June 4, 1968 R. T. EVANS 3,386,764

OVERSHOT FOR RETRIEVABLE BRIDGE PLUG

Original Filed Dec. 26, 1963 3 Sheets-Sheet 1

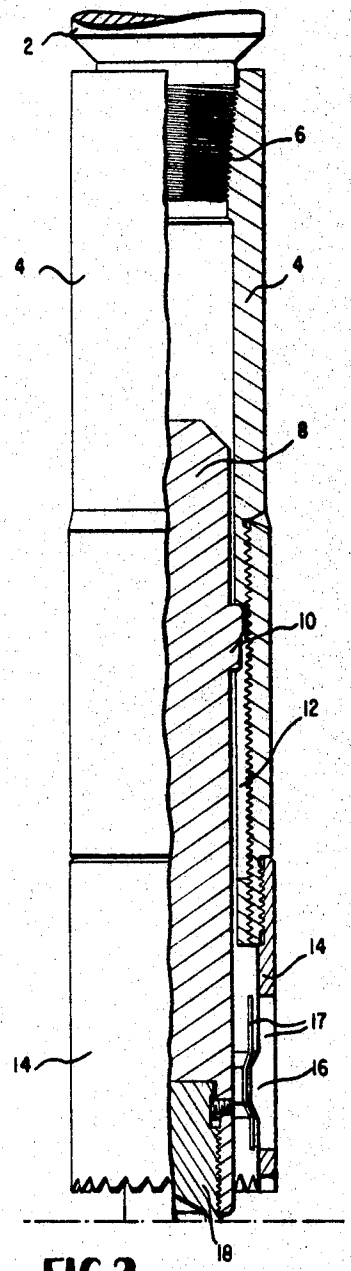


FIG. 2

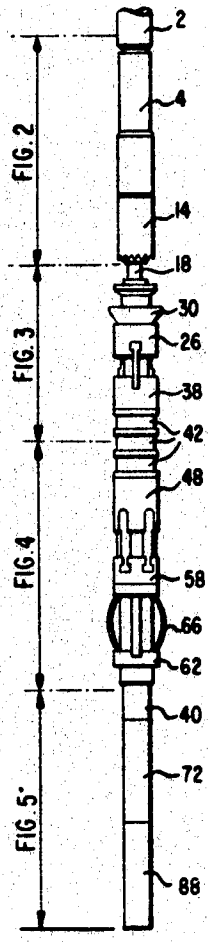
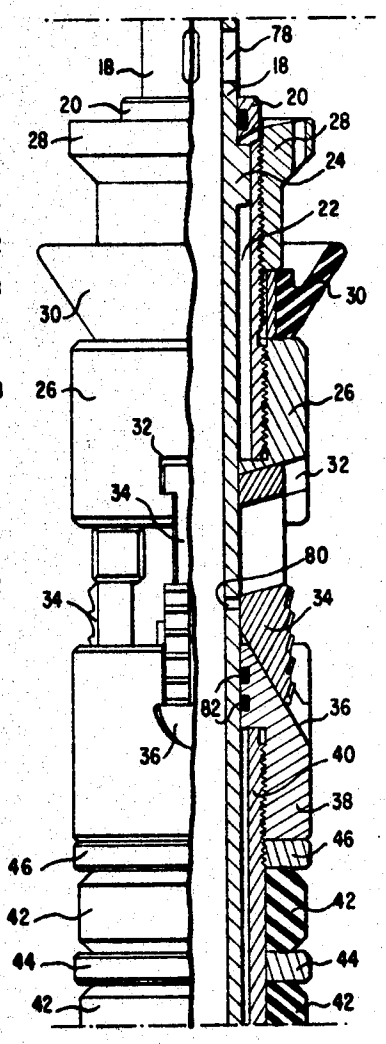


FIG. 1

FIG. 3



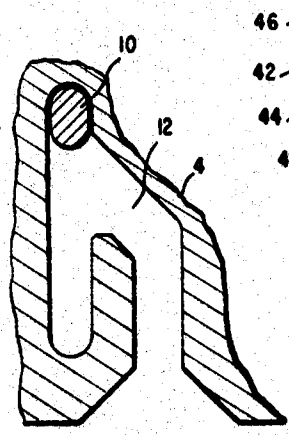


FIG. 2A

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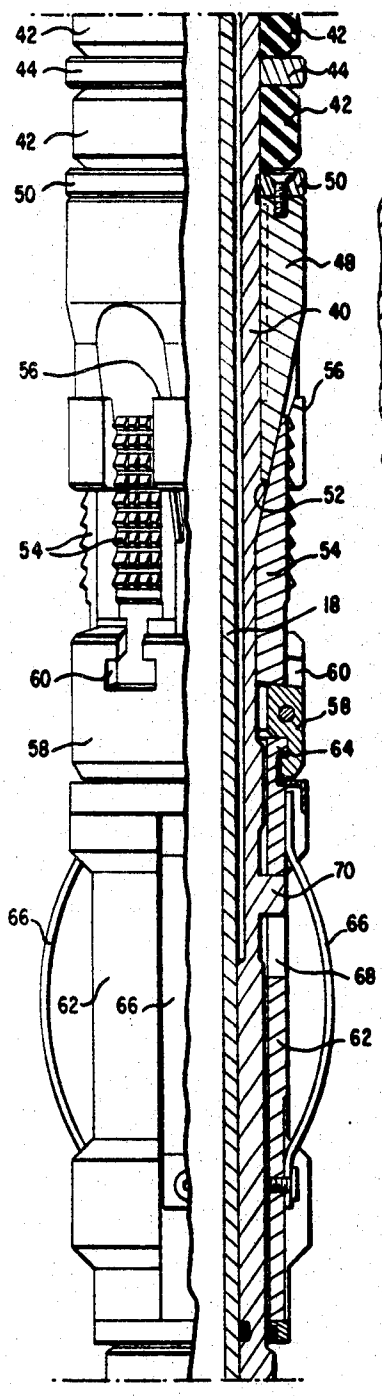
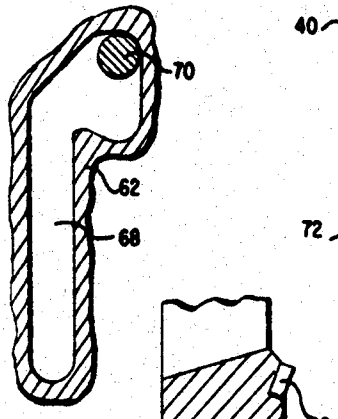


FIG. 4

FIG. 4A



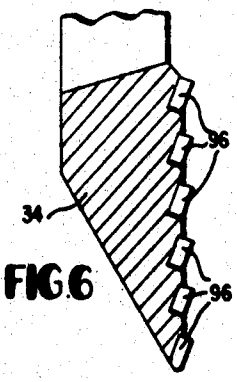


FIG. 6

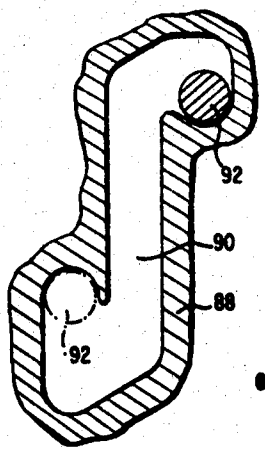


FIG. 5A

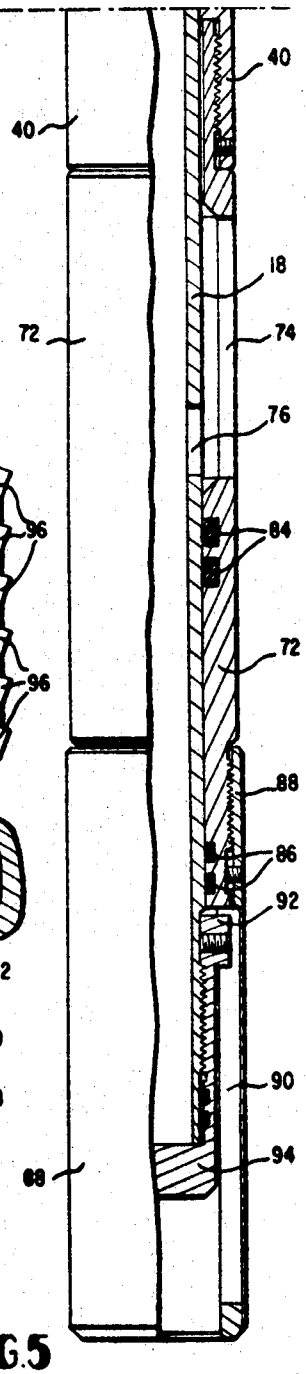


FIG. 5

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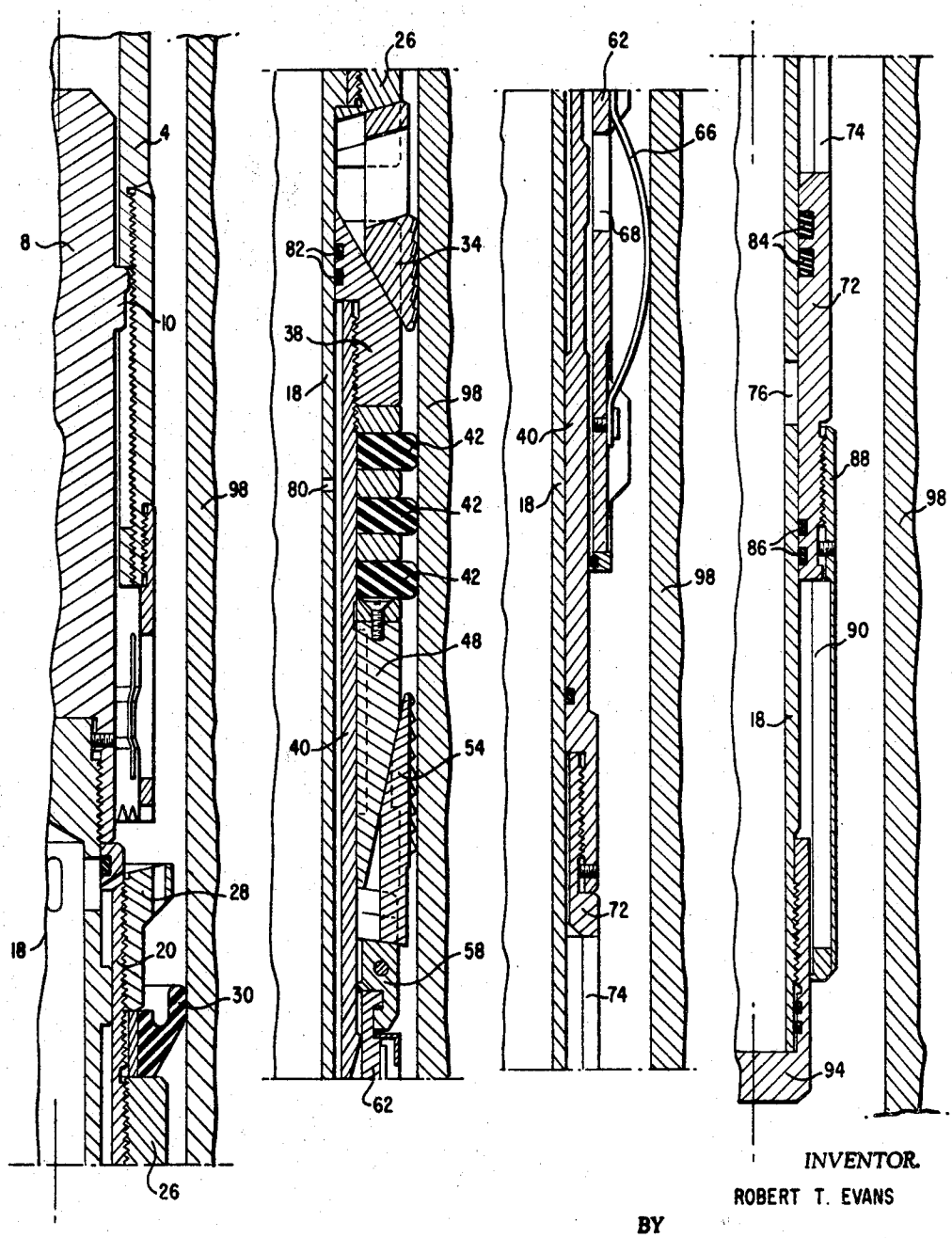
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FIG. 7 FIG. 8 FIG. 9 FIG. 10



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OVERSHOT FOR RETRIEVABLE BRIDGE PLUG

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Original application Dec. 26, 1963, Ser. No. 333,499, now Patent No. 3,308,886, dated Mar. 14, 1967. Divided and this application Dec. 15, 1966, Ser. No. 608,715
5 Claims. (Cl. 294—86.1)

This is a division of application Ser. No. 333,499 filed Dec. 26, 1963, now Patent 3,308,886.

This invention relates to a retrievable bridge plug and, more particularly, to a packer type retrievable bridge plug.

A packer type bridge plug includes packer rings which are expanded against the casing to separate one portion of the well from another. The common method of expanding the packer rings is to utilize fluid pressure to provide the force to distort the rings sufficiently for them to engage the well casing. Usually, fluid pressure not only expands the packer rings, but also maintains the packer rings in the set position. Fluid pressure differentials for expanding the packer rings are created by O-rings, or other types of seals. Since the seals are exposed to well fluids and high subsurface temperatures, they become deteriorated rapidly and failure of the seals may cause the packer rings to collapse unexpectedly.

Another problem associated with packer type bridge plugs is that a fluid pressure differential acting across the packer rings often causes the packer to be displaced in the casing. Slips may be provided on the bridge plug to resist its displacement, but the slips are actuated in response to the pressure differential on the packer rings. They are in a neutral or non-engaging position when no pressure differential exists. As the pressure differential changes from one face of the packer ring to the opposite face, the slips must disengage the casing, pass through the neutral position, then engage the casing in the opposite direction. While the slips are moving through the neutral position, the tool is free to move away from its desired position in the well, and therefore it may not be at the desired depth when the slips again engage the casing.

Accordingly, it is an object of this invention to provide a retrievable packer type bridge plug which may be set independently of fluid pressure.

It is a further object of this invention to provide a packer type retrievable bridge plug which resists movement relative to the casing after the packer is set.

It is a still further object to provide means for equalizing fluid pressure on opposite sides of the packer ring, before the ring is collapsed.

It is another object to provide a retrievable bridge plug which gives an indication at the surface after the packer is set of whether the tubing string is connected with the tool.

These objects are accomplished in accordance with a preferred embodiment of the invention by a bridge plug having packer rings mounted on a packer mandrel. A control mandrel is telescoped within the packer mandrel and a retrieving head is secured to the upper end of the control mandrel. Slips are mounted in mechanical bodies above and below the packer ring. The upper mechanical slip body is secured on the packer mandrel and the lower mechanical slip body is mounted on the packer mandrel for longitudinal movement thereon. The lower slips are set first by right-hand rotation and downward movement of the control mandrel, thereby moving a lug on the control mandrel in a J-slot. This movement of the control mandrel closes ports in the control mandrel above and below the packer rings. Drag springs engage the casing and resist movement of the drag spring sleeve while the control mandrel moves downwardly. At the same time, a lug on the packer mandrel moves out of a locked position in a J-slot in the drag spring sleeve. The slips move outwardly along an inclined surface on the lower mechanical slip body until they engage the casing. As the control mandrel moves downwardly, a shoulder on the mandrel engages the upper slip control body, thereby displacing the body downwardly relative to the lower slips. The downward movement of the slip control body moves an inclined surface on the upper mechanical slip body under the upper slips to displace them outwardly against the casing. At this point, the upper and lower slips are in engagement with the casing, but the packer rings are not yet expanded.

The downward force which is applied by the control mandrel to the slip control body causes the slip control body, the upper slips and the upper mechanical slip body to move downwardly. Since downward movement of the lower mechanical slip body relative to the casing is resisted by the lower slips which grip the casing, the packer rings are compressed axially and expand radially outwardly against the casing. During the expansion of the packer rings, the upper slips slide along the casing wall. The teeth on the slips slope away from the casing toward the packer rings, so that they do not bite into the casing until the slips are urged in the upward direction. After the packer rings are expanded, the upper slips bite into the casing to keep the packer rings expanded and to prevent movement of the tool. Continued right-hand rotation of the control mandrel, after the packer rings are expanded, moves the lug on the control mandrel into a locked position in its J-slot. The control mandrel then cannot be moved upwardly.

The bridge plug is released from the tubing by right-hand rotation and upward movement of the tubing string to cause a lug on the retrieving head to move out of the open end of a J-slot in the overshot. An overshot nose on the lower end of the overshot has an internal circumferential ridge. The diameter of the retrieving head plus the length of the lug is slightly greater than the internal diameter of the ridge, so that there is an interference fit between the lug and the ridge. Accordingly, a greater upward pull on the tubing string is required to raise the overshot nose across the lug, thereby serving as an indication at the surface that the bridge plug is set and that the overshot is released.

The control mandrel is provided with radial ports for equalizing fluid pressure in the annular space between the tool and the casting above and below the packer rings. When the control mandrel is displaced upward relative to the packer mandrel, the ports are opened, but when the control mandrel is displaced downward, the ports are closed, thereby blocking fluid communication through the tool, when the packer rings are set.

This preferred embodiment of the invention is illustrated in the accompanying drawings in which:

FIG. 1 is a schematic elevational view of the retrievable bridge plug of this invention attached to a tubing string;

FIG. 2 is an elevational view, partially in section, of the top portion of the bridge plug, as indicated in FIG. 1;

FIG. 2A is a schematic view of the J-slot in the overshot;

FIG. 3 is an elevational view, partially in section, of the upper intermediate section of the bridge plug, as indicated in FIG. 1;

FIG. 4 is an elevational view, partially in section, of the lower intermediate portion of the bridge plug, as indicated in FIG. 1;

FIG. 4A is a schematic view of the J-slot in the drag spring sleeve;

FIG. 5 is an elevational view, partially in section, of the bottom portion of the bridge plug, as indicated in FIG. 1;

FIG. 5A is a schemtaic view of the control J-slot in the J-slot body;

FIG. 6 is an enlarged cross sectional detail view of one of the upper slips;

FIG. 7 is a cross sectional view of the top portion of the bridge plug, after the packer rings have been set in a well casing;

FIG. 8 is a cross sectional view of the upper intermediate portion of the bridge plug, after the packer rings have been set;

FIG. 9 is a cross sectional view of the lower intermediate portion of the bridge plug, after the packer rings have been set; and

FIG. 10 is a cross sectional view of the bottom portion of the bridge plug after the packer rings have been set.

The retrievable bridge plug is attached to a coupling **2** on the end of a tubing string. An overshot **4** has internal screw threads **6** which cooperate with the threads on the coupling **2** to secure the overshot **4** to the coupling **2**. A retrieving head **8** is telescoped in the ovrshot **4** and a lug **10** on the retrieving head cooperates with an internal J-slot **12** in the overshot **4** to control the position of the retrieving head **8** relative to the overshot. An overshot nose **14** is secured to the lower end of the overshot. The nose **14** has a ridge **16** extending around the interior wall of the nose. The diameter of the retrieving head plus the length of the lug **10** is slightly greater than the internal diameter of the ridge **16**, thereby forming an interference fit therebetween. The wall of the nose **14** has a plurality of slots **17** which allow the nose to expand slightly as the lug **10** is forced over the ridge **16**. The retrieving head is secured by screw threads to the upper end of a control mandrel **18**. The mandrel **18** extends downward from the retrieving head **8** to the lower end of the bridge plug.

A slip control body **20** is telescoped over the control mandrel **18** and relative movement between the body **20** and the mandrel **18** is controlled by a cylindrical recess **22** in the body **20**. A collar **24** on the mandrel **18** is movable in the recess **22**. At the lower end of the body **20**, an upper slip retainer ring **26** is secured to the body **20** by screw threads. A junk catcher **28** is also threadedly secured on the slip control body **20** and a resilient cup **30** is clamped between the junk catcher **28** and the slip retainer ring **26** to prevent sand settlement around the upper slip assembly.

The slip retainer ring **26** has a plurality of T-slots **32** spaced around the circumference of the ring **26** and upper slips **34** each have one end mounted in one of the T-slots **32**. The lower end of each slip **34** has lateral flanges for cooperating with inclined T-slots **36** in a mechanical slip body **38**. The T-slots **36** slope downwardly, so that upon downward movement of the slips **34**, they will move outwardly in the slots **32** and **36**. The upper mechanical slip body **38** is movable longitudinally along the control mandrel **18** and is threadedly secured to a packer mandrel **40**. A plurality of packer rings **42** and spacer rings **44** are mounted on the mandrel **40** for sliding movement relative thereto. A spacer ring **46** is also threaded on the mandrel **40** between the slip body **38** and the first packer ring **42**. A lower mechanical slip body **48** on the mandrel **40**, having a spacer ring **50** secured thereto, is movable upwardly along the mandrel **40**. A shoulder **52** on the mandrel **40** prevents downward displacement of the body **48** relative to the mandrel and facilitates retraction of the lower slips. A plurality of slips **54** are spaced around the circumference of the packer mandrel **40** and each slip has one end mounted in one of the inclined T-slots **56** formed in the lower mechanical slip body **48**. The slips are retained in their respective T-slots **56** by lateral flanges on opposite sides of the slips. A split ring collar **58** having T-slots **60** formed therein is mounted on the packer mandrel **40** below the slips **54** and the opposite end of each lower slip **54** is mounted in one of the T-slots **60**. A drag spring sleeve **62** is mounted on the packer mandrel **40**, as shown in FIG. 4, and the collar **58** extends over a flange **64** on the sleeve **62**, so that the collar **58** and the sleeve **62** are connected together. Drag springs **66** having their opposite ends secured in the sleeve **62** are bowed outwardly to engage the walls of the casing. A J-slot **68**, as shown in FIG. 4A, is formed in the sleeve **62** and a lug **70** formed on the packer mandrel **40** extends radially outward through the J-slot **68**.

A bypass body **72** is threadedly secured to the lower end of the packer mandrel **40** and has a port **74** therein. The control mandrel **18** has bypass ports for providing fluid communication above and below the packer rings. There is a lower bypass port **76** in the control mandrel **18** in alignment with the port **74**, as shown in FIG. 5. Other bypass ports **78** and **80** are located in the control mandrel above the packer rings **42**. When the control mandrel **18** is displaced downward, O-rings cooperate with the mandrel to prevent leakage of fluid through the ports **76** and **80**. A pair of O-rings **82** are mounted in the mechanical slip body **38** to form a seal for the port **80**. The port **76** is sealed between two pairs of O-rings **92** and **94**, when the mandrel **18** is displaced downward.

A J-slot body **88** is threadedly secured to the lower end of the bypass body **72**. The J-slot body **88** is provided with a J-slot **90** having the shape shown in FIG. 5A. A lug **92** on a mandrel cap **94**, which is secured to the lower end of the control mandrel **18**, cooperates with the J-slot **90** to control the relative position of the mandrel **18**.

As shown in FIG. 6, the upper slips **34** have teeth **96** thereon for gripping the well casing. The teeth slope upwardly away from the packer rings. therefore, the teeth on the slips **34** may slide downwardly along the casing, but movement in the upward direction causes the teeth to become wedged against the casing. The teeth may be individual segments of a hard material, such as tungsten carbide, to avoid damaging the teeth as they are sliding along the casing. The tooth segments may be set into the slip and cemented in place.

FIGS. 7 to 10 show the tool as it is set in a casing, which is shown schematically at **98**. When the packer is lowered into a well, the ports **76**, **78** and **80** communicate between the interior of the control mandrel **18** and the annular space between the packer tool and the casing. When the desired depth for setting the packer rings is reached, the mandrel **18** is given a sufficient right-hand rotation to move the lug **92** out of the short upper portion of the J-slot **90**, as shown in FIG. 5A, to the long portion of the J-slot. The drag springs **66**, which engage the casing, resist movement of the sleeve **62**, and, while the lug **92** is moving into the long portion of the J-slot **90**, the lug **70** on the packer mandrel **40** moves into the long portion of the J-slot **68**. A downward force is then applied to the tubing string to displace the control mandrel **18** downwardly relative to the sleeve **62**. The downward force is transmitted through the retrieving head lug **10** which engages the top of the J-slot **12** in the overshot **14**. When the control mandrel **18** is displaced downwardly, fluid communication through the ports **76** and **80** is blocked by the respective O-rings **82**, **84** and **86**. When the mandrel **18** moves downward relative to the sleeve **62**, the lower end of the retrieving head **8** engages the slip control body **20** and force is transmitted to the packer mandrel **40**. Downward displacement of the packer mandrel **40** and the lower mechanical slip body **48** relative to the drag spring sleeve **62** causes the lower slips **54** to move outwardly along the inclined T-slots **56** until the slips engage the casing **98**, as shown in FIG. 8. After the lower slips engage the casing, the lower mechanical slip body **48** is blocked from further downward movement by the slips **54** which are wedged against the casing.

The upper slips **34** are then expanded by the further application of force to the tubing string. The force is transmitted to the slip control body **20** through the retrieving head **8** for displacing the slip retainer **28** downward, thereby causing the slips **34** to ride outwardly along

the inclined T-slots 32 and 36. The slips move outwardly until they engage the casing. Since the lower slips 54 are wedged against the casing, continued downward movement of the slip control body 20 axially compresses the packer rings 42 until they exand radially into engagement with the casing. The upper slips 34 slide downwardly along the casing with the upper mechanical slip body 38 while the packer rings are being expanded. The angular orientation of the teeth 96 on the upper slips 34 permits the slips to slide downwardly along the casing, but when the downward movement stops, the resiliency of the packer rings 42 urges the slips 34 upwardly and the teeth 96 are wedged into the surface of the casing, thereby resisting upward displacement of the slips. The wedging action of the upper and lower slips not only maintains the packer rings expanded, but also prevents vertical movement of the packer rings relative to the casing. The control mandrel 18 is locked in its downwardmost position by right-hand rotation of the tubing string, which moves the lug 92 into the lower short section of the J-slot 90, as shown in phantom lines in FIG. 5A.

The tubing string may be released from the tool by right-hand rotation and upward movement of the tubing string, which moves the lug 10 on the retrieving head 8 into the open end of the J-slot 12 in the overshot 4. The interference fit between the ridge 16 in the nose 14 and the lug 10 requires an upward pull of sufficient magnitude to indicate at the surface when the lug 10 has passed over the ridge and the overshot 4 is free from the remainder of the tool.

To collapse the packer rings and retrieve the tool, the overshot 4 is lowered over the retrieving head 3 and the lug 10 is cammed into the J-slot 12. The weight of the tubing string is slacked off until the lug 10 moves over the ridge 16. The shape of the J-slot 12 causes the lug 10 to be cammed into the short closed section of the J-slot, as shown in FIG. 2A. Downward movement of the control mandrel 18 moves the pin 92 out of the lower hooked section of the J-slot 90, as shown in FIG. 5A, and left-hand rotation of the mandrel 18 moves the pin 92 into the straight portion of the J-slot. Upward movement of the mandrel 18 then opens the bypass ports 76, 78 and 80, to equalize the fluid pressure above and below the packer rings. Continued upward movement of the tubing string causes the collar 24 to engage the shoulder at the upper end of the recess 22 in the slip control body 20. Upward movement of the slip control body 20 pulls the slips 34 away from the casing 98. This is done easily, since the pull is directly on the slips 34 and the wedge angle of the slips and the T-slot 36 in the slip body 38 is a relatively large angle. A small longitudinal movement of the slips will retract the slips inwardly enough to disengage them from the casing. After the upper slips are disengaged from the casing, the packer rings 42 are free to retract by their own resilience. While the tubing string is moving upwardly, the pin 70 is cammed into the short section of the J-slot 68 and the lug 92 is moved to the upper short section of the J-slot 90. The upward movement of the control mandrel 18 is then transmitted to the packer mandrel 40 and the shoulder 52 moves the lower mechanical slip body 48 upwardly to draw the lower slips 54 inwardly. The tool may then be removed from the well, or moved to another position in the well.

This retrievable bridge plug is an improvement over other retrievable bridge plugs now in use in that the packer rings are maintained in the sealing position by two opposing sets of mechanical slips, which positively engage the casing. Other retrievable bridge plugs depend upon internal fluid pressure retained by resilient seals which are subject to deterioration by well fluids or by high subsurface temperatures. Furthermore, the two sets of opposing slips engage the casing at all times and there can be no movement of the tool or the slips as pressure reversals occur in the well. Since the bridge plug is mechanically set by the application of downward weight to the tool, its operation is not dependent upon well fluids, or the lack of such fluids.

While this invention has been illustrated and described in one embodiment, it is recognized that variations and changes may be made therein, without departing from the invention as set forth in the claims.

I claim:

1. An overshot for selectively engaging a retrieving head on the control mandrel of a retrievable bridge plug, said retrieving head having a lug projecting radially outward from a side of said head, said overshot comprising an elongated hollow tubular body having screw thread means at one end thereof, said body including means forming a J-slot in the interior of the body, said body having a radial ridge adjacent the opposite end of said body, said J-slot means being between said ridge and said one end of said body and having an axially extending portion terminating in an open end adjacent said ridge, the internal diameter of said body at said ridge being substantially less than the internal diameter at said axially extending J-slot portion, whereby in forcing the lug across the ridge by axial force transmitted through the overshot, a positive indication of engagement or disengagement of the overshot with the retrieving head is provide.

2. The overshot according to claim 1 wherein said ridge is spaced axially from said J-slot means, whereby said overshot may be rotated relative to the lug while positioned between said ridge and said J-slot means to align said lug with said J-slot open end.

3. The overshot according to claim 1 wherein said ridge extends around substantially the entire circumference of said body, said body has a plurality of axially extending slots traversing said ridge, said slot being spaced from each other around the circumference of said body, whereby said body between said slots flexes outwardly as the lug passes over said ridge.

4. The overshot according to claim 3 wherein each of said slots extends from a location between said ridge and said body opposite end to a location between said ridge and said J-slot means.

5. The overshot according to claim 3 wherein said ridge has cam surfaces along opposite ends thereof, said cam surfaces being arranged to urge said ridge outwardly as the lug passes over the ridge in moving toward and away from said body opposite end.

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JAMES A. LEPPINK, *Primary Examiner.*