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METHOD OF RECOVERING DRILL PIPE FROM WELLS

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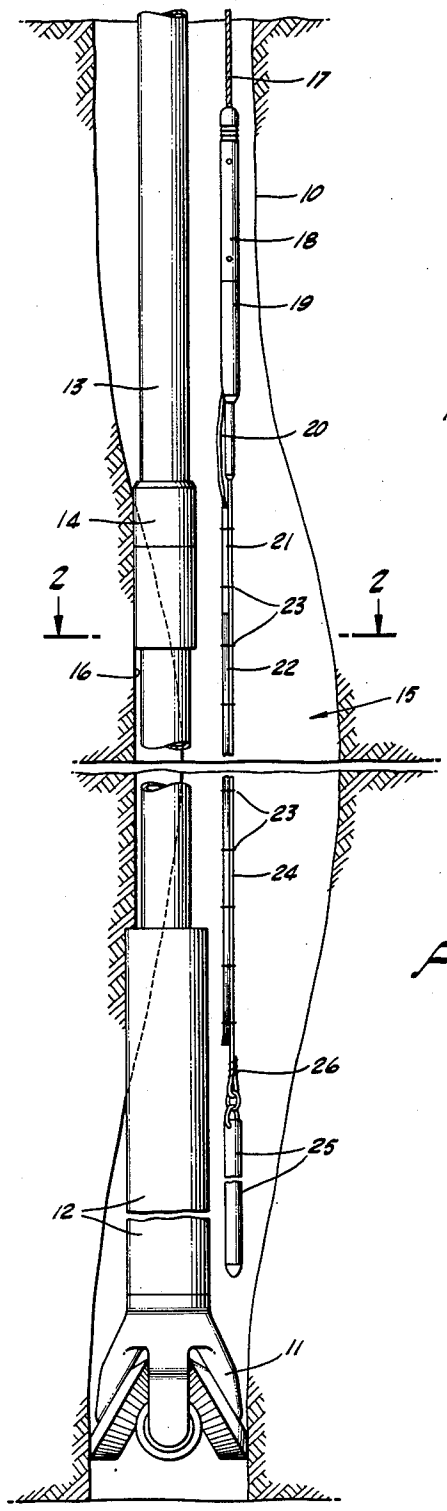


FIG. 1.

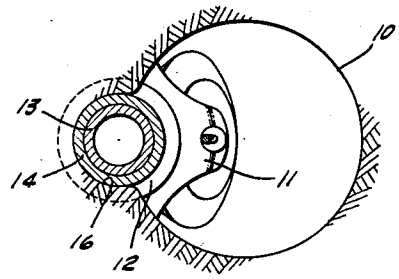


FIG. 2.

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X1016
X1014

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METHOD OF RECOVERING DRILL PIPE FROM WELLS

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6 Claims. (Cl. 255—1.8)

This invention relates to a method and apparatus of recovering a stuck drill pipe from wells.

Explanatory of the present invention, practically all well holes drilled by a rotary well drilling apparatus depart more or less from the true vertical. The amount of departure from the true vertical is to a large extent dependent upon the type of formation that is being drilled through. Other influential factors are the weight placed on the bit, the speed of rotation, and the volume of circulation. By way of illustration, a well hole drilled by the rotary well drilling apparatus may depart from the vertical from ½° to 2° to the north for five hundred feet of depth, then reverse the direction of its departure from the vertical and be ½° to 2° off toward the south or some other direction for the next five hundred feet or one thousand feet of depth. It is not uncommon for a well hole in plan to wander around through a complete circle and for it in vertical section to reverse the direction of its departure from the vertical several times. Wherever the hole does depart from the vertical there is produced a location of a possible "key seat" inasmuch as when the drill pipe is run into or out of the hole or while it is being rotated in tension opposite the inside of the bend in the hole it tends to cut or wear a hole in the well wall at the inside of the bend. If, for example, the well is being drilled with a 12¼" bit using 4½" drill pipe with 6¼" O.D. tool joints, the drill pipe will tend to cut a 6¼" hole in the well wall on the inside of the bend in the drilled hole. If the drill string is equipped with 7" or 8" drill collars above the bit these drill collars cannot pass through the 6¼" hole or key seat formed in the well walls. Consequently, if the drill pipe is being pulled rapidly from the well to replace the bit or for other purposes, the drill collars may start to enter the key seat rather than follow the curvature of the 12¼" hole. The high speed at which the drill string is being elevated and the momentum of the drill string frequently causes the drill collars to enter the key seat and become immovably lodged therein.

The key seats above referred to frequently occur where the strata of the formation being drilled is of varying hardness and solubility. In the Permian Basin of West Texas and New Mexico there is what is commonly referred to as the "salt section." This salt section in some areas is as much as two thousand feet in thickness and within it at random depths are stringers of anhydrite which vary in thickness from 1' to 10'. While drilling through the salt section the water of the drilling fluid tends to dissolve and wash out the salt leaving the harder stringers of anhydrite as ledges. The washed out or dissolved out sections of salt often create cavities of great size immediately beneath the hard ledges of anhydrite and there have been many experiences where fish left in the well have leaned or fallen back into these cavities to such an extent that they cannot be located or engaged by a fishing tool. Similar conditions conducive of the formation of key seats are also found in many sedimentary basins where there are stringers or

hard strata commonly referred to as "shells." These might, for example consist of a relatively hard cemented sandstone overlying softer bodies of shale which are susceptible of being washed out by the circulation fluid to form large cavities in the well walls beneath the shells. The ledges of anhydrite and the shell stringers tend to stand out around the drilled hole as hard ledges and the action of the drill pipe on the inside of a bend in the hole cuts a reduced size hole into them. This produces an ideal situation for the drill collars to become stuck when the drill pipe is being rapidly withdrawn from the hole.

Heretofore, under the circumstances above referred to, customary procedures for endeavoring to free the drill string and recover it from the hole have been to first attempt to locate the depth of the key seat or the stuck point along the length of the drill string. This can be done by lowering into the drill pipe any one of a number of free point indicators now available on the market. These free point indicators are in the nature of electrical strain gauges that can be seated in the pipe at various elevations. Stresses, either torsional or axial, are then imposed on the pipe and the strain of that portion of the pipe opposite the strain gauge is determined from the strain gauge. By locating the strain gauge at various depths and noting whether or not it is actuated by imposing a strain on the pipe the approximate point at which the drill string is stuck in the well can be ascertained. It has also been common practice to impose a tension on the drill pipe at the surface, note the amount of elongation produced in the pipe by the tension imposed and from this information compute or estimate the length of drill pipe down from the surface that is free. This latter practice which is now rapidly becoming obsolete, affords another method by which the stuck point in the drill pipe can be approximately located. After the stuck point has been located, the operator then usually backs off or unscrews the drill pipe some distance above the stuck point. This is frequently accomplished by imposing an unscrewing torque on the drill pipe and exploding a small explosive charge within the tool joint that it is desired to unscrew. Sometimes inside cuts are made in the drill pipe rather than attempting to unscrew at a tool joint. When the drill pipe is thus separated the upper portion of the drilling string is recovered from the hole, leaving the lower portion or fish therein. Generally, the operator will then follow one of three general programs in attempting to recover the fish that has become immovably lodged in the key seat.

One such program consists of again connecting to the fish either by screwing into it or by the use of an overshot and using jars, a bumper sub, and several heavy drill collars and attempting to bump the fish down out of the key seat or to jar it up the hole and out of the key seat.

A second procedure is to run in with a wash pipe and wash over the fish, thus removing the key seat and permitting the fish to fall to the bottom of the well and then attempting to recover the fish from the bottom.

The third procedure is to wash over the fish and attempt to catch the fish with a dog overshot, preventing it from falling to the bottom of the well. Regardless of which procedure is followed there are disadvantages, and recovering of the fish may either be very difficult or in some cases impossible. That is, since the drill string has been backed off or cut off two or three joints above the stuck point in order to have a portion which may be engaged protruding from the top of the key seat, there is thus an upstanding length of free drill pipe standing above the key seat. This upstanding portion is comparatively limber and obviously does not provide a good means of transmitting the blow from a bumper sub or

jars down to the stuck point. If the washover procedure is followed and the fish is permitted to fall to the bottom of the well, the operator is always faced with the problem of having the fish stick a second time in the well, and there is danger of the upper end of the fish falling or leaning back into a cavity beneath the anhydrite ledge or shell ledge, making it extremely difficult to engage and recover the fish.

A primary object of the present invention is to provide an improved method for recovering a drill string which has become immovably lodged in a key seat in a well wherein, instead of detaching the upper portion of the drill string from that portion which has become immovably lodged in the key seat, the drill string is left intact. Consequently, there is no danger of the fish dropping to the bottom of the hole when loosened and no danger of the fish falling or leaning back into a cavity in the well walls and the difficulties involved in re-engaging the fish are entirely eliminated.

More specifically, an object of the present invention is to provide an improved method of recovering drill strings that have become immovably lodged in key seats wherein the stuck point along the length of the string is located or approximated and an explosive is exploded in the well on the exterior of the drill string in the neighborhood of the stuck point. The explosive is preferably set off while the drill string is stressed in a direction tending to dislodge it from the key seat. When the explosive is exploded the key seat, either may be destroyed or at least the drill string is loosened therefrom so that it can thereafter be recovered from the well without having been previously separated.

With the foregoing and other objects in view, which will be made manifest in the following detailed description and specifically pointed out in the appended claims, reference is had to the accompanying drawings for an illustrative embodiment of the invention, wherein:

Figure 1 is a vertical section through a portion of a well illustrating in a somewhat exaggerated manner, a drill string immovably lodged in a key seat, and illustrating apparatus employed for freeing the drill string; and

Fig. 2 is a horizontal section taken substantially upon the line 2—2 upon Fig. 1 in the direction indicated.

Referring to the accompanying drawings wherein similar reference characters designate similar parts throughout, **10** indicates a well bore which may be regarded as having been drilled by means of a bit **11** above which there may be one or more drill collars **12** by which the bit is attached to a string of drill pipe **13**, the sections of which are connected to each other by means of tool joints **14**. As has been indicated in a rather exaggerated manner, the well bore **10** has deviated from the vertical and is shown as having subsequently returned to the vertical so that the bore has a bend therein generally indicated at **15**. On the inside of this bend, as drilling has progressed, the tool joints **14** have worn or cut a recess in the well wall, indicated at **16**, forming what has commonly been referred to in the field as a key seat. As illustrated in the drawing, this key seat has a size substantially equal to the outside diameter of the tool joints. In withdrawing the drill pipe from the well to replace the bit **11**, or for other purposes, the drill collars **12**, which usually are of greater diameter than the tool joints **14**, are illustrated as having been forced into the bottom of the key seat so as to become immovably lodged therein. This usually occurs when the drill pipe is being elevated in the well at a rapid rate. A similar situation may be created when the drill string is being lowered. Under the latter circumstance the bit or a portion of it, and sometimes portions of the drill collars, enter into the top of the key seat and become immovably lodged therein.

In order to free the drill pipe the stuck point along the length of the drill string is first ascertained. This may be accomplished by lowering a free point indicator through the drill pipe **13**. Any one of a number of different designs of free point indicators may be used for this purpose. In the illustration on the drawing such free point indicator would probably indicate that the drill pipe **13** is free above the drill collars **12** but that the top of the drill collars is the point at which the drill string has become stuck in the key seat. It is possible, however, that for one reason or another a tool joint has become stuck in the key seat, in which case the free point indicator would indicate this fact or that point along the length of the drill string that is stuck.

After having ascertained the point or depth along the length of the drill string at which it is stuck in the casing a cable **17** containing an electric conductor is lowered into the well bore **10** on the exterior of the drill string. This cable is connected to a rope socket **18** to which there is connected a shooting adapter **19**. The conductor in the cable indicated at **20** is connected to a detonating cap **21** beneath which there is disposed an adequate length of explosive, indicated at **22**. This explosive may be any one of a number of different types of explosives. A typical explosive consists of plastic-covered Primacord having 100 grains per foot. The average size of the explosive consists of twenty strings of 100 grain Primacord, fifty feet long, although the amount of explosive employed may be increased or decreased to meet various conditions. The strings of Primacord are arranged in side by side relationship beneath the detonating cap and are bound by means of ties or the equivalent indicated at **23** to a so-called by-pass line indicated at **24**. This by-pass line consists of a cable preferably formed of cold drawn plow steel having a high tensile strength such that it will not be apt to be blown in two when subjected to the explosion of the explosive. The by-pass line has its upper end connected to the shooting adapter **19** and has a weight **25** wired as at **26** to the bottom of the by-pass line. The weight **25** is preferably in the form of a thin-walled metal container filled with lead shot. The wire tie at **26** is such that, after the explosive has been exploded in the event that the weight **25** becomes caught in the well in the course of withdrawing the cable **17**, the wire tie will part before pulling out pull-out blocks conventionally employed in the rope socket **18**. In this manner the weight can be released and due to its thin wall and the nature of its contents the weight may subsequently readily be drilled up. In lieu of using the by-pass line **24** the weight **25** may be connected directly to the explosive **22** which, of course, would involve a release of the weight when the explosive is exploded. The by-pass line enables recovery of the weight from the well in the event that the weight is not caught in the well in the course of its withdrawal.

The explosive **22** which is lowered into the well bore **10** on the outside of the drill string is positioned so as to extend from a point below the stuck point as determined by the free point indicator to a point some distance above the stuck point. When the explosive has been thus positioned a stress is applied to the drill string tending to dislodge it. Thus if the drill string has become immovably lodged in the key seat in the course of withdrawal of the drill string, the weight of the drill string would be imposed in a downward direction. Conversely, if the drill string has become lodged in the key seat in the course of lowering the drill string into the well, an upward tension would be imposed on the drill string tending to free it from the key seat. While stress is thus imposed on the drill string the explosive **22** is exploded along the key seat and above and below the stuck point as determined by the free point indicator. Exactly what takes place in the well cannot be accurately ascertained. At all events when the explosive is thus exploded it is usually found that the drill string is immediately freed and may be recovered from the well. This may result from a complete destruction of the key seat or the well walls around the key seat, or it may be due to a combination of the stress imposed on the drill string coupled with the sudden jar created by the explosion. After the explosive has been

exploded the line 17 is withdrawn from the well and the drill pipe recovered.

As above explained, the well bore 10 may wander in several different directions so that when the drill string is suspended therein the drill pipe may be in close proximity to one side of the well bore at one depth and in close proximity to another side of the well bore at another depth. In the course of lowering the explosive into the well the weight 25 will descend between the drill pipe and a side of the well bore to which it is closely adjacent. Consequently it is frequently desirable to work the pipe in the well during the course of lowering the explosive. This consists of alternately imposing tension on the drill pipe so as to stretch it, and releasing it. This working of the pipe will usually facilitate the passage of the explosive down through the well bore on the exterior of the pipe.

It may happen that as the explosive is being lowered into the well adjacent the drilling string that it may progress around the drilling string so that the lowering cable or line is given a complete wrap around the drilling string. Under such circumstances further lowering or withdrawal of the line is prevented. This may be overcome by lowering a back-off shot down the inside of the pipe and exploding it so that the pipe may be unscrewed and rotated. The back-off shot referred to herein is the conventional back-off shot consisting of an elongated explosive which is lowered into the drill string and which is incapable of destroying the drill string. It is set off usually on the interior of a tool joint while the drill string is stressed in torque, tending to unscrew the tool joint. The shock of the explosive causes the tool joint to loosen and unscrew under this "reverse torque." When the tool joint has been thus loosened, it enables that portion of the drill string above the loosened tool joint to be rotated. Rotation of the pipe will tend to unwind the line from the exterior thereof and thus enable its being further lowered or its being recovered. Thereafter, the separated drilling string may be reconnected and recovered.

From the above described method and apparatus it will be appreciated that in the usual situation it is not necessary to detach the upper portion of the drill string from the lower portion or stuck portion thereof. Consequently there is no occasion to drop the lower portion or fish in the well with the resulting danger of the fish falling or leaning into a cavity in the well wall below the key seat. The method above described has heretofore proven very successful in recovering drilling strings from wells where the drill string has become immovably lodged in a key seat.

Various changes may be made in the details of the construction without departing from the spirit and scope of the invention as defined by the appended claims.

We claim:

1. The method of recovering a drill string which has become immovably lodged in a key seat in a well which comprises ascertaining the approximate point along the length of the drill string at which it is stuck, lowering an explosive into the well on the exterior of the string to the neighborhood of the stuck point which explosive is incapable of destroying and parting the drill string, setting off the explosive at the mentioned neighborhood of the stuck point while that portion of the drill string adjacent the stuck point is under stress tending to dislodge it from the key seat, and withdrawing the drill string from the well.

2. The method of recovering a drill string which has become immovably lodged in a key seat in a well which comprises ascertaining the approximate point along the length of the drill string at which it is stuck, lowering an explosive on a line into the well on the exterior of the string to the neighborhood of the stuck point which explosive is incapable of destroying and parting the string, imposing a stress on the drill string tending to dislodge it from the key seat, exploding the explosive in the well on the exterior of the drill string in the neighborhood of the stuck point, and withdrawing the drill string from the well.

3. The method of recovering a drill string which has become immovably lodged in a key seat in a well which comprises ascertaining the approximate point along the length of the drill string at which it is stuck, lowering an elongated explosive into the well on the exterior of the string to the neighborhood of the stuck point which explosive is incapable of destroying and parting the string, exploding the explosive in the well on the exterior of the drill string in the neighborhood of the key seat while that portion of the drill string adjacent the stuck point is under axial stress tending to dislodge it from the key seat, and withdrawing the drill string from the well.

4. The method of recovering a drill string which has become immovably lodged in a key seat in a well which comprises ascertaining the approximate point along the length of the drill string at which it is stuck, lowering an explosive into the well on the exterior of the string which explosive is incapable of destroying and parting the string, working the drill string while lowering the explosive, exploding the explosive in the well on the exterior of the drill string in the neighborhood of the stuck point, and withdrawing the drill string from the well.

5. The method of recovering a drill string which has become immovably lodged in a key seat in a well which comprises ascertaining the approximate point along the length of the drill string at which it is stuck, lowering an explosive into the well on the exterior of the string to the neighborhood of the stuck point which explosive is incapable of destroying and parting the string, lowering a back-off shot in the drill string, reverse torquing the drill string, setting off the back-off shot and unscrewing and rotating the thus loosened portion of the drill string to unwrap the line used to lower the explosive in the well in the event that such line has become wrapped around the drill string, exploding the explosive in the well on the exterior of the string in the neighborhood of the stuck point, and withdrawing the drill string from the well.

6. The method of recovering a drill string which has become immovably lodged in a key seat in a well which comprises ascertaining the approximate point along the length of the drill string at which it is stuck, lowering an explosive into the well on the exterior of the string to the neighborhood of the stuck point which explosive is incapable of destroying and parting the string, lowering a back-off shot in the drill string, reverse torquing the drill string, setting off the back-off shot and unscrewing and rotating the thus loosened portion of the drill string to unwrap the line used to lower the explosive in the well in the event that such line has become wrapped around the drill string, reconnecting the rotated upper portion of the drill string to the stuck portion, exploding the explosive in the neighborhood of the stuck point, and withdrawing the drill string from the well.

References Cited in the file of this patent

UNITED STATES PATENTS

2,259,564	Holland	Oct. 21, 1941
2,304,793	Bodine	Dec. 15, 1942
2,305,261	Kinley	Dec. 15, 1942
2,414,349	Alexander	Jan. 14, 1947
2,650,539	Greene	Sept. 1, 1953

OTHER REFERENCES

The Oil and Gas Journal, vol. 38, No. 47, Apr. 4, 1940, pages 39, 40, 43, 44 and 57.