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Kisling, III

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[54] MECHANICAL JAR

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Related U.S. Application Data

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[52] **U.S. Cl.** **267/137**

[51] **Int. Cl.** **F16f 1/02**

[58] **Field of Search** 267/136, 137, 178

[56] **References Cited**

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Attorney—Ernest R. Archambeau, Jr. et al.

[57] **ABSTRACT**

An illustrative embodiment in accordance with the present invention in jars includes a mandrel and housing which are telescopically disposed and adapted for connection in a pipe string, said mandrel and housing having spaced impact surfaces which can be brought together to deliver a jarring blow, an expansible sleeve member having threads meshed with threads on said mandrel, cam surfaces on said threads for expanding said sleeve member and releasing said threads from mesh with one another, means released by longitudinal relative movement between said housing and said sleeve member for locking said sleeve member in threaded engagement with said mandrel; and a resilient column structure coacting between said housing and said sleeve member for yieldably resisting longitudinal relative movement so that a force of a predetermined magnitude can be applied to said housing before said threads are permitted to release.

3 Claims, 7 Drawing Figures

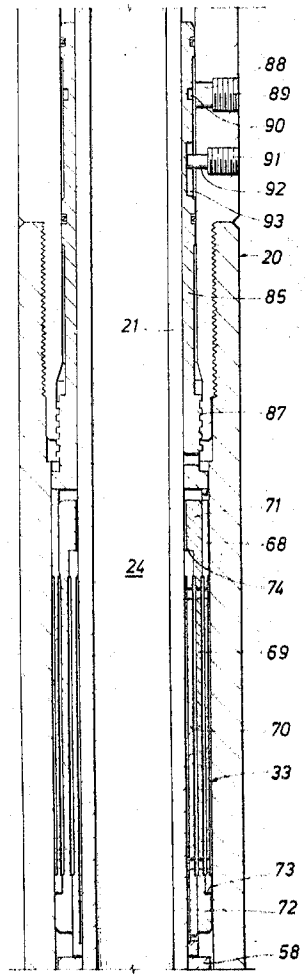


FIG. 1

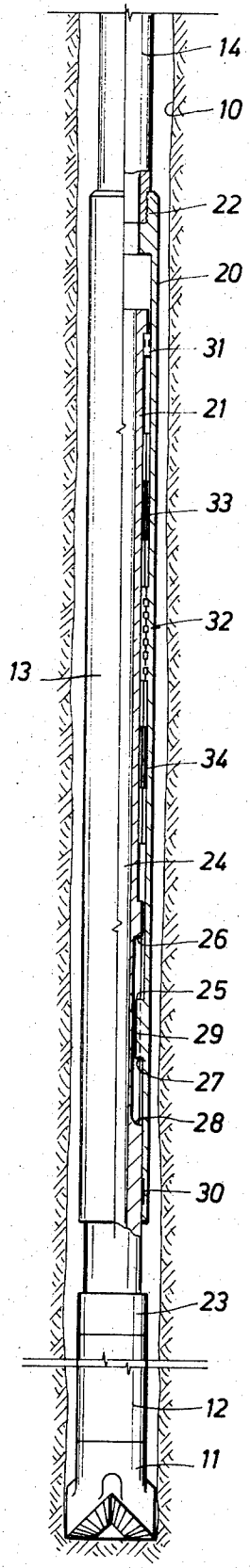
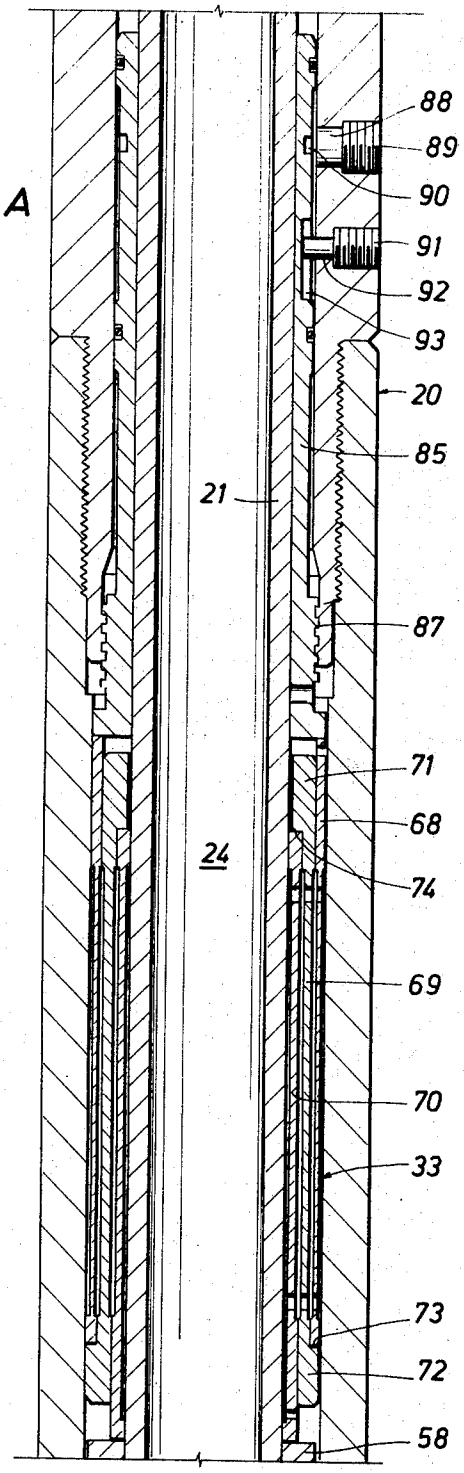

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FIG. 2A


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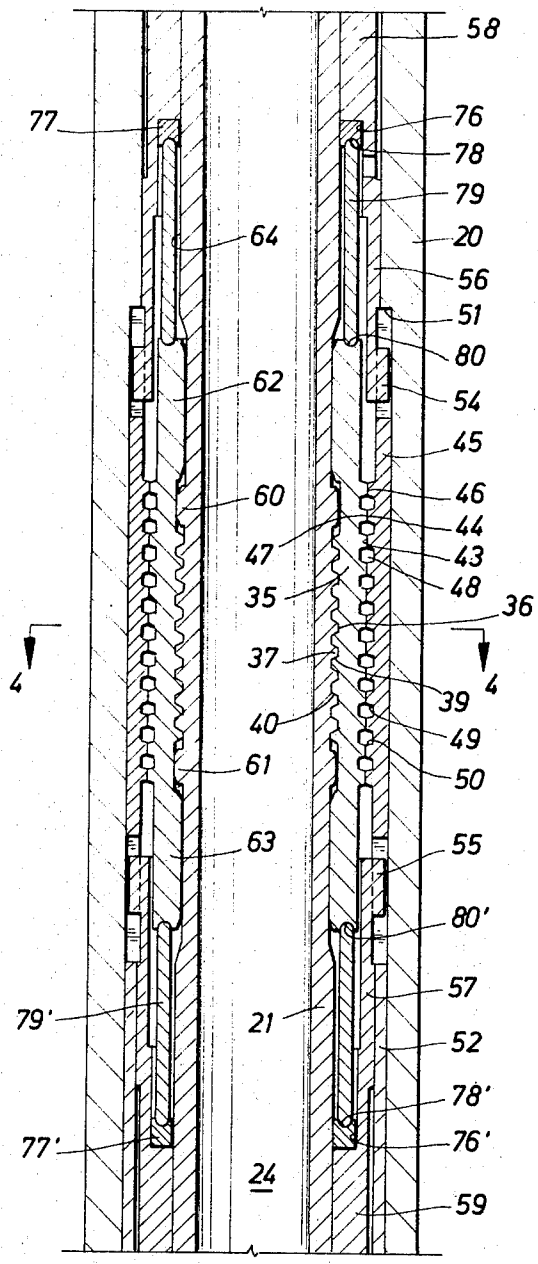

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FIG. 2B

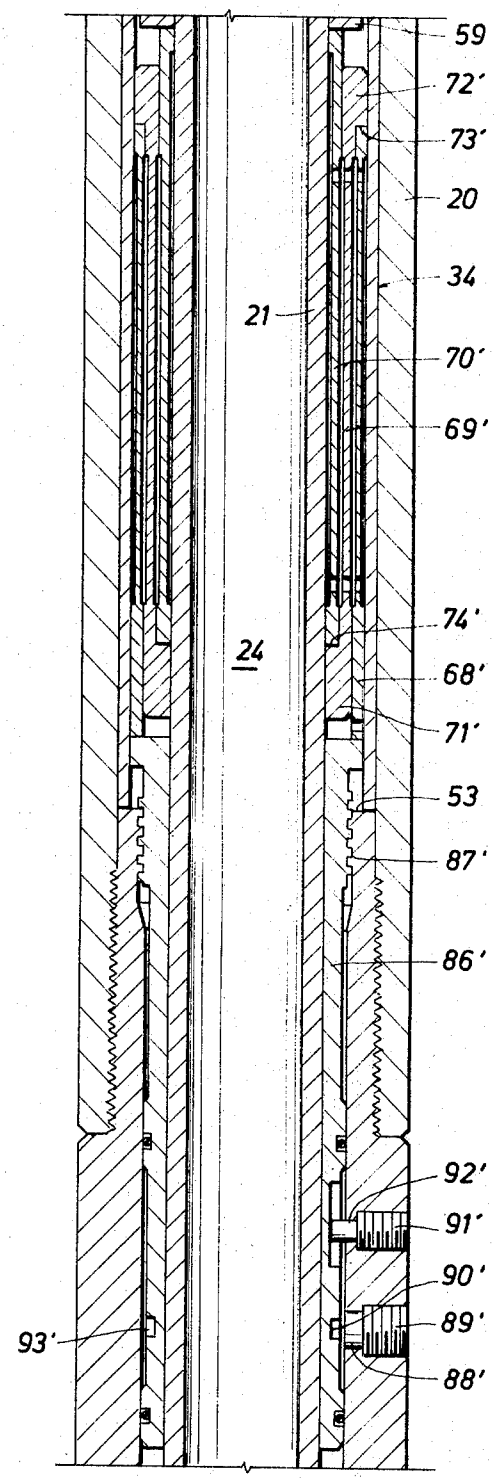

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FIG. 2C

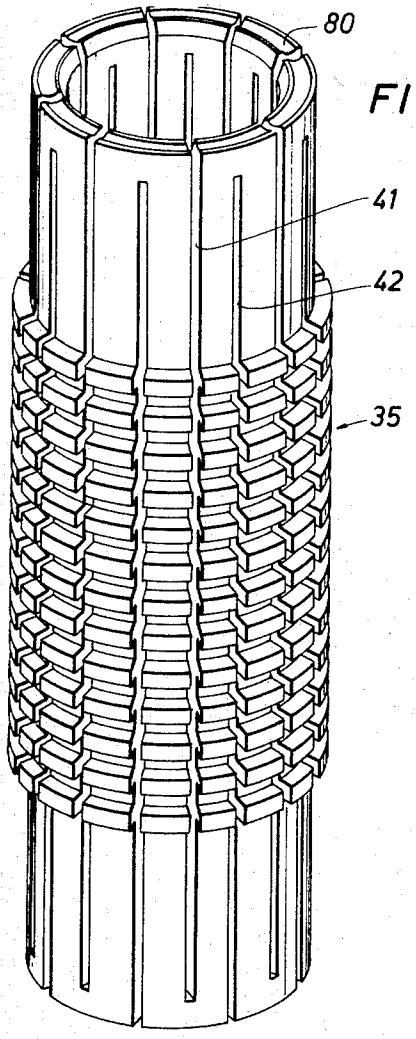


FIG. 3

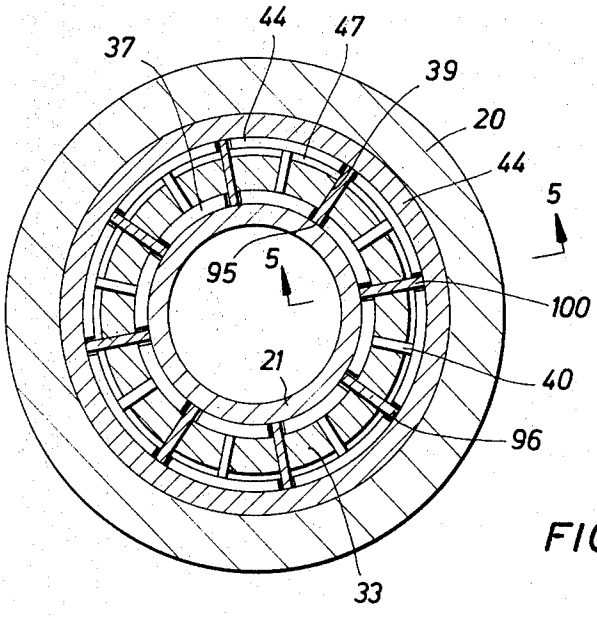


FIG. 4

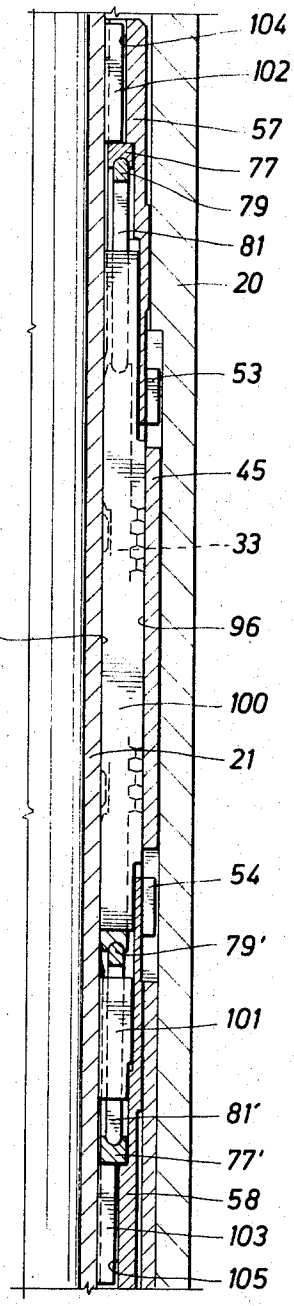


FIG.5

MECHANICAL JAR

This is a division of application Ser. No. 82,284, filed Oct. 20, 1970.

This invention relates generally to well jars used to extricate stuck objects from well bores, and more specifically to a new and improved mechanical jar having a tripping or release mechanism that is constructed and arranged to be wear resistant during long continued usage.

When drilling boreholes through earth formations where sticking is a problem, most drillers will run a jar in the drill string. A jar is a device having telescoping members with spaced apart impact surfaces which can be brought together in a violent manner in order to deliver a jarring blow to a stuck tool with the hope of freeing it. The jar includes a tripping mechanism that functions to prevent telescoping motion until a predetermined release force has been applied to the drill string, the force causing the drill string to stretch and store energy. When the tripping mechanism releases, the drill string contracts and causes the jar to hit and deliver a considerable impact force to the stuck tools. Usually, the jar must be operated many times before the stuck tools are driven free, and in fact circumstances requiring many hours of continuous jarring are not uncommon.

A number of the problems associated with prior art mechanical jars are related to wear on the tripping mechanism. Where the wear is substantial, of course the jar may quit operating altogether, and in any event the release force, which should remain substantially constant and predictable, may become either greater or lesser. A reduced release force will correspondingly reduce the hitting force and thus increase the time required to jar the stuck object loose. A substantially increased release force may result in damage to the jar itself due to excessive stress and loading applied to the parts thereof. In any event, because of the environment in which a jar must function, such devices must be extremely rugged in order to remain operational.

One object of the present invention is to provide a new and improved well jar apparatus having a tripping or release mechanism which is adapted to be extremely rugged and wear resistant.

Another object of the present invention is to provide a new and improved jar apparatus having a substantially constant and predictable release force for an extended period of time of use.

These and other objects are attained in accordance with the concepts of the present invention by a jar apparatus comprising telescopically disposed mandrel and housing members adapted for connection in a drill string and having impact surfaces that can be brought together to deliver a jarring blow. The tripping mechanism is arranged between the mandrel and the housing and includes an expansible sleeve member contracted around the mandrel and having internal threads that normally mesh with companion threads on the mandrel to prevent relative movement. The respective threads having inclined walls that function as cam surfaces for expanding the sleeve member outwardly, however expansion is prevented by locking surfaces on the sleeve member and the housing, the locking surfaces being releasable by longitudinal movement of the housing along the sleeve member. The use of threads as above mentioned provides a new and improved structure which distributes applied loads over a considerable length of area to maintain compression stresses within acceptable limits, thereby keeping wear on the tripping mechanism to a minimum and providing a jar having a substantially constant release force over an extended period of time of use.

In order to enable energy to be stored in the drill string by stretching it before the tripping mechanism releases, a resilient structure is disposed in opposition to the longitudinal movement required to disengage the locking surfaces on the housing and the sleeve member. In accordance with a preferred embodiment of the present invention, the resilient structure includes a plurality of concentrically disposed tubular elements having alternate opposite ends coupled to one another in such a manner that oppositely disposed force on the innermost element and the outermost element places alternate elements in compression and tension. Thus the composite structure is in the nature of a short column having a very high modulus of elasticity, the one or more elements that are in tension also providing a degree of lateral support to prevent buckling of those elements having compression loading.

The present invention has other objects, features and advantages which will become more clearly apparent in connection with the following detailed description of an embodiment taken in conjunction with the appended drawings in which:

FIG. 1 is a somewhat schematic view of a drill string and jar in a borehole;

FIGS. 2A–2C are longitudinal sectional views of the tripping mechanism and associated structure in accordance with the present invention;

FIG. 3 is an isometric view of the tripping sleeve;

FIG. 4 is a cross-section on line 4—4 of FIG. 2B; and

FIG. 5 is a longitudinal half-section view to illustrate further detail of the keying system used in the tripping mechanism.

Referring initially to FIG. 1, a borehole 10 is being drilled through earth formations by using conventional rotary drilling techniques. A drill bit 11 is attached to the lower end of a drill string which normally includes a number of heavy drill collars 12 to provide the necessary weight on the bit. A jar 13, constructed in accordance with the principles of this invention, can be selectively coupled at various locations in the drill string, but is preferably located at a point between the uppermost drill collar and the drill pipe 14. Under certain borehole conditions, such as soft or highly permeable formations, particularly when encountered in deviated wells, there is the risk that the bit and/or the drill collars may become stuck. When such sticking occurs for any reason, the jar 13 can be operated to free the stuck tools.

The jar 13 includes a tubular housing 20 that is telescopically disposed over a tubular mandrel 21, the housing having a threaded box portion 22 and the mandrel 21 having a similar portion 23 for coupling the jar in the drill string. The mandrel 21 has a central bore 24 which continues the drilling fluid circulation path through the drill string. The housing 20 is movable to some extent in both longitudinal directions along the mandrel 21 from a central or "cocked" position, upward movement causing one "hammer" provided by an

inwardly extending shoulder surface 25 to strike an "anvil" provided by an outwardly extending shoulder 26 on the mandrel, downward movement causing another hammer surface 27 to strike a second anvil surface 28. Thus the jar 13 is adapted to hit in both directions, upward and downward. The impact force in either direction is transmitted by the mandrel 21 to the stuck tools therebelow. The housing 20 and the mandrel 21 have coengaging splines 29 for transmitting rotation through the jar during drilling operations. A seal packing 30 prevents drilling fluids from entering in between the housing 20 and the mandrel 21 at their lower ends, whereas a floating or compensating seal packing unit 31 is used to prevent fluids from entering at their upper ends. The vacant spaces between the housing 20 and the mandrel 21 can be filled with a typical lubricating oil or the like.

A tripping mechanism indicated generally at 32 is disposed in between upper and lower resilient structures 33 and 34 and functions to restrain longitudinal movement of the housing 20 in either direction from the cocked or intermediate position to enable energy to be stored in the drill string before the jar hits so that a blow of considerable magnitude can be struck. Once the tripping mechanism 32 releases however, movement of the housing 20 along the mandrel 21 is unrestricted as the hammers approach the respective anvils. After a blow is stuck, the housing 20 is moved by the drill pipe 14 in the opposite direction, and the tripping mechanism 32 is automatically recocked in the intermediate position. The jarring action is repeated until the stuck tools are driven loose.

As shown in greater detail in FIG. 2B, the tripping mechanism 32 includes an expansible and contractible sleeve member 35 that is normally contracted around the mandrel 21, the sleeve member having internal threads 36 that mesh with companion external threads 37 formed on a reduced diameter section of the mandrel. The threads 36 and 37 have a stub form providing inclined wall surfaces 39 and 40. When the sleeve member 35 and the mandrel 21 are forced in opposite longitudinal directions the inclined wall surfaces provide radial force components tending to expand the sleeve member outwardly. Such outward expansion can occur due to the provision of slots 41 and 42 as shown in FIG. 3, extending in alternating longitudinal directions for less than the full length of the sleeve member 35, such slots dividing the sleeve member into a plurality of segments, each having its ends joined to an end of an adjacent segment. In the cocked position however, the sleeve member 35 is locked in contracted condition around the mandrel 21 by locking surfaces 43 (FIG. 2B) provided by threads 44 on a locking sleeve 45, the surfaces slidably engaging like surfaces 46 provided by threads 47 formed on the exterior of the sleeve member 35. As disclosed in full detail in application Ser. No. 82,287, Berryman, filed concurrently herewith and assigned to the assignee of this invention now U.S. Pat. No. 3,658,140, the release grooves 48 formed between the locking surfaces 43 are adapted to receive the threads 47 on the sleeve member 35 upon relative longitudinal movement of the locking sleeve 45 and the member 35, thus permitting expansion of the sleeve member to a condition where the threads 36 and 37 are disengaged. The locking surfaces 43 and 46 extend parallel to the axis of the sleeve member 35 and thus positively prevent any outward expansion of the sleeve member during the longitudinal movement required before disengagement can occur. The release grooves 48 have inclined wall surfaces 49 and 50 in order to provide an inward camming action in the presence of longitudinal force on the sleeve member 35 when the threads 47 are meshed with the release grooves 48.

The upper end of the locking sleeve 45 abuts against an inwardly extending shoulder 51 on the housing 20, whereas the lower end is engaged by a bushing 52 that is disposed above an inwardly extending shoulder 53 (FIG. 2C) on the housing to fix the locking sleeve longitudinally with respect to the housing. Each end of the locking sleeve 45 is also slotted at circumferentially spaced locations to receive outwardly extending projections 54 and 55 formed on depending portions 56 and 57 of upper and lower drive rings 58 and 59 which are keyed to the mandrel 21 in a manner and for purposes to be more fully described below.

Annular thickened portions 60 and 61 of the mandrel 21 are provided above and below the threads 37, the portions having larger lateral dimensions than the height of the threads, but are considerably long with respect to the lead of the threads. The sleeve member 35 has similar inwardly thickened portions 62 and 63 which engage above and below the respective portions 60 and 61 on the mandrel 21. Further, the crests of the threads 37 are formed on a smaller diameter than the outer diameter of the mandrel 21, whereas the bore size through the sleeve threads 36 is larger than the transverse dimension of the portions 60 and 61. Thus, when the sleeve member 35 is permitted to expand and move upwardly, for example, along the mandrel 21, the portion 62 will ride along the outer surface 64 or the mandrel 21, while the lower portion 63 will ride first over the outer surface of the lower mandrel portion 61 and then along the crests of the threads 37. The crests of the sleeve member threads 36 will slide along the upper mandrel portion 60, with the result being that the respective sleeve member and mandrel threads 36 and 37 are positively held out of engagement as the sleeve member 35 moves relatively along the mandrel 21 in either direction.

It will be apparent that in order for the sleeve member 35 to be released from the mandrel 21 to enable unrestricted telescoping movement, the housing 20 and the locking sleeve 45 must move either upwardly or downwardly relative to the sleeve member 35. Such relative movement is restrained however by the resilient structures 33 and 34. Since each structure is made of identical, oppositely disposed parts, the upper structure will be discussed in detail with the appropriate numbers referred to in the drawings, the lower resilient structure 34 having parts numbered in the same manner but with the prime notation. The upper resilient structure 33 is shown in FIG. 2A as including an outer tube 68, an intermediate tube 69 and an inner tube 70 all concentrically disposed and made of metallic materials. The intermediate tube 69 has thickened sections 71 and 72 at its ends, the lower section providing an upwardly facing shoulder 73 and the upper section providing a downwardly facing shoulder 74. The lower end of the outer tube 68 abuts against

the shoulder 73, whereas the upper end of the inner tube 70 abuts the shoulder 74. Thus it will be appreciated that oppositely directed longitudinal forces applied to the outer tube 68 and the inner tube 70 will place these tubes in compression and the intermediate tube 69 in tension. The total deflection of the composite structure of course will be the sum of the respective elongation and foreshortenings of the individual tubes, so that the tubes provide a resilient structure in the nature of a spring having a high modulus of elasticity. The upper end of the outer tube 68 and the lower end of the inner tube 70 extend beyond the adjacent ends of the intermediate tube 69.

The drive rings 58 and 59 are located between the sleeve member 35 and the respective resilient structures 33 and 34, each drive ring having an internal annular recess 76 (FIG. 2B) that receives a washer 77. The washer 77 has a concave annular groove 78 that receives a rounded end of a thrust sleeve 79. The other end of each thrust sleeve 79 is also rounded and is received within an annular groove 80 in the end of the sleeve member 32. Each of the thrust sleeves 79 is also made to be radially expansible and contractible by slots 81 (FIG. 5) extending in alternating longitudinal directions for less than the full length thereof in the same manner as the slots in the sleeve member 35 shown in FIG. 4. The provision of the slotted thrust sleeves 79 having the same capability for expansion as the sleeve member 35, together with the rounded end surface construction thereof, substantially prevents any inward component of force that resists expansion of the ends of the sleeve member 35 such as might occur for example, between two sliding surfaces were the thrust rings 58 and 59 to engage the ends of the sleeve member 35 directly.

Each of the resilient structures 33 and 34 can be adjustably positioned within the housing 20 in order to selectively adjust the required tripping force. As disclosed in full detail in application Ser. No. 82,285, Nutter, filed concurrently herewith and assigned to the assignee of the present invention, now U.S. Pat. No. 3,685,598 this is accomplished by providing upper and lower jack mandrels 85 and 86, each having an end portion adapted to engage the outermost tube 68 of the respective resilient structures 33, 34. Each jack mandrel is threaded to the housing at 87 so that relative rotation will cause feeding thereof along the housing 20. Suitable windows 88 are provided in the wall of the housing 20 adjacent to the distal end section of each jack mandrel, the windows being normally closed by plugs 89. Removal of the plugs 89 provides access openings through which a suitable tool (not shown) can be inserted and engaged in circumferentially spaced recesses 90 and used to rotate the jack mandrel with respect to the housing 20. Such rotation causes the threads 87 to feed the jack mandrel along the housing in one direction or the other, depending upon the direction of rotation, to correspondingly change the amount the resilient structures 33 and 34 must be foreshortened in order to position the release grooves 48 opposite the outer sleeve member threads 47. Since the required tripping force is a direct function of the amount of longitudinal deflection of the resilient structures 33 and 34, the tripping force can be adjusted as desired. A stop plug 91 having a tang 92 that projects into one of a plurality of circumferentially spaced external grooves 93 on the jack mandrel is of course removed during rotation and is then engaged to lock the jack mandrel in the selected longitudinal position by preventing rotation thereof.

To prevent relative rotation of the various parts of the tripping mechanism 32 and thereby maintain the proper alignment of the threads and the locking surfaces during operation as well as the slots in the sleeve member 35 and thrust sleeves 79 for proper expansion during operation, a system of keys is used as shown more clearly in FIGS. 4 and 5. The sleeve member 35 can have, for example, 16 slots (eight opening in each direction as shown in FIG. 3) with the mandrel 21 and the release sleeve 45 each having eight radially aligned keyways provided by longitudinally extending grooves 95 and 96. In this example, each of the thrust sleeves 79 also has eight slots 81 extending in each direction. Thus the upper thrust sleeve can have its downwardly opening slots longitudinally aligned with the upwardly opening slots in the sleeve member 35, and a series of elongated keys 100 are provided, each extending into the aligned slots. The inner edge of each key 100 rides in a respective mandrel keyway 95, whereas the outer edge is received by the radially aligned keyway 96 in the locking sleeve 45. A separate set of shorter keys 101 ride in the same mandrel keyways 95 and extend into slots of the lower thrust sleeve so that the upwardly opening slots in the lower thrust sleeve are longitudinally aligned with the downwardly opening slots 42 in sleeve member 35. Also upper and lower sets of short keys 102 and 103 are received in radially extending slots 104 and 105 cut in the drive rings 58 and 59 and ride in the mandrel keyways 96 to rotatively position the drive rings and thus the locking sleeve 44 with respect to the mandrel 21 and the sleeve member 35. Accordingly, the release threads 36 and 37 and the locking surfaces 43 and 46 are fixed rotationally for the proper meshing relationship, and the slots that enable expansion of the sleeve member 35 and the thrust sleeves 79 are properly aligned for opening and closing movement during such expansion.

In operation, the jar 13 in its fully open or extended condition is connected in the drill string above the drill collars 12 and lowered into the borehole for drilling operations. During drilling, rotary motion is transmitted through the jar 13 by virtue of the interengagement of the splines 29, and during normal operations the jar is always in tension. In case the tools below the jar 13 become stuck, the jar is operated as follows. The drill pipe is lowered until a restraint is seen on the rig weight indicator which means that the tripping mechanism 32 is in the cocked position as shown in FIG. 2B. To hit upwardly, an upward strain is applied to the drill pipe 14 at the top of the borehole, causing the string to stretch and store energy. The upward force will tend to pull the housing 20 upwardly relative to the mandrel 21, however such upward movement is resisted by the resilient structure 34 disposed between the lower jack mandrel 86 and the lower drive ring 59, which is held against upward movement by the sleeve member 33 and the thrust sleeve 79. The upward force on the sleeve member 35 and the threads 36 and 37, due to their inclined wall surfaces of the latter, will tend to cause expansion of the sleeve member; however the

top or crest surfaces 43 and 46 lock the sleeve member in gripping engagement with the mandrel 21. As the lower resilient structure 34 deflects or foreshortens, the housing 20 and thus the locking sleeve 45 move upwardly relative to the sleeve member 35 to a point where the release grooves 48 are positioned laterally opposite the threads 47. At this point, which corresponds to a predetermined tripping or release force, the inclined walls of the threads 36 and 37 will cause the sleeve member 35 to expand outwardly and suddenly release the gripping engagement with the mandrel 21. The housing 20 will be accelerated upwardly, causing the hammer surface 25 to strike the anvil surface 26 in a violent manner. The impact force is transmitted via the mandrel 21 to the stuck tools therebelow. As the sleeve member 35 shifts upwardly along the mandrel 21, the thickened portions 62, 63 ride along outer surfaces of the mandrel to prevent any contact or other chattering of the threads 36 and 37.

To recock the jar 13, the drill pipe 14 is lowered to effect corresponding downward movement of the housing 20 and the sleeve member 35 relative to the mandrel 21. When the sleeve member 35 arrives opposite the threads 37 it will contract into gripping engagement with the mandrel 21, such contraction being assisted by the reaction force of the deflected structure 34 which is translated to radial inward force components by the inclined wall surfaces 49 of the release grooves 48. The mandrel portions 60 and 61 coact with the internal configuration of the sleeve member 35 and function in such a manner that there is only one longitudinal position where the sleeve member can contract, thus minimizing thread wear.

Jarring blows can be applied repeatedly in an upward direction, or downward jarring can be effected by slacking off the weight of the drill pipe onto the jar housing 20. The same coaction of parts will occur as described above except involving the upper resilient structure 33, drive ring 58 and thrust sleeve 79, release of the sleeve member 35 enabling the hammer surface 27 to strike the anvil surface 28 in a violent manner.

As previously mentioned, the use of threads 36 and 37 as the gripping means between the sleeve member 35 and the mandrel 21 minimizes wear on the parts. This is because the maximum stress on the threads 36 and 37 is directly proportional to the contact pressure and inversely proportional to the total length of contact surface. In order to keep the maximum stress within values which will minimize wear, it is important to provide the longest possible contact surface, which the threads 36 and 37 do provide as opposed to other structure such as parallel ribs or the like. Moreover, threads can be conveniently formed for the proper full length contact with conventional tooling. The thrust sleeves 79 having rounded end surfaces engaging the annular grooves in the ends of the sleeve member 35 practically isolate the sleeve member from any radially inward force on one end thereof due to static and sliding friction that might otherwise cause uneven stresses in the threads 36 and 37 during release. The resilient structures 33 and 34 provide movement opposing devices in the nature of a spring, each having very high composite modulus of elasticity so that jarring blows of considerable and constant magnitude can be delivered to a stuck object over an extended period of time.

Although the disclosed embodiment of the present invention is illustrated in connection with a two-way hitting jar (both upward and downward), it will be appreciated that the jar could be readily modified to an embodiment that hits only in one direction, upwardly for example, by eliminating the upper resilient structure, jack mandrel and associated structure and correspondingly shortening the housing and the mandrel.

Since certain changes or modifications may be made in the disclosed embodiment without departing from the inventive concepts involved, it is the aim of the appended claims to cover all such changes and modifications falling within the true spirit and scope of the present invention.

I claim:

1. A resilient structure capable of longitudinal deflection and providing a reaction force that is a function of the amount of such longitudinal deflection, comprising: a plurality of concentrically disposed tubular members having means for coupling adjacent ends of adjacent members in such a manner that longitudinal force applied to one of said members places alternate members in tension and compression.

2. A resilient structure capable of longitudinal deflection and providing a reaction force that is a function of the amount of such longitudinal deflection, comprising: an outer tube, an inner tube and an intermediate tube disposed between said inner and outer tubes, said intermediate tube having an outwardly extending shoulder at one end that is engaged by the adjacent end of said outer tube and an inwardly extending shoulder at its other end that is engaged by the adjacent end of said inner tube so that longitudinal compressive force applied to one of said inner and outer tubes places said inner and outer tubes in compression and said intermediate tube in tension, said intermediate tube providing lateral support to prevent buckling of said inner and outer tubes.

3. The resilient structure of claim 2 wherein the other ends of said inner and said outer tubes extend beyond the adjacent ends of said intermediate tube.

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