

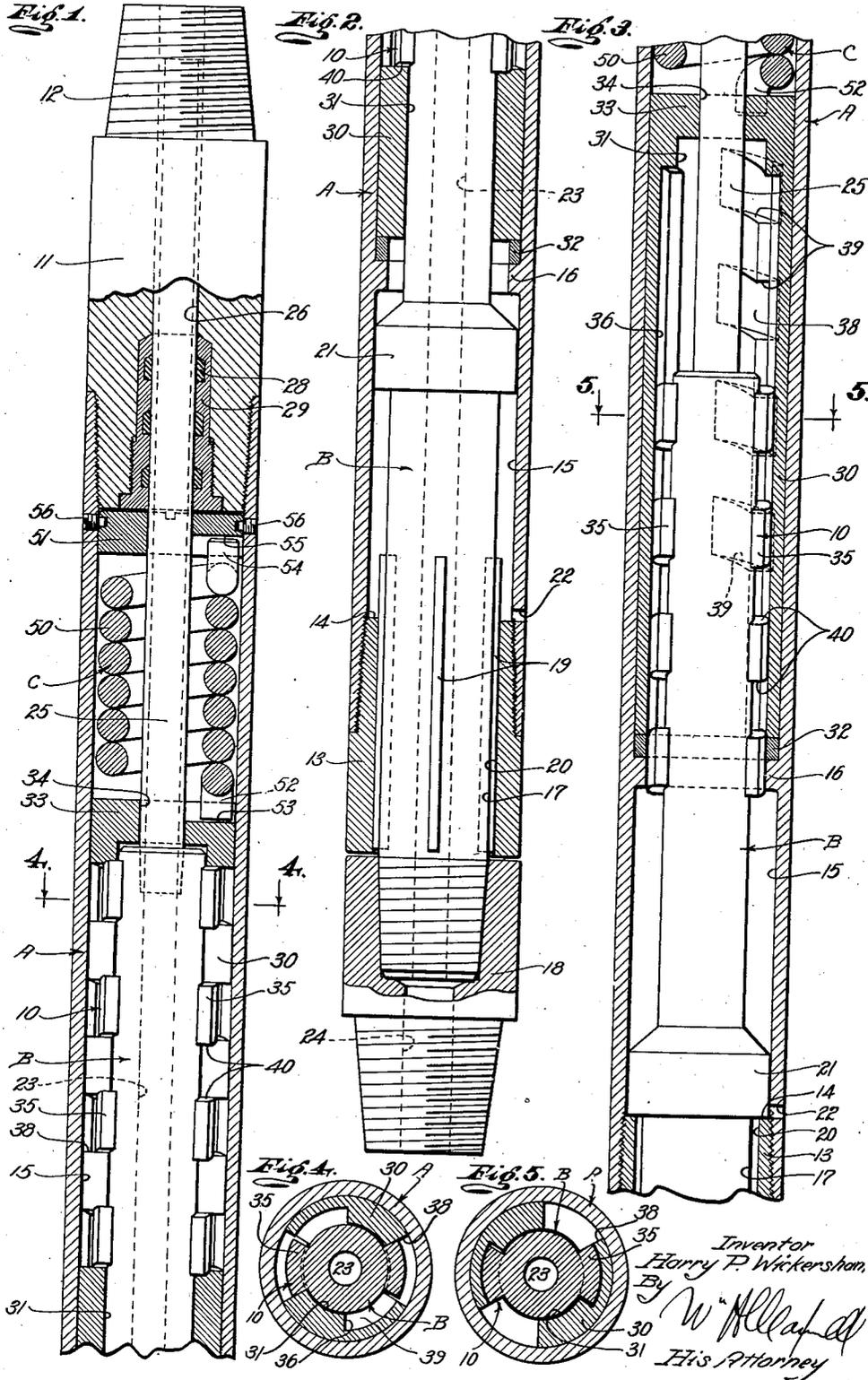
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JAR

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JAR

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This invention relates to a well tool and relates more particularly to a rotary jar. A general object of the invention is to provide a simple practical and improved rotary jar for imparting a jarring action to a part or object in a well.

Jarring tools have been introduced that are operated to effect a jarring action by maintaining a torsional strain on the string in which the tool is interposed and then putting the string under a tensile strain to actuate the tool. To provide a jarring action of effective or substantial magnitude it is necessary to maintain the string under a comparatively heavy torsional strain. When the fish or object to be jarred is capable of rotating the fishing string cannot be held under any appreciable torsional strain and the type of jarring tool referred to cannot be operated or employed.

Another object of the invention is to provide a jarring tool that may be operated by a simple up-strain or tensile strain to effect a heavy jarring action. The jarring tool of the present invention may be actuated to impart an effective jarring blow to the fish by merely putting a tensile strain on the operating or fishing string and is, therefore, adapted to jar a fish that may turn or rotate.

It is another object of the invention to provide a rotary jar that is capable of successive operation to impart any required or desired number of jarring impulses to the caught object or fish in rapid succession.

It is another object of the invention to provide a rotary jar of the character mentioned that may be successively operated by reciprocating the string in which it is connected.

It is another object of the invention to provide a jarring tool that may be set or adjusted to operate under tensile strains of different magnitudes or intensities.

It is another object of the invention to provide a jarring tool that includes a sleeve or movable part having faces adapted to cooperate with faces on a body section to hold the tool in a contracted or unactuated condition which faces are releasable or disengageable by a tensile strain on the tool, and a control in the form of a spring which yieldingly holds said movable part against releasing movement and that operates to automatically reset the said part in the releasable holding position after actuation of the tool.

It is a further object of the invention to provide a rotary jar that is simple and compact and that is inexpensive of manufacture.

Other objects and features of the invention may

become apparent from the following detailed description of a typical preferred form and application of the invention throughout which description reference may be had to the accompanying drawing, in which—

Fig. 1 is a longitudinal detailed sectional view of the upper portion of the tool illustrating the parts in the unactuated positions.

Fig. 2 is a longitudinal detailed sectional view of the lower portion of the tool with the parts in the unactuated positions.

Fig. 3 is a longitudinal detailed sectional view of the central or intermediate portion of the tool illustrating the parts in the actuated or jarred positions.

Fig. 4 is a transverse detailed sectional view taken as indicated by line 4—4 on Fig. 1 and Fig. 5 is a transverse detailed sectional view taken as indicated by line 5—5 on Fig. 3.

The jarring tool provided by the invention includes generally two sections, A and B related or connected for limited longitudinal movement, releasable means 10 for holding the sections A and B against relative longitudinal movement, and a control C for the releasable holding means 10.

The sections A and B are the body parts or members of the tool and are adapted to be connected or interposed in a string of drill pipe or the like. The body sections A and B may be connected in a drilling string of drill pipe carrying a well drilling tool or may be connected in a fishing string of drill pipe carrying a fishing tool for engaging a caught object or fish in a well. The sections A and B are telescopically related or fit one into the other, and are connected for limited relative longitudinal movement.

In the particular case illustrated in the drawing, the section A which is the upper body section is tubular and receives the section B which is in the nature of a mandrel section or stem section. Means is provided on the upper end of the section A to facilitate connection with the string. In the construction illustrated in the drawing, a sub 11 is threaded into the upper end of the tubular section A and has a tapered pin 12 on its upper end adapted to be threaded into a tool joint section, or the like, of the string. A collar or nut 13 is threaded into the lower end of the section A and its upper end forms an upwardly facing annular shoulder 14 in the lower portion of the section A. The opening 15 of the body section A may be uniform in diameter throughout its length except that an inwardly projecting annular flange

16 is provided on its wall at a point spaced some distance above the shoulder 14.

The body section B is adapted to be connected with the object to be jarred, that is, it may be connected with a fishing tool for engaging the caught part or fish. The section B slidably passes through the central longitudinal opening 17 of the nut 13 and extends upwardly through the opening 15 of the section A. A sub or connecting member 18 is provided on the lower end of the section B to facilitate the connection of the section with a fishing tool or with a part of the string. In accordance with the invention, the sections A and B are connected against relative rotation so that the tool is adapted to transmit torque or rotational strains. Longitudinal keys or splines 19 are provided on the body section B to slidably cooperate with keyways 20 in the wall of the opening 17 to key the sections A and B together against relative rotation. An abutment 21 is provided on the section B to be engaged or jarred against by the shoulder 14 of the section A to provide an upward jarring effect when the means 10 is actuated or released. The abutment 21 is in the form of an annular enlargement or flange on the section B between the shoulder 14 and the flange 16. The lower end of the abutment 21 is preferably flat and normal to the longitudinal axis of the tool to be evenly and effectively engaged by the shoulder 14. A relief port or breather opening 22 may be provided in the wall of the section A adjacent the shoulder 14 to permit the escape of fluid that may be trapped in the section A between the shoulder 14 and the abutment 21.

The invention provides means for circulating or passing the circulation fluid through the sections A and B. The section B is provided with a central longitudinal fluid passage 23 which extends from its upper end to its lower end where it communicates with a longitudinal passage 24 in the connecting member 18. A tube or wash pipe 25 projects upwardly from the upper end of the section B and is slidable in a central longitudinal opening 26 in the sub 11 to conduct fluid downwardly to the passage 23. The wash pipe 25 is sufficiently long to have its upper portion project into the passage 26 when the sections A and B are in their extending or actuated positions. Packing 28 carried by a follower or carrier 29 is provided to seal about the wash pipe 25 in the lower portion of the passage 26.

The means 10 is adapted to hold the body sections A and B in the unactuated or contracted positions and is releasable by a tensile strain on the sections to allow the section A to suddenly move upwardly relative to the section B so that the shoulder 14 jars against the anvil or abutment 21, the release of the means 10 being governed by or under the control of the control C. The releasable holding means 10 includes a sleeve 30 supported or arranged in the body section A for limited rotation. The sleeve 30 is preferably of considerable length and its central longitudinal opening 31 receives the upper portion of the section B. In the particular construction illustrated in the drawing the sleeve 30 is supported by the flange 16. A suitable bearing ring or thrust washer 32 may be interposed between the lower end of the sleeve 30 and the flange 16. The lower end of the sleeve 30 is open to pass or receive the section B and a cap portion 33 is provided on the upper end of the sleeve 30. The cap portion 33 has a central opening 34 for passing the wash pipe

25. The invention provides one or more projecting parts or lugs 35 on the section B for cooperating with the sleeve 30 to releasably hold the section A against upward movement with respect to the section B. In the typical construction illustrated in the drawing there are two diametrically opposite series of longitudinally spaced projecting parts or lugs 35 on the section B for cooperating with the sleeve 30. The several lugs 35 may be alike in size and shape and may be integral with the section B. There is preferably a like number of lugs 35 in each series and the lugs of the two series are preferably directly diametrically opposite.

Longitudinally extending slots or grooves 36 are provided in the wall of the sleeve opening 31 for passing or receiving the series of lugs 35 to permit longitudinal movement between the sections A and B. The grooves 36 extend downwardly to the lower end of the sleeve 30 so that the lowermost lugs 35 may project from the lower end of the sleeve through the washer 32 and flange 16 to allow the shoulder 14 to jar upwardly against the abutment 21. In accordance with the invention the projecting parts or lugs 35 of the body section B and the sleeve 30 have faces or surfaces adapted to cooperate to releasably hold the sections A and B against relative longitudinal movement and to cause turning of the sleeve 30 to bring the grooves 36 into longitudinal alignment or registration with the series of lugs 35 when a comparatively heavy tensile strain is put on the tool to permit the section A to suddenly move upwardly with respect to the section B. A plurality of longitudinally spaced windows or openings 38 are provided in the sleeve 30 to communicate with each longitudinal groove 36. The openings 38 are provided to receive the lugs 35 of the section B and the end walls of the openings 38 and the ends of the lugs 35 constitute the releasably cooperating surfaces referred to above.

The upper and lower walls 39 of the openings 38 are pitched or spiralled and the upper and lower ends 40 of the lugs 35 are correspondingly spiralled to cooperate with the walls 39. The openings 38 are sufficiently large to entirely receive the lugs 35 so that their walls 39 may have full cooperation with the surfaces 40 of the lugs 35. In the particular embodiment of the invention illustrated in the drawing, the surfaces 39 and 40 are pitched in a right hand direction, it being understood that they may be pitched in either direction as the direction of pitch or inclination of surfaces depends upon the direction of force exerted by the control C. The helical pitch of the walls 39 of the openings 38 and the ends 40 of the lugs 35 is such that their engagement or cooperation causes turning of the sleeve 30 relative to the body sections A and B against the action of the control C when a heavy tensile strain is put on the tool. This turning of the sleeve 30 results in the movement of the grooves 36 into longitudinal registration with the series of lugs 35 when a sufficiently heavy tensile strain has been applied to the tool to overcome the resistance offered by the control C and the frictional cooperation between the section B and the sleeve 30. With the tool disposed as illustrated in the drawing the lower inclined or pitched walls 39 of the openings 38 cooperate forceably or actively with the lower ends 40 of the lugs 35 when an up strain or tensile strain is put on the string, in which the tool is connected. The lugs 35 do not leave the grooves 36 when the sections A and B are in the jarred or extended po-

sitions. The lugs 35 cooperate with the grooves 36 and the openings 38 to form means for limiting rotation of the sleeve 30.

The control C governs the release of the holding means 10 and operates to automatically re-engage the cooperating surfaces 39 and 40 when the body sections A and B have been returned to their normal contracted positions after actuation of the tool. The control C is a spring means which yieldingly exerts a torque or rotational force on the sleeve 30 in a direction to resist turning of the sleeve through the cooperation of the surfaces 39 and 40 when the tool is under a tensile strain which torque or rotational force acts to automatically reset the sleeve 30 in a position where its openings 39 fully and actively receive the lugs 35 when the section A is returned to its normal or unactuated position with respect to the section B. The control C includes a spiral or helical spring 50 for acting on the sleeve 30. The spring 50 is arranged in the body section A between the upper end of the sleeve 30 and an adjusting collar 51. The spring 50 surrounds the wash pipe 25 with substantial clearance. It is preferred to make the spring 50 comparatively heavy so as to exert a torque of substantial magnitude whereby a heavy tensile strain must be exerted on the string to release the means 10 against the action of the spring, it being understood that the intensity of the jarring action obtained is determined by the magnitude of the tensile strain required to actuate the tool. The spring 50 may be normally maintained under a rotational strain to impart a considerable torque to the sleeve 30 and the collar 51 may be set in various rotative positions to vary the torque of the spring. The lower convolution of the spring 50 has a downwardly projecting part 52 cooperating with a socket or slot 53 in the upper end of the sleeve 30. A similar projecting part 54 is provided on the upper end of the spring and cooperates with a slot 55 in the collar 51. The collar 51 may be turned to any one of a plurality of different rotative positions to adjust the spring 50 as desired and may then be releasably locked against turning by screws 56.

Assuming that the tool is connected in a fishing string having a fishing tool on its lower end in engagement with an object caught in a well, the tool may be actuated by imposing a tensile strain on the string. With the parts in their normal positions as illustrated in Figs. 1, 2 and 4 of the drawing, the spring 50 tends to turn the sleeve 30 in a direction to hold its spiralled surfaces 39 in tight engagement with the surfaces 40 of the lugs 35. When the tensile strain is applied to the fishing string, the cooperating spiralled surfaces 39 and 40 tend to slip and to turn the sleeve 30 in a direction opposite to the direction of the torque of the spring 50. In practice a comparatively heavy up strain or tensile strain must be put on the fishing string before any slippage occurs between the surfaces 39 and 40 so that the string is elongated or stretched to a considerable extent. Upon the tensile strain on the string reaching a magnitude sufficient to cause the cooperation of the spiralled surfaces 39 and 40 to overcome the torque or rotational force exerted by the spring 50 and to turn the sleeve 30 to bring the longitudinal grooves 36 into registration with the longitudinal series of lugs 35, the lugs suddenly move into the grooves and allow the section A to move upwardly relative to the section B. The tensile strain on the string and the resiliency of the stretched or elongated string moves the

section A upwardly with great force to bring the shoulder 14 into heavy jarring engagement with the abutment 21. The resulting jarring force is, of course, transmitted to the caught object or fish with which the section B is connected and may loosen or tend to loosen it for recovery from the well. The tensile strain required to release the means 10 must be sufficient to cause the cooperating pitched surfaces 39 and 40 to turn the sleeve 30 against the torque of the spring 50 and, therefore, the torque or rotational force exerted by the spring 50 determines the tensile strain required to operate the tool. As described above, the spring 50 may be adjusted to yieldingly impose rotational strains of different intensities on the sleeve 30 by setting or adjusting the collar 51 in different rotative positions.

After the tool has been actuated as above described so that its parts are in the positions illustrated in Figs. 3 and 5 of the drawing the lugs 35 remain in the longitudinal grooves 36 and the tool may be reset for another operation by lowering the section A to a position where the openings 38 are opposite the lugs 35. When the openings 38 are opposite the lugs 35 the spring 50 automatically turns the sleeve 30 to a position where the lugs 35 are fully received in the openings 38 and have their pitched ends in cooperation with the pitched walls 39 of the openings. The tool is then ready for another operation. From the above it will be seen that the tool may be successively operated to impart any required number of upward jarring blows to the lost object or fish. The tool of the present invention may be operated by a simple up strain or tensile strain on the string and, therefore, is adapted for use in connection with the fishing or recovering of a fish that may turn or rotate. The jarring tool is sturdy, simple and compact in construction.

Having described only a typical form and application of the invention, I do not wish to be limited or restricted to the specific form or application herein set forth, but wish to reserve to myself any modifications or variations that may appear to those skilled in the art or fall within the scope of the following claims:

Having described my invention, I claim:

1. A well tool for use in combination with a drill string including two sections related for limited relative longitudinal movement and adapted to be secured to members of the string, a turnable sleeve movably carried by one section and receiving the other section for movement relative thereto, parts on the said other section and sleeve having faces adapted to releasably cooperate and pitched to cause turning of the sleeve upon a tensile strain being applied to the sections, and a separate yielding means interposed between the sleeve and said other section tending to resist turning of the sleeve and disengagement of said parts.

2. A well tool of the character described including two sections related for limited relative longitudinal movement, an element carried by one section and turnable about an axis extending longitudinally thereof, parts on the other section and element having faces adapted to cooperate to hold the sections against relative longitudinal movement and releasable by turning of the element, said faces being pitched to cause turning of the element upon a tensile strain being applied to the sections, and a separate spring control member secured to one of the sections

and to the element yieldably resisting said turning of the element.

3. A well tool for use in combination with a drill string including inner and outer sections adapted to be secured to members of the string and related for limited relative longitudinal movement, an element movable longitudinally with one section and rotatable with respect thereto about an axis extending longitudinally of the tool, parts on the other section and element having lower and upper faces respectively cooperating to hold the sections against relative longitudinal movement and releasable by turning of the element, said faces being pitched to cause turning of the element upon a tensile strain being applied to the sections, and a control in a section resisting said turning of the element, the control including a spring secured at one end to the outer section and at its opposite end to said element thereby exerting a rotational force on the element.

4. A well tool for use in combination with a drill string including two sections adapted to be secured to members of the string and connected for limited relative longitudinal movement and for the transmission of torque, means for holding the sections against relative longitudinal movement including a member rotatably carried by one section, and faces on the member and the other section cooperating to hold the sections against relative longitudinal movement and pitched to cause slippage between them and turning of the member upon a tensile strain being put on the string, and a control for said means arranged in one of the sections and acting independently of the string to determine the tensile force required to cause turning of the member and disengagement of the faces to permit relative longitudinal movement between the two sections.

5. A well tool for use in combination with an operating string including two sections adapted to be secured to members of the string connected for limited relative longitudinal movement and for the transmission of torque, means for holding the sections against relative longitudinal movement including a member carried by one section to turn with respect thereto about its longitudinal axis, and inclined faces on the member and the other section disengageable and releasable by turning of the member and adapted to cooperate to hold the sections against relative longitudinal movement, the faces being pitched to cause slippage between them upon a tensile strain being put on the sections, and a control for said means including a separate spring element in the first named section yieldably acting on the member to urge the member to turn in a direction opposite to the direction of turning caused by said slippage.

6. A well tool for use in combination with an operating string including two sections adapted to be secured to members of the string and connected for limited relative longitudinal movement and for the transmission of torque, means for holding the sections against relative longitudinal movement including a sleeve rotatably carried by one section and adapted to receive the other section, and inclined faces on the sleeve and the said other section to cooperate to hold the sections temporarily against relative longitudinal movement and pitched at an angle sufficient to turn out of cooperation upon a tensile strain being put on the sections whereby to release said sections, for longitudinal movement, a yieldable control element for said means yield-

ably resisting disengagement of the inclined faces, and means for adjusting the control to provide for the release of said means under tensile strains of different magnitudes.

7. A well tool for use in combination with a drilling string including two sections adapted to be secured to members of the string, means connecting the sections for limited relative longitudinal movement and for the transmission of torque, means for holding the sections against relative longitudinal movement including a member carried by one section to turn about an axis extending longitudinally of the tool, and inclined faces on the member and the other section cooperating to hold the sections against relative longitudinal movement and pitched to cause turning of the member and disengagement of the faces upon a tensile strain being put on the sections, and a separate yielding means in one of the sections urging the member to turn in a direction counter to that caused by cooperation of the faces to resist their disengagement and operable to automatically reset the member in a position where the inclined faces are in cooperation when the sections are returned to their normal positions.

8. A well tool for use in combination with a drilling string including two sections connected for relative longitudinal movement and for the transmission of torque, one section being a tubular section secured to a member of the string, the other a mandrel section secured to another member of the string and operating in the tubular section, a sleeve carried in the tubular section for rotation relative thereto and adapted to receive the mandrel section, parts on the mandrel section and sleeve having faces adapted to cooperate to releasably hold the sections against relative longitudinal movement, the faces being pitched at an angle sufficient to cause turning of the sleeve and disengagement of the parts upon a tensile strain being applied to the sections, and separate yieldable means in the tool exerting a rotational force on the sleeve to resist said turning of the sleeve and to rotate the sleeve and return it to its original position when said tensile strain is removed and the sections are returned to their collapsed positions.

9. A well tool for use in combination with a drill string including two sections connected for relative longitudinal movement and for the transmission of torque, one section being a tubular section secured to a member of the string, the other a mandrel section operating in the tubular section and secured to another member of the string, a sleeve carried in the tubular section for rotation relative thereto and adapted to receive the mandrel section and with relation to which the mandrel may move, parts on the mandrel section and sleeve having faces adapted to cooperate to releasably hold the sections against relative longitudinal movement, the faces being pitched to cause turning of the sleeve and disengagement of the parts upon a tensile strain being applied to the sections, and a torsional spring interposed between the tubular section of the sleeve exerting a turning force on the sleeve counter to the direction of the force on the sleeve caused by cooperation of the faces.

10. A well tool for use in combination with a drill string including two sections connected for relative longitudinal movement and for the transmission of torque, one section being a tubular section secured to a member of the string, the other mandrel section operating in the tubular

section and secured to another member of the string, a sleeve carried in the tubular section for rotation relative thereto and adapted to receive the mandrel section and with relation to which the mandrel may move, there being openings in the wall of the sleeve, lugs on the mandrel section for reception in the openings and disengageable therefrom by turning of the sleeve, the lugs and the openings having surfaces adapted to cooperate to hold the sections against relative longitudinal movement, and pitched to cause turning of the sleeve upon a tensile strain being put on the sections, and spring means interposed between the tubular section of the sleeve yieldingly resisting turning of the sleeve mandrel and the resultant disengagement of the lugs from the openings.

11. A well tool including two sections connected for relative longitudinal movement and for the transmission of torque, one section being a tubular section the other a mandrel section operating in the tubular section, a sleeve carried in the tubular section for rotation relative thereto and adapted to receive the mandrel section, there being openings in the wall of the sleeve, lugs on the mandrel section for reception in the openings, the lugs and the openings having surfaces adapted to cooperate to hold the sections against relative longitudinal movement, said surfaces being pitched at an angle sufficient to cause slippage between them upon a tensile strain being put on the sections, the sleeve having longitudinal grooves for passing the lugs when the sections are moved relative to one another upon disengagement of the lugs from the openings, and spring means yieldingly resisting slippage between the surfaces and disengagement of the lugs from the openings.

12. A well tool for use in combination with a drill string including two sections connected for relative longitudinal movement and for the transmission of torque, one section being a tubular section secured to a member of the string, the other a mandrel section operating in the tubular section and secured to another member of the string, a sleeve carried in the tubular section for rotation relative thereto and adapted to receive the mandrel section and with relation to which the mandrel may move, means for conducting circulation fluid through the sections, parts on the mandrel section and sleeve having faces adapted to cooperate to releasably hold the sections against relative longitudinal movement, the face being pitched to cause turning of the sleeve and disengagement of the parts upon a tensile strain being applied to the sections, and means acting independently of the string exerting a rotational force on the sleeve and mandrel to resist said turning of the sleeve.

13. A well tool including two sections connected for relative longitudinal movement and for the transmission of torque, one section being a tubular section the other a mandrel section operating in the tubular section, a sleeve carried in the tubular section for rotation relative thereto and adapted to receive the mandrel section, the sleeve having longitudinal grooves and longitudinally spaced openings communicating with the grooves, longitudinal series of spaced lugs on the mandrel section, the said series being adapted to move longitudinally in the grooves and the lugs being adapted to cooperate with the openings to hold the sections against relative longitudinal movement, the cooperating surfaces of the lugs and openings being pitched at an angle sufficient to cause slippage between them and turning of the sleeve to a position where the lugs are received

by the grooves when a tensile strain is imposed on the sections, and a spring normally tending to turn the sleeve in a direction counter to that caused by cooperation of said faces.

14. A well tool including two sections connected for limited relative longitudinal movement and for the transmission of torque, means for holding the sections against relative longitudinal movement including a rotatable member carried by one section, and faces on the member and the other section to cooperate to hold the sections against relative longitudinal movement and pitched at an angle sufficient to cause slippage between them upon a tensile strain being put on the sections and a control for said means which determines the tensile force required to cause slippage between the faces and disengagement of the face, the control including a torsional spring having one end connected with the member to exert a turning force thereon counter to that caused by slippage between said faces, and a part connecting the other end of the spring with the first named section and adapted to be set in different rotative positions.

15. A jarring tool for use in combination with a drilling string including a tubular section having means for non-rotatably connecting with a member of the string, a mandrel section to reciprocate in the tubular section and having means for non-rotatably connecting with another member of the string, means connecting the sections for the transmission of torque and for limited relative longitudinal movement, inclined lugs on the mandrel section, and a sleeve in the tubular section rotatable relative to the sections, the sleeve having an internal longitudinal groove along which the lugs may move and openings in communication with the groove adapted to receive the lugs, walls of the openings and surfaces of the lugs cooperating to hold the sections against relative longitudinal movement and pitched to cause the sleeve to turn and bring the groove in position to receive the lugs upon a tensile strain being applied to the string.

16. A jarring tool for use in combination with a drilling string including a tubular section to be secured to a member of the string, a mandrel section to reciprocate in the tubular section and secured to another member of the string, means connecting the sections for the transmission of torque and for limited relative longitudinal movement, inclined lugs on the mandrel section, a sleeve turnable in the tubular section, the sleeve having an internal longitudinal groove along which the lugs may move and openings in communication with the groove adapted to receive the lugs, walls of the openings and surfaces of the lugs cooperating to hold the sections against relative longitudinal movement and pitched to cause the sleeve to turn to a position where the groove receives the lugs upon a tensile strain being applied to the string, and separate means in the tubular section yieldingly resisting such turning movement of the sleeve.

17. A jarring tool for use in combination with a drill string, comprising a tubular section connected with one member of the string, a mandrel section connecting with the other member of the string and telescoping into the tubular section, means carried by the mandrel and the tubular section for permitting longitudinal movement therebetween while preventing relative rotation, an impact member carried by the mandrel, an impact member carried by the tubular section and acting to limit the longitudinal movement of the

mandrel and the tubular section in one direction
and to create a jarring blow, lock means mounted
for rotation within the tubular member and
through which the mandrel extends and in mov-
5 able relation to both the tubular member and the
mandrel, inclined faces formed on the lock means
and the mandrel for engagement to temporarily
hold the lock means and the mandrel against ro-
tation and to produce rotation of the lock means
10 with relation to the mandrel under tensile strain

imposed upon the lock means by the tubular
member, and separate yieldable means between
the tubular member and the lock means for creat-
ing a predetermined degree of resistance to torque
upon the lock means whereby the inclined faces 5
will move into positions of disengagement and
allow relative longitudinal movement of the tubu-
lar member and the mandrel when a tensile strain
of predetermined magnitude has been exerted.

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