United States Patent

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[54] **SEGMENTED FRANGIBLE SLIPS WITH GUIDE PINS**
12 Claims, 6 Drawing Figs.

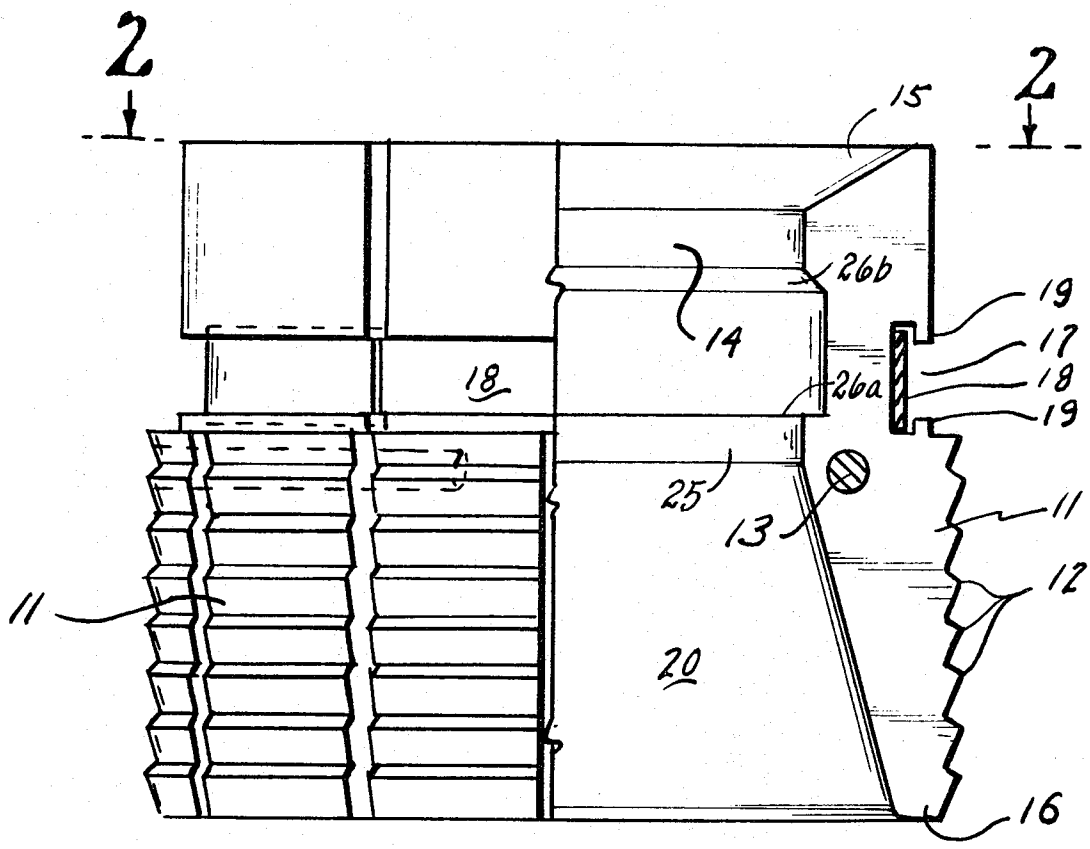
[52] **U.S. Cl.** **166/134,** 166/206
[51] **Int. Cl.** **E21b 33/129**
[50] **Field of Search** ..... 166/120, 206, 123—125, 134—140, 212, 214; 277/116.2

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ABSTRACT: Disclosed is a well tool employing a new type of breakable segmented slips for use in anchoring in well bores. Guide pins mounted transversely to the length of the segmented slips maintain uniformity in the circumferential spacing as well as horizontal alignment of the slips as they are expanded or moved radially outward. Each of the slip segments has a retaining band segment which is trapped in a flanged retaining groove on an outer surface of the slip segments. The band segments serve to maintain alignment of broken portions of the slip segments in a horizontal plane during final setting of the slips.



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Fig. 1

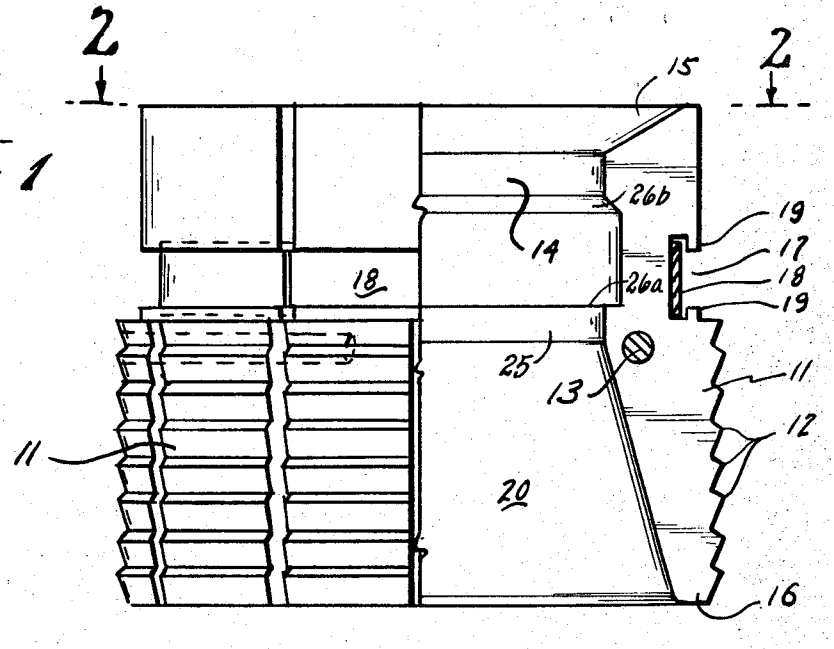


Fig. 3

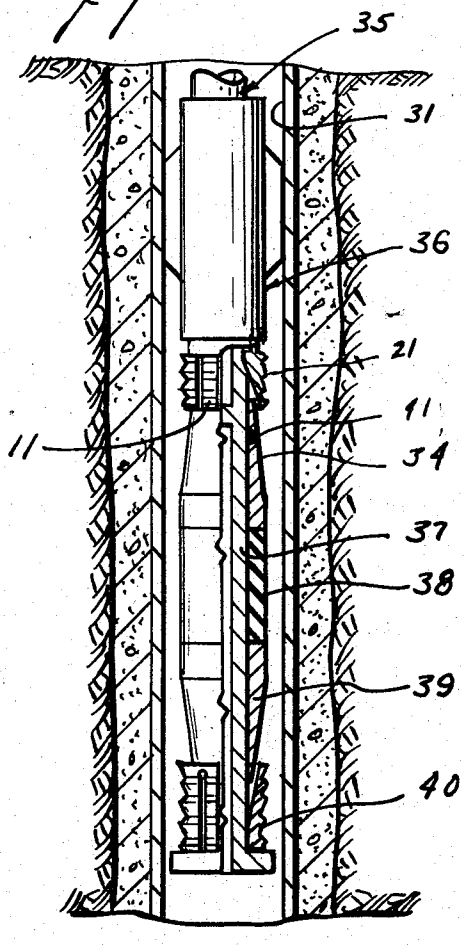
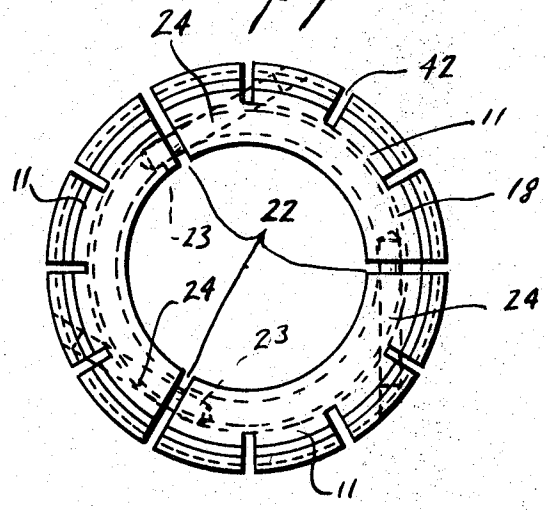


Fig. 2



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Fig. 4

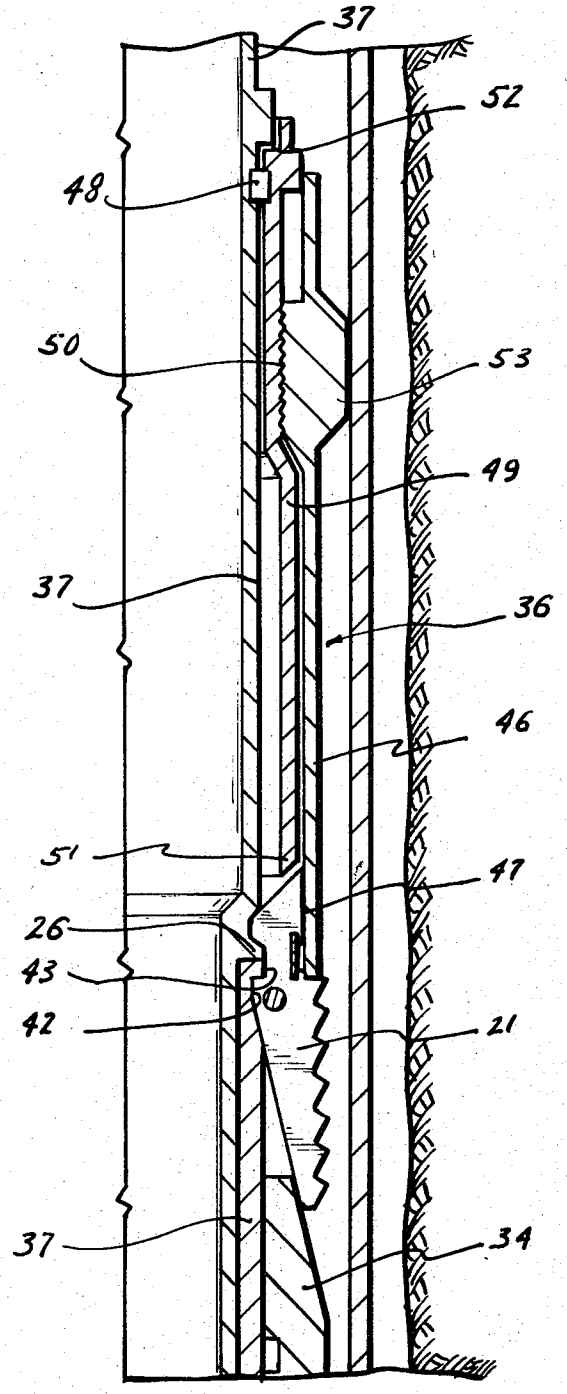


Fig. 5

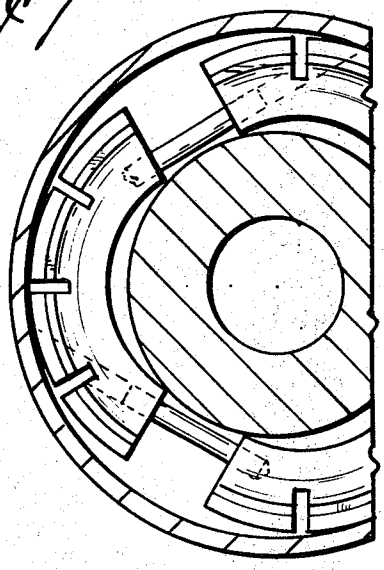
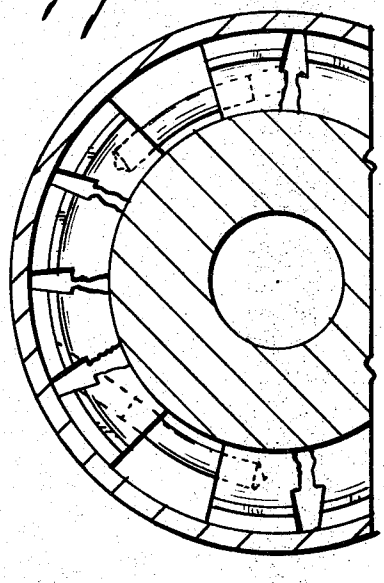


Fig. 6



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SEGMENTED FRANGIBLE SLIPS WITH GUIDE PINS

BACKGROUND OF THE INVENTION

This invention relates to a well tool and more particularly to anchoring means on a well tool.

Slips, generally provided with teeth or wickers on their external surface, are typically used to either permanently or temporarily anchor well tools such as packers or plugs to the well casing at some point in the well bore. If permanently anchored, it may be desirable at some later date to remove the tool and this is usually done by drilling, milling or chipping. For this reason, it is desirable to construct the tool and the slips of a frangible material such as cast iron, which may easily be disrupted.

One-piece frangible slip assemblies which have a plurality of longitudinal weakened sections defined by longitudinal notches spaced about their circumference can be fractured along this plurality of weakened sections during setting, and thus can be made to more nearly conform to the inner surface of the well casing. This provides more gripping surface area of the slip in contact with the well casing and greater holding power of the slips. One-piece slips have had a disadvantage in that there is no reliable way to regulate or control the spacing and alignment of the broken slip sections during the setting operation.

Where segmented slip elements are used as upper slips on a well tool, it is possible to release one slip element slightly ahead of release of the others during setting and such a slip element can slide down the expander cone to prematurely engage or wedge between the expander cone and the casing wall causing misalignment between corresponding portions of the slip elements in a plane at right angles to the well bore axis (hereafter called misalignment in a horizontal plane). If this occurs, it stops the free upward movement of the expander cone and causes the teeth of this particular slip element to bite into the casing before the other slip elements have begun to grip the casing. Thus, the prematurely engaged, horizontally misaligned slip element sets first and is forced to carry most of the load.

Moreover, if the well tool is not centered in the well bore when expansion of the slips is begun the problem is further aggravated. This can occur most often in cases where the well bore is not vertical, but rather is slanted or inclined. In this case, if a slip segment is free to slide down the expander cone prematurely it can engage the wall of the well bore on the side of the tool farthest away from the well and wedge itself in there. While further intrusion of the expander cone can set the slips, the tool will then be set off center in the well bore and maximum efficiency of the packer element will not be realized.

To alleviate these problems, prior art slips have used powerful radial expander springs to forcibly thrust and propel the slip elements into contact with the casing wall immediately upon their release. Further, prior art slips have used complex arrangements of either snugly fitting or loosely fitting guide pins joining the segments to assist horizontal alignment, along with vertically inclined guide bars passing longitudinally through the slip segments and possibly guide slots in the upper and lower slip skirts. Such slots are generally adapted to engage guide pins which assist in radially and circumferentially guiding the slip elements.

Accordingly, it is an object of the present invention to provide new and improved well tool anchoring means including segmented breakable slip elements with a combination of effective means for maintaining horizontal alignment and circumferential spacing of the elements and integrity of the alignment of later broken segments of the slip elements until all such segments are in gripping contact with the casing wall.

SUMMARY OF THE INVENTION

In the well tool of the present invention, the anchor means includes a plurality of frangible, arcuate, segmented slip elements preferably made of cast iron and, when placed together, forming a segmented hollow cylinder. Each slip element is provided with a plurality of longitudinal weakened sections defined by longitudinal notches cut into the external surface.

Each slip element is further provided on one of its longitudinal edges with a transverse retaining pin which is force-fit or screwably connected into the edge of this element. This pin fits slidably but not snugly into a corresponding aligned transverse hole in the longitudinal edge of an adjoining slip element and serves as a mechanical link between these slip elements for maintaining circumferential spacing and horizontal alignment as the slip elements are moved radially outward by an expander cone.

Further, each arcuate slip element has, on its external surface, a flanged groove which retains an arcuate segment of flexible steel band. These band segments serve to maintain the horizontal alignment of corresponding portions of the broken longitudinal segments formed upon the fracture of the original slip element by the expander cone. The inner surface of each slip element is conically tapered over the lower portion of its length to cooperatively engage the expander cone.

The novel features of the present invention are set forth with particularity in the appended claims. The present invention, both as to its organization and manner of operation together with further objects and advantages thereof, may best be understood by way of illustration and example of an embodiment when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially-sectioned view of slips embodying the present invention;

FIG. 2 is a top view of the slips embodying the present invention taken along line 2–2 of FIG. 1;

FIG. 3 is a schematic partially-sectioned view of the present invention utilized as the upper slips on a tool in a well bore;

FIG. 4 is a schematic sectioned view of the upper portion of the well tool of the present invention including the setting tool;

FIG. 5 is a schematic view showing the slips of the present invention in a partially expanded condition; and

FIG. 6 is a schematic view showing the slips of the present invention when setting is complete.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention concerns a new and improved segmented, frangible slip for use in anchoring well tools in a well bore. The slip attains improved gripping with the inner wall of the well casing by using a novel combination of effective means to assure proper horizontal and circumferential alignment of corresponding portions of the original sectioned portions of the slip and also the later broken portions thereof.

In FIG. 3, a well casing **31** is shown traversing earth formations and cemented in place. A well tool **30**, such as a cement retainer, is suspended from a pipe string **35** in casing **31**. Pipe string **35** is coupled to a setting tool **36** which is releasably coupled to the tool **30**.

The tool **30** has a central mandrel **37** which carries, from top to bottom, an upper slip assembly **21**, an upper expander cone **34**, a packing element **38**, a lower expander cone **39**, and a lower slip assembly **40**.

The setting tool **36** can be enabled to produce an opposing relative motion between the mandrel **37** and slips **21**. This action is such that the upper slips **21** are moved downwardly relative to mandrel **37**. During this motion, expander cone **34** moves slip elements **11** into contact with casing **31** and finally fractures the expansible slip elements to anchor the upper slip assembly to the well casing. Subsequently, packer element **38** and lower slips **40** are set. A one-way body lock **41** connects the mandrel **37** and upper expander **34** to one another to prevent the mandrel from moving downwardly relative to expander **34** when the setting process is finished.

Lower slips **40** have alternate, longitudinally extending grooves from respective end surfaces to provide an integral annular member. Further details on lower slips **40** can be found by reference to U.S. Pat. No. 3,298,440.

Referring now to FIGS. **1** and **2**, the upper slip assembly **21** is comprised of a plurality of arcuate slip elements **11** made of a frangible material, preferably cast iron. The outer surface of each element **11** is provided, over at least a portion of its length, with a plurality of circumferential teeth or wickers **12** for grippingly engaging the inner wall of a well casing **31**. Moreover, each slip element **11** is provided with a plurality of longitudinal weakened sections defined by notches **42** which extend from the outer surface of segments **11** partially through their thicknesses.

Slip elements **11** are interconnected by a plurality of steel connecting pins **22** which are mounted along axes transverse to the central axis of the slip assembly **21**. Pins **22** are respectively force-fitted or threadedly connected at one end thereof to openings **23** located intermediate the length of a slip element **11** and on one side face of an element. In the adjacent facing surface of an adjoining element is a bore **13** arranged for alignment with an opening **23** and sized to slidably, but not snugly, receive a pin **22**. The arrangement is such that the segments are interconnected so that, from the position shown in FIG. **2**, when the slips are moved radially, the pins **22** slide in holes **23** and the spacing between adjacent elements is uniform thus providing uniform circumferential spacing of the elements. At the same time pins **22** maintain horizontal alignment of the elements.

Additionally, each slip element **11** is provided with an external arcuate retaining groove **17** having upper and lower retaining flanges **19** for retaining a retention band segment **18**. Band segments **18** serve to prevent horizontal misalignment of the broken longitudinal slip segments formed when expander cone **34** urges elements **11** into contact with the well casing **31** and elements **11** fracture along the weakened sections defined by notches **42**. Band segment **18** extends over the circumferential length of groove **17** and may be made of common steel.

Each slip element **11** has an inner conically shaped or tapered surface **20** which is arranged for cooperation with an expander surface. The inner circumferential surface **25** of each element is cylindrically shaped to be slidably received on a mandrel. A recess **26** in surface **25** is provided and defined between a lower perpendicular surface **26*a*** and an upper inclined surface **26*b***. The upper end of an element **11** has an inclined surface **15** for cooperation with a setting tool or port.

Before discussing the operational aspects of the slips, the use of slips on a cement retainer and the interaction with a setting tool will be explained with respect to FIG. **4**.

In FIG. **4**, a schematic illustration is given for the setting tool **36** with respect to the slips **21** and upper section of a packer. As shown in FIG. **4**, the upper end of mandrel **37** slidingly carries the upper expander **34**. The mandrel **37** has an annular shaped recess **42** which also forms an upper flange **43**. Flange **43** is cooperatively received in recess **26** of the slips and the recess **42** accommodates the lower part of the slips. To retain the interlocking engagement of the slips on mandrel **37**, an outer sleeve **46** is received over an upper, cylindrically shaped surface **47** on the slips. For use with a cement retainer the setting tool may have a more sophisticated structure for operation of valves disclosed in a copending application Ser. No. 673,175, filed October 5, 1967 now U.S. Pat. No. 3,465,821, which is assigned to the same assignee as the present invention.

The setting tool **36** further includes a splined connection at **48** between mandrel **37** and a setting sleeve **49**. The setting sleeve **49** is threadedly coupled to the outer sleeve **46** at **50**. In the position shown, the setting sleeve has a lower setting portion **51** disposed above the slips and is prevented from moving upward by abutting surfaces at **52** and prevented from moving downward by the interlock of the slips to the mandrel and the overlap of sleeve **46** with respect to the slips.

The outer sleeve **46** has friction drag blocks **53** which frictionally engage the wall of casing **31**. If the mandrel **37** is rotated, by virtue of the keyed connection to setting sleeve **49**, the outer sleeve **46** is moved upwardly relative to the setting sleeve **49** to uncover the upper ends of the slips. At this point in time, the slips are not held in confinement with respect to the mandrel and upward pull on the mandrel **37** will bring the slips into engagement with the setting sleeve which is held stationary by the friction blocks **53**. This action moves expander **34** under the slips to set them with respect to the casing.

During setting of the slips, as the expander cone **34** intrudes into and along the cooperatively conically tapered inner surfaces **20** of slip elements **11**, it urges them radially outward. During this movement, pins **22** slide in aligned holes **13** and serve to maintain horizontal alignment of corresponding portions of slip elements **11** and prevent the elements from separating and prematurely sliding down expander cone **34**. As cone **34** intrudes further along inner surfaces **20**, teeth **12** engage the inner wall of the well casing and arrest the radial movement of elements **11**. This condition is shown in FIG. **5**.

From the position shown in FIG. **5**, further forceful intrusion of expander cone **34** then causes elements **11** to fracture along the weakened sections defined by notches **42** and to form broken longitudinal segments which more uniformly match the radius of curvature of the well casing **31** than did original elements **11** as shown in FIG. **6**. When fracturing occurs, band segments **18**, retained in arcuate flanged retaining groove **17**, function to supply upward (longitudinal) force necessary to maintain the horizontal alignment of corresponding parts of the now broken longitudinal sections of elements **11**. Thus, throughout the expansion, horizontal alignment of corresponding portions of elements **11** is maintained. This serves to insure uniform engagement of teeth **12** about the inner surface of the well casing **31** and thus a more uniform load distributed grip is provided by the slip. The length of band segments **18** is such as to retain integral contact with flanged retaining groove **17** in each of the broken segments with the slip assembly fully expanded. When the upper slips have set, further upward movement of mandrel **37** causes expansion of packer element **38** and the setting of lower slips **40** as previously discussed.

While one particular embodiment of the present invention has been shown and described, it is apparent that changes may be made without departing from this invention in its broader aspects; and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of this invention.

I claim:

1. Well tool apparatus for use in a well bore comprising:
   a body member;
   a slip assembly on said body member including circumferentially spaced breakable slip elements;
   means for expanding said slip assembly into anchoring engagement with the wall of a well bore;
   first slip interconnecting means for permitting radial movement while maintaining uniform circumferential spacing between said slip elements and maintaining horizontal alignment of said slip elements; and
   second interconnecting means on said slip elements for maintaining horizontal alignment and interconnection of segments of said slip elements produced by breaking when forced against the wall of a well bore.

2. The combination of claim **1** wherein said first interconnecting means comprises plural aligning pins carried in cooperatively aligned holes in a longitudinal edge of each of said slip assembly elements.

3. The apparatus of claim **2** wherein each of said plural aligning pins is fixedly attached at one of its ends in said aligned hole in a first slip element of said slip assembly and slidably carried by the cooperatively aligned hole in a second adjacent element of said slip assembly.

4. The combination of claim **1** wherein said second interconnecting means comprises a segmented flexible band car-

ried in a flanged retaining groove on an exterior surface of each of said slip elements.

5. The combination of claim 4 wherein said band segments are of such a length as to retain integral contact with each broken segment of its respective slip element when said slip assembly is in its fully expanded position.

6. Well tool apparatus for use in a well bore comprising:

a body member;

an annular, breakable slip assembly having a plurality of separate arcuate sections, each such section adapted to be expanded radially outwardly and to permit said sections to break into segments when so expanded;

means for expanding said slip assembly radially outward;

means for preventing the premature expansion of said slip assembly;

first means for maintaining horizontal and circumferential alignment of said arcuate sections of said slip assembly as said sections are expanded radially outward; and

second means for maintaining horizontal alignment of the broken segments of said arcuate sections when produced.

7. The combination of claim 6 wherein said means for preventing premature expansion of said slip assembly comprises:

a locking recess on the inside surface of each section of said slip assembly, said locking recesses cooperatively engaging a circumferential flange on the body of the well tool upon which said slip assembly is utilized; and

a restraining sleeve, coupled to the body of the well tool upon which said slip assembly is utilized, said restraining sleeve extending downwardly about and overlapping at least a part of the exterior surface of said slip sections in such a manner as to prevent disengagement of said locking recesses and said cooperatively engaging circumferential flange.

8. A slip assembly for use in a well tool comprising:

an annular slip assembly having independent, wall-engaging slip sections adapted for movement between radially contracted and expanded positions said sections further being adapted to break into segments when in their expanded position;

first aligning means for controlling the relative positional relationship of slip sections, including plural rigid transverse members adapted for coupling said sections, said members having sufficient length to continuously couple said sections while moving between said contracted and expanded positions; and

second aligning means for controlling the relative positional relationship of segments of said slip sections, including plural flexible transverse members adapted for coupling said segments, together with means providing retaining force between said flexible members and said segments, said flexible members having sufficient length to continuously couple said segments to one another while moving between said contracted and expanded positions.

9. Anchoring means for anchoring a well tool in a well bore comprising:

an annular slip assembly having a plurality of separate arcuate sections, each such section having circumferentially spaced longitudinal weakened sections adapted to permit said sections to break during setting of said slip assembly to form longitudinal slip segments;

means for expanding said slip assembly radially outward;

a plurality of circumferential teeth distributed along the outer surface of said slip assembly;

an inner, conically tapered surface on said slip assembly extending over at least a portion of its length to cooperatively engage said expander means;

first aligning means for maintaining horizontal and circumferential alignment of said arcuate sections of said slip assembly as said sections are expanded radially outward; and

second aligning means for maintaining horizontal alignment of broken longitudinal segments of said arcuate sections when set against a well bore wall.

10. The apparatus of claim 9 wherein said first aligning means comprises:

plural aligning pins, each of said pins carried in a pair or cooperatively aligned holes in a longitudinal edge of each of said slip assembly sections, said pins being fixedly attached in said holes at one of their ends and slidably carried in the other of said holes, and of sufficient length to retain integral contact between said slip sections when said slip assembly is fully expanded.

11. The apparatus of claim 9 wherein said second aligning means comprises:

plural flexible band segments, each carried in a flanged retaining groove on an exterior surface of each of said slip assembly sections, said band segments having a length sufficient to retain integral contact with each segment of said slip assembly sections when said slip assembly is in its fully expanded position.

12. A well tool for use in a well bore comprising:

a central mandrel;

expansible packing means on said mandrel adapted to provide a seal with respect to the wall of a well bore;

an expander cone slidably mounted on said mandrel; and

means for anchoring said tool in a well bore including at least one slip means comprising;

an annular, breakable slip assembly having a plurality of separate arcuate sections, each such section adapted to be expanded radially outwardly and to permit said sections to break into segments when so expanded;

first aligning means for maintaining horizontal and circumferential alignment of said arcuate sections of said slip assembly as said sections are expanded radially outward; and

second aligning means for maintaining horizontal alignment of broken segments of said arcuate slip sections as said broken segments are expanded radially outward.