

Aug. 9, 1955

A. E. THOMPSON

2,714,932

BRIDGING PLUG

Filed Aug. 8, 1951

2 Sheets-Sheet 1

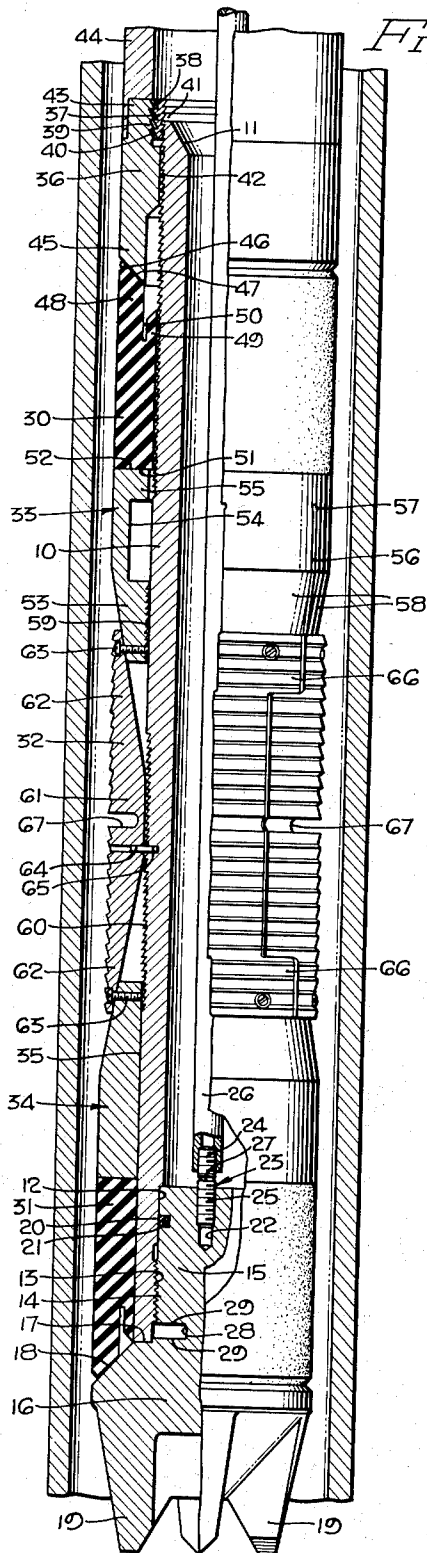


FIG. 1.

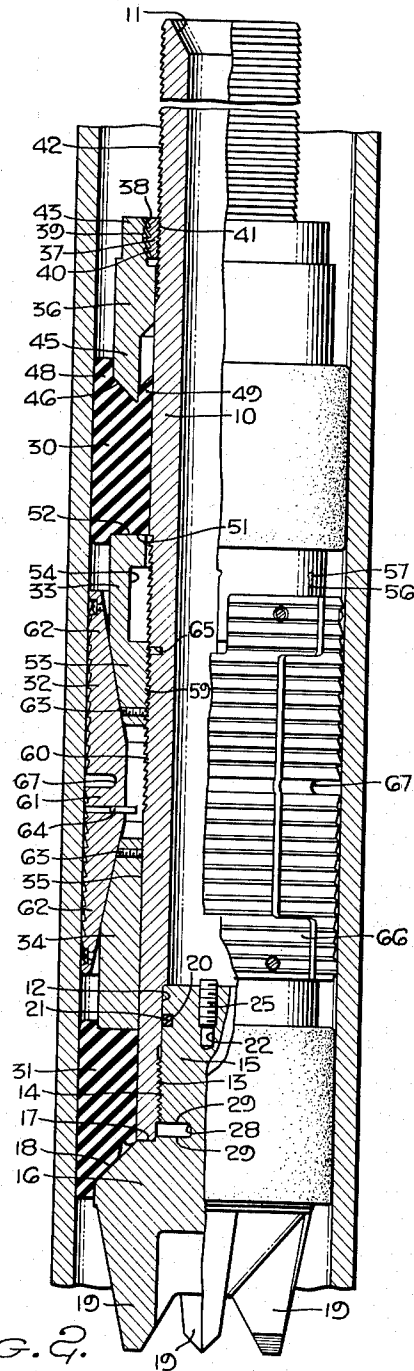


FIG. 2.

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2 Sheets-Sheet 2

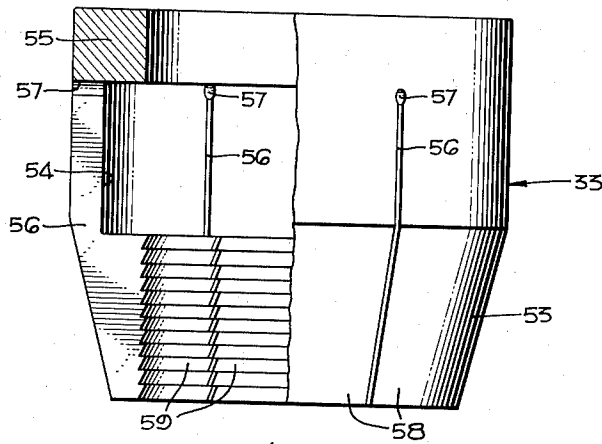


FIG. 3.

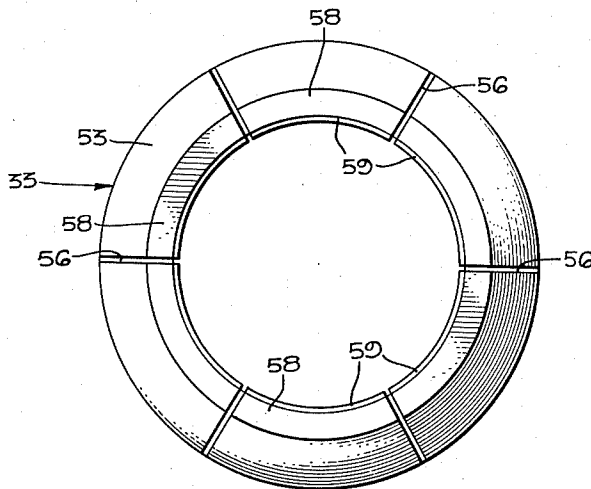


FIG. 4.

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2,714,932

BRIDGING PLUG

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Application August 8, 1951, Serial No. 240,856

4 Claims. (Cl. 166—119)

This invention relates to bridging plugs for well boreholes and casings, and is particularly concerned with the anchoring and packing devices thereof, together with the actuating and securing means for such devices.

Bridging plugs of the type to which the present invention relates are primarily used to seal or pack off a well section while pumping, testing, or cementing operations are carried on above the section thus sealed off. Since it is desirable that the well bore or casing above the bridging plug be free and clear during such operations and since high pressure differentials must often be resisted by the bridging plug under such conditions, it is obviously desirable to provide a plug capable of withstanding such pressures and which at the same time may be quickly and easily set in well bore or casing sealing position by instrumentalities which may be readily detached from the plug and withdrawn, leaving the space thereabove unobstructed. To accomplish its desired purpose, the plug must be capable of self-securement and retention in set position without danger of inadvertent dislodgment under high differential pressures. Heretofore, bridging plugs have been proposed which sought to satisfy these and like requirements, but difficulties have been encountered in accomplishing that purpose with a simplicity of design compatible with economic manufacture and with such strength and durability as desired.

It is, accordingly, an object of the present invention to provide a bridging plug in which certain undesirable strength limitations heretofore prevalent in conventional bridging plugs have been eliminated.

More specifically, it is an object of the present invention to provide a novel, simple, and improved bridging plug having effective and efficient means whereby the plug may be quickly and securely set by a readily removable setting tool.

A further object of the invention is to provide a novel, simple, and improved bridging plug which will securely retain its set position, effectively and efficiently sealing the well bore or casing without danger of dislodgment after detachment and removal of the setting tool.

Another object of the invention is to provide a bridging plug having a novel arrangement and combination of slips, cones, packers, and actuating means such that disengagement and removal of such parts may readily be achieved when termination of the bridging function is desired.

Other objects of the invention include the provision of a unique combination and interrelation of parts whereby strength and durability are achieved with minimum material cost and operational expense in manufacture or assembly.

These and other objects, advantages, and features of novelty will be evident hereinafter.

In the drawings, which show, by way of illustration, a preferred embodiment of the invention, and in which like reference characters designate the same parts throughout the several views:

Figure 1 is a vertical elevation, partly in longitudinal section, of the plug of the present invention assembled in position to be lowered into the well bore or casing for subsequent setting;

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Figure 2 is a view similar to Figure 1, showing the plug as it appears in set position within a well casing;

Figure 3 is a side view, partly in section, of the upper slip cone shown in Figures 1 and 2; and

Figure 4 is a bottom view of the same.

In considering the present invention as exemplified by the present specification and accompanying drawings, it will be understood that the inventive concept hereof, as outlined by the appended claims, is in no way limited to the structural details herein set forth. Thus, the invention may be practiced in a wide variety of combinations with component parts wholly dissimilar from those here presented. Changes, modifications, and the full use of equivalents are therefore contemplated in the practice of the invention.

The invention here claimed relates more particularly to the packers, slips, cones, and their actuating and retaining means, as well as to the general combination and interrelation of such parts. Certain other novel and improved features, such as, for instance, the fracturable bull plug, are herein disclosed in combination with the claimed structure, and with respect thereto reference may be had to the copending application of George A. Bouvier, Serial No. 240,847, filed on even date herewith and including a similar disclosure but having claims directed to structural features not necessarily combined with the claimed features hereof.

Referring now to the drawings, the present structure comprises a central cylindrical mandrel 10 preferably of uniform smooth internal diameter. The upper open end of the mandrel 10 is shown as formed with an internal bevel 11. The opposite lower end of the mandrel is provided with a counterbore 12, the intermediate surface of which is threaded at 13 to engage the intermediate external threads 14 of the upwardly extending shank 15 of a bull plug nosepiece 16 which closes the lower end of the mandrel 10. Below the shank 15, the nosepiece 16 is formed with an expanded head portion having a mandrel-receiving shoulder 17 at the junction of the shank and a downwardly diverging frusto-conical packer engaging surface 18 extending therefrom, together with conventional prongs 19.

Above the threads 14 of the shank 15 there is provided in the external cylindrical wall of the shank a circumferential groove 20, in which is seated an "O" ring 21 adapted to form a fluid-tight seal between the mandrel and the nosepiece. Centrally of the upper end surface of the shank 15 of the nosepiece, a coaxial threaded hole 22 is formed, into which is threadedly secured an actuating stud 23. The stud 23 has upper and lower spaced threaded surfaces 24 and 25, respectively. The lower threads 25 engage the threads of the hole 22 to secure the stud to the upper end of the shank 15, while the upper threads 24 are adapted to be engaged by a central actuating rod 26 of a setting tool (not otherwise shown). Intermediate the threads 24 and 25 of the stud 23, the body thereof is formed with a circumferential groove 27, preferably semicircular in cross section and of such depth with respect to the thickness of the stud as to provide a transverse fracture plane such that upon the application of a sufficient upward pull on the rod 26 the plug will fracture or fail at the groove 27 at a predetermined maximum tension, thereby freeing the actuating rod 26 from the shank 15 and permitting withdrawal of the setting tool and the upper portion of the stud after the plug is properly set.

Another important feature of the nosepiece 16 is the provision of a peripheral fracture groove 28 adjacent the shoulder 17 and between it and the upper threaded portion 14 of the shank 15. As here shown, the groove 28 is of substantial depth in relation to the diameter of the shank of the nosepiece, and to attain such depth

is formed with parallel, radially extending side walls 29. While the relation of the depth of the groove 28 to the diameter of the shank of the nosepiece may well vary with the design of the bridging plug and the material used, the present design with the groove depth approximately two-thirds the radius of the shank has been found desirable. A lesser groove depth may be employed if weaker materials are used or in conjunction with hollow nosepieces; conversely, a groove of greater depth would be formed in nosepieces formed of material having a greater tensile strength.

It is important to note that the groove 28 is located at a point between the threaded attachment at 13, 14 of the nosepiece shank 15 with the mandrel 10 and the head of the nosepiece 16 which receives the packing setting thrust at the surface 18. It will thus be seen that the groove 28 provides a transverse fracture or failure section across the nosepiece so as to permit dismemberment and separation of the enlarged lower head member 16 from the shank 15 and from the mandrel 10 upon the application of a predetermined maximum upwardly directed force through the mandrel, which force is transferred from the head at surface 18 to the packing and plug setting mechanism hereinafter described.

The well bore or casing engagement elements of the bridging plug comprise upper and lower sleeve-shaped, resilient packings 30 and 31, respectively, slips 32, and intermediate upper and lower slip actuating cones 33 and 34, respectively. The packings, slips, and cones are all slidably mounted in interrelated coaxial alignment on the cylindrical outer surface 35 of the mandrel 10. Such parts are retained in assembled relation upon the mandrel by disposition between the protruding surface 18 of the head of the nosepiece 16 and a compression sleeve 36 on the upper end of the mandrel.

The compression sleeve 36 is mounted upon the mandrel to permit relative longitudinal slidable movement thereof along the mandrel toward the nose thereof and to preclude return from such relative movement by means of an internally and externally wickered lock ring 37. The lock ring 37 is seated within an internally wickered counterbore 38 at the upper end of the compression sleeve 36 and is retained within the counterbore by the external wickers 40 of the ring. As indicated, the lands of the internal wickers 39 of the counterbore 38 are buttress-shaped and face downwardly, while the matching lands of the external wickers 40 of the ring face upwardly so as to provide restraining interengagement therebetween upon relative downward movement of the compression sleeve with respect to the ring 37. The ring 37 is, of course, a split resilient ring, permitting contraction thereof whereby it may be received within the counterbore. A similar one-way slidable locking engagement between the ring 37 and the mandrel 10 is provided by internal, buttress-shaped wickers 41 formed on the inside surface of the ring and matching external wickers 42 formed on the outer surface of the mandrel 10 at the upper end thereof. The relation of the mandrel wickers 42 to the wickers 41 on the inner surface of the ring is similar to the relation of the sleeve wickers to those on the outer surface of the ring in that the mandrel wickers 42 have buttress-shaped lands facing downwardly to abut upwardly facing, buttress-shaped lands of the internal ring wickers. Thus there may be relative downward movement of the compression sleeve 36 and ring 37 with respect to the mandrel 10 and relative upward movement of the mandrel 10 through the sleeve 36 and ring 37, but the interengagement of the wickers is such as to preclude opposite relative movement, i. e., upward movement of the sleeve 36 and ring 37 over the mandrel 10 or downward movement of the mandrel 10 through the ring and sleeve. The lock ring 37 is, of course, permanently secured within the sleeve against relative downward movement by abutment of its inner face against the upper face of the shoulder formed by the end of

the counterbore. As here indicated, it is preferable that the depth of the wickers between mandrel and ring be substantially less than that of the wickers between ring and sleeve counterbore, since no longitudinal sliding movement between ring and sleeve takes place after assembly, while such sliding movement between mandrel and ring is required during setting of the bridging plug. In the form of the invention shown, the mandrel wickers and their companion lock ring wickers are of approximately one-half the depth of the ring-to-sleeve wickers, and sufficient radial clearance must be provided between the wickers on the outside surface of the locking ring and the wickers on the inside of the counterbore of the sleeve to permit the wickers between the lock ring and the mandrel to ratchet over one another.

The upper end of the compression sleeve 36 is formed with a portion 43 of reduced diameter concentric with the internal counterbore 38 and adapted to receive upon the annular shoulder formed thereby downward thrust from the tubular body 44 of a setting tool (not otherwise shown). The compression sleeve 36 is further provided with a downwardly extending, cylindrical flange 45 encircling, but spaced from, the outer surface of the mandrel 10. The lower edge of the flange 45 is formed with a downwardly diverging, frusto-conical thrust surface 46 adapted to engage a conforming edge surface 47 formed on the upwardly extending outer lip 48 of the upper packing sleeve 30. The upper end of the packing sleeve 30 is also provided with an inner lip 49 parallel to the outer lip 48 and spaced therefrom by a short, longitudinally extending, coaxial slot 50. The inner lip 49 is shorter than the outer lip and terminates in an oppositely slanting, frusto-conical surface such that any pressure leakage thereto will seal the lip against the outer surface of the mandrel. Below the lips 48 and 49, the upper packing sleeve 30 is formed as a relatively thick walled tubular body of resilient or yieldable material terminating at its lower end with a flat, transverse, pressure transmitting surface 51.

While the inner surface of the body of the packing sleeve 30 snugly fits the smooth outer surface of the mandrel 10 below the upper external wickers 42 thereof, it will be understood that the packing sleeve is free to slide longitudinally upon the mandrel prior to expansion thereof under axial pressure from the compression sleeve 36. Upon such sliding movement, pressure is transmitted through the packing sleeve from the compression sleeve 36 to the upper slip cone 33, the upper flat surface 52 of which abuts the lower flat surface 51 of the packing sleeve 30.

The upper slip cone 33 has a substantially cylindrical portion and a downwardly converging, frusto-conical portion 53. An upper bearing for the cone upon the outer surface of the mandrel, with respect to which it may slide, is provided by an internal annular counterbore 54 forming an inwardly extending, annular flange 55. The cone 33 is further formed with longitudinally extending, circumferentially spaced slots 56, the upper ends of which have radially directed, circular apertures 57. The slots 56 extend inwardly from the apex ends through the frusto-conical portion 53 of the slip cone 33 to a point adjacent the flange 55, thus dividing the frusto-conical portion into individual fingers 58, each of which is resiliently flexible. The inner faces of the fingers 58 are provided with upwardly facing, buttress-shaped wickers 59 similar in shape and size to the internal wickers 41 of the lock ring 37. The internal finger wickers 59 are adapted to engage external wickers 60 formed on the surface of the mandrel 10 intermediate the ends thereof. The wickers 60 are buttress-shaped and similar to wickers 42 at the upper end of the mandrel, and thus, while relative upward movement of the mandrel 10 with respect to the cone 33 is permitted as the spring-like fingers 58 flex and ratchet over the mandrel wickers 60, opposite relative movement is thereby prevented.

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The slips 32 are mounted between the cones 33 and 34 with their outer tapered ends seated upon the cones. Each slip comprises an elongated, externally wickered member formed with a central body section 61 and tapered end 62. The outer faces of the slips and the internal faces of the central body sections thereof are parallel and disposed in planes parallel to the axis of the bridging plug. The inner faces of the tapered ends 62 incline outwardly from the central section with an angle of inclination approximately equal to the angle of inclination of the taper of the cones. In original assembly, as shown in Figure 1, the ends of the slips are temporarily secured to the cones by shear screws 63. As the cones are forced inwardly toward each other when setting the plug, the shear screws 63 are sheared and the slips ride out on the inclined surfaces of the cones to engage the well bore or casing. One or more of the slips 32 are provided with guide pins 64 which are slidably received within apertures 65 extending radially of the mandrel, and serve to retain the slips midway between the cones after the pins 63 are sheared.

Each slip is preferably, although not necessarily, formed with circumferentially offset end portions 66 which overlap and interengage with adjacent slips. The width of each slip and of each offset end 66 is preferably equal to the width of each finger 58 of the upper cone; thus each slip may partake of the individual movement of each such finger. Each slip is further provided with a central exterior groove 67, which grooves 67 together constitute a central circumferential groove to receive a securing band or spring to secure the parts in assembled relation before setting, or to assist in collapsing the slips after setting pressure is relieved. The grooves 67 also constitute weakened areas across each slip so as to permit flexure or fracture thereof without loss of grip should the plug be set against a wall surface of such irregularity that the ends of the slips may not otherwise contact and grip the same.

The lower cone 34 is similar to the upper cone 33, except that the slots forming the individual fingers are omitted, and the inner face of the tapered end is not wickered for engagement with the mandrel wickers. Thus the mandrel 10 may move freely within the lower cone. By upward movement of the mandrel in the lower cone 34, the lower packer may be compressed to effect the setting thereof.

The lower packing 31 is preferably identical with the upper packing 30 and is mounted in reverse position on the mandrel, its outer lip lying against the outer frusto-conical surface 18 of the nosepiece 16 in similar but reverse relation to that of the contact of surface 47 of packing 30 against the frusto-conical surface 46 of the compression sleeve 36.

Prior to lowering the bridging plug into the well, the slips, cones, and packings are arranged upon the mandrel 10 in relaxed interrelation, as shown in Figure 1, the compression sleeve 36, together with the nosepiece 16, retaining the parts in such assembly without longitudinal pressure. A setting tool is applied to the bridging plug by means of the actuating rod 26, as before described, and the whole assembly is lowered on the setting tool to the position within the borehole where it is desired it be set. Such setting tools may be of widely varying types and designs with respect to which the present invention is not concerned. A preferred type of setting tool admirably adapted for lowering and setting the present bridging plug is that disclosed in the patent to Hart, No. 2,308,004, issued January 12, 1943. Such devices have an external cylindrical body, as indicated at 44, which may be applied in telescoping abutment with the necked portion 43 at the top end of the compression sleeve 36, together with a central actuating tension rod such as shown at 26. In operation, the setting of the plug is accomplished by imparting relative downward movement of the outer cylinder 44 to the com-

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pression sleeve 36 and opposite relative upward movement of the central rod 26 to the shank 15 and nosepiece 16.

In the setting operation of the present tool, equal and opposite movement of the rod 26 and cylinder 44 causes the nosepiece 16 and sleeve 36 to move toward one another, thus applying longitudinal pressure to the upper packing by the sleeve 36. Since the packing is free to slide upon the mandrel 10, such pressure is transmitted therethrough to the cone 33, which is thus urged downwardly along the mandrel toward the lower cone 34. As the cones thus move toward each other, the apex ends thereof slide under the slips, forcing them radially outwardly after first shearing the shear screws 63. Such outward radial movement of the slips is terminated by the firm anchoring engagement thereof with the inside surface of the well bore or casing, and thereafter further longitudinal pressure exerted between the nosepiece 16 and compression sleeve 36 by the setting tool compresses the packings. The packings are thus expanded radially against the inside surface of the well bore or casing to securely pack the same on either side of the anchoring slips 61.

When the bridging plug is fully set, further setting movement is precluded by well bore or casing resistance to outward expansion of the slips and packers, whereupon further setting pressure results in a fracture or failure of the stud 23 at the groove 27. After such fracture, the setting tool may be removed, it being noted that the outer cylinder 44 is detachably coupled to the sleeve 36 and is not secured to the setting tool and that the actuating rod 26 constitutes the only fixed attachment between the setting tool and the bridging plug.

In thus setting the plug, it will be noted that the mandrel 10 has been moved upwardly with respect to the cones 33 and 34, packings 30 and 31, and slips 61 and with respect to the compression sleeve 36, which is moved equally and oppositely downwardly relative to the upward movement of the nosepiece 16. In such movement, the external wickers 42 of the mandrel have ratcheted through the internal wickers of the lock ring 37 and slip cone fingers 58. In such movement, the ring 37 is retained against upward movement with the mandrel by interengagement of its external wickers 40 with the internal wickers 39 of the counterbore 38, while the upper cone 33 is retained by the upper packing 30 and the engagement of wickers 59 of the slip cone fingers 58 with wickers 60 of the mandrel 10. Upon release of the actuating rod 26 by fracture of the stud 23 at groove 27, return of the original relation between mandrel and sleeve, or mandrel and upper cone, under influence of the resilience of the packings, is precluded by interengagement of the mandrel and lock ring wickers and mandrel and slip cone finger wickers. Thus the plug is firmly and positively retained in set position with the parts in the positions shown in Figure 2.

When it is desired to remove the plug, a retrieving tool is run into the mandrel and there expanded to grip the internal walls of the mandrel, an expanding spear being commonly employed for this purpose. With the mandrel securely gripped by such a tool, upward force is exerted, which force is transmitted to the nosepiece 16 through the shank 15 and through the reduced section thereof formed at the groove 28. Such force is, however, resisted by the firm engagement of the anchoring means and packings with the well bore or casing, and the strains of such force are therefore distributed through the nose piece. When such forces have acquired a predetermined degree, the nosepiece shank will fracture at its weakest point, namely, at the section bounded by the inner surface of the groove 28, and after such fracture the mandrel with the nosepiece shank 15 thereto attached may be withdrawn upwardly by the retrieving tool, leaving the head of the nosepiece 16 free to drop down in the casing or well bore. Since the mandrel may always

move freely upwardly through the ring 37 and upper cone 33, it will slip out of all of the companion parts of the plug, leaving such parts unsupported by the mandrel and free to drop downwardly to be subsequently withdrawn by suitable means such as a junk basket or other fishing tools. The entire plug is thus simply and easily removed from the well.

From the foregoing, it will be seen that the present invention provides a novel, simple, effective, and efficient bridging plug which may be readily set to pack off a desired well zone, and which may be easily and quickly removed to permit free passage of well fluid, drilling tools, or the like without requiring a drilling operation for the destruction of the parts. It will further be noted that the invention provides for a self-locking of the parts in set position, permitting the simple withdrawal of the setting tool at any time after setting.

A particular advantage of the construction of this bridging plug also resides in the self-locking characteristics of the upper slip cone 33, which permits high setting forces to be applied to the packings and retained without the usual danger of failure of the locking ring as conventionally employed for this purpose. The slotted construction of the slip cone 33, together with the wickered fingers 58, provides for the gripping of the mandrel wickers 60 by the slip cone finger wickers 59 with a radial force which is proportional to the longitudinal force applied to the slip cone by the slips 52. Thus the secureness with which the slip cone 33 is anchored to the mandrel is always commensurate with the setting forces to be resisted thereby.

As hereinbefore indicated, the invention is not limited to the exact structural features herein disclosed, and the invention may be successfully practiced with numerous changes, modifications, and the full use of equivalents without departure from the spirit or scope of the appended claims. The present invention, although shown and described in connection with a bridging plug having the described construction, is directed particularly to the upper slip cone with its resilient fingers and wickers. It will be understood, however, that this invention may be applied to other types of well tools and, in fact, to many other forms of apparatus employing a collar or sleeve on a cylindrical body to be secured against movement with respect thereto in one direction but freely movable in the opposite direction.

What is claimed is:

1. A well tool as described comprising in combination: a mandrel having external wickers formed thereon; a first slip cone on said mandrel; a second slip cone slidably mounted on said mandrel for longitudinal movement toward said first slip cone, the converging ends of said cones being directed toward each other; a plurality of slips carried by and between said slip cones; a packing sleeve on said mandrel, one end thereof being adjacent the diverging end of said second slip cone; a packer expander sleeve slidable on said mandrel toward the other end of said packing sleeve for expanding said packing sleeve and for moving said second slip cone toward said first slip cone for setting said slips; circumferentially spaced, longitudinal slots formed in the converging end portion of said second slip cone, forming a plurality of radially flexible finger portions; and wickers formed on the inside surface of said finger portions to effect locking engagement with said wickers on said mandrel after movement of said second slip cone to a slip setting position.

2. A well tool as described comprising in combination: a mandrel having external wickers formed thereon; a first slip cone on said mandrel; a second slip cone slidably mounted on said mandrel for longitudinal movement toward said first slip cone, the converging ends of said cones being directed toward each other; a plurality of double-ended slips carried by and between said slip cones, each of said slips having a plurality of oppositely

directed casing-engaging wickers; a packing sleeve on said mandrel, one end thereof being adjacent the diverging end of said second slip cone; a packer expander sleeve slidable on said mandrel toward the other end of said packing sleeve for expanding said packing sleeve and for moving said second slip cone toward said first slip cone for setting said slips; circumferentially spaced, longitudinal slots formed in the converging end portion of said second slip cone, forming a plurality of radially flexible finger portions; and wickers formed on the inside surface of said finger portions to effect locking engagement with said wickers on said mandrel after movement of said second slip cone to a slip setting position.

3. A well tool as described comprising in combination: a mandrel having external wickers formed thereon; a first slip cone slidable on said mandrel; a second slip cone slidably mounted on said mandrel for longitudinal movement toward said first slip cone, the converging ends of said cones being directed toward each other; a plurality of slips carried by and between said slip cones; a first packing sleeve on said mandrel, one end thereof being adjacent the diverging end of said first slip cone; a second packing sleeve on said mandrel, one end thereof being adjacent the diverging end of said second slip cone; a packer expander means on said mandrel adjacent the other end of said first packing sleeve; a packer expander sleeve on said mandrel adjacent the other end of said second packing sleeve and slidable toward said expander means for expanding said packing sleeves and for moving said second slip cone toward said first slip cone for setting said slips; circumferentially spaced, longitudinal slots formed in the converging end portions of said second slip cone, forming a plurality of radially flexible finger portions; and wickers formed on the inside surfaces of said finger portions to effect locking engagement with said wickers on said mandrel after movement of said second slip cone to a slip-setting position.

4. A well tool as described comprising in combination: a mandrel having external wickers formed thereon; a first slip cone slidable on said mandrel; a second slip cone slidably mounted on said mandrel for longitudinal movement toward said first slip cone, the converging ends of said cones being directed toward each other; a plurality of double-ended slips carried by and between said slip cones, each of said slips having a plurality of oppositely directed, casing-engaging wickers; a first packing sleeve on said mandrel, one end thereof being adjacent the diverging end of said first slip cone; a second packing sleeve on said mandrel, one end thereof being adjacent the diverging end of said second slip cone; a packer expander means on said mandrel adjacent the other end of said first packing sleeve; a packer expander sleeve on said mandrel adjacent the other end of said second packing sleeve and slidable toward said expander means for expanding said packing sleeves and for moving said second slip cone toward said first slip cone for setting said slips; circumferentially spaced, longitudinal slots formed in the converging end portions of said second slip cone, forming a plurality of radially flexible finger portions; and wickers formed on the inside surface of said finger portions to effect locking engagement with said wickers on said mandrel after movement of said second slip cone toward said first slip cone to a slip-setting and packing expanding position.

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