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Chestnut et al.

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[54] **METHOD FOR THERMALLY CUTTING TUBING**

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[52] **U.S. Cl.** **166/255,** 166/297, 166/301, 166/55

[51] **Int. Cl.**.....**E21b 47/00,** E21b 29/02

[58] **Field of Search**.....166/250, 255, 297, 166/301, 315, 55, 63

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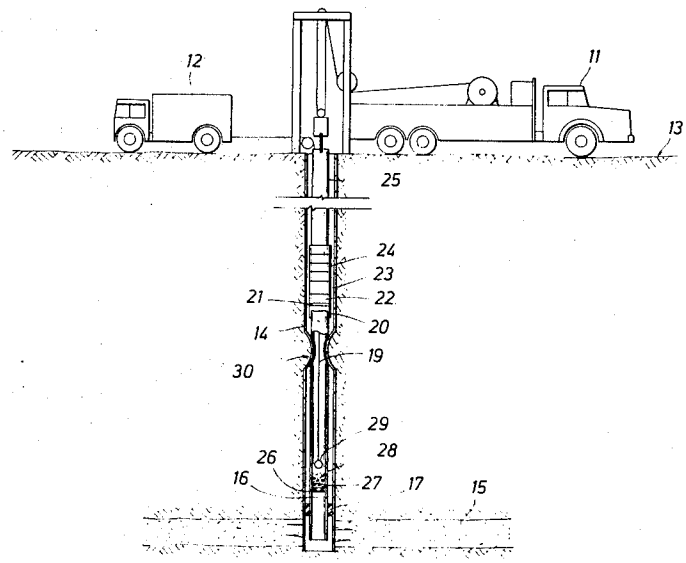
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[57] **ABSTRACT**

A method for thermally cutting tubing, such as below an internal restriction in a tubing string located in a well bore, which comprises placing in the tubing at the desired location a mixture of finely granulated aluminum with an oxide of iron or other metal and igniting the mixture while applying a tensile load to the tubing string.

6 Claims, 2 Drawing Figures



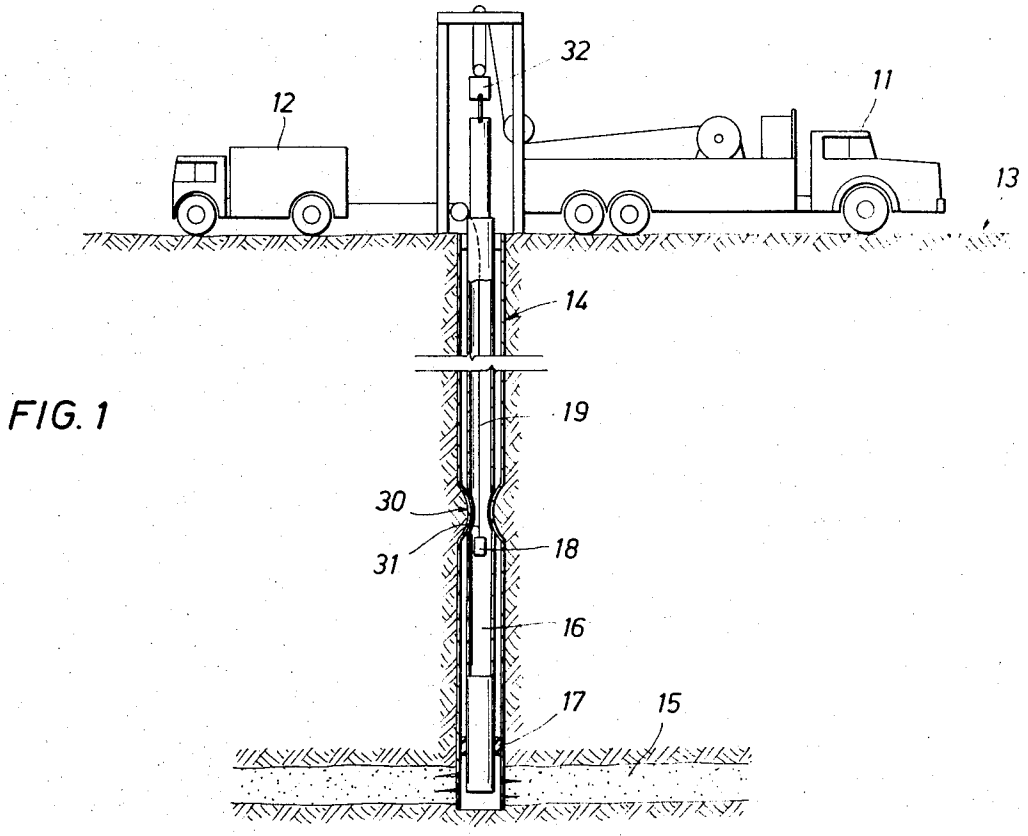

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FIG. 1

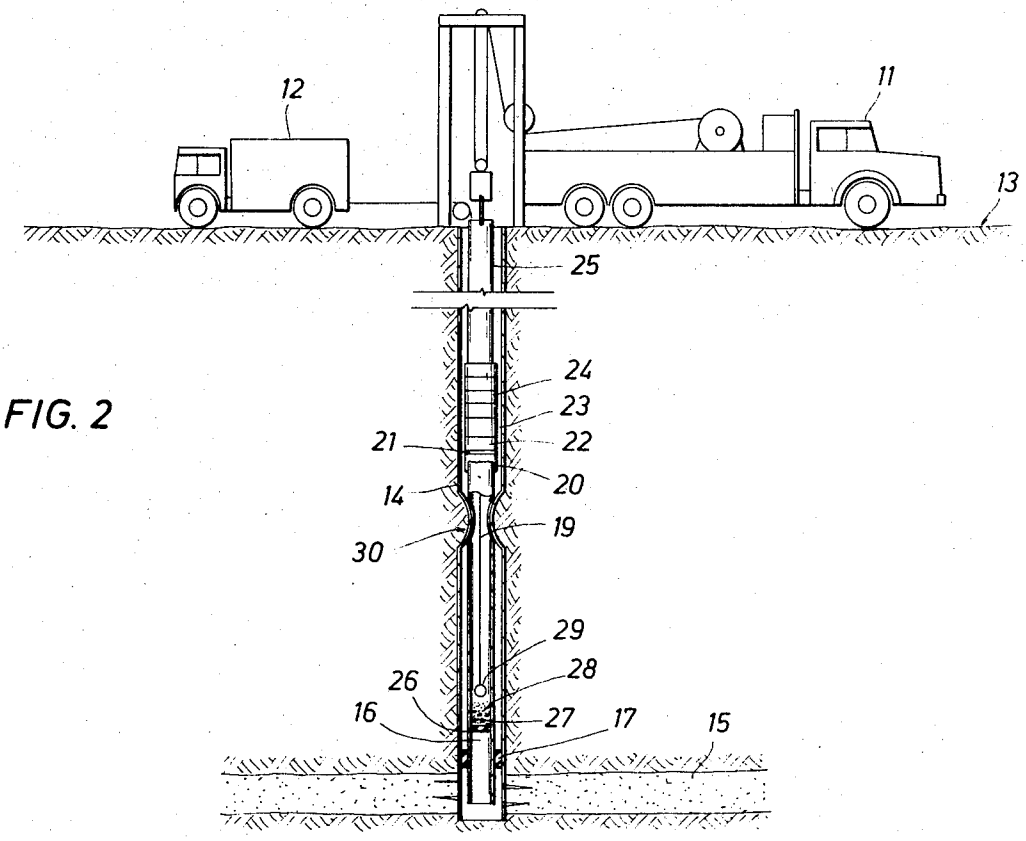

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FIG. 2

METHOD FOR THERMALLY CUTTING TUBING

BAKCGROUND OF THE INVENTION

The invention relates to a method of removing partially collapsed or deformed tubing by thermally cutting the tubing below the collapsed interval and removing the tubing from the well bore.

DESCRIPTION OF THE PRIOR ART

The oil industry in its operations involving production of hydrocarbons from wells drilled into the earth's formations has encountered many occasions when production tubing installed in the well bore casing has become stuck. This may happen for several reasons such as stuck packers and tubing anchors, casing leaks, or casing collapse.

In removing stuck tubing from a well bore, many different devices have been employed. Perhaps the most popular and frequently used device is the chemical cutter. A chemical cutter, to be effective, requires a small diametrical clearance between its outer diameter and the inner diameter of the tubing to be cut. If the tubing has been deformed, that is, if the inner diameter has been reduced by a substantial amount, a chemical cutter cannot be employed to cut the tubing below the deformity as it will not pass through the restriction and still cut the tubing.

Another device that has been used is the "string shot". The device is lowered into the well bore by a wire line through the tubing to the interval where the tubing is desired to be separated. The tubing is then rotated clockwise by suitable means at the surface of the well bore until the tubing is "torqued up". The device is subsequently detonated by electrical means from the surface. By detonating the charge within the string shot device, the tubing is hopefully "untorqued," and, if the operation is successful, the tubing will separate at a connection, that is, by a pin unscrewing from a collar. The disadvantage of this device is that if the well casing has been deformed such that it is in contact with the tubing, torque cannot be transmitted to the tubing below this point. In such a case the string shot device could not be used if it was desired to remove the tubing from the collapsed interval in the well casing.

A third device that has been employed to cut tubing in a well bore is through the use of mechanical cutters. These cutters can either be external or internal type cutters. An internal mechanical tubing cutter has blades that extend and contact the inner wall of the tubing when the cutter is rotated. The disadvantage of this device is that it too depends upon small diametrical clearance to be effective and, therefore, cannot be effective if the tubing has been deformed to any great extent.

SUMMARY OF THE INVENTION

The disadvantage inherent in these devices has been advantageously solved by applicant's invention such that tubing may be thermally cut below internal restrictions and removed from the well bore so that the well may be repaired and restored to production.

It is a further object of this invention to thermally cut tubing while applying a tensile load to tubing in an upward direction enabling the tubing to separate while leaving a relatively smooth surface at the top of the tubing left in the well bore.

It is even a further object of this invention to restore the well to production after removal of the deformed tubing from the well bore thereby precluding abandonment of a producing well that has significant hydrocarbon reserves or one that does not have sufficient reserves to profitably justify redrilling a replacement for the abandoned well.

BRIEF DESCRIPTION OF THE DRAWING

The nature of the invention will be more fully appreciated with reference to the drawing in which:

FIG. 1 is a sectional view showing a typical well in which the tubing string is restricted preventing normal removal;

FIG. 2 is a sectional view illustrating the equipment that may be utilized in the practice of the invention for cutting and removing the tubing in the restricted interval.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIG. 1, a well is shown in communication with a hydrocarbon bearing formation **15** and the earth's surface **13** through well casing **14**. A tubing string **16** is installed in well casing **14** and is held in tension by a packer or tubing anchor **17**. The tubing anchor **17** forms an integral part of tubing string **16** and when properly actuated contacts well casing **14** such that the tubing string **16** may be maintained in tension. During normal operation if the tubing string **16** is required to be removed from well casing **14**, the tubing anchor **17** is first released by rotation of tubing string **16** and then tubing string **16** is removed using conventional procedure, well known in the art. In abnormal circumstances, a collapse **30** may occur in well casing **14** such that a restriction **31** may develop in tubing string **16**, preventing release of tubing anchor **17** thereby precluding removal of tubing string **16** from well casing **14**. Even further if tubing anchor **17** is not installed in tubing string **16**, conventional oil field tubulars are normally of the externally upset type which will also prevent removal of tubing string **16** from well casing **14**. It is well known in the art that some oil field tubulars are flush in that they have a continuous external diameter such that they may be removed from well casing **14** even though the collapse **30** exists in well casing **14**. In the case where the tubing string **16** has become restrained within well casing **14** such that it has a restriction **31** a conventional workover unit **11** is installed over the well bore and tubing string **16** is placed in tension with suitable means with which unit **11** is equipped. While the tubing string **16** is in tension wire line unit **12** is used to lower a free point instrument **18** that is electrically connected to wire line **19** into tubing string **16**. Read out equipment on board wire unit **12** is used to indicate the interval in which tubing stirng **16** is restrained. Use of such equipment is well known to those skilled in the art and will not be discussed further.

When it has been determined at which point or interval tubing string **16** is restrained within well casing **14** a suitable tubing plug **26** is lowered into tubing string **16** to a point below restriction **31** by suitable means such as wire line **19** or a sand line from workover unit **11**. Tubing plug **26** may be any suitable means such as a

conventional swab cup in its most simple form since all that is required in an obstruction within tubing string **16** below restriction **31** capable of creating a bridge.

After setting a tubing plug **26** some distance below restriction **31**, say 15 to 20 and more preferably above the first tubing collar below casing collapse **30**, a conventional slim hole dump bailer is lowered in tubing string **16** by wire line **19** and is used to first place a predetermined volume of sand. A mixture of finely granulated aluminum with an oxide of iron or other metal, which is sold under the trademark Thermit **27** is then placed on top of the sand using wire line **19** and dump bailer. Preferably a volume of Thermit **27** equalling 6 to 18 of tubing volume is used. After placement of Thermit **27**, dump bailer is removed from tubing string **16**. Wire line **19** is then used to lower electrical squib **29** and starting Thermit into contact with Thermit **27** whereupon squib **29** is activated using wire line unit **12** thereby igniting starting Thermit which ignites Thermit **27** upon reaching a temperature of approximately 2200°F. At a predetermined time after ignition of the starting Thermit, preferably 10 seconds, tension is pulled on tubing string **16** equalling 5,000 to 30,000 pounds over the weight of tubing string **16** in well casing **14** from the surface to the interval where tubing string is restrained in well casing **14**. The resulting tubing cut after this operation is smooth, enabling conventional swaging techniques to be used to enlarge well casing **14** such that a conventional overshot may then be used to retrieve the remainder of tubing string **16** from well casing **14** without damage to well casing **14** from the thermal cutting of tubing string **16**.

In another embodiment of the invention, if the tubing is old or has a low yield point, a conventional chemical cutter may be used to cut tubing string **16** at a point above the collapsed interval **30** of well casing **14**, say 15 to 20 feet, after which the tubing string **16** above the cut is removed from well casing **14**. A tubing overshot **20**, safety joint **21**, hydraulically operated jars **23**, drill collars **24** are lowered in well casing **14** using a high strength work string **25** with workover unit **11**. Preferably overshot **20** is of the type which has internal seals such that a pressure seal is present between tubing string **16** and overshot **20** after overshot **20** has come into gripping contact with tubing string **16**. After overshot **20** has engaged tubing string **16** a tensile force is applied to tubing string **16**. The tubing is then thermally cut using the previously described procedure.

We claim as our invention:

1. A method for thermally cutting tubing in well casing below an internal restriction in said tubing, said method comprising the steps of:

determining the interval in which the tubing is restricted;

plugging said tubing below said restriction by lowering suitable plugging means in said tubing a predetermined distance below said restriction;

placing a predetermined volume of Thermit using suitable means below said restriction and on top of said plugging means;

lowering starting Thermit and suitable ignition means into said tubing such that it is in contact with said thermit;

igniting said starting Thermit with said ignition means;

applying a tensile force to said tubing at a predetermined time interval after igniting said starting Thermit; and

removing said tubing from said well.

2. The method of claim **1** wherein determining the interval in which the tubing is restricted is by free-pointing said tubing string using suitable means.

3. The method of claim **1** wherein the volume of Thermit is equal to the volume of 6 to 18 inches of tubing volume.

4. The method of claim **1** wherein plugging the tubing a predetermined distance below said restriction is above the first tubing collar occurring below the restriction.

5. The method of claim **1** wherein a tensile force of 5,000 to 30,000 pounds over the weight of said tubing string is applied to said tubing string.

6. The method of claim **1** wherein the predetermined time interval ranges from 5 to 15 seconds.

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