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2,877,851

COUPLING APPARATUS

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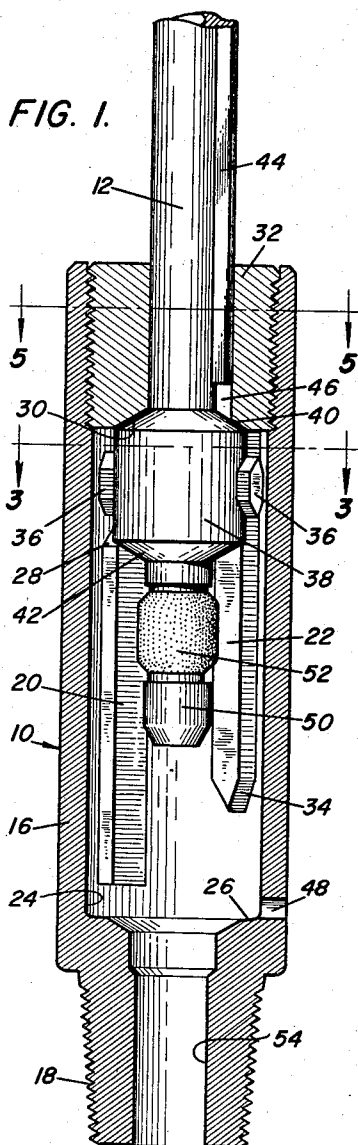


FIG. 1.

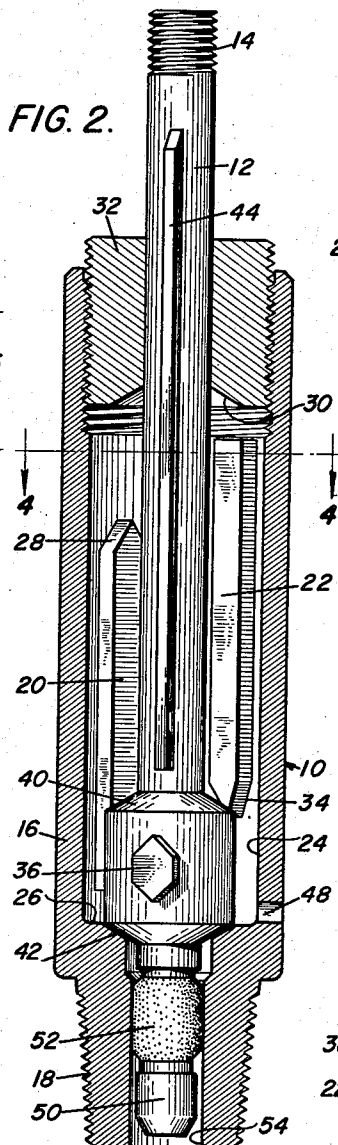


FIG. 2.

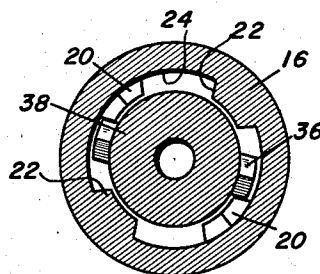


FIG. 3.

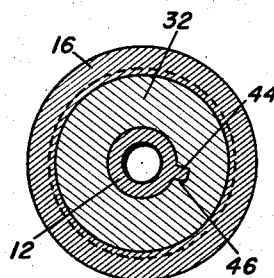


FIG. 5.

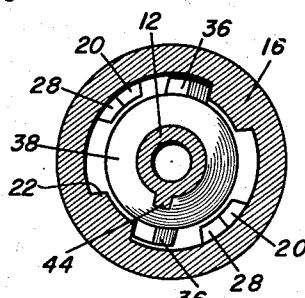


FIG. 4.

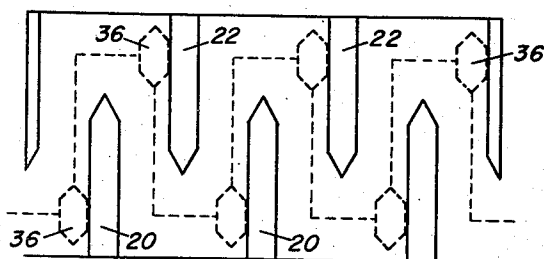


FIG. 6.

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COUPLING APPARATUS

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Application March 28, 1955, Serial No. 497,246

8 Claims. (Cl. 166—178)

This invention relates to apparatus for coupling together parts of an equipment string of the type which is lowered into an oil or gas well or the like and, more particularly, to coupling apparatus of the type described which is useful for controlling or adjusting the relative position of and movement between the parts of the string connected thereto.

The invention may be applied to coupling apparatus in general, but has advantages which make it particularly applicable to an arrangement suited for releasably interconnecting parts of a string of well equipment or the like. For example, in the performance of drilling, testing, cementing, and various other well operations it is not uncommon to discover that a tool, such as the drilling bit used in drilling operations or the well packer used in various other operations, has become stuck in the well to the extent that it becomes expedient or necessary to apply a sudden jarring force to loosen or dislodge the tool. Where the tool cannot be released in this manner, it is common practice to attempt to separate the string at a convenient point above the tool so that as much of the string as possible can be withdrawn from the well.

In order to facilitate separation of the string under these circumstances, the well operator when making up the string commonly includes a safety joint or releasable connection immediately above the tool which is likely to become stuck in the well. Such safety joints or releasable connections commonly depend for their operation upon the application of force to release frangible members or to produce relative rotation between certain parts of the string. While such prior art devices have heretofore been widely used, difficulties have often been encountered. For example, it is at times difficult to control the forces applied to break or separate the string, with the result that oftentimes undue stress occurs at other connections or points in the string. At times separation undesirably is effected at connections or points considerably above the tool which is stuck in the well. This is particularly likely to occur where the safety joint depends for its operation on relative rotation in a reverse direction from that used in making up the string, since such reverse rotation tends to unscrew the other connections in the string.

It is an object of this invention to provide improved apparatus for coupling together parts of an equipment string of the type which is lowered into an oil or gas well or the like.

It is another object of this invention to provide improved coupling apparatus of the type described having provision for applying a sudden or jarring force to tools or other apparatus included in an equipment string connected thereto.

It is another object of this invention to provide an improved safety joint or releasable connection for use between parts of a string of well equipment or the like.

It is a more specific object of this invention to provide an improved safety joint or releasable connection having provision whereby a string of equipment connected

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thereto may be separated without rotating the string in a reverse direction from that involved in making up the other connections in the string.

It is a further object of this invention to provide improved coupling apparatus suited for use as a combined positioning device, jarring tool and safety joint in connection with the performance of various well operations.

In accordance with the invention, there is provided coupling apparatus which includes inner and outer telescoping members having abutment or guiding means therebetween for controlling movement of the members with respect to each other. The abutment or guiding means includes a plurality of longitudinally extending splines or the like angularly spaced about one of the members and a laterally projecting part or lug on the other of the members adapted to register with the spaces between the splines. The splines permit the inner member to be reciprocated or moved longitudinally between first and second relative longitudinal positions within the outer member, but engage the lug to limit relative rotation between the members.

The splines are so constructed and arranged that upon moving the inner member to either of its first or second relative longitudinal positions, the inner member may then be rotated or shifted angularly an increment in one direction to change its relative angular position within the outer member. Thereafter, the inner member may be moved to the other of such relative longitudinal positions and then may again be rotated or shifted angularly another increment in the same direction. By selectively performing and repeating these operations, it is possible for a well operator to control or adjust the relative position of and movement between parts of a string of equipment connected, respectively, to the inner and outer members.

Also, since limited relative longitudinal movement between the members is allowed, the arrangement permits the application of a sudden or jarring force to tools or other apparatus which become stuck in the well.

In order that the coupling apparatus may be used as a releasable connection or safety joint, the abutment or guiding means includes means detachably interconnecting the inner and outer members and responsive to relative movement therebetween to separate the members. The arrangement is such that each rotation or angular shift of the inner member an increment in one direction causes the members to be partially separated. However, complete separation may be effected only by selectively moving the inner member through a predetermined number of operations, each of which involves relative angular movement of the inner member in said one direction and also involves movement of the inner member between its first and second relative longitudinal positions within the outer member.

The foregoing and other objects and advantages of the invention will, it is believed, become more apparent from the following detailed description when read in connection with the accompanying drawing in which similar numerals refer to similar parts and wherein:

Figure 1 is a longitudinal sectional view of coupling apparatus constructed in accordance with the invention, showing the apparatus with its parts in the positions occupied by them at one stage of operation;

Figure 2 is a view similar to that of Figure 1, but showing the apparatus with its parts in the positions occupied by them at another stage of operation;

Figure 3 is a transverse sectional view taken along line 3—3 of Figure 1;

Figure 4 is a transverse sectional view taken along line 4—4 of Figure 2;

Figure 5 is a transverse sectional view taken along 5—5 of Figure 1; and

Figure 6 is a graphical representation which it is believed will be helpful in understanding the operation of the invention.

Referring to the drawing in detail, and first to the arrangement of Figure 1, the invention is illustrated, by way of example, as being applied to coupling apparatus 10 which is suited for use as a combined positioning device, jarring tool and safety joint in connection with any of various well operations in the performance of which there is a likelihood that a tool or other apparatus will become lodged or stuck in the well.

The coupling apparatus 10 includes an inner tubular member or mandrel 12 having its upper end portion 14 (see Figure 2) adapted to be threadedly or otherwise connected to the upper part of an equipment string (not shown) to be lowered into a well. For example, the end portion 14 may be connected to the lower end of a drill pipe or other conduit extending upwardly therefrom to the surface of the ground.

The coupling apparatus 10 also includes an outer tubular member or case 16 which encircles the mandrel 12 and has its lower end portion 18 adapted to be threadedly or otherwise connected to the lower part of the equipment string. For example, the end portion 18 may be connected to the upper end of a tool, such as a drilling bit or well packer, which is likely to become stuck in the well.

If desired, the mandrel 12 and the case 16, or either of them, may be constructed integral with or as extensions of tools or other apparatus included in a well string.

When the coupling apparatus 10 is connected in an equipment string, the mandrel 12 is movable within the case 16 by manipulating the upper part of the string at a time when the lower part is supported against substantial movement with respect thereto. For example, when a tool or other apparatus connected to the lower end portion 18 of the case 16 becomes stuck in the well, the mandrel 12 may then be moved within the case 16 by manipulating the drill pipe or other conduit connected to the upper end portion 14 of the mandrel 12.

An important feature of the invention resides in the abutment or guiding means which is provided between the mandrel 12 and case 16 for controlling or limiting relative longitudinal and angular movement therebetween.

As illustrated, the abutment or guiding means includes a plurality of longitudinally extending splines 20 and 22, which are disposed about the inner wall 24 of the case 16 in angularly spaced relation to each other. Where more than two splines are provided, they are preferably arranged about the wall 24 in an alternate manner, as shown best in Figures 3 and 4. It will be noted that each spline 20 is shown disposed between two splines 22 and each spline 22 is shown disposed between two splines 20.

As shown best in Figures 1 and 2, each spline 20 extends upwardly from a point at or near a lower abutment 26 provided on the inner wall 24 and has an upper end portion 28 disposed a suitable distance below an upper abutment 30, which in the arrangement shown is provided by a collar 32 or the like detachably connected to the upper portion of the wall 24. Each spline 22, on the other hand, extends downwardly from a point at or near the upper abutment 30 and has a lower end portion 34 disposed a suitable distance above the lower abutment 26.

The abutment or guiding means also includes one or more laterally projecting parts or lugs 36, which are provided on the mandrel 12. Each lug 36 is adapted to register with and, when the mandrel 12 is moved with respect to the case 16, travels along any of the spaces on the case 16 provided, respectively, between each set of adjacent splines 20 and 22, between the lower abutment 26 and the lower end portion 34 of each spline 22, and between the upper abutment 30 and the upper end portion 28 of each spline 20. It is understood that, if

desired, the splines 20 and 22 may be provided on the mandrel 12 and the lug or lugs 36 may be provided on the case 16.

A plurality of lugs 36 are preferably provided on the mandrel 12, in which event the splines 20 and 22 are preferably equally spaced on the case 16 and the total number of splines 20 and 22 should equal a multiple of the total number of lugs 36. The lugs 36 are preferably also equally spaced and should be aligned about the periphery of the mandrel 12 so that when any lug 36 is in registry with any of the spaces provided, as aforesaid, on the case 16, the remaining lugs 36 will each be in registry with a corresponding space at another location on the inner wall 24 of the case 16.

It will be noted that the lugs 36 and the splines 20 and 22 are constructed and arranged so that the mandrel 12 may be reciprocated or moved longitudinally within the case 16 between limits defined generally by the abutments 26 and 30. Also, it will be noted that the splines 20 and 22 by engaging the lugs 36 normally prevent the mandrel 12 from being rotated a complete cycle within the case 16 when in any given relative longitudinal position therein.

For certain applications, it may be desirable or satisfactory to construct and arrange the mandrel 12 and lugs 36 so that relative longitudinal movement of the mandrel 12 within the case 16 is limited by the lugs 36 coming into engagement with the abutments 26 and 30 provided on the case 16. With such an arrangement, however, there is a likelihood that the lugs 36 will become damaged or broken, particularly so where the coupling apparatus 10 is used as a jarring tool.

Accordingly, as shown best in Figures 1 and 2, the mandrel 12 preferably has an intermediate raised portion 38 on which the lugs 36 are mounted. The raised portion 38 provides an upwardly facing shoulder 40 adapted to engage the upper abutment 30 to limit relative upward movement of the mandrel 12 and provides a downwardly facing shoulder 42 adapted to engage the lower abutment 26 to limit relative downward movement of the mandrel 12.

As a result of this arrangement, the mandrel 12 is movable or, if desired, may be reciprocated within the case 16 between a first or uppermost position in which the shoulder 40 engages the upper abutment 30, as shown in Figure 1, and a second or lowermost position in which the shoulder 42 engages the lower abutment 26, as shown in Figure 2.

As shown best in Figures 1 and 3, upon the mandrel 12 being moved to its uppermost position within the case 16, each lug 36 is then angularly adjacent to or opposite the space above a spline 20. The mandrel 12 then may, if desired, be rotated or angularly shifted in a direction such as to move each lug 36 into laterally abutting relation to a spline 22 on the other side of the spline 20, this being possible because the space provided above each spline 20 is sufficient to permit any of the lugs 36 to travel therethrough.

Similarly, as shown best in Figures 2 and 4, upon the mandrel 12 being moved to its lowermost position within the case 16, each lug 36 is then angularly adjacent to or opposite the space (shown best in Figure 2) below a spline 22. The mandrel 12 then may, if desired, be rotated or angularly shifted in a direction such as to move each lug 36 into laterally abutting relation to a spline 20 on the other side of the spline 22, this being possible because the space provided below each spline 22 is sufficient to permit any of the lugs 36 to travel therethrough.

Thus, upon the mandrel 12 being moved to either of its extreme relative longitudinal positions within the case 16, it may then be rotated or angularly shifted an increment in one direction to change its relative angular position therein. Thereafter, the mandrel 12 may be moved to the other of its extreme relative longitudinal positions and then may be rotated or angularly shifted

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another increment in the same direction to again change its relative angular position within the case 16. If desired, these operations may be repeated again and again, with the increments of angular movement or rotation always being in the same (for example, clockwise) direction and with the lugs 36 successively following the same general path along the spaces provided, as aforesaid, on the inner wall 24 of the case 16.

Figure 6 is a graphical representation showing in broken lines a portion of the general path followed by each of the lugs 36 and also showing in broken lines certain positions successively assumed by each lug 36 as it moves along the spaces provided between the splines 20 and 22. The positions represented have been arbitrarily selected and correspond generally to certain successive positions assumed by one of the lugs 36 after each of several successive incremental shifts of the mandrel 12 in the same (for example, clockwise) direction.

Looking generally from left to right on the graph of Figure 6, it will be noted that the lug 36 is first shown in a position laterally abutting a spline 20 after having been moved to that position by rotating the mandrel 12 (for example, in a clockwise direction) when in its lowermost position within the case 16. The lug 36 is next shown in a position laterally abutting a spline 22 after having been moved to that position by moving the mandrel 12 to its uppermost position within the case 16 and then rotating the mandrel 12 in the same (for example, clockwise) direction as before. The lug 36 is then shown in a position laterally abutting another spline 20 after having been moved to that position by moving the mandrel 12 to its lowermost position within the case 16 and then rotating the mandrel 12 again in the same (for example, clockwise) direction.

It will be noted that in an arrangement, for example, wherein only two splines 20 and two splines 22, all equally spaced, are provided on the case 16, the mandrel 12 will have been rotated 180° or one-half of a complete revolution in moving the lug 36 from a position laterally abutting one spline 20 to a position laterally abutting the other spline 20. By repeating the foregoing operations, the lug 36 may be caused to successively assume the subsequent positions shown in broken lines in Figure 6, the total travel of the lug 36 shown being representative, in the example given, of approximately one and one-half complete revolutions of the mandrel 12 within the case 16.

In order that the coupling apparatus 10 may be used as a safety joint or releasable connection, the abutment or guiding means provided between the mandrel 12 and case 16 also includes means detachably interconnecting the mandrel 12 and case 16 in such manner that, when desired, the well operator may separate the coupling apparatus 10 to permit the upper part of the equipment string to be withdrawn from the well. To this end, the mandrel 12 and case 16 are shown as being detachably interconnected by the collar 32, which provides the upper abutment 30 on the inner wall 24 of the case 16.

The collar 32 is slidably mounted on the mandrel 12 and is screwed into the upper portion of the case 16. As shown best in Figure 5, the collar 32 is supported against rotation with respect to the mandrel 12 by a key 44, which extends lengthwise of the mandrel 12 and is in registry with a keyway 46 provided in the collar 32. It will be noted that the collar 32 is rotatable with the mandrel 12 and with respect to the case 16. As a result of this arrangement, each rotation or angular shift of the mandrel 12 an increment in one direction (for example, clockwise) causes the collar 32 to rotate an increment in a direction such as to screw it out of the case 16.

For best results in oil and gas well applications the collar 32 is preferably connected to the inner wall 24 of the case 16 by threads which are of opposite hand to those used at other connection points in the equipment string. For example, if the other connections are made

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by rotation in a clockwise or right-hand direction, the threads interconnecting the collar 32 and the case 16 should be such that connection is made by rotation of the collar 32 in a counterclockwise or left-hand direction.

5 This connection will ordinarily be made by screwing the collar 32 into the case 16 before the coupling apparatus 10 is connected into the equipment string and lowered into a well.

In operation, the coupling apparatus 10 will ordinarily be lowered into a well with the collar 32 fully screwed into the case 16 and with the mandrel 12 in its uppermost position within the case 16, as shown in Figure 1. In certain applications, however, such as where the lower part of the string includes a tool having drag springs or the like which resist downward movement of the string, the mandrel 12 may move downwardly within the case 16 to some extent as the string is lowered into the well.

Where the coupling apparatus 10 is lowered into a well bore containing substantial quantities of fluid such as drilling mud, the lowering will ordinarily be facilitated if fluid entering the case 16 from below is permitted to escape into the annular space surrounding the well string. To this end, the coupling apparatus 10 is shown as including a by-pass valve which remains open during the lowering of the string into the well.

Referring to Figures 1 and 2, the by-pass valve includes one or more lateral ports 48 provided in the lower portion of the case 16 and also includes an elongated valve member 50, which is screwed into the lower end of the mandrel 12. The valve member 50 is movable with the mandrel 12 and carries a sealing ring 52.

When the coupling apparatus 10 is lowered into a well with the mandrel 12 in its uppermost position within the case 16, fluids entering the case 16 from below are permitted to flow upwardly therein and outwardly through the ports 48 into the annular space surrounding the string. After the lower portion of the string has reached the bottom of the well or has otherwise become supported against further downward movement, the mandrel 12 may then be moved downwardly within the case 16 by further lowering the upper part of the string. As the mandrel 12 approaches its lowermost position within the case 16, the sealing ring 52 engages the inner wall 54 of the lower portion of the case 16, as shown in Figure 2, thus effecting below the ports 48 a fluid tight seal and closing the by-pass valve. It will be noted that since the sealing ring 52 does not engage the wall 54 until the mandrel 12 approaches its lowermost position within the case 16, the by-pass valve will ordinarily remain open while the string is being lowered even if the mandrel 12 moves downwardly to some extent within the case 16.

If, during or after the lowering of the string, a tool or other apparatus connected below the case 16 becomes lodged or stuck in the well, the coupling apparatus 10 may, if desired, be used to apply a sudden or jarring force in an attempt to loosen or dislodge the stuck tool or other apparatus. For example, when it becomes apparent that a tool has become stuck, the upper portion of the string may be lowered to move the mandrel 12 to its lowermost position within the case 16. Then the upper portion of the string may be raised in such manner as to cause the mandrel 12 to move suddenly and with considerable force to its uppermost position within the case 16. As the mandrel 12 reaches its uppermost position, the upwardly facing shoulder 40 strikes a sharp blow against the upper abutment 30 on the case 16 and thereby applies a sudden or jarring force to the equipment, including the stuck tool or other apparatus, included in the lower part of the string. If desired, this procedure may be repeated until the stuck tool or other apparatus is released or until it becomes apparent that it cannot be released in this manner.

If it becomes necessary or expedient to separate the string while in the well, such as is commonly the case where a tool in the lower portion of the string is stuck

and cannot be released by jarring or similar actions, this may be accomplished by selectively moving the mandrel 12 within the case 16 in such manner as to screw the collar 32 out of the case 16.

In operations where, for example, rotation of the collar 32 in a clockwise direction is required to screw it out of the case 16, the drill pipe or other conduit accessible at the surface of the ground may be raised to move the mandrel 12 to its uppermost position within the case 16, as shown in Figures 1 and 3. Then the drill pipe or other conduit may be rotated in a clockwise direction, causing the mandrel 12 to shift angularly within the case 16 sufficiently to move each lug 36 from a position angularly adjacent to or opposite the space above a spline 20 to a position laterally abutting a spline 22 on the other side of the spline 20. This causes the collar 32 to screw partially out of the case 16.

The drill pipe or other conduit may then be lowered to move the mandrel 12 to its lowermost position within the case 16, as shown in Figures 2 and 4. Then the drill pipe or other conduit may be again rotated in a clockwise direction, causing the mandrel 12 to shift angularly within the case 16 sufficiently to move each lug 36 from a position angularly adjacent to or opposite the space below a spline 22 to a position laterally abutting a spline 20 on the other side of the spline 22. This causes the collar 32 to screw farther out of the case 16.

In order to completely disconnect the collar 32 from the case 16 and thus effect complete separation of the string in the well, it is necessary to repeat the manipulations of the drill pipe or other conduit, as aforesaid, to selectively move the mandrel 12 through a predetermined number of successive operations, each of which involves relative angular movement of the mandrel 12 an increment in a clockwise direction within the case 16 and relative longitudinal movement of the mandrel 12 between its extreme longitudinal positions within the case 16. A portion of the path of travel of each of the lugs 36 during these successive operations is shown graphically in Figure 6, as hereinabove described.

It is obvious that the number of revolutions of the collar 32 required to completely screw it out of the case 16 is determined by the number of threads connecting it to the case 16. It should be noted, however, that the upper abutment 30 provided by the collar 32 moves upwardly to some extent each time the collar 32 is rotated an increment in a direction such as to unscrew it from the case 16. Accordingly, it is possible that before the collar 32 has been completely screwed out of the case 16, there will be sufficient clearance between the upper abutment 30 and the upper ends of the splines 22 to permit the lugs 36 to travel therebetween, and thus to permit the mandrel 12 to be rotated the remaining number of cycles while remaining in its uppermost position within the case 16.

If desired, the apparatus 10 may be constructed and arranged so that the collar 32 becomes disconnected from the case 16 before the clearance between the upper abutment 30 and the upper ends of the splines 22 becomes sufficient to permit the lugs 36 to travel therebetween.

It will ordinarily be desirable for the apparatus 10 to be constructed and arranged so that, in order to completely screw the collar 32 out of the case 16, the mandrel 12 must be selectively moved within the case 16 a sufficient number of times so that there will be little likelihood that the coupling apparatus 10 will be inadvertently or accidentally separated during the performance of a well operation.

As herein disclosed, the invention provides an improved coupling apparatus for coupling together parts of an equipment string lowered into an oil or gas well or the like. The arrangement shown includes provision for applying a sudden or jarring force to tools or other apparatus which become stuck or lodged in the well and also includes a safety joint which is releasable only by positive action on

the part of the well operator. In particular, since the collar 32 may be, and preferably is, connected to the case 16 by threads which are of opposite-hand to those used in other joints or connections in the string of equipment in the well, the arrangement provides a safety joint which may be separated without applying undue stress to other parts of the string and without applying forces which tend to unscrew the other joints or connections in the string.

From the foregoing description it will be obvious to those skilled in the art that the coupling apparatus 10 may also be used as a positioning device in connection with various well operations. In the drawing there is shown a relatively simple arrangement in which the coupling apparatus 10 functions to control the flow of fluids through a by-pass valve included as part of the apparatus 10.

While only one embodiment of the invention has been illustrated and described, it is apparent that various modifications thereof will now suggest themselves to those skilled in the art. Accordingly, the invention is best defined by the scope of the appended claims.

I claim:

1. In coupling apparatus for use between parts of a string of equipment lowered into a well, the combination of an inner mandrel, a case encircling said mandrel, said case having a plurality of longitudinally extending splines angularly spaced about its inner wall, said mandrel having a lug thereon adapted to engage said splines and thereby limit relative angular movement of said mandrel within said case and adapted to move between said splines to permit relative longitudinal movement of said mandrel within said case, lower abutment means on said case for limiting relative downward movement of said mandrel therein, and upper abutment means including a collar slidably mounted on and rotatable with said mandrel and threadedly connected to said case for normally limiting relative upward movement of said mandrel within said case, alternate splines on said case each extending upwardly from near said lower abutment means and terminating a suitable distance below said upper abutment means, the remaining splines on said case each extending downwardly from near said upper abutment means and terminating a suitable distance above said lower abutment means, whereby upon said mandrel being in either of its extreme relative longitudinal positions within said case sufficient relative angular movement therebetween is permitted to move said lug past an end of one of said splines, the arrangement being such that said collar may be disconnected from said case to permit withdrawal of said mandrel therefrom by selectively moving said mandrel longitudinally and angularly within said case.

2. In coupling apparatus including inner and outer telescoping members, the combination of a multiplicity of longitudinally extending splines equally spaced about the inner wall of said outer member, each spline having an end thereof disposed intermediate the opposite ends of another spline, a plurality of equally spaced lugs aligned about the periphery of said inner member and adapted to register with the spaces provided between said splines, upper and lower abutment means on said outer member adjacent opposite ends of said splines for limiting relative longitudinal movement between said members, alternate splines on said outer member each having its upper end disposed a sufficient distance below said upper abutment means to permit a lug on said inner member to be moved therebetween and into engagement with an adjacent spline, and the remaining splines each having its lower end disposed a sufficient distance above said lower abutment means to permit a lug on said inner member to be moved therebetween and into engagement with an adjacent spline, whereby said inner member after being moved to either of its extreme relative longitudinal positions within said outer member may be rotated therein an increment in one direction to change its relative angular position therein and then may be moved to

the other of its extreme relative longitudinal positions within the outer member without first being rotated therein in a reverse direction, one of said abutment means including means detachably interconnecting said members and adapted to permit separation thereof upon successive rotation of said inner member a plurality of increments in said one direction.

3. Coupling apparatus for use between parts of a string of equipment lowered into a well comprising an inner mandrel, a case encircling said mandrel, connection means on said mandrel and case for connecting each to one part of said string, said case having a multiplicity of longitudinally extending splines equally spaced about its inner wall, each spline having an end thereof disposed intermediate the opposite ends of another spline, said mandrel having a plurality of equally spaced lugs aligned about the periphery thereof and adapted to register with the spaces provided between the splines on said case, upper and lower abutment means on said case adapted to engage said mandrel to limit relative upward and downward movement thereof within said case, alternate splines on said case each having its upper end disposed below said upper abutment means a sufficient distance to permit a lug on said mandrel to be moved therebetween and into engagement with an adjacent spline upon rotation of said mandrel when in its uppermost position within said case, the remaining splines on said case each having its lower end disposed above said lower abutment means a sufficient distance to permit a lug on said mandrel to be moved therebetween and into engagement with an adjacent spline upon rotation of said mandrel when in its lowermost position within said case, and means detachably interconnecting said case and mandrel and responsive to relative rotation therebetween at least one revolution in one direction to remove said upper abutment means from said case and thereby permit withdrawal of said mandrel therefrom.

4. The invention as claimed in claim 3 wherein said upper abutment means and said means detachably interconnecting said case and mandrel include a collar slidable along and rotatable with said mandrel and threadedly connected to said case.

5. Coupling apparatus for use between parts of a string of equipment lowered into a well comprising inner and outer telescoping members each adapted to be connected to one part of said string, splines angularly spaced on one of said members and extending lengthwise thereof between said members, each spline having an end thereof disposed between the opposite ends of another spline, a lug on the other of said members adapted to engage said splines and thereby limit relative rotation between said members and adapted to move along the space between said splines and thereby permit relative longitudinal movement between said members, upper and lower abutment means on said splined member for limiting relative longitudinal movement between said members and thereby normally preventing separation of said members, at least one of said splines having its upper end disposed below said upper abutment means a sufficient distance to permit said lug to be moved through the space therebetween and into engagement with another spline upon relative rotation of said members when in one extreme relative longitudinal position with respect to each other, the remaining splines each having its lower end disposed above said lower abutment means a sufficient distance to permit said lug to be moved through the space therebetween and into engagement with another spline upon relative rotation of said members when in the other extreme relative longitudinal position with respect to each other, and means including said upper abutment means detachably interconnecting said members and responsive to relative rotation therebetween a plurality of complete revolutions in one direction to separate said members.

6. In coupling apparatus, the combination of inner and

outer telescoping members, said outer member having an internally threaded upper end portion and having a plurality of splines angularly spaced thereon below said threaded portion, each spline having one end thereof disposed above and the other end thereof disposed below one of the upper and lower ends of each adjacent spline whereby a space is provided on the splined member above each alternate spline and a space is provided on such member below each of the other splines, said inner member having a lug thereon adapted to move along the spaces provided between and above and below said splines, abutment means on said outer member below said splines adapted to engage said inner member to limit relative downward movement thereof, a collar slidable along and rotatable with said inner member and having external threads engageable with the threaded upper end portion of said outer member, and shoulder means on said inner member above said lug adapted to engage said collar and thereby limit relative upward movement of said inner member with respect to said collar and with respect to said outer member when threadedly connected to said collar.

7. In coupling apparatus for use between parts of a string of equipment lowered into a well, the combination of inner and outer telescoping members, one of said members having a plurality of splines angularly spaced thereon and extending generally lengthwise thereof between said members, the other of said members having a lug adapted to engage said splines and thereby limit relative angular movement between said members and adapted to move along the spaces between said splines to permit relative longitudinal movement between said members, upper and lower abutment means on the spline-carrying member adapted to engage the other of said members and thereby limit relative longitudinal movement between said members, certain splines each extending upwardly from near said lower abutment means toward the top of the spline-carrying member and the other splines each extending downwardly from near said upper abutment means toward the bottom of such member, said upwardly extending splines each having its upper end disposed a suitable distance below said upper abutment means whereby upon said inner member being in its uppermost position with respect to said outer member sufficient relative angular movement between said members is permitted to move said lug past said upper end and into engagement with one of said downwardly extending splines, said downwardly extending splines each having its lower end disposed a suitable distance above said lower abutment means whereby upon said inner member being in its lowermost position with respect to said outer member sufficient relative angular movement between said members is permitted to move said lug past said lower end and into engagement with one of said upwardly extending splines, and means detachably interconnecting said members and responsive to relative rotation therebetween to separate said members, the arrangement being such that said members may be separated by selectively moving one of said members longitudinally and angularly with respect to the other of said members in such manner as to move said lug at least once past an end of each of said splines in succession.

8. In coupling apparatus for use between parts of a string of equipment lowered into a well, the combination of inner and outer telescoping members, one of said members having a plurality of splines angularly spaced thereon and extending generally lengthwise thereof between said members, the other of said members having a lug adapted to engage said splines and thereby limit relative angular movement between said members and adapted to move between said splines to permit relative longitudinal movement between said members, abutment means on one of said members adapted to engage the other of said members and thereby limit relative longitudinal movement between said members, each spline having one end

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thereof disposed above and the other end thereof disposed below one of the ends of each spline angularly adjacent thereto, whereby a space is provided on the spline-carrying member above each alternate one of the splines and a space is provided on such member below each of the other splines, said lug being adapted to move along the spaces provided above and below said splines, whereby upon said members being in either extreme relative longitudinal position with respect to each other sufficient relative angular movement therebetween is permitted to move said lug past an end of one and into engagement with another of said splines, and means detachably interconnecting said members and responsive to relative rota-

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tion therebetween to separate said members, the arrangement being such that said members may be separated by selectively moving one of said members longitudinally and angularly with respect to the other of said members in such manner as to move said lug at least once past an end of each of said splines in succession.

References Cited in the file of this patent

UNITED STATES PATENTS

1,732,577	Durdin	Oct. 22, 1929
2,097,755	Brown	Nov. 2, 1937
2,708,100	Sutliff	May 10, 1955