July 8, 1958 F. I. ALEXANDER 2,842,207

METHOD AND APPARATUS FOR DISCONNECTING WELL PIPE JOINTS

Filed Sept. 6, 1955

FIG. 1.

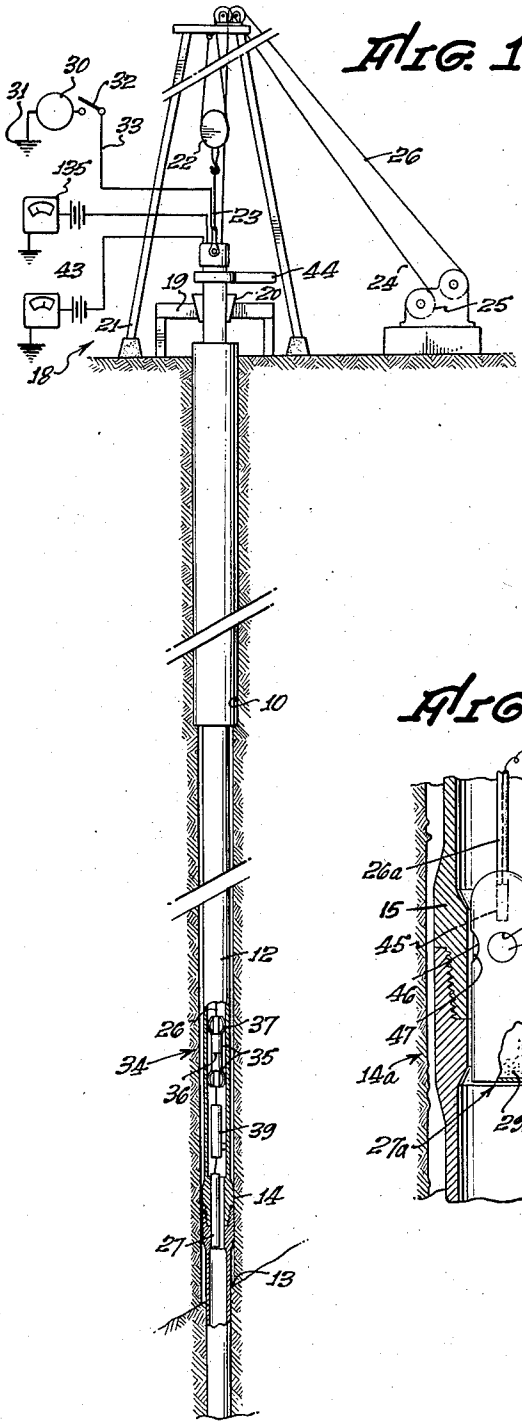


FIG. 2.

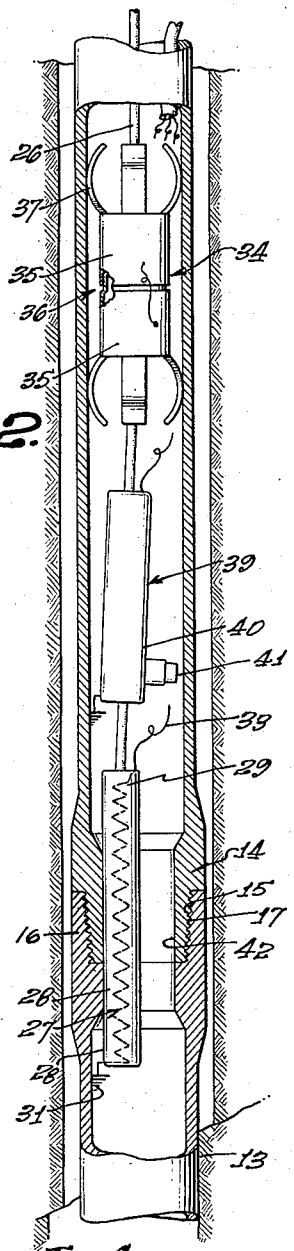


FIG. 3.

FORD I. ALEXANDER,
INVENTOR.

BY William P. Green

ATTORNEY.

United States Patent Office

2,842,207

Patented July 8, 1958

2,842,207

METHOD AND APPARATUS FOR DISCONNECTING WELL PIPE JOINTS

Ford I. Alexander, Arcadia, Calif.

Application September 6, 1955, Serial No. 532,636

2 Claims. (Cl. 166—46)

This invention relates to improved methods and apparatus for breaking a joint, deep within a well, between two stands of a stuck drill string or other well pipe.

When a rotary drilling string becomes stuck in a well, as a result of a cave-in or similar condition, it is desirable to disconnect whichever joint of the pipe is just above the stuck location, and to then remove the upper free portion of the string from the well. The problem thus arises of breaking that particular joint of the string while leaving all of the other joints intact, so that as much of the pipe is recovered as possible.

The general object of the present invention is to provide an improved method for this purpose which will very effectively break a predetermined single joint deep within a well, and yet will do so in a manner avoiding any possibility of damage to that joint or to any other portion of the string during the loosening operation. At the same time, the present method is adapted for very easy and reliable control from the surface of the earth.

Further contemplated is a type of apparatus which can function, on a single run within a well, to first locate the stuck point of a drill pipe, and then loosen the joint directly above that point. Heretofore, these two operations have required two separate runs into the well with two different units, since the type of loosening operation normally utilized has employed an explosive, whose firing would damage the very sensitive type of instruments utilized as stuck point indicators.

In order to achieve the above results, I employ a method which involves the application of both force and heat to the joint, so that the force and heat together cause the desired breaking of the joint. More particularly, I apply force to the string tending to break the joint, and in conjunction with the force, I apply heat locally to the joint in an amount raising the joint to a very high temperature sufficient to initiate unscrewing of the joint under the applied force. The force may be a torque tending to unscrew the joint, or a lifting force relieving the joint of the weight of the string. Preferably, both a torque and a lifting force are utilized. If difficulty is encountered, the lifting force may be alternately applied and relieved, in a manner tending to vertically reciprocate the string while it is heated.

The heat may be applied by a relatively small heater lowered into the well, typically either an electric heater or a burner unit carrying a suitable combustible material. The heater may include means for holding the heater body laterally against one side of the well pipe, as by provision of magnetic means on the heater attractable to the pipe. When lowered into a pipe, the heater may be connected to a stuck point indicator for locating the highest point at which the pipe is stuck, and also to a joint finder for locating the nearest joint in the pipe after the stuck point is found.

The above and other features and objects of the present invention will be better understood from the following

detailed description of the typical embodiment represented in the accompanying drawing in which:

Fig. 1 is a partially schematic representation of a well containing a stuck drill string, together with the apparatus which is utilized for breaking one of the joints of the string directly above the stuck point;

Fig. 2 is an enlarged fragmentary vertical section through a portion of the Fig. 1 apparatus, and

Fig. 3 is a fragmentary sectional view similar to Fig. 2, but showing a variational type of heater for raising the temperature of the joint which is to be broken.

Referring first to Fig. 1, I have shown at **10** a well bore, containing a rotary drilling string **12** or other pipe string which has become stuck in the well. The lower portion of the drill string **12** may be considered as being stuck up to a point **13**, typically by caving in of the lower portion of the well in a manner tightly packing the earth about the drill string. Above the point **13**, the string **12** is free, and it is therefore desired to break the nearest threaded joint **14** above point **13**, so that the portion of the string above joint **14** may be recovered from the well.

As seen best in Fig. 2, each of the joints **14** of the drill string **12** includes the usual threaded pin and box sections **15** and **16**, which are connected together by right hand rotation of the pin section, and which are then effective to transmit rotary motion from the pin section to the box section, so that rotation of the upper end of the drill string in a right hand direction turns the entire string during a drilling operation. The threads **17** interconnecting sections **15** and **16** are normally of a tapered configuration, as shown, and made up sufficiently tightly to require a considerable unwinding torque in order to break the joint.

The movements of the drill string are controlled by the usual equipment **18** at the surface of the earth, including a power driven rotary table **19** adapted to receive slips **20** for suspending the weight of string **12**. The rig **18** includes also a derrick **21**, having a traveling block **22** from which string **12** may be supported by a suspension element **23**, block **22** being movable upwardly by winding of its cable **24** on the usual power driven elevating drum **25**.

For conditioning a particular joint **14** to be broken by forces exerted by the rotary table and traveling block, I lower into the well on a suspending cable **26** a heater **27**, which acts to internally heat the drill string at the desired lowermost free joint **14**, to a temperature such that vertical and rotary forces exerted against the upper end of the pipe by the rotary table and traveling block will be effective to break the desired joint, while leaving the other joints of the string intact. This heater **27** may include a vertically elongated tubular preferably metal and fluid tight outer housing **28**, containing a suitably insulated electrical heater element or coil **29**, adapted to be energized by current from a suitable electrical power source **30** at the surface of the earth. One side of the power source **30** may be connected to heater element **29** through a ground connection **31**, while the other side of power source **30** may be connected to the heater element through a switch **32** and a lead **33** extending downwardly within the well. The heater **27** is preferably of a length somewhat greater than the length of the threaded joint which is to be broken. Also, it is desirable to provide some means for holding heater **27** laterally against and in heat transferring engagement with one side of the inner wall of the joint (see Fig. 2). Such positioning of the heater may be effected by permanently magnetizing the outer magnetic metal housing **28** of heater **27**, typically by making its upper end a north pole and its lower end a south pole, so that the magnetized housing automati-

cally clings to one side of the steel drill pipe. The weight of the heater must of course be sufficient to cause lowering of the heater in spite of the described magnetic attraction, when such lowering is permitted by the suspending cable **26**.

Cable **26** also preferably suspends, desirably at a location above heater **27**, a conventional "free point indicator" or "stuck point indicator" **34**, which electrically controls an associated indicating unit **135** at the surface of the earth, in a manner such that the indicator locates the uppermost point **13** at which string **12** is stuck. This free point indicator may be of any of the well known types now in use, and need not be described in detail for present purposes. To describe the free point indicator **34** very briefly, this device includes two tubular vertically extending elements or sections **35** which interfit telescopically at **36** in a manner allowing relative vertical telescopic movement of the two sections. A set of upper bowed springs **37** carried by the upper section **35** of device **34** acts to frictionally hold that section in a particular set position within drill string **12**, while a second and lower set of springs **38** acts to correspondingly frictionally hold the lower section **35** in a desired set position. When unit **34** is lowered into the drill string to a particular location, and traveling block **22** is then actuated to exert a vertical force against the string, the resulting slight relative movement of the two sections **35** of unit **34** acts through a strain gauge or other responsive member contained within the device to produce an electrical response which is indicated to an operator at the surface of the earth on the indicating unit **135**. If this same type of operation is performed with free point indicator **34** positioned in string **12** at a location beneath the stuck point or free point **13**, the engaged portion of the string of course will not be elongated or extended even slightly when traveling block **22** is actuated to exert an upward force on the string, so that the indicating unit **135** will apprise an operator of the fact that the unit **34** is within a stuck portion of the pipe. By thus taking a series of readings from stuck point indicator **34**, it is possible to very precisely locate the uppermost point **13** at which the drill pipe is stuck.

After the point **13** has thus been determined, it is desirable to elevate heater **27** upwardly to its Fig. 1 position within the next upper joint **14**, in order that that joint may be broken. To locate the joint **14** for such positioning of heater **27**, I suspend on cable **26**, in addition to heater **27** and free point indicator **34** (and preferably vertically therebetween and substantially directly adjacent heater **27**) a conventional instrument of the type referred to as an "electrical joint finder," designated **39** in the drawing. As in the case of instrument **34**, it is unnecessary for present purposes to describe specifically the construction of joint finder **39**, other than to say that it includes a body or housing **40** movably carrying a laterally projecting and typically spring pressed, finger or element **41**, which is deflected relative to body **40** by engagement with the reduced dimension portion **42** of the drill string at each joint **14**, and which electrically controls an indicator **43** at the surface of the earth to tell when joint finder **39** is positioned within one of the joints **14**.

As an example of one of the various types of conventional "stuck point indicators" which have been utilized commercially in the past, reference is made to U. S. Patents 2,530,308 and 2,530,309. Similarly, as an example of the type of device which could be utilized as the "joint finder" in the present apparatus, reference is made to U. S. Patent 2,322,343.

In performing a joint breaking operation in accordance with the present method, a first step may be to lower the instruments **27**, **39** and **34** into the stuck drill pipe **12**. The drill pipe elevating mechanism **22–25** may then be actuated, by driving drum **25**, to exert an upward force on the upper end of drill string **12**, this upward force or movement preferably being sufficient to lift substantially all of the weight of the drill string off of the joint **14**. Slips **20** may then be inserted into the rotary table, so that the drill pipe is suspended from the rotary table in the described condition in which the weight of the pipe is relieved from joint **14**. Rotary table **19** is then driven in a left hand direction with a force to apply a very substantial unscrewing torque to the upper pin section **15** of the joint **14** which is to be unscrewed. This torque is sufficiently great to perform the desired function of assisting in breaking the joint **14**, while at the same time being insufficient to twist off or otherwise damage the pipe.

Heater **27** is properly located within the desired joint **14** by first utilizing free point indicator **35** to determine the exact location of the uppermost stuck point **13**, following which cable **26** is pulled upwardly to a point at which indicating unit **43** responsive at joint finder **39** indicates that instrument **39** is located directly within the nearest joint **14** above point **13**. After this position has been located, cable **26** is raised through a predetermined measured distance corresponding to the effective vertical spacing between unit **39** and heater **27**, which raising of cable **26** is just sufficient to very accurately locate heater **27** in its Figs. 1 and 2 position within joint **14**.

With heater **27** positioned as shown in Fig. 2 within joint **14**, and with the weight of string **12** suspended and an unscrewing torque applied by rotary table **19** as previously discussed, switch **32** at the surface of the earth may be closed to energize heater **27** and thus raise the temperature of the pin and box ends interconnected at joint **14**. Since the outer metal casing of heater **27**, which is directly heated by element **29**, is in direct heat transferring engagement with the metal of the two joint sections at the joint location, heater **27** is capable of very effectively and directly heating the joint sections to a rather high temperature. This causes expansion of the two threadedly interconnected sections, which expansion causes sufficient relative movement of the sections to somewhat loosen the heated threaded joint so that the torque and suspending forces exerted against the drill string will unscrew the heated joint (without unscrewing the unheated joints thereabove). If the joint does not break when the temperature is thus raised by heater **27**, slips **20** may be removed from the rotary table **19**, and drum **25** may be alternately driven several times in opposite rotary directions to alternately exert an upward force against the drill string and then allow the weight of the string to again rest on the joint **14**. Preferably, during such repeated suspension and release of the drill string, an unscrewing torque is exerted against the upper section of the drill pipe, as by a suitable power tong or other unit typically represented at **44**, acting to apply a torque of the same value previously described in connection with rotary table **19**. Thus, the combined heating, torque application, and vertical working of the drill string will serve to break even the most tightly made joint **14**. After the threaded connection is broken, the instruments **27**, **39** and **34** may be withdrawn upwardly from the well, and rotary table **19** may be driven to complete the unscrewing of the upper portion of the pipe from the lower stuck portion at joint **14**, following which the upper portion may be removed upwardly from the well, leaving the lower stuck portion in the well. Subsequent operations may of course be performed to free a portion or all of the stuck pipe, so that it too may be removed from the well.

Fig. 3 represents fragmentarily a variational form of the invention, which is identical with that of Figs. 1 and 2 except as to the type of heater **27*a*** which is employed. This heater **27*a*** is suspended by a cable **26*a*** beneath units of the type previously described at **34** and **39**. Heater **27*a*** comprises an outer vertically extending tubular housing **28*a***, filled with a mass of highly combustible material, which is adapted when ignited by an electrically energized fuse **45** to produce a very high temperature within the threaded pipe joint **14*a***. The hot gases produced by

ignition of charge **29***a* may be directed outwardly through apertures **145** in the side of housing **28***a* against the threaded portion of the joint. Housing **28***a* is preferably formed of sufficiently rigid metal or other material to effectively withstand the pressure and high temperatures encountered upon burning of charge **29***a*. The charge **29***a* is formed of a material which is adapted to burn effectively when completely submerged in water or other well liquid, and may initially be completely sealed from the well liquid by fluid tight plugs **47** received in apertures **46** and adapted to be easily ejected from those apertures by the pressure developed during burning of charge **29***a*.

Whether the heater employed is of the type shown at **27**, or that shown at **27***a*, or some other type of heater, it must be capable of raising the temperature of the threaded joint sections under normal well conditions to a rather high temperature, preferably to a temperature at least about 250° F. higher than the temperature of the joint being heated and the adjacent formation prior to heating. However, the temperature rise should not be great enough to destroy the temper or substantially affect the hardness of the metal of the string sections or their joint ends, and for this purpose the heater should not elevate the joint or string temperature higher than about 950° F. The heat from heater **27** or **27***a* is desirably applied over a somewhat extended period of time, rather than merely instantaneously, the heat preferably being applied over a period of at least about one minute, and desirably between one and ten minutes. If the joint is still stuck after being heated for a substantial period of time, say ten minutes, the heater may then be alternately turned off and on for a few minutes at a time, to cause the joint to alternately expand and contract, and thus increase the possibility of breaking the joint.

Where a heater of the type shown at **27***a* is employed, the burning charge **29***a* may be formed of any suitable slow burning material or mixture, such as black powder mixed with sawdust to slow its burning rate, and suitably compounded to burn when submerged in well fluid.

I claim:

1. The method of breaking a threaded joint deep within a well between sections of a string of pipe stuck in the well, that comprises applying force to the string above said joint tending to break the joint, locally heating said joint from the inside thereof, and loosening the joint by the heat induced expansion thereof to an extent such that said force becomes effective to unscrew said joint, said force including a lifting force alternately applied and relieved to tend to vertically reciprocate the string.

2. The method of breaking a threaded joint deep within a well between sections of a string of pipe stuck in the well, that comprises alternately applying to the string and relieving a lifting force to tend to vertically reciprocate the string, applying a torque to the upper portion of the string tending to unscrew the joint, locally heating said joint from the inside thereof, and loosening the joint by the heat induced expansion thereof to an extent such that said alternately applied and relieved lifting force and said torque become effective to unscrew said joint, said heating being continued for at least about one minute, and acting to raise the temperature of said joint at least about 250 degrees F. above the ambient temperature at said joint.

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