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ROTARY CAM CASING SWAGE

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Fig. 2

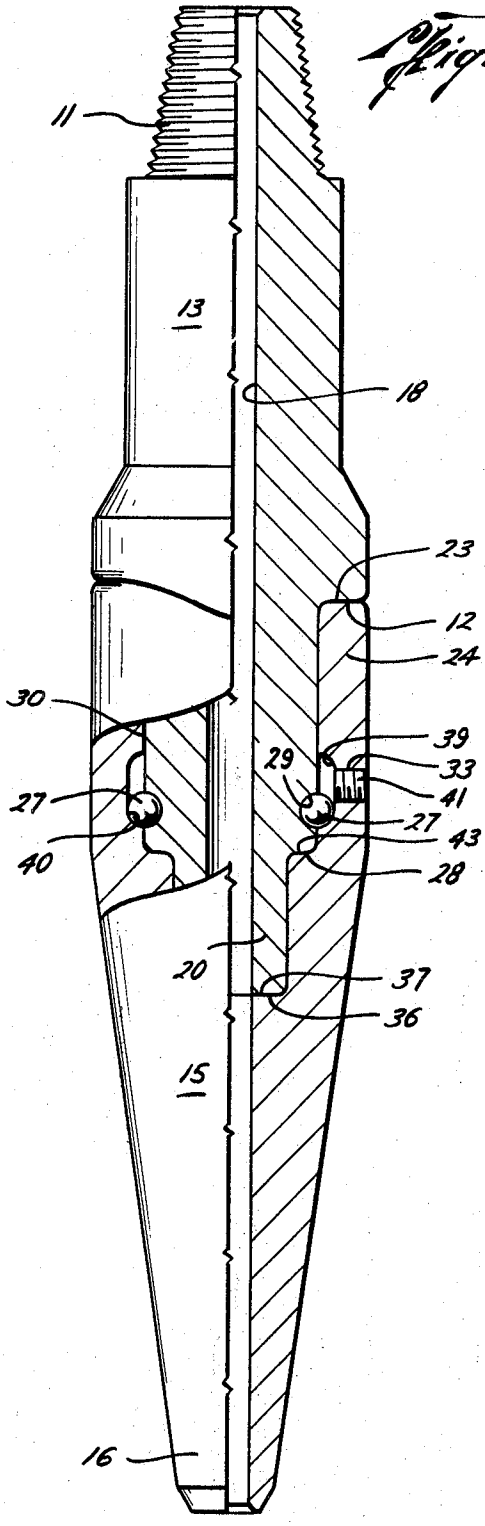


Fig. 1

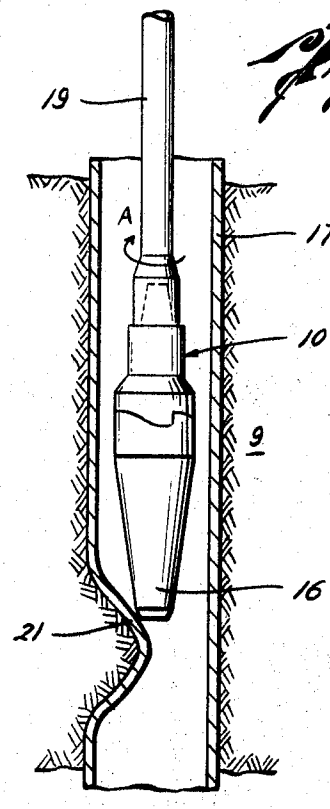
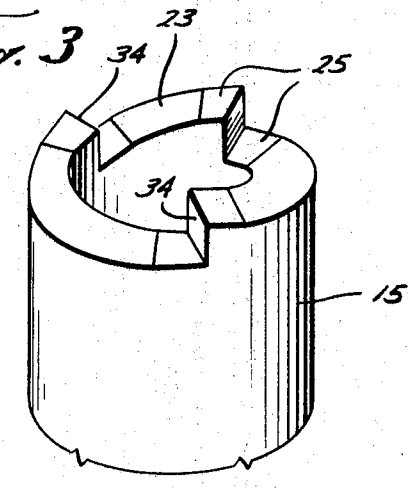


Fig. 3



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ROTARY CAM CASING SWAGE

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ABSTRACT OF THE DISCLOSURE

A rotary swage for straightening or reforming well casings set in a borehole comprises an upper hammer portion and a lower anvil portion having a swaging head for striking the casing. The mating surfaces of the hammer and anvil form an inclined planar cam which upon rotation of the hammer causes the hammer to rise and fall striking a blow upon the anvil. The hammer and anvil are joined by means of a series of ball bearings maintained in an internal circular race between the two pieces. Secondary impact surfaces distribute the force of the downward blow of the hammer so that not all of that downward force is concentrated on the cam surface.

BACKGROUND AND SUMMARY OF THE INVENTION

The instant invention relates to a novel reciprocating tool for use in a borehole to correct bends or deformities in the well casing. More particularly, the instant invention provides a simple two-piece mechanical swaging tool for connection to the end of a drill string which produces a reciprocating swaging action by suitable rotation of the drill string.

Formation pressure, deviations of the borehole, and other conditions which occur downhole often result in the collapse, bending, or deformation of a well casing set in a well bore. Such deformities in the casing can obstruct the passage of other tools downhole or otherwise interfere with well operations. Under such conditions, it becomes necessary to reform the casing to its original shape and diameter.

The straightening or reforming of downhole casing can be effected using a number of tools known to the prior art. For example, devices using hydraulic pressure to force a forming tool into the collapsed region of casing have been used. Also rotary swages have been employed which restore the shape of the casing using pressure and rolling action.

However, a very efficient method for reforming bent or collapsed casing is simply to hammer it into its original shape.

Accordingly, there is provided by the instant invention a simple rugged device to impart a reciprocating swaging action to a swaging head by rotary action of the drill string, which device comprises an upper hammer portion independently rotatable from a lower anvil portion which has a swaging head. The hammer and anvil portion have mating surfaces forming an inclined planar cam so that upon rotation of the hammer in the proper direction, the hammer climbs the inclines on the mating surfaces of the anvil and then sharply drops delivering a blow of considerable force to the anvil. Secondary impact surfaces between hammer and anvil are also in contact when the blow is delivered so that the entire force of the blow is not received by the cam surface. Thus, the tool of this invention is preferably designed with a number of surfaces perpendicular to the direction in which the hammer strikes the anvil to distribute this force. For example, the anvil may receive a reduced diameter portion of the hammer having shoulders which are in contact with mating shoulders of the anvil when the

downward blow is transmitted to the anvil. Continued rotation in the proper direction produces a repeated hammering action while rotation in the opposite direction locks the anvil and the hammer into combined rotation.

The hammer and anvil portions of the novel device of this invention are held together by a series of ball bearings disposed in an inner race between the two members which bearings function as the sole detent means between the members, thus facilitating rotation and providing an easily replaceable detent means for securing the members into working relationship.

BRIEF DESCRIPTION OF THE DRAWINGS

The instant invention will be more particularly understood by reference to the particular embodiments illustrated in the accompanying drawings.

FIG. 1 is a pictorial illustration of a swaging tool in accordance with this invention disposed downhole in working relationship with respect to a deformity in a well casing.

FIG. 2 is a partially sectioned elevational view of a rotary swage in accordance with this invention.

FIG. 3 is a perspective view of the cam surface on the lower anvil piece of the swaging device of this invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Referring in particular to FIG. 1, there is shown a representative view of a subsurface well bore **9** lined with casing **17**. A deformity in the casing, shown as **21**, is an obstruction to the passage of pipe and/or tools to downhole positions. The rotary swage **10** in accordance with this invention is shown in place above the deformity with the cam surfaces of the upper hammer portion **13** and the lower anvil portion **15** in mating engagement. The hammer **13** is connected to drill pipe **19**, which when rotated in the direction of arrow A produces a reciprocating hammering action of the hammer **13** upon anvil **15**. This hammering action transmitted to swaging head **16** enables the casing to be reformed in the region of the deformity.

In FIG. 2, the rotary swage is shown in greater detail and in partial section. Upper hammer portion **13** is provided with a typical upper threaded end **19** to effect a typically threaded joint with the drilling pipe or with a string of drill collars. Any other suitable method of joining the tool to the drill pipe may be used as will be appreciated by those skilled in the art. The lower portion of hammer **13** is formed of progressively reduced diameter, axially aligned shanks **14** and **20** which respectively form downwardly facing cam surface **12** and shoulder **28** and bottom surface **36**.

Semicircular groove **29** is provided about the periphery of shank **14** to accommodate bearings **27** which are disposed about the entire inner race formed by grooves **27** and **31** as will be discussed further below.

Lower anvil portion **15** carries a suitable swaging head **16** which may be of any desired shape depending upon the use contemplated. As will be apparent below, the design of the novel rotary swage of this invention is such that the anvil portion can be easily replaced if a particular swaging head is desired.

Anvil **15** has a central axially aligned recess **30** which receives the reduced diameter shank portions of hammer **13**. Upwardly facing cam surface **23** of anvil **15** is designed to mate with the downwardly facing cam surface **12** of hammer **13**. Cam surface **23** may be more clearly seen by reference to FIG. 3.

Cam surface **23** comprises three upwardly inclined rotary surfaces each terminating in a vertical step **34**. When mating cam surface **12** of hammer **13** is in engagement with cam surface **23** and hammer **13** is rotated, the

cam surface on hammer 13 will climb the inclines of the anvil cam surface and deliver three striking blows to the anvil for each full rotation of the hammer.

Similarly, so long as some downward weight is maintained upon the anvil 15 by the hammer, rotation of the hammer in the opposite direction will lock the hammer with the anvil and make both portions of the tool turn as a unit.

It will be readily understood that suitable mating cam surfaces may be designed to deliver a single striking blow or any number of striking blows to the anvil for each revolution of drill pipe by providing the proper number of inclines and steps in the cam arrangement. Of course, the more striking blows struck per revolution of the hammer, the lesser will be the force of each blow. This is apparent inasmuch as the slope of the cam inclines, and hence the distance which the hammer falls to strike the anvil, is limited by frictional considerations.

Edges 25 of vertical steps 34 may be suitably hardened with a tungsten carbide surfacing or the like to minimize wear during the hammering operation. Such hard surfacing would also be preferred on the mating surfaces of cam 12 of the anvil.

Wall 24 of anvil 15, which surrounds the axial recess in the anvil is produced with a groove 31 to accommodate ball bearings 27 which ride in the semicircular groove 29 of the hammer. Hence, groove 31 in semicircular groove 29 forms an internal race within the tool for a series of ball bearings to minimize friction between hammer and anvil and permit the hammer to be readily rotated with respect to the anvil.

The vertical length of groove 31 is sufficient to permit the ball bearings 27 held in groove 29 to move during the reciprocating movement of the hammer 13 with respect to the anvil upon such rotation. Groove 31 is also sufficiently deep to receive the halves of bearings 27 protruding from semicircular groove 29. Quarter circular ends 39 and 40 of groove 31 accommodate the bearings 27 at their limits of upward and downward travel respectively.

Insert hole 33 communicates with groove 31 and the internal race in which bearings 27 are maintained to enable replacement of bearings when they become worn. Insert hole 33 may be suitably threaded and fitted with a screw plug 41 to retain the bearings and lubricating material in the groove during use of the tool.

Thus, bearings 27 form the only detent holding shank 14 within the axial recess of anvil 15. The dimensions of semicircular groove 29 and groove 31 are such that bearings 27 are held in groove 29 but have sufficient vertical freedom in groove 31 to move freely over the full traverse of reciprocating motion of said hammer. When the tool is withdrawn from the hole, bearings 27 will travel to the upper surface 39 of groove 31, thus performing the detent function.

Below semicircular groove 29, shoulders 28 and 43 of the hammer and anvil, respectively, make contact when hammer 13 reaches the limit of its downward movement with respect to anvil 15. Likewise, shoulder 37 of anvil 15 is in contact with the lowermost surface of the hammer 36. These surfaces 37 and 43 are disposed perpendicular to the force of the hammers and function as secondary impact surfaces to distribute the force of the blow delivered by the hammer to the anvil over not only cam surface 23, but also over the accumulative areas of the shoulders as well. This distribution of the force serves not to diminish the amount of force which the swaging head 16 delivers to the pipe deformity such as 21, but rather minimizes the concentration of hammering action in any one single surface of the anvil. When hammer 13 is rotated with respect to anvil 15, only the cam surfaces are in contact and offer frictional resistance to this rotation.

Mating cam surfaces 12 and 23 of the hammer and anvil, respectively, may be suitably lubricated using a solid lubricant such as molybdenum sulfide or graphite or the like. As indicated above, the internal race for bearings 27 is maintained lubricated to minimize frictional resistance to rotation.

Design modifications may be indulged in the structural detail of a rotary swage within the scope of this invention. For example, the cam surfaces might be circular inclined planar surfaces or might have a slight catenary shape. Despite such variations in design, the said surfaces will function as inclined cam surfaces in accordance with this invention.

Similarly, the swaging device may be provided with a central recess illustrated as 18 in FIG. 2 to minimize resistance to well fluid in the borehole when passing the tool down hole, particularly in those instances when the outer diameter of the tool is of substantially the same diameter as the casing. Likewise flutes or grooves could be provided on the exterior of the anvil to permit fluid passage thereby.

In addition, it will be appreciated that cylindrical bearings could be provided instead of spherical bearings, in which case the internal race between grooves 29 and 31 would be suitably altered in shape. It will also be appreciated that the design of the instant novel tool could provide the reduced diameter shank as an upwardly extending member from the anvil received in a recess within said hammer. Secondary impact surfaces between the members would function identically.

Also as a design alternative, the cammed surfaces could be provided internally of the tool, between the reduced diameter portion and the recess. For example, surfaces 28 and 43 could cooperate to form mating cam surfaces and surface 23 could then function as a secondary impact surface. However, it is pointed out that as the cam surface reduces in diameter, a greater slope of incline is required to produce the same traverse in total reciprocating motion. Indeed both these surfaces could be cammed, in which case an additional perpendicular secondary impact surface would still be preferred.

What is claimed is:

1. A rotary swaging tool for use in a well borehole which comprises:
   - a hammer member;
   - an anvil member provided with a swaging head at one end thereof;
   - said hammer member and anvil member having mating cam surfaces to produce reciprocating motion of said hammer member with respect to said anvil member when said hammer member is rotated with respect to said anvil member;
   - at least one secondary impact surface upon said anvil member disposed perpendicularly to the direction of reciprocating motion, which surface is in contact with a surface of said hammer member when said mating cam surfaces are in mating engagement; and
   - bearing means disposed between said hammer member and said anvil member to facilitate rotation of said hammer member with respect to said anvil member, said bearing means functioning as the sole detent means between said hammer member and said anvil member.

2. The rotary swaging tool of claim 1 wherein said hammer member and said anvil are capable of being combined in operating relationship by means of a reduced diameter portion of one of said members adapted to be received into a recess in the other of said members, and wherein said secondary impact surface is between said reduced diameter portion and the surface of said recess.

3. The rotary swaging tool of claim 2 wherein said recess has at least two secondary impact surfaces, at least one of which disposed as a shoulder perpendicular to the direction of reciprocating motion.

4. The rotary swaging tool of claim 2 wherein said bearings are disposed in an internal race defined between cooperating grooves in said reduced diameter portion and

the walls of said recess, the said bearing means occupying the full radial dimension of said race between said hammer member and said anvil member.

5. The rotary swaging tool of claim 4 including means to obtain access to said internal race between said hammer member and said anvil member when said reduced diameter portion is within said recess.

6. A rotary swaging tool for use in a well borehole which comprises:

a hammer member adapted to be connected in a drill string;

an anvil member having a swaging head at one end thereof;

said hammer member and anvil member capable of being combined in operational relationship by means of a reduced diameter portion on one of said members adapted to be received into a recess in the other of said members;

a first peripheral groove on said reduced diameter portion;

a second peripheral groove on the walls of said recess cooperating with said groove to form an internal race between said hammer member and said anvil member when disposed in working relationship;

said hammer member and said anvil member having mating inclined planar cam surfaces to produce reciprocating motion of said hammer member with respect to said anvil member when said hammer member is rotated;

at least one secondary impact surface disposed on said anvil member perpendicularly to the direction of reciprocating motion, which surface is in contact with a surface of said hammer member when said mating cam surfaces are in mating engagement; and

a plurality of bearings disposed in said race occupying the full radial dimension of the said race between said hammer member and said anvil member, said bearings functioning as the sole detent means between said hammer member and said anvil member.

7. The rotary swaging tool of claim 6 wherein said inclined planar cam surfaces are disposed about the periphery of said hammer member and said anvil member to produce a cam surface having the greatest possible diameter.

8. A rotary swaging tool of claim 6 wherein one of said grooves has a dimension in the direction of reciprocating motion sufficient to permit full traverse of said one of said grooves by said bearings during reciprocating motion of said hammer member with respect to said anvil member.

9. The rotary swaging tool of claim 6 wherein the walls of said recess are provided with an opening to permit access to said internal race.

10. The rotary swaging tool of claim 6 wherein the said anvil member is provided with at least two secondary impact surfaces, one of which being defined between the innermost surface of said recess and the end of said reduced diameter portion, and another of which being defined between mating shoulder surfaces in said recess and on said reduced diameter portion.

11. The rotary swaging tool of claim 6 wherein said reduced diameter portion is provided on said hammer member and said recess exists in said anvil member.

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U.S. Cl. X.R.

72—370, 476; 175—298