This invention relates to improvements in valve apparatus. In one of its aspects, it relates to valve apparatus in which upstream line pressure provides a force to assist in holding a closure member closed. In another of its aspects, it relates to such apparatus in which the face of a sealing strip of resilient material normally projects from the inner end of a closure member for sealably engaging an opposing surface in the bore of the valve body to close same.

One example of valve apparatus having both of these characteristics is a conventional blowout preventer which has two or more closure members forming about a pipe within the bore of the preventer body to close off the annulus between the pipe and bore, or for abutting with one another to close off an open bore. In a preventer of this type, the rams are adapted, in their closed position, to form a continuous surface with one another across their inner ends and with the guideways in which they are slideable along their sides and across their tops. Well fluid from beneath the closed rams is admitted to an effective pressure area on the outer end of each of which is larger than the effective area on the inner end thereof so as to provide a resultant force which supplements the force of the operator to maintain the rams closed. The face of the sealing strip which normally projects from the inner end of each ram provides an excess of resilient material which is extruded upon closing of the rams to activate sealing strip portions along the sides and over the tops of the rams into sealing engagement with the guideways.

It has been found, however, that although the admission of well fluid to the outer ends of the rams is advantageous in assisting the operator to hold them closed, this additional closing force has necessitated a correspondingly higher force to open the rams. This has in turn necessitated larger power operators which are not only costly but extremely inconvenient due to their size and need for a large storage of standby power. It has also been found that when such rams are opened and closed against high well pressures, the restriction of flow which takes place across the projecting faces of their sealing strips will damage the resilient material to the point of making it useless.

An object of this invention is to provide valve apparatus of this type, including blowout preventers and the like, having lower operating requirements for opening each closure member or ram under pressure.

Another object is to provide such valve apparatus which may be opened and, in some cases, closed under high pressure without substantial damage to the resilient material of the sealing strip across the inner end of each closure member or ram.

Still another object is to provide valve apparatus of this type having both of the aforementioned advantages.

The first of these objects is accomplished, in accordance with the present invention, by valve apparatus in which the closure member comprises separate parts extending longitudinally of the guideway in side-by-side relation. One of these parts is a carrier having means thereon for reciprocating it in opposite directions to open and close the bore of the valve body. The other is a plate which is connected to the carrier for limited longitudinal reciprocation with respect to it. The carrier and plate are sealed with respect to one another as well as with respect to the guideway in closed position to prevent the escape of pressure fluid from the chamber on their outer ends.

Due to the lost motion connection between the carrier and plate, the operator need overcome only the resultant force urging the carrier inwardly to separate the seal means across its inner end from the sealing surface in the body. Then, upon this initial movement of the carrier in an opening direction, the forces on opposite ends of the carrier are substantially balanced and the operator need overcome only the forces on the plate which resist its outward movement as the carrier reaches its limit of reciprocation with respect to the plate. As the carrier continues to move in an opening direction, the plate moves outwardly with it, with the forces across the entire carrier substantially balanced.

In accordance with a preferred form of the invention, by means of which all of the above-mentioned objects are accomplished, the inner end of the plate engages the surface in the body and extends laterally across one side of a sealing strip on the carrier to maintain the bore closed during this initial reciprocation of the carrier in the opening direction. In this manner, the face of the sealing strip is withdrawn from the surface in the body which it engages prior to the time that the bore is choked by the initial withdrawal of the inner end of the plate from the said surface. Thus, the greater proportion of wear due to the rush of well fluid past the closure member will occur across the inner end of the plate rather than across the face of the sealing strip.

In this preferred form of the invention, an area on the inner end of the plate adjacent one side of the sealing strip is recessed. Thus, as the face of the sealing strip is separated from the surface in the body, the upstream pressure is effective over such area to reduce the resultant force urging the plate inwardly which must be overcome by the operator during continued opening movement of the carrier.

The second of the above-mentioned objects is also accomplished by another form of the invention in which the plate for maintaining a closure in the bore upon initial opening movement of the carrier and separation of the face of the sealing strip from the surface in the body is yieldably urged toward such laggng position by a portion of the sealing strip which is disposed between the carrier and the outer end of the plate. This plate also serves to extrude the resilient material of the sealing strip for the purpose of activating the remainder of the seal means on the ram. More particularly, in this form of the invention, there may be two such plates, one on each side of the sealing strip portion, thereby enabling a more uniform extrusion of the resilient material.

In the drawings, wherein like reference characters are used throughout to designate like parts:

FIG. 1 is a side view of a blowout preventer construction in accordance with the preferred form of the present invention and with one side thereof in section to show one ram in closed position about a pipe in the bore of the preventer body;

FIG. 2 is a perspective view of an enlarged scale of a ram identical to those on the preventer of FIG. 1, except that, for purposes of illustration, it is a "blind" ram for closing an open hole in the bore;

FIG. 3 is an enlarged sectional view of a pair of blind rams of the type shown in FIG. 2 in closed position within the preventer of FIG. 1;

FIG. 4 is a view similar to FIG. 3, but during the initial opening movement of the rams;

FIG. 5 is another view of the rams in their opened position;

FIG. 6 is still another view of the rams upon initial engagement of the sealing strips thereacross with one another during the final closing movement of the rams;
FIG. 7 is a perspective view of the other form of ram constructed in accordance with the present invention and for use in a preventer body similar to that shown in FIG. 1; FIG. 8 is a cross-sectional view of the second form of rams in closed position within the body of a preventer; FIG. 9 is a view similar to FIG. 8, but during the in-between period of the rams of FIG. 2 and FIG. 7; FIG. 10 is another view in which the rams of FIGS. 8 and 9 have been moved to positions opening the bore of the preventer.

Referring now particularly to the drawings, there is shown in FIG. 1 a blowout preventer 20 having a body 21 of more or less conventional construction in which a bore 22 therethrough is intersected by a pair of oppositely disposed guideways 23. The opposite ends of the guideways are closed by bonnets 24 bolted or otherwise secured to the flanged ends of the body, and the upper and lower flanged ends of the preventer body are bolted or otherwise connected to flanges 25 and 26, respectively, to which other wellhead members (not shown) may be connected to provide continuations of the bore 22. Seal rings 27 are received in corresponding and oppositely disposed grooves in the flanges and the preventer body for sealing the connection therebetween.

The preferred form of the invention, closure members or rams 28 are disposed within the guideways 23 for movement longitudinally thereof between positions opening the bore 22, as shown in FIG. 5, and positions closing the bore, as shown in FIGS. 1 and 3. As previously noted, the rams may be "blind," as shown in FIG. 2, wherein they have flat inner ends which abut with one another to close off the bore when it is empty. On the other hand, the rams may be provided with registering recesses 28a extending vertically of their inner ends for fitting about a pipe 29, as shown in FIG. 1, and abutting with one another on opposite sides of the pipe to close off the annulus about the pipe. Obviously, and as well known in the art, the pipe ram of FIG. 1 and "blind" ram of FIG. 2 are interchangeable to suit the particular conditions desired. For purposes of simplicity, the novel features of the present invention will be described in connection with the blind ram which is shown in FIGS. 3 to 6 as well as FIG. 2.

As shown in FIGS. 1 to 6, ram 28 includes a carrier 30 threadedly connected to the inner end of a stem 31 sealably carried in the bonnet 24 for rotation without longitudinal movement. The outer end 32 of the stem is non-circular to accommodate a tool for rotating same to move the carrier toward and away from the bore. The interior of the carrier is recessed at 33 to accommodate the inner end of the stem as the carrier is rotated inwardly and outwardly with respect to it.

The lower side of the carrier 30 is slidable along the lower portion of the correspondingly contoured guideway 23, and a groove 34 is formed in the carrier longitudinally of the body to admit well fluid within the bore 22 below the ram to a chamber 34a in the guideway rearwardly of the carrier. A port 35 in the carrier connects the recess 34 with the groove to permit free movement of the inner end of the stem into and out of the recess. A plate 36 extends longitudinally between the top side of the carrier 30 and the upper portion of the guideway 23, and has a top side shaped correspondingly to the upper portion of the guideway for sliding longitudinally with it therefrom. As shown in the drawings, the lower side of this plate carries a seal member 37 of resilient material which extends laterally thereacross to provide a sliding seal between the plate and carrier. A lost motion connection between the carrier and plate includes a laterally extending slot 38 in the top side of the plate and a rib 39 on the lower side of the plate received within the slot for limiting longitudinal movement of the plate relative to the carrier between a first position in which it abuts the inner end of the slot, as shown in FIGS. 4 and 5, and a second position in which it abuts the outer end of the slot, as shown in FIGS. 2, 3 and 6.

Each ram 28 has means for sealing across its inner end and along its sides, and transversely across the top thereof. This sealing means includes a strip 40 of resilient material extending laterally across the inner end of the carrier as well as additional sealing strip portions 40a (FIG. 2) extending from the opposite ends of the strip 40 longitudinally along its opposite sides. Another sealing strip portion 41 is carried by the plate 36 and extends from the portions 40a laterally across the top plate 36. When the rams are closed, the sealing strip 40 will seal about a pipe within the bore as well as with respect to the strip 40 of the opposite ram, portion 41 will seal along the sides of the guideway, and the sealing strip portion 41 will seal across the upper portion of the guideway, in a manner to be described below. Also, as will be understood from the drawings, particularly FIG. 2, the seal strip 37 cooperates with sealing strip portions 40a and 41 to confine well fluid admitted through groove 34 to the chamber 34a.

As previously mentioned, it is conventional in blowout preventer rams of this general type, to provide the sealing strip with an outwardly projecting part for engagement with the object to be sealed about as well as an opposing or opposing face or sealing strip portion 40b and 41b. FIGS. 4 and 5, and a second position in which it abuts the outer end of the slot, as shown in FIGS. 2, 3 and 6. Each ram 28 has means for sealing across its inner end and along its sides, and transversely across the top thereof. This sealing means includes a strip 40 of resilient material extending laterally across the inner end of the carrier as well as additional sealing strip portions 40a (FIG. 2) extending from the opposite ends of the strip 40 longitudinally along its opposite sides. Another sealing strip portion 41 is carried by the plate 36 and extends from the portions 40a laterally across the top plate 36. When the rams are closed, the sealing strip 40 will seal about a pipe within the bore as well as with respect to the strip 40 of the opposite ram, portion 41 will seal along the sides of the guideway, and the sealing strip portion 41 will seal across the upper portion of the guideway, in a manner to be described below. Also, as will be understood from the drawings, particularly FIG. 2, the seal strip 37 cooperates with sealing strip portions 40a and 41 to confine well fluid admitted through groove 34 to the chamber 34a.

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be a resultant inwardly directed force for assisting the operator stem 31 in holding the rams closed. In conventional ram constructions, it would be necessary for the operator to overcome this entire resultant force in opening the rams. However, due to the lost motion between the inner end 36b and 35b, respectively, of the carrier and rams which, as will be understood, is dependent upon that portion of the face of the sealing strip 40 which seals against the face of the sealing strip 40 of the opposite ram. Then, as the faces of the sealing strips are separated from one another, well fluid is effective over the entire inner end of the carrier so as to at least substantially equalize the forces thereon.

When the carrier reaches its limit of rearward movement with respect to the plate by engagement of the rib 39 with the inner end of the slot 38, as shown in FIG. 4, the operator need overcome only the inwardly directed force resulting from the difference in effective pressure area of the inner end and outer end 36b and 35b, respectively, of the carrier and rams which, as will be understood, is dependent upon that portion of the face of the sealing strip 40 which seals against the face of the sealing strip 40 of the opposite ram. Then, as the faces of the sealing strips are separated from one another, well fluid is effective over the entire inner end of the carrier so as to at least substantially equalize the forces thereon.

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arated, as shown in FIG. 9. Thus, when the inner ends of the plates are also separated from one another upon continued opening of the carriers, the well fluid rushing through the chocked opening between the inner ends of the plates will not severely damage the face of the sealing strips 49 but, to the contrary, the greater proportion of the heat will take place across the inner ends of the plates which are made of relatively rigid material to confine the face of the sealing strip 49 similarly to the relatively rigid plate 36 of the previously described embodiment. Of course, upon closing of the rams, the bore will be chocked by the inner ends of the plate as they approach the FIG. 9 position. At this time, the faces of sealing strips are, as in opening, spaced outwardly of such inner ends.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matters herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. Valve apparatus, comprising a body having a bore therethrough and a guideway therein intersecting the bore, a closure member longitudinally slidable within the guideway to open and close the bore, and comprising a carrier and a plate extending longitudinally of the guideway in side-by-side relation, means for reciprocating the carrier to move the closure member between bore opening and closing positions, means operative to seal, in the closed position of the closure member, between the inner end of the carrier and a surface in the bore opposite the guideway and between the guideway and closure member along the sides and laterally across the closure member, means sealing between the carrier and plate to form with said first-mentioned seal means a pressure chamber in the guideway comprising in part pressure responsive surfaces on the outer ends of the carrier and plate, means for admitting fluid pressure on the space between the plate and opposite the plate into the chamber in the bore for urging each of the carrier and plate toward said surface in the bore, and means connecting the plate and carrier for limited longitudinal reciprocation with respect to one another upon initial reciprocation of the carrier in a direction to open the bore, whereby the seal means between the inner end of the carrier and said surface is separated prior to movement of the plate with the carrier.

2. Valve apparatus of the character defined in claim 1, wherein said first-mentioned seal means includes a sealing strip extending laterally across the inner end of the carrier and having a face normally projecting from said inner end to engage said surface, and at least a portion of the inner end of the plate extends laterally across one side of the sealing strip, in the closed position of the closure member, and is longitudinally reciprocated with respect to the carrier between a first position in which said portion of the inner end of the plate is substantially flush with the seal means on the inner end of the carrier, and a second position in which said portion of the inner end of the plate is engaged with said surface in the bore, to maintain said bore closed during said initial reciprocation of the carrier.

3. Valve apparatus of the character defined in claim 2, wherein there is a recessed area on the side of the inner end of the plate adjacent the face of the sealing strip which is held out of engagement with said surface during engagement of the remaining area therewith for exposure to the fluid pressure in the bore upon the separation of the face of the sealing strip from said surface.

4. A valve closure member, comprising a longitudinally extending carrier, a sealing strip of resilient material extending laterally across the inner end of the carrier, a plate extending longitudinally of the carrier in side-by-side relation thereto, means for moving the carrier in opposite longitudinal directions, said carrier and plate having smooth portions intermediate their inner and outer ends for sliding longitudinally within a guideway in sealed relation thereto and said outer ends having surfaces responsive to fluid pressure acting in a longitudinal direction over the cross sectional area of the intermediate smooth portions of said closure member, a lost motion connection between the plate and carrier to permit limited longitudinal reciprocation therebetween, and means sealing between the adjacent surfaces of the plate and carrier so that the plate may be held against movement with the carrier, during limited movement by the carrier in an outward direction, by a force due to fluid pressure on the fluid pressure responsive surface on its outer end.

5. A valve closure member of the character defined in claim 4, including additional sealing portions extending longitudinally from opposite ends of the first-mentioned strip along opposite sides of the carrier and then laterally across the plate rearwardly of the inner end thereof, said additional portions forming a continuation of the sealing means between the plate and carrier.

6. A valve closure member of the character defined in claim 4, wherein the face of the first-mentioned sealing strip normally extends beyond the inner end of the carrier, and the plate is reciprocable with respect to the carrier between a first position in which at least a portion of its inner end is substantially flush with and a second position in which such portion of its inner end extends beyond said face in its normal position.

7. A valve closure member of the character defined in claim 6, wherein the inner end of the plate is recessed along an area on the side thereof adjacent the face of the sealing strip across the inner end of the carrier.

8. Valve apparatus, comprising a body having a bore therethrough and a guideway therein intersecting the bore, a closure member longitudinally slidable within the guideway to open and close the bore, said closure member comprising a carrier having a sealing strip of resilient material extending longitudinally from opposite ends of the first-mentioned strip along opposite sides of the carrier and then laterally across the plate rearwardly of the inner end thereof, said additional portions forming a continuation of the sealing means between the plate and carrier.

9. A valve closure member of the character defined in claim 8, wherein the plate and carrier extend longitudinally of one another in side-by-side relation to dispose their inner and outer ends laterally adjacent one another and including means sealing between the adjacent faces of the carrier and plate.

10. A valve closure member of the character defined in claim 8, wherein said means for yieldingly urging the plate inwardly includes a portion of said sealing strip, said por-
tion being of resilient material and disposed between the carrier and the outer end of the plate.

11. A valve closure member of the character defined in claim 10, including another plate of relatively rigid material carried by the carrier with its inner end extending laterally across the other side of the sealing strip, and wherein said means for yieldably urging the other plate inwardly includes another portion of said sealing strip, said other portion being of resilient material and disposed between the carrier and the outer end of the other plate. 10

12. A valve closure member of the character defined in claim 8, including additional sealing strip portions of resilient material extending from opposite ends of said first-mentioned sealing strip along the sides of the closure member and then laterally thereacross.

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