Nov. 18, 1952 E. W. BAGNELL ET AL 2,618,467

ROTARY WELL JAR

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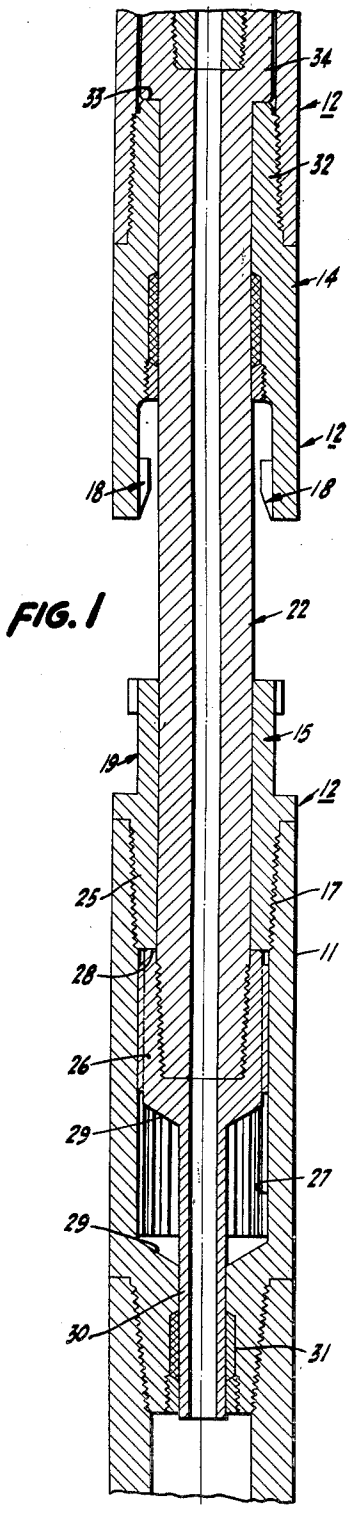


FIG. 1

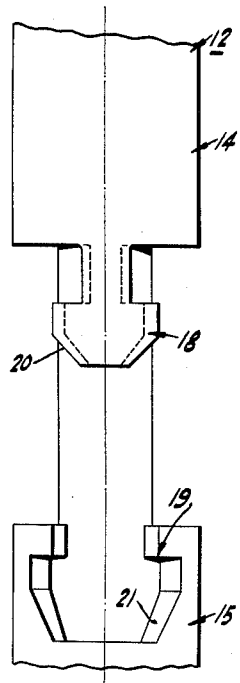


FIG. 3

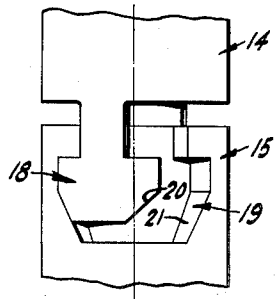


FIG. 4

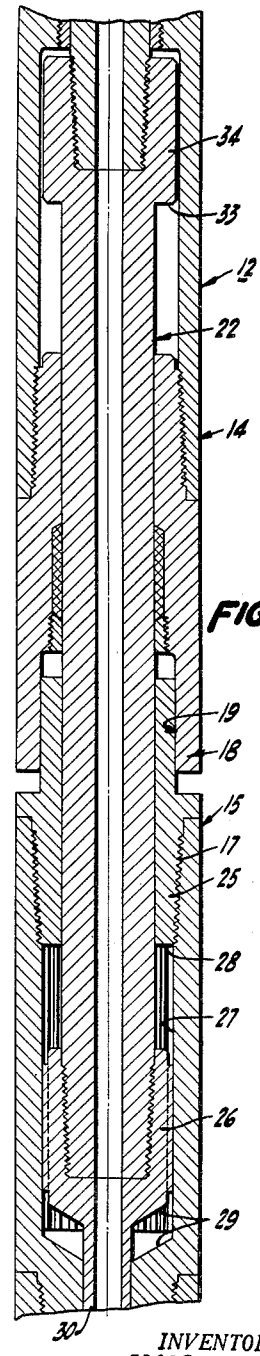


FIG. 2

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FIG. 5

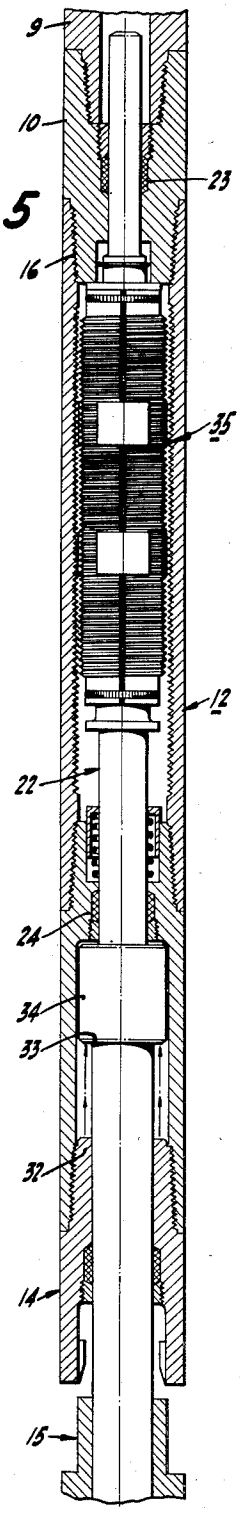
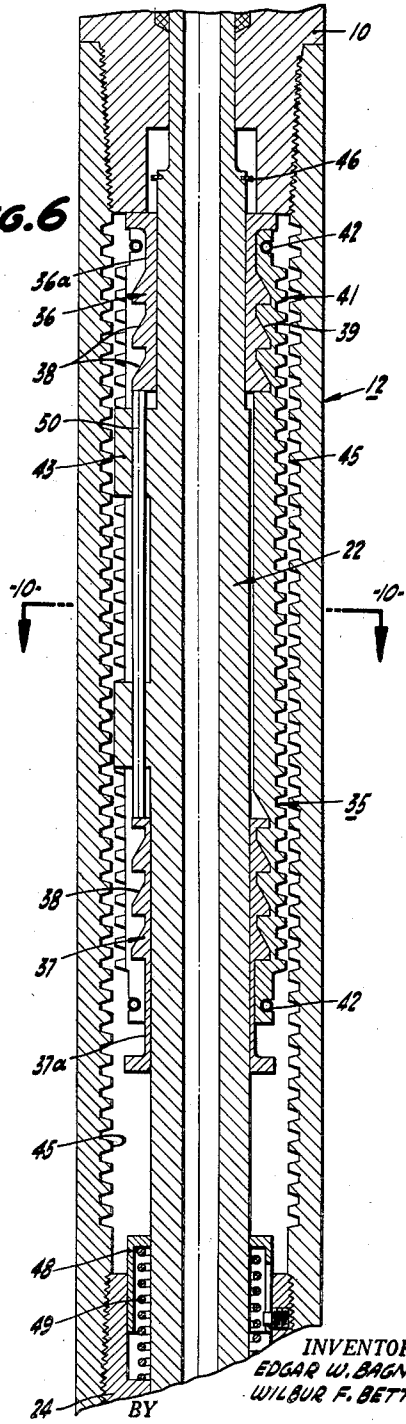


FIG. 6



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ROTARY WELL JAR

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FIG. 7

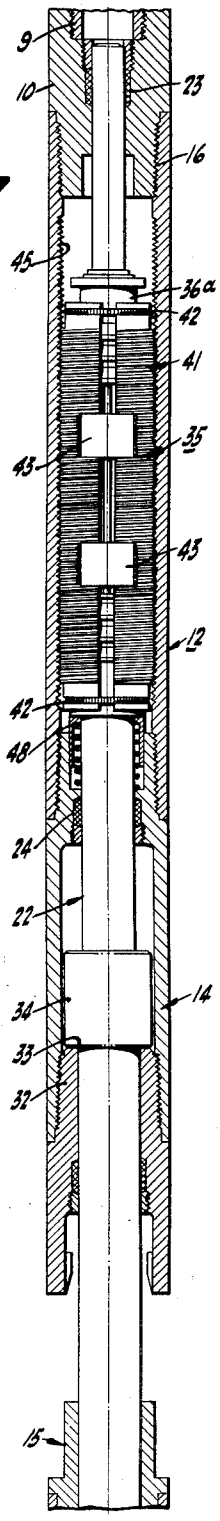
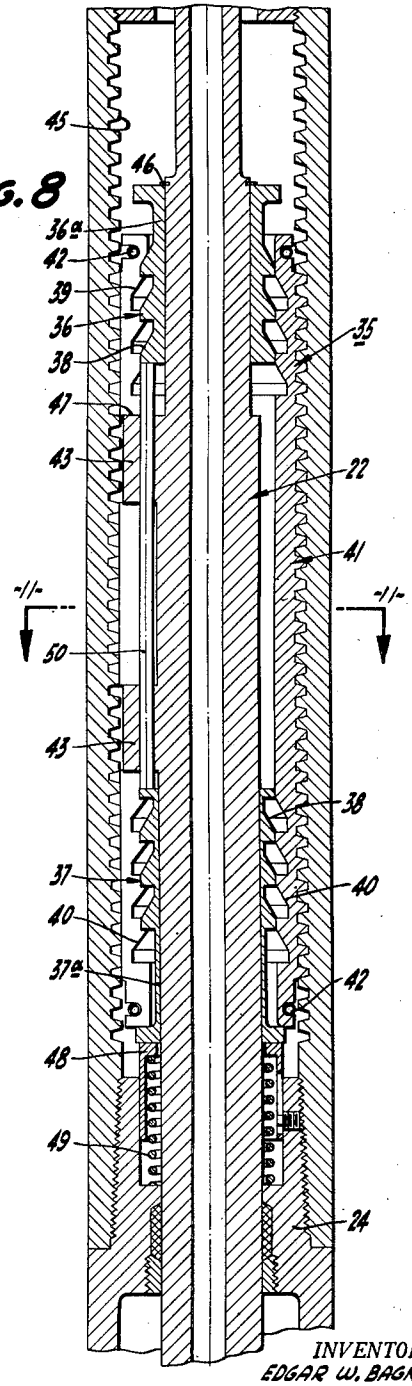


FIG. 8



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ROTARY WELL JAR

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FIG. 10

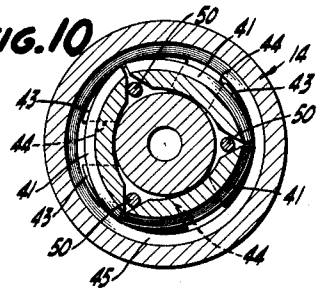


FIG. 9

FIG. 11

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UNITED STATES PATENT OFFICE

2,618,467

ROTARY WELL JAR

Edgar W. Bagnell and Wilbur F. Bettis, Glendale, Calif., assignors, by mesne assignments, to Johnston Testers, Inc., Houston, Tex., a corporation of Delaware

Application September 1, 1950, Serial No. 182,802

11 Claims. (Cl. 255—27)

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This invention relates to a rotary well jar and is a continuation-in-part of our prior application entitled "Variable Stroke Rotary Well Jar," filed April 16, 1948, bearing Serial No. 21,540.

It is the principal object of our invention to provide an improved rotary well jar which may be incorporated in a string of drill pipe or tubing in a manner enabling such string of drill pipe or tubing to perform all of its normal functions in a well during the operation of various tools in the bore, such as bits, formation testers, fishing tools, etc., and which may be easily and quickly conditioned to create a succession of violent upward jarring blows on the string of drill pipe or tubing in which it is incorporated, while enabling maintenance of a constant upward pulling-out strain on the string of drill pipe or tubing at the surface of the well.

It is a further object of the present invention to provide a well jar which may be incorporated in a string of drill pipe or tubing, and which is capable of operation to permit a succession of upward jarring blows on the string in which it is incorporated by continued rotation of the string at the surface of the well bore in a single direction and while enabling maintenance at all times of an upward pulling-out strain on the string of drill pipe or tubing.

It is another object of the present invention to provide a well jar which may be incorporated in a string of drill pipe or tubing and be relatively immovable with respect thereto, but which may be released to enable the string above the jar to be rotated relative to the string below the jar, by which rotation the jar will be operated to produce a succession of intermittent upward jarring blows on the string, while a constant upward pulling-out strain is maintained on the entire string of tubing.

Broadly speaking, the rotary well jar embodying the preferred form of our invention consists in providing a pair of mandrels mounted in concentric relationship. One of the mandrels is formed with a fixed hammer to cooperate with an anvil fixed or formed on the other mandrel. The two mandrels are constructed for relative telescopic movement and are normally relatively positioned with the hammer and anvil disposed closely contiguous.

The mandrels are each equipped with complementary parts of a connecting mechanism for threadedly connecting the mandrels together when the hammer and anvil are disposed contiguous so that relative rotation between the mandrels will cause relative axial movement between the two in a direction spacing the hammer from the anvil. A medium is provided for automatically releasing or rendering ineffective the connecting mechanism after a predetermined amount of spacing between the hammer and the anvil is effected, which relatively frees said mandrels for relative axial movement in a direction causing impact between the hammer and the anvil.

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When the jar is made up in a string of drill pipe or tubing, the axial movement between the mandrels in the direction spacing the hammer from the anvil is employed to create additional tensional strain and stretch in the string, so that when the connecting mechanism is released, the hammer and the anvil will snap together with violent impact, producing the jarring action.

One form which the invention may assume is exemplified in the following description and illustrated by way of example in the accompanying drawings, in which:

Fig. 1 is a fragmentary view in central longitudinal section showing the construction of the lower end of the jar, and showing the upper and lower sections of the jar in disconnected condition which they assume when the jar is to be placed in operation for producing impact jarring blows.

Fig. 2 is a view similar to Fig. 1 with the exception that the upper and lower sections of the drive mandrel are shown in connected condition.

Figs. 3 and 4 are fragmentary views in side elevation of the contiguous ends of the upper and lower sections of the drive mandrel, showing the means of connecting the sections of the drive mandrel together and disconnecting them; Fig. 3 showing the sections of the drive mandrel in disconnected condition and Fig. 4 showing the drive mandrel sections in connected condition.

Fig. 5 is a view in longitudinal section through the jarring tool embodying the preferred form of the invention with the anvil mandrel and the feed nut thereon shown in full, with the tool conditioned for striking an upward jarring blow.

Fig. 6 is a fragmentary view in longitudinal and central section of the upper section of the drive mandrel, showing the parts in the condition which they assume just immediately prior to striking the upward jarring blow.

Fig. 7 is a view identical to that of Fig. 5 with the exception that the parts are shown in the position and condition which they assume just subsequent to the creation of the jarring blow.

Fig. 8 is a view the same as Fig. 6 with the exception that the parts are in the position and

condition which they assume just subsequent to the creation of the jarring blow.

Fig. 9 is an exploded view of the feed nut and the portion of the anvil mandrel assembly with which the feed nut is associated.

Fig. 10 is a view in transverse section through the tool taken on line 10—10 of Fig. 6.

Fig. 11 is a transverse sectional view taken on line 11—11 of Fig. 8.

Referring more particularly to the accompanying drawings, we have there illustrated a rotary well jar embodying the preferred form of our invention. This rotary well jar is adapted to be incorporated in a string of drill pipe or tubing and is capable of use in all of the various capacities in which jars of this character are employed. For example, it may be made up in a drilling string for use in the event of a stuck bit during drilling. Also, it may be made up in a fishing string for use in jarring a fish loose after the fishing tool at the lower end of the string has been attached to the fish. It may also be made up in the tubing string of a formation tester or like tool where jarring may become necessary to free the tool in the hole. In that the well jar herein disclosed has a variety of uses in well work, it will be here described merely as made up in a string of tubular drill pipe. The various uses to which it may be put will be obvious to those skilled in the art.

The tool comprises a top sub 10 and a bottom sub 11 by means of which the tool is made up in the drill pipe string 9. A two-part tubular outer drive mandrel 12 is provided, the upper section of which is identified by the numeral 14, and the lower section of which is designated by the numeral 15. The upper section of the drive mandrel 12 is threadedly connected to the top sub as at 16 and the lower section of the drive mandrel is connected to the bottom sub 11 by a threaded connection 17.

The contiguous ends of the upper and lower sections 14 and 15 of the drive mandrel 12 are detachably connected by means of T-lugs 18 formed on and projecting from the lower end of the upper section 14 and T-slots 19 formed in the upper end of the lower section 15 of the drive mandrel 12. The relative dimensions of the T-lugs 18 and T-slots 19 are such that when in proper central register, the T-lugs 18 may be withdrawn from the T-slots 19 by relative axial movement between the two parts, as clearly illustrated in Figs. 3 and 4 of the drawings.

It will be noticed that the side ends of the T-lugs 18 and the T-slots 19 are formed with coacting cam faces 20 and 21 which act, when the upper section 14 is lowered to center the T-lugs 18 in the T-slots 19 to enable the upper section 14 of the drive mandrel 12 to be elevated and disconnect the sections 14 and 15.

Obviously, as illustrated in Fig. 4, when the T-lugs 18 are engaged with the T-slots 19 and a turning movement is imparted to the drill pipe string, this turning movement will be imparted through the T-lugs 18 to the lower section 15 of the tubular drive mandrel, and when in this position, it is obvious that an upward pull on the upper section 14 of the drive mandrel will be exerted on the lower section 15 thereof. It should be pointed out that there are two T-lugs 18 and two T-slots 19 which are arranged at 180° apart so that any endwise strain or rotational torque will be properly distributed between the two sections 14 and 15 of the drive mandrel.

Thus, by means of the T-lugs 18 and T-slots 19, means are provided enabling the upper and lower sections 14 and 15 of the drive mandrel to be relatively fixed together for both rotary and axial movement, but by disconnecting the lugs 18 from the slots 19, the two sections 14 and 15 of the drive mandrel may be disconnected so that they may relatively rotate and move axially.

Arranged coaxially within the drive mandrel 12 is a tubular anvil mandrel 22 which is reciprocable in a packed bearing 23 in the top sub 10, in a packed bearing 24 in the upper section 14 of the drive mandrel 12, and in a bearing 25 in the lower section 15 of the drive mandrel. These bearings permit reciprocation of the anvil mandrel 22 within the drive mandrel 12.

At its lower end the anvil mandrel 22 is provided with an enlarged head 26 splined in a bore 27 in the bottom sub 11. Coacting annular shoulders 28 at the lower end of the lower section 15 of the drive mandrel 12 and at the upper end of the head 26 limits the upward movement of the anvil mandrel 22 relative to the drive mandrel 12. Downward endwise movement of the anvil mandrel 22 relative to the drive mandrel 12 is limited by coacting annular shoulders 29 on the lower end of the head 26 and at the lower end of the bore 27 of the bottom sub 11.

Extending downwardly from the head 26 is a wash pipe 30 which projects downwardly through a packed bearing 31 to a point below the bottom sub 11 so that fluid may be conducted downwardly through the anvil mandrel and through the sub 11 to the tubular string therebelow for obvious purposes.

The drive mandrel 12 is formed with an internal annular hammer 32 adapted to engage the underface 33 of an external annular anvil 34 formed on the anvil mandrel 22. It is the striking of the hammer 32 against the face 33 of the anvil 34 in an upward direction which provides the jarring effect which is produced by operation of the present apparatus. We intend that intermittent blows be struck by the hammer 32 upwardly against the anvil face 33 by simply maintaining a strain on the drilling or tubing string 9 above the jar and rotating the string 9 continuously in one direction, which is to the right. By this medium, as many blows as desired may be caused to be struck by the operator without in any fashion whatsoever necessitating the recocking or resetting of the tool or releasing the upward strain on the tubing string 9.

The tripping mechanism by which this is accomplished is generally indicated by the numeral 35 in the drawings, and it comprises an upper set of three circular cams 36 formed on a cam sleeve 36*a* and a lower set of three similar circular cams 37 formed on a cam sleeve 37*a*, all of said cams being identical and each cam formed with an inwardly and upwardly tapered cam face 38. The cam sleeves 36*a* and 37*a* are reciprocable to a limited extent on the anvil mandrel 22 within the upper section 14 of the drive mandrel 12. The cams 36 and 37 are complementary in formation and spacing to annular cam grooves 39 and 40 formed in the inner bore of an externally threaded segmental feed nut 41. This feed nut 41 is longitudinally divided into three segmental sections which are relatively radially movable. It is intended that the cams 36 and 37 and the cam grooves 39 and 40 cooperate to enable the feed nut 41 to be expanded and contracted. Garter springs 42 circumscribe the segments of the feed nut 41 and constantly tend to maintain the same in contracted condition.

The segments of the feed nut 41 are collared against endwise movement relative to the anvil or inner mandrel 22 and guided for radial movement relative thereto by complemental radial lugs 43 fixed on the anvil mandrel 22 and radial sockets 44 formed in the segments of the feed nut 41, all as particularly illustrated in Fig. 9. The engagement of the lugs 43 in the sockets 44 prevent the segments of the feed nut 41 from moving endwise relative to the mandrel 22, but permit the same to move radially relative to the mandrel 22 resulting in radial expansion or contraction of the feed nut 41.

It is intended that when the cams 36 and 37 are out of register with their respective and complemental cam grooves 39 and 40, and in engagement with the inner bore of the feed nut 41, the feed nut 41 will be fully expanded with the external thread formed on the outer face thereof in threaded engagement with the threaded inner bore 45 of the upper section 14 of the drive mandrel 12. This threaded bore 45 extends from a point just short of the lower end of the upper sub 10 to a point just short of a spring cage 48 in the upper section 14 of the drive mandrel 12, so that the threaded bore 45 is of a length somewhat greater than the length of the feed nut 41.

It is seen, however, that when the cams 36 and 37 are in register with the cam grooves 39 and 40, that the garter springs 42 will contract the segmental feed nut 41 an amount disengaging the thread on the feed nut from the thread of the bore 45 and permit relative endwise movement between the feed nut 41 and consequently the anvil mandrel 22 and the drive mandrel 12.

The upper cams 36, as previously described, are relatively fixed in that they are formed integral with the cam sleeve 36*a* which is reciprocable on the anvil mandrel 22 between a lock ring 46 and the upper face 47 of the uppermost radial lugs 43. The distance which the cam sleeve 36*a* may move endwise is sufficient to enable the cams 36 to be moved into and out of register with the cam grooves 39. Similarly, the lowermost cams 37 are integrally formed on the cam sleeve 37*a* which is also reciprocable on the anvil mandrel 22 between the lower faces of the lowermost radial lugs 43 and an axially yieldable spring cage 48 reciprocable in the bearing 24 of the upper mandrel section 14. This spring cage 48 is constantly urged upward by means of a compression spring 49.

Actuating pins 50 abut at their lower ends the cam sleeve 37*a* and are reciprocable through bores in the radial lugs 43 and also abut the underside of the cam sleeve 36*a* so that endwise motion imparted to either of the cam sleeves 36*a* or 37*a* will be similarly imparted to the other cam sleeve, so that they will cooperate and work in synchronism.

In operation of the device, it is constructed and assembled substantially as illustrated in the drawings. The tool may be incorporated in an ordinary string of drill pipe or tubing for use in conjunction with various tools used in well drilling. When incorporated in a string of drill pipe, the string may perform all of its normal functions because when the upper and lower sections 14 and 15 of the drive mandrel are connected together by means of the T-lugs 18 and the T-slots 19, the drive mandrel 12 will be relatively fixed through the medium of the anvil mandrel 22 to the drill pipe or tubing or tool connected to the bottom sub 11. Thus, no relative rotation or axial movement will be permitted by the jar between the ends of the string in which the jar is interposed. Also, the mandrel 22 being tubular, drilling or other fluid may be conducted in the usual fashion downwardly through the string of drill pipe or tubing 9, and thence downwardly through the anvil mandrel 22 and its wash pipe 30. In this capacity the rotary well jar is rigidly incorporated within the drilling string and functions no differently than an ordinary tool joint made up in the string.

Of course, the jar may be directly connected to a fishing tool by connecting the bottom sub 11 thereto, or it may be directly connected to a drill collar of a bit by connecting the bottom sub 11 to the drill collar. If desired, of course, the jar may be made up at any point in the string of drill pipe or tubing 9. Likewise, the jar can be used in conjunction with any type of tool used in a well bore, such as a bit, formation tester, fishing tool or the like.

In the event that it is used in a drilling string with a bit suspended from the lower end of the string below the jar and the bit becomes stuck, the anvil mandrel 22, being non-rotatably connected to the lower sub 11, will be stationarily anchored to the bit in the well. Then, by releasing the upper section 14 of the drill mandrel 12 from the lower section 15 thereof by disengaging the T-lugs 18 from the T-sockets 19, as previously described, the jar may be operated to create an upward jar in the string to release the bit in the bore.

The same action will result if the jar is incorporated in the string above a fishing tool which has become connected with the fish. It is also important in this instance to be enabled to have the jar form a rigid connection between the upper portion of the string 9 and the portion connected to the fishing tool, particularly if the fishing tool is of a character such as an overshot requiring rotation to effect connection between the fishing tool and the fish.

Obviously, the jar may be incorporated in the string of tubing from which a formation tester or any other tool is suspended for operation in a well bore, which may necessitate the use of a jar in freeing the tool and removing it from the bore. In every instance, of course, the function and mode of operation of the jar remain the same.

Assuming that the lower end of the drilling string or the tool to which the bottom sub 11 is substantially stationarily fixed in the well bore, a jarring action my be produced by first lowering the drilling string 9 so that the coacting cam faces 20 and 21 on the T-lugs 18 and T-slots 19 will center the T-lugs 18 and the T-slots 19 by turning the drilling string 9 slightly to the left to enable the T-lugs 18 to be disengaged from the T-slots 19 upon subsequent elevation of the drilling string 9, thereby causing disengagement and separation of the upper drive mandrel section 14 with relation to the lower section 15 thereof. Thereafter an upward pulling-out strain is imposed on the pipe string 9 by means of the draw-works of the derrick. The greater the upward strain put on the drill pipe or tubing string 9, the more violent will be the impact of the jarring blow, as will be obvious from this description of the operation of the tool.

This upward strain on the string 9 is maintained substantially constant even during the operation of the jar in imparting upward jarring blows to the string 9. This is important in that

by this medium any upward dislodging movement of the fish will be retained and the fish will not be allowed to again lower. This enables the fish to be jarred out step by step with an upward pulling-out strain constantly maintained thereon at all times during the jarring action.

To create the jarring action, it will be assumed that the tool is in the condition shown in Figs. 1, 7 and 8, at which time the faces of the hammer 32 and the anvil 34 will be contiguous and substantially in contact. The segmental nut 41 is expanded into threaded engagement with the internal threaded bore 45 of the drive mandrel 12. The expansion of the feed nut 41 will have previously taken place due to the fact that the cam sleeves 36a and 37a had been moved axially upwardly relative to the feed nut 41 placing the cams 36 and 37 out of register with the cam grooves 39 and 40, thus mechanically expanding the feed nut 41 into threaded engagement with the threaded bore 45 of the drive mandrel 12. During this time, of course, the upward pulling-out strain is maintained on the string 9.

Thereafter, the string 9 at the surface of the well is rotated (by the rotary table at the surface) to the right a sufficient number of turns which causes, through the threaded engagement between the feed nut 41 and drive mandrel, downward travel of the upper section 14 of the drive mandrel 12 relative to the feed nut 41, because the latter is collared against endwise movement and rotation on the anvil mandrel 22. The anvil mandrel is of course fixed to the fish or the portion of the drill pipe string 9 stationarily stuck in the bore below the jar. This turning movement of the drive mandrel 12 will cause a stretch in the string of drill pipe or tubing 9 sufficient for the drive mandrel to move downwardly to sufficiently space the coacting faces of the hammer 32 and the anvil 34. This spacing is the amount of relative endwise movement permitted between the feed nut 41 and the threaded bore 45.

Thus, by rotation, the drive mandrel 12 is forced downwardly due to its threaded connection with the anvil mandrel through the feed nut 41. Just prior to the drive mandrel's reaching the end of its downward stroke, the upper end of the cam collar 36a will engage the lower end of the top sub 10 within the drive mandrel 12, as illustrated in Fig. 5. As the drive mandrel 12 continues to the end of its downward stroke, the engagement referred to will move the cam collar 36a downwardly on the anvil mandrel 22 relative to the feed nut 41 and at the same time, through the actuating pins 50, causes similar movement of the cam collar 37a. This axial movement of the cam collars 36a and 37a relative to the feed nut 41 is sufficient to register the cams 36 and 37 with their respective cam grooves 39 and 40. Immediately that such registration takes place, the pressure angle of the threads will cause radial collapsing or contraction of the feed nut 41 in an amount sufficient to disengage its threads from the threads of the bore 45. This will release the threaded connection between the drive mandrel 12 and the anvil mandrel 22.

Instantly that this occurs, the reaction of the tensional strain in the tubing string 9 in an upward or pulling-out direction will cause the upper section 14 of the drive mandrel 12 to snap upwardly relative to the anvil mandrel 22, causing the hammer 32 to violently impact against the anvil 34 of the mandrel 22. This impact will be a violent upward blow imparted to the string 9 through the tool, tending to upwardly jar the fish or whatever tool with which the string 9 is connected.

Immediately that the jarring blow is struck, the parts again assume the position shown in Fig. 7 because when the upper section 14 of the drive mandrel 12 moves upwardly relative to the anvil mandrel 22 and the feed nut 41 it travels a distance sufficient to cause abutment between the lower end of the cam sleeve 37a and the spring cage 48, which abutment will cause the cam sleeves 36a and 37a to move the cams 36 and 37 to cam out of register with their respective cam slots 39 and 40 and expand the segmental feed nut 41 into threaded engagement with the bore 45. By having the spring case 48 spring-loaded as illustrated, it will be seen that the force expanding the feed nut is slightly yielding to compensate for any slight delay in complete engagement with the threads of the bore 45, the threads coming into complete register. The yielding force, however, effects engagement immediately such register is effected.

Just as soon as this threaded connection between the drive collar 12 and the feed nut 41 is reestablished, continued turning movement of the string 9 and the upper section of the drive mandrel 12 to the right will repeat the operative cycle just described and produce a successive jarring blow. Thus, by merely continuing to turn the string 9 and the drive mandrel 12 to the right a succession of jarring blows will be intermittently created, and such jarring action may be continued until the fish is loosened and recovered.

We again emphasize here that all during the jarring action an upward pulling out strain is constantly maintained on the upper end of the string 9, therefore maintaining a constant pulling-out effort on the mandrel 22 which is connected through the sub 11 to that portion of the drilling or tubing string 9 below the jar, or to the fish or tool below the jar. This, of course, will aid in recovery of the fish as it is loosened by the jarring and also prevents the fish from lowering back down the hold at any time after it is jarred upwardly.

Obviously, after the jarring operation has been completed the tool on the string 9 below the jar may be set on the bottom and the upper section 14 of the drive mandrel reconnected to the lower section 15 of the drive mandrel 12 to reestablish an operating connection between the portion of the string 9 above the jar to that portion or tool below the jar.

From the foregoing it is obvious that we have provided an improved rotary well jar which may be incorporated in a string of drill pipe or tubing in a manner enabling such drill pipe or tubing to perform all of its normal functions in a well during the operation of various tools in the bore, such as bits, formation testers, fishing tools, etc., but which may be easily and quickly conditioned to create a succession of violent upward jarring blows on the string of drill pipe or tubing in which it is incorporated, while enabling maintenance of a constant pulling-out strain on the string of drill pipe or tubing at the surface of the well so as to maintain a constant pulling-out strain on that portion of the tubing and the tool to which it is connected below the jar.

While we have shown the preferred form of our invention, it is to be understood that various changes may be made in its construction by those skilled in the art without departing from the

spirit of the invention as defined in the appended claims.

Having thus described our invention, what we claim and desire to secure by Letters Patent is:

1. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of a drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a thread formed on one mandrel and a mating threaded member engaging said thread and being mounted on the other mandrel for radial separating movement for disengagement from the thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel.

2. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of a drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a thread formed on one mandrel and a mating threaded member engaging said thread and being mounted on the other mandrel for radial separating movement for disengagement from the thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward poistion to cause a re-engagement of the threaded member with said thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel, the last-named means including spring means urging radial disengagement of the threaded member from said thread.

3. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of a drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a thread formed on one mandrel and a mating threaded member engaging said thread and being mounted on the other mandrel for radial separating movement for disengagement from the thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel, the last-named means including spring means urging radial disengagement of the threaded member from said thread, and cam means for causing re-engagement of the threaded member with said thread.

4. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said said means comprising a continuous thread formed on one mandrel and a mating threaded member engaging said continuous thread and being mounted on the other mandrel for radial separating movement for disengagement from the continuous thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said continuous thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel, the last-named means including cam means carried by said other mandrel engageable with an abutment device on said one mandrel to cause engagement of the threaded member and said continuous thread.

5. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper

mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a continuous thread formed on one mandrel and a mating threaded member engaging said continuous thread and being mounted on the other mandrel for radial separating movement for disengagement from the continuous thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said continuous thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel, the second named means including a tubular member slidably but non-rotatably engaging the inner mandrel and being connected to the outer tubular mandrel by a slip joint, and having means on its lower end for connection to the member to be jarred.

6. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a continuous thread formed on one mandrel and a mating threaded member engaging said continuous thread and being mounted on the other mandrel for radial separating movement for disengagement from the continuous thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said continuous thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel, the second named means including a tubular member slidably but non-rotatably receiving the inner mandrel and being connected to the outer tubular mandrel by a releasable lock slip joint, and having means on its lower end for direct connection to the member to be jarred.

7. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a continuous thread formed on one mandrel and a mating threaded member engaging said continuous thread and being mounted on the other mandrel for radial separating movement for disengagement from the continuous thread to allow the drill string to contract and cause a violet impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said continuous thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel.

8. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movement, means for connecting the upper mandrel to the lower end of a string of drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel relative to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a continuous thread formed on one mandrel and a mating threaded member engaging said continuous thread and being mounted on the other mandrel for radial separating movement for disengagement from the continuous thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, and means responsive to a predetermined amount of downward movement of the upper mandrel relative to the lower mandrel to cause a separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said continuous thread, whereby a series of violent jars will be produced upon continuous rotation of the first mandrel relative to the second mandrel, the last-named means including spring means urging the threaded member out of engagement with said continuous thread and cam means carried by said other mandrel engageable with an abutment device on said one mandrel to cause engagement of the threaded member and said continuous thread, and subsequently with an axially displaced abutment on said one mandrel to release the threaded member for disengagement under the influence of the spring means.

9. A rotary well jar, comprising an upper outer tubular mandrel and a lower inner mandrel coaxially arranged for relative rotary and axial movements, means for connecting the upper mandrel to a string of drill pipe, means for connecting the lower mandrel to a member to be jarred, a hammer and an anvil fixed one to each of the mandrels and being contiguously disposed in axial registry with respect to one another, means responsive to rotation of the upper mandrel relative to the lower mandrel for causing downward movement of the upper mandrel rela-

tive to the lower mandrel to stretch the drill string and separate the hammer and anvil, said means comprising a thread formed on one mandrel and a mating threaded member engaging said thread and being mounted on said other mandrel for radial separating movement for disengagement from said thread to allow the drill string to contract and cause a violent impact between the hammer and anvil, means responsive to a predetermined amount of downward movement of said upper mandrel relative to the lower mandrel to cause a radial separation of the threaded connection between the mandrels and being operable upon a return of the upper mandrel to its upward position to cause a re-engagement of the threaded member with said thread whereby a series of violent jars will be produced upon continuous rotation of said upper mandrel relative to said lower mandrel, the last-named means including spring means urging the threaded member out of engagement with said thread and cam means carried by said other mandrel engageable with an abutment device on said one mandrel to cause engagement of the threaded member and said thread, and subsequently with an axially displaced abutment on said one mandrel to release the threaded member for disengagement under the influence of the spring means.

10. A rotary well jar comprising a top sub, a bottom sub, a drive mandrel, said drive mandrel being formed of an upper section fixed to the top sub and a lower section fixed to the bottom sub, a detachable connection between the contiguous ends of said sections for connecting them together against relative rotative and axial movement, an anvil mandrel concentrically positioned within the drive mandrel, the lower end of the anvil mandrel being splined against rotation in the bottom sub, coacting annular shoulders in the bottom sub and on the anvil mandrel permitting the anvil mandrel a limited amount of axial movement relative to the bottom sub, an annular anvil formed on the anvil mandrel, an annular hammer formed in the drive mandrel in axial register with the anvil, a segmental feed nut having external threads, said feed nut being collared on the anvil mandrel against endwise and rotative movement relative thereto, said segmental

feed nut being expansible and collapsible in a radial direction, spring means normally tending to maintain said feed nut in collapsed condition, a threaded bore in the drive mandrel in register with the feed nut but of a length greater than the length of the feed nut, the threads of said feed nut when in collapsed condition being threadedly disengaged from said bore but threadedly engaged therewith when in expanded condition, cam means associated with the feed nut and operable upon relative axial movement of the mandrels causing an impact of the hammer against the anvil to expand said feed nut into threaded engagement with the threaded bore in the drive mandrel whereby relative rotation between the mandrels will cause relative axial movement between the mandrels in a direction spacing the hammer from the anvil, said cam means being automatically operated by relative axial movement of the mandrels upon a predetermined spacing between the anvil and the hammer to permit the spring means to collapse the feed nut out of engagement with the threaded bore of the mandrel and relatively free the mandrels for relative movement in a direction causing the hammer to impact against the anvil.

11. The structure defined in claim 10 wherein the cam means comprise annular cams mounted on the mandrel interiorly of the feed nut for a limited amount of axial movement relative thereto from a position expanding the feed nut to a position enabling the same to contract and vice versa, the axial movement being imparted to the cams by their engagement with fixed opposed abutments at opposite ends of the threaded bore of the drive mandrel.

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