Oct. 30, 1962 T. M. THOMAS, JR 3,061,013

BRIDGING PLUG

Filed Nov. 21, 1958

2 Sheets-Sheet 1

Fig. 1

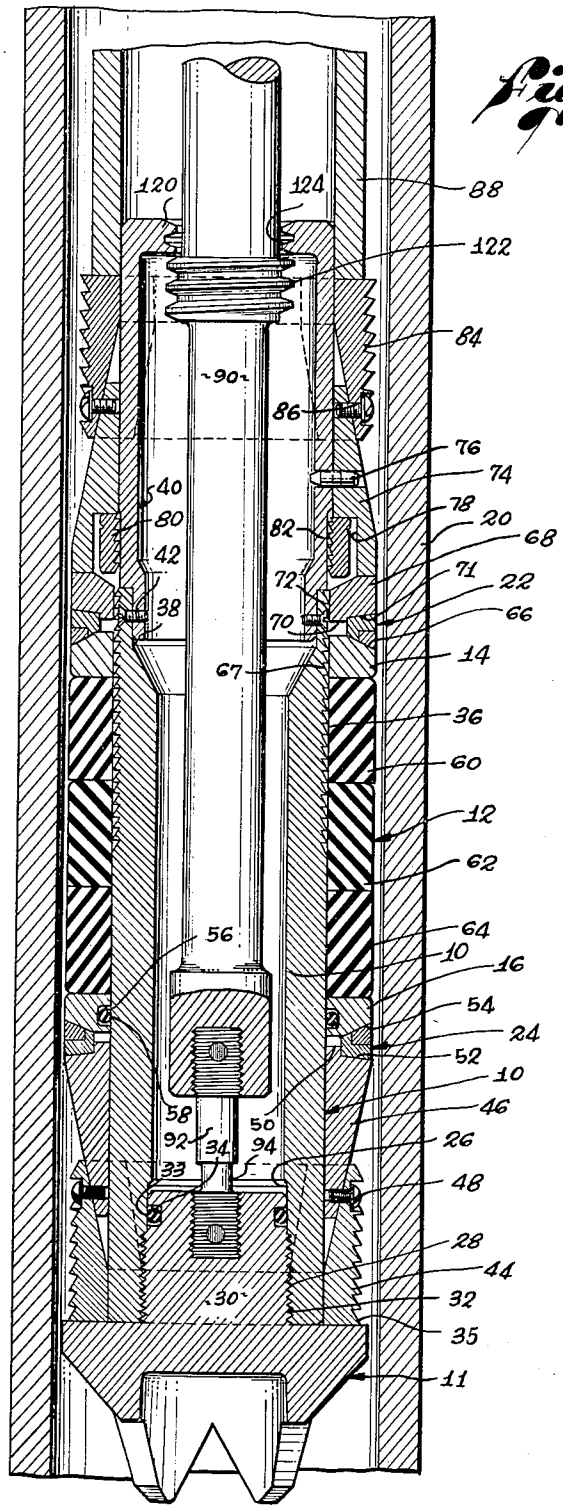
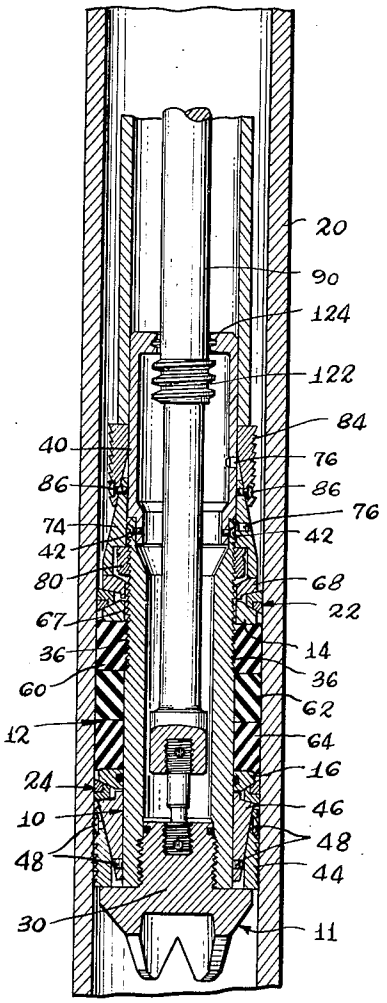


Fig. 2



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Fig. 3

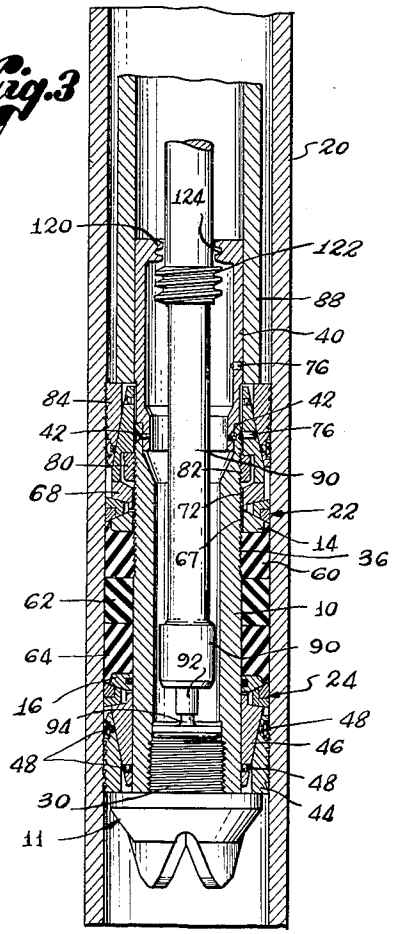


Fig. 4

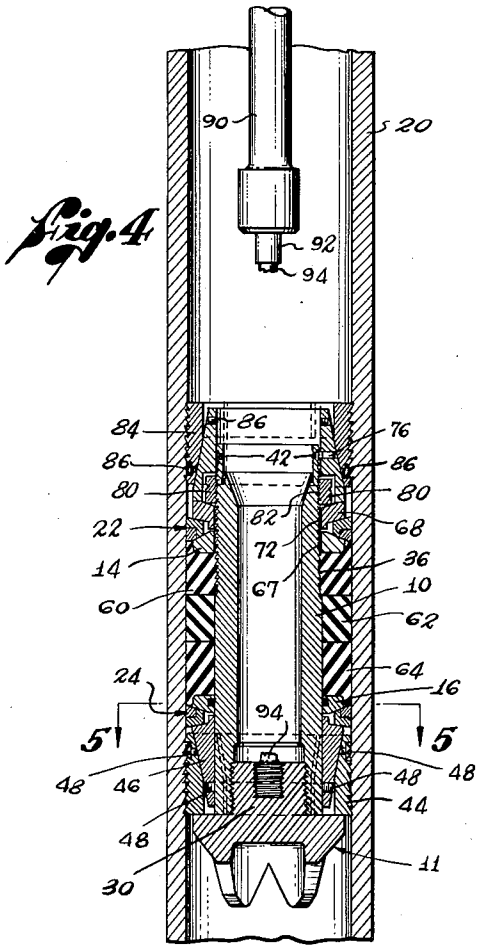


Fig. 5

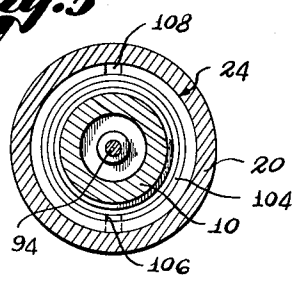
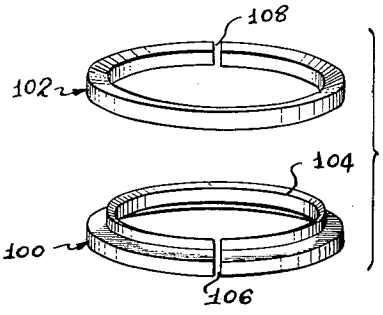


Fig. 6



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3,061,013

BRIDGING PLUG

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3 Claims. (Cl. 166—204)

The present invention relates generally to well packing devices and more particularly to bridging plugs and the like apparatus adapted to be set within well bore holes and casings.

Packing devices particularly of the bridging plug type are usually employed for the well-known purpose of closing or sealing off a lower portion of a well bore or to separate upper and lower sections thereof for various purposes. In bridging plugs of the usual type employing a double-ended, resilient packing sleeve body and a pair of sets of oppositely acting casing gripping devices such as serrated slips, it frequently happens that the material of the packing sleeve body will extrude axially toward the casing gripping devices. This is most likely to occur where the bridging plug is set in high temperature and/or high pressure well zones. Such extrusion of the packing sleeve body will usually result in a failure of the seal provided by the bridging plug. It is then necessary to provide another bridging plug at the desired zone. Such replacement is usually time-consuming and expensive and may require that the malfunctioning plug be removed by drilling.

It is accordingly an object of the present invention to provide a bridging plug in which the packing sleeve body will not extrude out of sealing relationship with the well bore.

It is a further object of the present invention to provide a well bridging plug which will have improved holding and sealing capabilities under conditions of high differential pressures and under conditions of high well temperatures.

A further object of the present invention is to provide a well bridging plug of the aforedescribed nature utilizing well-known construction and operational features of existing bridging plugs and not requiring other than a minimum increase in cost over the cost of conventional bridging plugs.

The objects of the present invention are accomplished in general by interposing a radially expandable metallic ring adjacent the ends of the packing sleeve body, such rings expanding into tight engagement with the well casing when the bridging plug is set so as to restrain extrusion of the packing sleeve material beyond the rings.

These and other objects and advantages of the present invention will become apparent from the following detailed description, when taken in conjunction with the appended drawings wherein:

FIGURE 1 is a longitudinal sectional view of a preferred form of bridging plug embodying the present invention as the latter appears when assembled ready to be lowered into a well or when being lowered or suspended within a well casing just prior to setting;

FIGURE 2 is a longitudinal sectional view of said bridging plug in reduced scale showing its appearance and positions of its parts after a setting operation has been initiated;

FIGURE 3 is a longitudinal sectional view of said plug showing its appearance and positions of its parts just after completion of the setting operation;

FIGURE 4 is a longitudinal sectional view of said plug showing its appearance and positions of its parts after the setting operation has been completed and its setting tool has been withdrawn;

FIGURE 5 is a horizontal sectional view taken on line 5—5 of FIGURE 4; and

FIGURE 6 is a vertically exploded perspective view of one of the expansion ring assemblies of said bridging plug.

Referring to the drawings and particularly FIGURE 1 thereof, a preferred form of bridging plug embodying the present invention includes a centrally located, elongated tubular body or mandrel 10 of substantially uniform external diameter throughout its length and terminating at its lower end in a bull plug 11 of greater diameter. A packing body 12 of resilient material encircles the intermediate portion of the mandrel 10 with its lower end in abutment with a lower packing expander ring 16 and its upper end in abutment with an upper packing expander ring 14. The packing assembly 12 initially has substantial clearance with the walls of the confining enclosure, such as a well casing 20, to insure its unimpeded lowering through the well bore to the desired point at which it is to be set. This is the condition indicated in FIGURE 1. When the bridging plug reaches the portion of the well bore at which it is to be set the packing body is axially compressed between the upper and lower packing expander rings 14 and 16 by suitable means to be fully described hereinafter. This axial compression of the packing body 12 effects its radially outward expansion against the well casing 20, as indicated in FIGURES 2, 3 and 4.

It is a particular feature of the present invention that the aforedescribed bridging plug includes upper and lower expansion ring assemblies 22 and 24, respectively, disposed immediately above and immediately below the packing body 12. These expansion ring assemblies are radially expandable from an initial retracted position shown in FIGURE 1 wherein their outer diameter approximates the outer diameter of the packing body 12 to a radially expanded position shown in FIGURES 2, 3 and 4 wherein their outer peripheries are tightly engaged with the well casing 20. In their expanded position, the expansion ring assemblies 22 and 24 restrain the material of the packing body 12 from extruding beyond the area disposed between these expansion ring assemblies.

More particularly, and with continued reference to FIGURE 1, the lower portion of the mandrel 10 is formed with a counterbore 26 of slightly enlarged diameter with this counterbore having internal threads 28. The bull plug 11 is formed with a boss 30 that has external threads 32 received by the threads 28 of counterbore 26. The upper portion of boss 30 is formed with an annular groove 33 wherein is disposed a resilient seal ring, such as an O-ring 34. The bull plug 11 includes an upwardly-facing shoulder 35 which abuts the underside of the mandrel 10. The upper intermediate portion of the external cylindrical surface of the mandrel 10 is formed with a length of downwardly-facing ratchet grooves or buttress threads 36 for a purpose to be described hereinafter. The upper portion of the mandrel 10 is formed with a counterbore 38 of enlarged diameter that receives the lower end of a pull-out sleeve 40. The latter is normally affixed within the counterbore 38 by a plurality of upper shear screws 42.

A plurality of lower wedge-shaped slips 44 having downwardly-facing serrations or wickers are normally positioned upon the upwardly facing shoulder 35 of the bull plug 11, with their upper portions being positioned about an upwardly diverging lower slip cone 46 that encircles the lower portion of the mandrel 10 and is axially slidably carried thereby. The upper portion of the lower slips 44 are initially affixed to the lower portion of the lower slip cone 46 by a plurality of lower shear screws 48. The lower slips 44 are adapted to undergo radial expansive movement towards the well casing 20 upon downward axial movement of the lower slip cone 46. The upper end

of the lower slip cone is formed with an upstanding annular lip **50** with the lower end of the latter merging into a downwardly and radially outwardly sloping shoulder **52**. The aforementioned lower expansion ring assembly **24** rests upon the shoulder **52** with its inner periphery encircling the slip cone annular lip **50**.

The aforementioned lower packing expander ring **16** rests upon the lower expansion ring assembly **24** and is axially slidably carried by the mandrel **10**. The lower portion of the packing expander ring **16** is formed with a downwardly and radially inwardly tapering shoulder **54** corresponding to the upwardly and radially outwardly tapering upper surface of the lower expansion ring assembly **24**. The lower packing expander ring **16** is formed at its radially inner portion with an annular groove **56**. A resilient sealing ring, such as an O-ring, **58** is disposed within this groove **56** so as to provide a fluid-tight seal between the ring **16** and the external surface of the mandrel **10** at this point.

The lower end of the packing body **12** abuts the upper end of the lower packing expander ring **16**. The packing body **12** consists of three separate rings designated **60**, **62** and **64**, preferably formed of a molded rubber of the synthetic type, such as neoprene, which material is resistant to the solvent effects of petroleum. The upper end of the top packing ring **60** abuts the underside of the upper packing expander ring **14** which ring is axially slidably carried on mandrel **10**. The upper expansion ring assembly **22** abuts the upper end of the upper packing expander ring **14**. The upper portion of the latter is formed with a downwardly and radially outwardly tapering shoulder **66** corresponding to the upwardly and radially outwardly tapering underside of the upper expansion ring assembly **22**. A back-up ring **68** abuts the upper end of the upper expansion ring assembly **22**, the back-up ring **68** being axially slidably carried by the upper end of the mandrel **10**. The lower portion of the back-up ring **68** is formed with a depending annular flange **70**, the outer circumferential surface of which merges into the lower end of a radially outwardly and upwardly extending shoulder **71** whereby the back-up ring **68** complementarily receives the upper portion of the upper expansion ring assembly **22**.

The upper end of the back-up ring **68** abuts the lower end of an upwardly converging upper slip cone **74**, the latter being axially slidably carried upon the pull-out sleeve **40**. The upper slip cone **74** is initially fixed against axial movement relative to the pull-out sleeve **40** by a shear pin **76**. The lower portion of the upper slip cone **74** is formed with a counterbore **78**. A split lock ring **80** is disposed within this counterbore **78**. The inner diameter of the locking ring **80** is formed with upwardly-facing buttress shaped grooves or threads **82** adapted to ratchet over and make one-way locking engagement with the downwardly-facing buttress shaped grooves or threads **36** of the mandrel **10**. A plurality of wedge-shaped upper slips **84** having upwardly-facing serrations or wickers are positioned upon the upper portion of the upper slip cone **74** with their upper portions encircling the pull-out sleeve **40**. The upper slips **84** are initially affixed to the upper slip cone **74** by a plurality of top shear screws **86**.

The upper surfaces of the upper slips **84** abut the lower end of a tubular ram adapter sleeve **88** forming a part of a conventional setting tool, the details of which are not encompassed within the present invention. The lower portion of the adapter sleeve **88** slidably telescopes over the upper end of the pull-out sleeve **40**. The lower tubular strut portion or connector rod **90** of the aforementioned setting tool depends coaxially through the pullout sleeve **40** and into the mandrel **10**. The lower end of this connector rod **90** is threadedly connected to the upper end of a rupture stud **92**. The lower end of the rupture stud **92** is threadedly connected to the upper end of boss **30** of the bull plug **11**. The rupture stud **92** is provided with a reduced-diameter necked portion **94**. The adapter sleeve **88** and the connector rod **90** may essentially resemble the outer sleeve extension of the cylinder and the inner piston parts, respectively, of a setting tool of any suitable type, for example, as disclosed respectively at 60 and 79 in Forsyth et al. Patent No. 2,566,323, at 11 and 13 in Spangler Patent No. 2,326,404, or at 6 and 16 in Batchelder Patent No. 2,382,770.

Referring now particularly to FIGURE 6, there is shown a vertically exploded persepective view of the lower expansion ring assembly **24**. It should be understood that the upper expansion ring **22** is substantially identical in construction to the lower expansion ring **24** but that the parts thereof are inverted. Each expansion ring assembly includes vertically stacked lower and upper split rings **100** and **102**, respectively. The lower split ring **100** is formed with an upstanding coaxial annular neck **104** having an inner diameter slightly smaller than the inner diameter of the upper ring **102** in order that the neck **104** may telescopically receive the upper split ring **102**. The gaps **106** and **108** of the lower and upper split rings **100** and **102**, respectively, should be vertically misaligned, preferably by 180 degrees when the rings are assembled. The upper and lower split rings should be formed of a hard, yet flexible, material, as for example, cast iron, that permits the expansion ring assemblies to undergo radially outward horizontal flexure without undergoing any change in cross-sectional dimension. As indicated in FIGURE 1, the expansion right assemblies **22** and **24** in their relaxed position have an outer diameter approximating that of the packing body **12**. The upper and lower surfaces of the lower expansion ring assembly **24** are flared radially outwardly so as to be received by the complementarily flared upwardly and downwardly facing surfaces of the lower packing expander ring **16** and the lower slip cone **46**, respectively. Similarly, the upper and lower surfaces of the upper expansion ring assembly **22** are flared radially outwardly so as to be received by the complementarily flared upwardly and downwardly facing surfaces of the back-up ring **68** and the upper packing expander ring **14**, respectively. Accordingly, when a longitudinal squeezing force is exerted upon the upper and lower expansion ring assembles, they will be wedged radially outwardly and expanded into tight engagement with the walls of the well casing **20**, as indicated in FIGURES 2, 3 and 4.

In the operation of the aforedescribed bridging plug, the plug assembled as shown in FIGURE 1 is lowered into the well bore upon a suitable setting tool as hereinbefore mentioned to the point at which it is desired to bridge the well. Setting force is then applied to the bridging plug from the setting tool, an upward tension being thereby transmitted through the connector rod **90** to the bull plug boss **30** and thence as an axial compressive force from the bull plug **11** upward through the bridging plug mandrel **10**. This upward compressive force is initially balanced by an equal downward compressive force applied from the setting tool through the adapter sleeve **88**, slips **84**, shear screws **86**, slip cone **74** and shear pin **76**. The upward force thus applied to the bridging plug mandrel **10** tends to move the mandrel **10** and pull-out sleeve **40** upwardly with respect to and in opposition to the downward force from the adapter sleeve **88** to a position such as that indicated in FIGURE 2. However, shear pin **76** initially resists such relative motion and opposing forces until the force reaches a value equal to the shearing strength of the pin. Upon shearing of the pin **76**, the opposing forces thus initially applied upwardly through the mandrel **10** and downwardly through the adapter sleeve **88** are suddenly transferred into a longitudinal compressive force acting through the several bridging plug elements on the mandrel between the bull plug shoulder **35** and lower slips **44** and the adapter sleeve **88** and the upper slips **84**. This force causes the bottom shear screws **48** to be next sheared. This permits further movement of the adapter sleeve **88** and bull plug **11** toward one another so as to cause the lower slip cone **46** to wedge the lower slips **44** radially

outwardly into engagement with the walls of the well casing **20**, as indicated in FIGURE 2. The beforementioned compressive force acting through the several bridging plug elements will also cause the upper and lower expansion ring assembles **22** and **24** to be squeezed radially outwardly and addtionally the packing body **12** will likewise be squeezed longitudinally and thereby expanded radially outwardly against the walls of the well casing **20**, as indicated in FIGURE 2. With continued reference to FIGURE 2, it should be noted that during the relative movement of the various parts carried by the mandrel **10**, the lock ring **80** will have ratcheted downwardly over the grooves **36** of the mandrel so as to lock the back-up ring **68** against return movement and thereby retain all of the relative downward movement as it takes place.

Referring now to FIGURE 3, continued downward movement of the adapter sleeve **88** relative to upward movement of the bull plug **11** will finally cause the top shear screws **86** to rupture. The upper slips **84** will then move downwardly relative to the slip cone **74** so as to be wedged thereby radially outwardly against the walls of the well casing **20**. Both the upper and lower slips **84** and **44**, respectively, will now be in tight gripping engagement with the inside surface of the well casing **20**. Additionally, the packing body **12** will be expanded into fluid-tight sealing engagement with the inside surface of the well casing. The upper and lower expansion ring assemblies **22** and **24** will likewise be maintained in tight engagement with the inside surface of the well casing. Accordingly, as indicated in FIGURE 3, the upper and lower expansion ring assemblies will serve to positively restain any extrusion of the material of the packing body **12** beyond the point of engagement of the expansion ring assemblies with the inside surface of the well casing **20**.

The mandrel **10**, and the parts encircling the mandrel, are now positively fixed against longitudinal movement relative to the well casing **20**. Accordingly, upon continued application of tensile force through the connector rod, the necked portion **94** of the rupture stud **92** will finally fail in tension. The connector rod **90** will then be free to move upwardly. Such upward movement of the connector rod **90** will be directly transferred to the upper wall **120** of the pull-out sleeve **40** by means of an enlarged-diameter threaded portion **122** of the rod. This threaded portion **122** of the connector rod **90** was originally screwed downwardly through complementary internal threads **124** formed on the pull-out sleeve's top wall **120**, when the parts of the bridging plug were assembled as shown in FIGURE 1. When the upwardly moving connector rod **90** thus exerts sufficient upward force on top wall **120** of the pull-out sleeve **40**, the shear screws **42** will fail and the pull-out sleeve **40** will be free to be withdrawn upwardly from the remainder of the bridging plug, the entire aforementioned setting tool being withdrawn upwardly through the well bore, leaving the bridging plug element set as shown in FIGURE 4. It should be particularly observed that the expansion ring assemblies **22** and **24** are urged into engagement with the walls of the well casing **20** prior to the time that the packing body **12** has undergone complete axial compression and resultant radial expansion into forceful sealing engagement with the borehole wall. This arrangement insures that the ends of the packing body will not be extruded beyond the points of engagement of the expansion ring assemblies and the inside surface of the well casing during the plug setting operation, and this permits the packing body to be set and maintained at high setting pressure.

With the bridging plug set as shown in FIGURE 4, the upper slips **84** securely anchor it in place against upwardly-directed forces produced by fluid pressures below the plug. The lower slips **44** similarly anchor the plug in place against the downwardly-directed forces produced by fluid pressures acting downwardly upon the plug. The expanded packing body **12** will serve to form a fluid-tight seal within the annulus between the mandrel body **10** and the inside surface of the well casing **20**. The bull plug **11** blocks fluid flow through the mandrel **10**. The material of the packing body will be positively restrained against movement beyond the upper and lower expansion ring assemblies **22** and **24**, even where the bridging plug is exposed to high temperature and high pressure conditions. Accordingly, the bridging plug will fulfill its well sealing function until such time as the plug is to be removed from the well bore. The offsetting of the gaps **106** and **108** of the expansion ring assemblies insures that the material of the packing body **12** cannot extrude axially through the gaps **108** of the ring elements **102**. In a bridging plug of the type herein disclosed, substantially all of its principal parts are preferably constructed of materials which are relatively easily drillable by ordinary well drilling tools. This permits removal of the bridging plug if necessary after the plug has been set.

It is to be understood that the foregoing is illustrative only and that the invention is not limited thereby, but may include various modifications and changes made by those skilled in the art without departing from the spirit of the invention or the scope of the following claims.

I claim:

1. In a bridging plug that is adapted to be lowered into a well bore, the combination of: a longitudinally extending mandrel; an annular packing body of elastic material encircling said mandrel; upper and lower packing expander rings axially slidably encircling said mandrel adjacent the upper and lower ends respectively of said packing body, the upper portion of said upper expander ring sloping radially inwardly and upwardly from its outer periphery and the lower portion of said lower expander ring sloping radially inwardly and downwardly from its outer periphery; upper and lower expansion ring assemblies encircling said mandrel, the upper assembly being disposed above the upper packing expander ring and the lower expansion ring assembly being positioned below the said lower expander ring, each of said assemblies including coaxially stacked upper and lower split rings circumferentially slidable upon one another, with the gaps of said rings being circumferentially off-set with respect to one another and the upper portion of each said assembly sloping radially inwardly and downwardly from its outer periphery with the lower portion of each said assembly sloping radially inwardly and upwardly from its outer periphery; a back-up ring axially slidably encircling said mandrel above said upper expansion ring assembly, the lower portion of said back-up ring sloping radially inwardly and downwardly from its outer periphery; a slip cone encircling said mandrel below said lower expansion ring assembly, the upper portion of said slip cone sloping radially inwardly and upwardly from its outer periphery; and means for effecting axial movement of said back-up ring toward said slip cone whereby said split rings will be equeezed radially outwardly against said well bore without undergoing any change in cross-sectional dimension, with said split rings thereby being positioned to directly engage the upper and lower end portions of said packing body so as to restrain the material of said packing body against movement longitudinally beyond said upper and lower expansion ring assemblies.

2. In a bridging plug that is adapted to be lowered into a well bore, the combination of: a longitudinally extending mandrel; an annular packing body of elastic material encircling said mandrel; upper and lower packing expander rings axially slidably encircling said mandrel in contact with the upper and lower ends respectively of said packing body, the upper portion of said upper expander ring sloping radially inwardly and upwardly from its outer periphery and the lower portion of said lower expander ring sloping radially inwardly and downwardly

from its outer periphery; upper and lower expansion ring assemblies encircling said mandrel, the upper assembly being disposed above the upper packing expander ring and the lower expansion ring assembly being positioned below the lower expander ring, each of said assemblies including coaxially stacked upper and lower split rings circumferentially slidable upon one another with the gaps of said rings being circumferentially off-set with respect to one another and the upper portion of each said assembly sloping radially inwardly and downwardly from its outer periphery with the lower portion of each said assembly sloping radially inwardly and upwardly from its outer periphery; a back-up ring axially slidably encircling said mandrel above said upper expansion ring assembly, the lower portion of said back-up ring sloping radially inwardly and downwardly from its outer periphery; a slip cone encircling said mandrel below said lower expansion ring assembly, the upper portion of said slip cone sloping radially inwardly and upwardly from its outer periphery; and means for effecting axial movement of said back-up ring toward said slip cone whereby said split rings will initially be squeezed radially outwardly against

the sides of said well bore without undergoing any change in cross-sectional dimension, whereafter said packing body will be squeezed radially outwardly against said well bore with said split rings thereby being positioned directly to engage the upper and lower end portions of said packing body so as to restrain the material of said packing body against longitudinal extrusive movement beyond said upper and lower expansion ring assemblies.

3. Apparatus according to claim 2, and lock means associated with said back-up ring and operative in connection with said mandrel to allow said back-up ring to be moved toward said slip cone as aforesaid but to lock said back-up ring upon said mandrel against retrograde movement.

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