T_2 of the recess, measured from the wedge face 24 to the bottom of the recess 54. A coaxial protuberance 64 from either the seal or the recess or from both, provides a fulcrum about which the radial seal extension 61 may be rotated. Here, the protuberance 64 is on the seal, with the principal support therefor on the bottom of the recess 54. The outer annular portions 70 of the seal 44 and the central protuberance 64 are separated by a relatively wide annular space 66 which permits radial contraction and deflection of the outer portion 70 of the seal ring, as will hereinafter be described.

When the seal is supported by engagement of the protuberance 64 on the bottom 54, the distance d_1 from the bottom of the recess 54 to a point on the recess internal shoulder 58 is less than the normal axial distance d_2 from the recess bottom 54, to a corresponding point on the external shoulder 60 of the seal. Hence, the external shoulder is pulled back when the seal member is in place as shown in FIGS. 3 and 4. That is, the radially outward portions 70 of the seal member is deflected axially towards the bottom of the recess 54 to preload the seal in the nature of a disc-type or Belleville spring.

The manner in which the seal 44 is placed is illustrated in FIG. 3 in three stages. There, the seal ring is inserted into the recess 54 until the bottom circumferential corner 62a of the seal comes into contact with the large frustoconical surface 68 of the seal ring recess. Thereafter, as shown in phantom, further force applied on the seal ring causes the radial extension 61 to be cammed inward by the frustoconical surface and this distortion is permitted by reason of the cantilever shape of the outer portions 70 which causes the lower section of the radial extension 61 to deflect inward. Finally, the radial extension 61 moves past the shoulder 58 and expands outward into the recess 56. By reason of the fact that the distance from the recess bottom 54 to the recess shoulder 58 is less than that to the seal ring shoulder 60, the outer portion 61, 62 of the seal member 44 is deflected axially through a slight angle, e.g., the outer rear portion of the seal is rotated between the enlarged rear center portions 64 and the engaging shoulders 58 and 60. Hence, the seal ring is deflected in the nature of a disc type of Belleville spring and, due to the resilience of the seal ring material, it is preloaded onto the frustoconical retention shoulder 58.

Referring now to FIG. 4, the seal member 44 is shown in its normal preloaded disposition, undistorted by fluid or sealing pressure. The sealing ridge 46 is limited in its protrusion beyond the face 24 of the disc 26 and is of such diameter, relative to the body seat 42 that initial contact of the sealing ridge is always within the surface of the body seat ring 42 when the freefloating valve gate 26 is lowered. This limited protrusion T_3 is to avoid engagement with the fluid passage bore 18 or the radius 43 which could deflect the seal 46 radially and, if it takes a permanent set, leakage may result. Then, as the valve gate 26 continues downward into firm metal-to-metal contact between the gate 26 and the body seat 42 the seal ridge 46 is forced downward to rotate the seal rim 70 even more until sealing engagement is between the inner diameter 46a of the outer sealing ridge and the working seat surface 42. That is, engagement of the ridge 46 with the body seat 42 produces further rotation of the seal ring so that the shoulder 60 will lift off the shoulder 58 transferring the preload onto the seat surface 42. Also, at the higher temperatures, the thickness of the seal T_1 is equal to or slightly more than the depth T_2 of the recess which will push the outer corner 62a onto the bottom of the recess 54 to create a seal between the recess bottom 54 and the opposing working surface of the body 42 in the event that the central portion of the seal member 44 leaks or is blown out.

It should be noted that the inner and outer edges 46a and 46b of the seal ridge 46 are preferably finished to a relatively sharp edge so that fluidtight line-sealing engagement is assured to form a positive seal even though the normal, characteristic resilience of the seal ring is lost at cryogenic temperatures. To create a good seal between two nonelastomeric surfaces, the contact area should be small enough to create a stress level which is close to the yield stress of the softest of the two surfaces to make the seal conform to the body seat.

With the seal exposed to cryogenic temperatures, the plastic seal material is very hard, which means that, to deform this material, specific loading has to be high. To create this high specific load or stress, when the seal is in contact with the seat, the contact area should be very small. The preferred seal contact is a line or "knife edge" contact, in which the stress in the seal material is as high as the yield stress of this material at the specific temperature level.

At this stress level, the seal material will yield at the higher points of contact to conform to the seat and thus create a leak-tight closure.

It is obvious that if we dimension the contact area for low temperature, we have not enough contact area at high temperature where the yield stress is low and the seal will deform easily.

To prevent excessive deformation of the seal material, the complete assembly is made temperature sensitive. The coefficient of expansion (and contraction) of the plastic seal materi-

al is larger than that of the valve closure members. When a seal is mounted in a conventional recess of a closure member, i.e., the valve disc, and at room temperature is worn or deformed to a point where the seal is flush with the disc face, at cryogenic temperature, the seal will shrink to a point below the disc face. This is because the seal will contract relative to the valve disc axially as well as radially.

However, by making the face of contact 58, 60 conical, with the apex 69 of the projected cone located beyond the seating surface 24 of the valve disc, the greater relative contraction of the seal member 44 will actually make the seal face 46 extend further beyond the seating surface 24. That is, as the seal member 44 contracts radially the shoulder 60 slides up the frustoconical retention shoulder 58 toward the apex 69 which may be located well beyond the surface 24 of the valve disc. Hence, the shoulder 60 moves outwardly as it contracts, and with the apex 69 beyond the valve disc surface 24, this more than compensates for axial contraction of the seal 44.

The reverse of this action is also important since at high temperatures the sealing edge 46 will be retracted partly into the recess where it will be protected against overloading or other seat damage. In addition, the seal 44 will expand in thickness where it will equal or exceed the recess depth T so that the outer corner 62a again seals with the bottom of the recess, protecting the center portion of the seal 44 against blowout.

Referring now to FIGS. 6 and 7 there is shown another embodiment of this invention wherein the recess 80 in the valve disc 82 has a frustoconical retention shoulder 84 with an apex 86 located beyond the surface 88 of the valve disc 82. A central fulcrum protuberance 90 extends outward from the recess bottom 92 to engage the concave bottom surface 94 of the seal member 96. A complementary frustoconical shoulder 98 on the seal member 96 rotates the outer portions 100 of the seal about the fulcrum to preload the seal. As the seal member 96 contracts relative to the valve disc 82, as shown in FIG. 7, the shoulder 98 will move up the slope of the retention shoulder 84 toward the cone apex 86. Preferably, the cone apex 86 is located far enough beyond the surface 88 of the valve disc that the increased protrusion by reason of engagement higher on the retention shoulder more than compensates for axial contraction of the seal member 96.

Referring now to FIG. 8, there is shown a ring-type seal 104 carried in a recess 106 in a valve disc 108. An annular central portion 110 is snugly received on a central hub 112 in the recess and engages the recess bottom 114 to function as the fulcrum. An external shoulder 116 is engaged by the tapered, frustoconical retainer shoulder 118 having its apex 120 beyond the surface 121 of the valve disc 108 to preload the seal as in the previously described embodiments. At lower temperatures, the seal shoulder 116 will move toward the apex 120 and the seal will shrink tighter onto the fixed hub 112 to increase the seal. If desired a pressure seal lip 122 may be provided around the central portion to increase the seal against the recess bottom 114 around the hub 112.

While the seal of this invention has been described in a wedge-type gate valve, it will seal equally well in other types of valves including a flatgate valve. Hence, the invention is not limited to a particular environment. Further, while this inven-

tion has been described in conjunction with preferred embodiments thereof, it is obvious that modifications and changes therein may be made by those skilled in the art without departing from the spirit and scope of this invention as defined by the claims appended hereto.

What is claimed is:

1. In a valve construction comprising a valve body member having flow passages therethrough and a valve closure member movable into and out of closed position wherein said flow passages are blocked, sealing means for said valve member comprising:

a circular recess in said closure member,
a flexible circular seal member in said recess,
an annular working surface on said valve body,
an annular sealing surface on said seal member adjacent the periphery thereof extending beyond the adjacent surface of said closure member to be engageable with said working surface when said valve member is in closed position,
a central protuberance forming a fulcrum between the back of said seal member and the bottom of said recess,
the axial distance from the plane of said sealing surface to the bottom of said recess being greater than the distance from the plane of said sealing surface to the plane of radially outward portions of the back of said seal, and
interengaging means on said closure member and radially outer portions about said protuberance toward the back of said recess so that said seal member is preloaded as a Belleville washer.

2. The combination defined by claim 1 wherein said interengaging means comprises:

a radial extension around said recess forming an internal radial retention shoulder of frustoconical configuration with the apex thereof located axially outward from said adjacent surface,

and a complementary external shoulder around said seal member.

3. The combination defined by claim 2 including:

relatively thin portions of said seal member around said central protuberance to enable said external shoulder to contract radially and be inserted past said internal shoulder for mechanical retention thereby.

4. The combination defined by claim 2 wherein:

the peripheral surface of said recess axially outward of said internal shoulder is frustoconical to accommodate said rotation of the outer portions of said seal member.

5. The combination defined by claim 2 wherein:

engagement of the surface of said closure member and said annular working surface produces further axial deflection of said radial outer portions of said seal member depressing said external shoulder off said retention shoulder.

6. The combination defined by claim 2 wherein:

the coefficient of expansion of said seal member is greater than that of said closure member so that relative contraction of said seal member along said frustoconical shoulder results in increased extension of said annular sealing surface.

7. The combination of claim 1 wherein:

said protuberance is an integral part of the seal member.

* * * * *