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(54) **Method and apparatus for deforming a metal workpiece while exerting ultrasonic oscillations**

(57) Method of deforming a metal workpiece, wherein a mechanical force is exerted on the workpiece, and wherein ultrasonic oscillations are transferred to the workpiece. The exertion of the mechanical force and the transfer of the ultrasonic oscillations may occur substantially simultaneously. In an embodiment, the metal workpiece comprises a casing member of a borehole. The mechanical force is exerted on the casing member having a first diameter to expand the casing member to a larger, second diameter, the force being radially outwardly oriented with respect to the geometrical axis of the borehole. Further, ultrasonic oscillations are transferred to a casing area on the casing member.

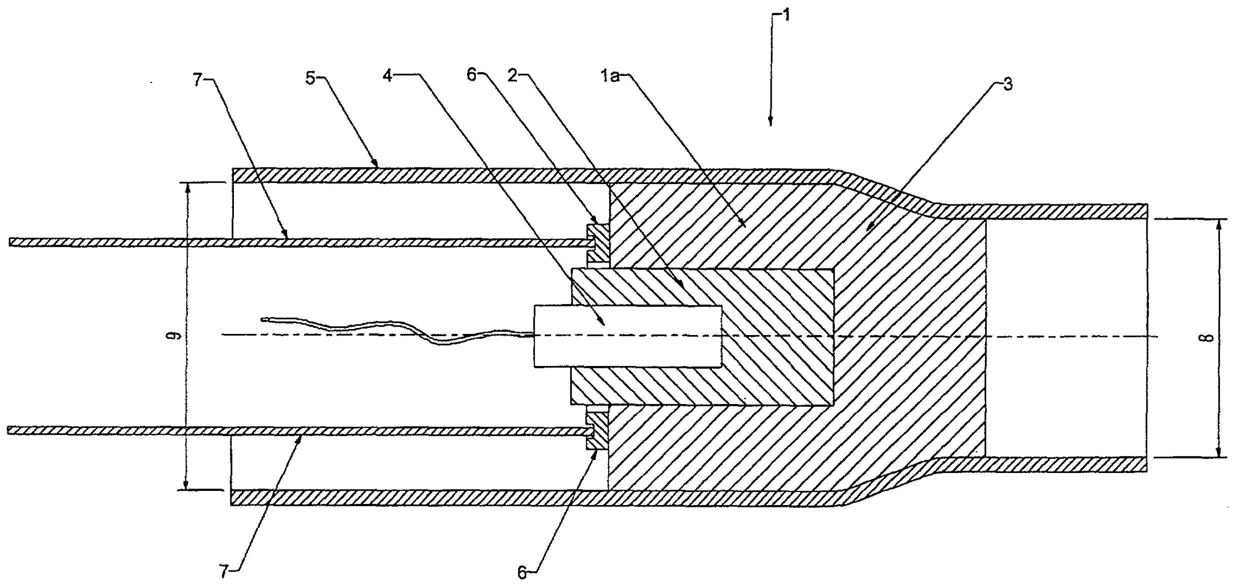

Figure 1

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Description

TECHNICAL FIELD

[0001] The present invention is generally directed to deforming a metal workpiece and more particularly to a method and apparatus for deforming a metal workpiece by application of a mechanical force and ultrasonic oscillations, as well as a method for extracting subterranean hydrocarbons.

BACKGROUND ART

[0002] Methods of deforming metal workpieces by application of mechanical forces are well known. Also known are methods for expanding the inner diameter of a cylindrical workpiece by application of a mechanical force. One such method for use in expanding an inner diameter of a casing disposed in a borehole is described in U.S. patent publication US 2003/ 0051885. Generally, boreholes are used for transporting exploration means up and down as well as for transporting mineral fluids, such as hydrocarbons, including oil and natural gas, from subterranean fields inside the Earth towards the surface. In order to increase the net transported fluid volume, it is desired to expand the cross sectional area of existing boreholes, e.g. if the boreholes have been used for exploration ends only. US 2003/ 0051885 teaches a method including stretching a metal casing member of a borehole, wherein an expansion tool is lowered into the casing member having a first diameter. The expansion tool disclosed in US 2003/ 0051885 expands the casing member to a larger, second diameter using pulsed mechanical forces at a frequency between 10 and 50 Hz.

[0003] However, casings are constructed quite heavily to sustain hydraulic pressures without causing leakages. Therefore a large mass is required to provide a downward oriented force that has a sufficiently large amplitude. In practice, the mass is always limited. Further, much driving energy is required for exerting the mechanical force. Especially when expanding long casings, e.g. several kilometers, this will be a time consuming operation.

[0004] Transferring ultrasonic oscillations to metal constructions for strengthening and processing metal surfaces as a relaxation treatment is discussed in U.S patent publication US 2002/0014100. This method is known as ultrasonic peening or ultrasonic impact treatment. The peening process treats only the upper metal surface, e.g. in the case that cracks occurred. US 2002/0014100 does not teach that plastic deformation involving the entire thickness of a metal plate occurs. Further, in the peening process of US 2002/0014100, no significant mechanical forces are applied; instead, a repeating sequence of relatively low force mechanical impacts or impulses is exerted. Thus, the peening process of US 2002/0014100 is not suitable for deforming a workpiece, and more particularly for expanding an inner diameter of a casing.

[0005] The present invention is directed toward overcoming one or more of the problems discussed above.

SUMMARY OF THE INVENTION

[0006] A first aspect of the invention is a method of deforming a metal workpiece, wherein the mechanical force is more effective. To that end, ultrasonic oscillations are transferred to the metal workpiece.

[0007] The invention is particularly useful in expanding the inner diameter of a casing. By transferring ultrasonic oscillations to the casing, less mechanical energy is required to obtain a predetermined expansion rate of the casing member using an expansion tool such as an expansion cone. Without being bound by theory, this is believed to be due to the fact that the deformation energy needed for the plastic irreversible deformation is provided not only by means of mechanical energy, but also by means of the ultrasonic oscillations. In particular, the ultrasonic oscillations render the atomic structure of the casing member more apt for deformation, so that the mechanical force can deform it more easily and more effectively after the material of the workpiece has reached some saturation level. Hence, given the same amplitude of the mechanical force, this results in a faster deformation of the metal workpiece, so that in the situation of a casing a longer borehole length can be expanded per time unit. Conversely, a substantially equal expanded borehole length per time unit can be obtained by applying less mechanical energy, thus saving costs in energy and equipment. Exerting less mechanical force on a casing advantageously results in less damage on the surface of the casing, e.g. sandscreens. Also, a larger deformation of the workpiece (e.g., casing) can be achieved by using ultrasonic oscillations. For example, a deformation of approximately 25% may be obtained instead of 15% as obtained by conventional methods in casings. Hence, a larger cross sectional area of a borehole can be obtained, leading to a larger throughput.

[0008] After ending the application of ultrasonic oscillations, the material properties of the workpiece return to the normal values of the material before the application of ultrasonic oscillations. The material properties are substantially the same or better than compared to the situation in which the workpiece has been deformed using mechanical forces only.

[0009] It is noted that in this application it is understood that ultrasonic oscillation signals have a non-zero frequency spectrum which lies above the audio range, i.e. above 15-20 kHz, preferably in the range of 15 kHz to 100 kHz and higher.

[0010] Further, it is noted that metal workpieces also include workpieces made of alloys comprising a metal, such as steel.

[0011] In an advantageous embodiment of the invention, the exertion of the mechanical force and the transfer of the ultrasonic oscillations occur substantially simultaneously, so that the oscillations and the mechanical energy cooperate in deforming the workpiece. It is noted that the term substantially simultaneously means that the mechanical force is applied within a certain time frame after transferring the ultrasonic oscillations to the workpiece, in which time frame the material properties still deviate from the normal values, so that both kinds of energy cooperate. Hence, the ultrasonic oscillations and the mechanical energy can be applied to the working piece at the same instant, but it is also possible that the method comprises a sequence of transferring the ultrasonic oscillations to the workpiece and subsequently exerting the mechanical force to it within the time frame.

[0012] Advantageously, the casing area to which the ultrasonic oscillations are transferred is annular, so that the ultrasonic oscillations are equally distributed over the part of the casing member which is to be expanded. This is the situation in particular if the expansion tool is provided with an expansion cone at the lower part, so that the ultrasonic oscillations and the mechanical energy are transferred to substantially the same casing area for optimal performance of the expansion tool.

[0013] By generating the ultrasonic oscillations by means of a piezoelectric transducer an elegant and efficient ultrasonic energy conversion is achieved. Thus, hereby a reduction in weight and costs of electrical energy sources is obtained. Further, heating processes causing undesired changes in material parameters of the casing member are reduced.

[0014] The ultrasonic oscillations can also be generated by means of a magnetostrictive transducer.

[0015] In an advantageous embodiment of the invention, the ultrasonic oscillations are transferred to the metal piece work via an intermediate medium, so that a more efficient coupling of the ultrasonic oscillations is obtained from an energetic point of view.

[0016] The ultrasonic oscillations are applied to an operative portion of the casing. The ultrasonic oscillations preferably vibrate the operative portion of the casing with an amplitude of at least 40 micrometers. The ultrasonic oscillations may be of a radial mode, a longitudinal mode or a combination of radial and longitudinal modes.

[0017] A second aspect of the present invention is a tool for deforming a metal workpiece. The tool includes a deformer exerting a mechanical force on the workpiece sufficient to deform the shape of the workpiece and an ultrasonic means for exerting ultrasonic oscillations on the workpiece. The deformer may include an expansion cone and driving means operatively associated with the expansion cone for driving the expansion cone. Such an embodiment is particularly advantageous where the workpiece is cylindrical, such as a casing. In such an application the driving means drives the expansion cone axially of the casing. The ultrasonic means may be a piezoelectric transducer or a magnetostrictive transducer. In those embodiments where the ultrasonic means is a piezoelectric transducer, the piezoelectric transducer may include a high strength, high ware plate.

[0018] A third aspect of the present invention is a casing member of a borehole made by a process including exerting ultrasonic oscillations on the casing member having a first diameter and exerting a mechanical force on the casing member, the mechanical force producing a deformation between the first and a second diameter increasing the inner diameter at least about 25%.

[0019] A fourth aspect of the present invention is a method for extracting hydrocarbon for a subterranean hydrocarbon deposit. The method includes drilling a borehole in communication with the subterranean hydrocarbon deposit and installing a casing having a first diameter in the borehole. A mechanical force is exerted on an operative portion of the casing having a first diameter to expand the operative portion of the casing to a larger, second diameter, the mechanical force being radially outwardly oriented with respect to a geometrically axis of the borehole. Ultrasonic oscillations are exerted on the operative portion of the casing member substantially simultaneously to exerting the mechanical force. Preferably, the radially outwardly oriented mechanical force is exerted using an expansion tool having an expansion zone, the expansion tool being located above or inside the borehole near the operative portion of the casing member having the first diameter, the expansion cone of the expansion tool being subjected to a downwardly oriented mechanical force. Preferably, the ultrasonic oscillations on the operative portion of the casing vibrate the operative portion of the casing with an amplitude of at least 40 micrometers. The ultrasonic oscillations are preferably of a longitudinal mode, a radial mode or a combination thereof. The ultrasonic oscillations are preferably exerted on the workpiece by converting electrical energy to the ultrasonic oscillations using at least one of the piezoelectric transducer and a magnetostrictive transducer. The ultrasonic oscillations may be exerted on the metal workpiece via an intermediate medium.

[0020] Other advantageous embodiments according to the invention are described herein. The invention will be explained below, in more detail with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] Fig. 1 shows a schematic view of an expansion tool according to the invention;

[0022] Fig. 2 shows a graph of a plot of deformation curves; and

[0023] Figs. 3A and 3B are schematic views of an alternate embodiment of an expansion tool according to the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0024] The figures are merely schematic views of preferred embodiments according to the invention. In the figures, equal or corresponding parts are referred to by the same reference numerals.

[0025] Figure 1 shows a schematic view of a tool 1 for deforming a workpiece according to the invention. In the preferred embodiment described herein, the tool 1 is an expansion tool 1 comprising a deformer. The deformer may be a stamp which, in the preferred embodiment disclosed herein for use in deforming casings, is in the form of a cylindrical body 1a with an expansion cone 3. Further, the expansion tool 1 comprises ultrasonic means for transferring or exerting ultrasonic oscillations. The ultrasonic means comprise an ultrasonic transducer or transducers 4, such as a piezoelectric transducer or transducers and/or a magnetostrictive transducer or transducers or a combination of both types of transducers. During use, the expansion tool 1 is placed above or within the casing 5 of a borehole, also called a tubing downhole, such as a steel pipe, which is a first embodiment of a workpiece to be deformed. Typical boreholes have a diameter ranging from approximately 0.1 m to approximately 1 m, but smaller or larger dimensions are also possible.

[0026] The expansion tool 1 comprises receiving means 6 for cooperating with driving means 7 which exerts mechanical forces. The driving means 7 may comprise any number of devices (either alone or in combination) for applying a mechanical force to a deformer such as a stamp or the expansion cone 3. By way of example and not by way of limitation, the driving means 7 may be a mechanical construction such as a vibration hammer, mechanical and/or electrical cylinder, rams, jacks, jack screws, tooth rack mechanisms, winches and/or linear motors. The driving means 7 may also be a structure for applying hydraulic pressure difference on the respective sides of the deformer by pressurizable fluids; for example, hydraulic cylinders. The expansion tool 1 is driven through a section 8 of the borehole with a first inner diameter (ahead of the expansion tool 1), so that a section 9 with a second, larger diameter is obtained (behind the expansion tool 1). As used herein, an "operative portion of a casing" is the part of the casing experiencing the diameter change.

[0027] The mechanical force may be exerted by the driving means on the deformer in a downward, upward or any other direction such as horizontally, so that an operative portion of a workpiece can be deformed as desired. For the specific example of a casing residing in a borehole and the expansion cone 3 described herein, the critical aspect of application of the force is that the operative portion of the casing is enlarged during continuous movement of the expansion tool in an axial direction of the borehole. Typically in such an application the mechanical force will be exerted in a downward direction.

[0028] In another embodiment of the invention which is illustrated in Fig. 3A and Fig. 3B, the expansion tool 1' may comprise a deformer in the form of a cylinder 20 with a substantially constant first diameter D1 which is inserted into a casing segment 22 and which is subsequently expanded to a second larger diameter by mechanical force from some form of a driving means 24 of the type described above operatively associated with the cylinder 20, thereby forcing the casing to a larger diameter D2. See Fig. 3B. The cylinder is then returned to its first diameter and moved axially to an adjacent casing segment and the process is repeated. This embodiment is also intended for use with the ultrasonic means as described below.

[0029] In situ in the borehole, electrical power, e.g. in the range of 3-30 kW, is available. The electrical power can be generated locally by means of a generator, such as a hydro turbine, or can be made available via electrical energy transport means, such as copper cables 10.

[0030] The ultrasonic transducer 4 or transducers convert energy from the electric domain to the acoustic domain by converting electrical signals, such as alternating signals, to acoustic signals, such as ultrasonic oscillations. Ultrasonic oscillations could be produced by means of either the magnetostrictive effect or by the piezoelectric effect.

[0031] In the borehole, ultrasonic oscillations generally comprise longitudinal modes and/or radial modes. Longitudinal modes comprise waves oscillating lengthwise along the tube, while radial modes comprise waves oscillating in a radial direction, which can be more difficult to generate. In contrast to peening technology, also radial modes can be applied. Typically, ultrasonic oscillations of a longitudinal mode or a radial mode are transferred to the material of the borehole casing 5 via the transferring means comprising, in addition to the ultrasonic transducer(s), a transformer. Also a combination of longitudinal mode or radial mode ultrasonic oscillations can be introduced into to the casing 5, whereby the material of the casing 5 is forced to vibrate. Vibrations of the operative portion of the casing having an amplitude of greater than 40 micrometers are preferred, although vibrations of an amplitude less than 40 micrometers may also be effective.

[0032] The ultrasonic means further comprises a body 2 which is tuned to resonate near the frequency of the ultrasonic oscillations. By a proper design of the eigenfrequencies of the body 2, the amplitudes of the ultrasonic oscillations can be optimized and amplified, so that the effect on the material parameters of the workpiece to be deformed is also maximized. The body can be integrated with the expansion cone 3, so that the mechanical force and the ultrasonic oscillations are applied to the workpiece via the same contact area. However, it is also possible to implement the body of the ultrasonic means differently, at different location, so that the mechanical force and the ultrasonic oscillations are separately exerted on the workpiece. By providing a device which manipulates the vibrating modes via digital signal processing, the tuned body can further be optimized to vibrate at desired frequencies. In this way, desired modes can be amplified while other modes that could be harmful to the structure can be suppressed.

[0033] The ultrasonic oscillations enhance the expansion process, as will presently be explained using Fig. 2, which shows hypothetical deformation curves of materials on which mechanical forces are exerted. On the vertical axis of the plot, the symbol F represents a force which is a measure for applied pressure on the workpiece. On the horizontal axis, the symbol D represents a deformation rate. Curve B is an exemplary deformation curve of a specific material. In the area near the origin the curve is substantially linear, as the material behaves according to Hook's law. The deformation is reversible. If the deformation level increases, the curve passes a twist, after which the deformation is irreversible.

[0034] By employing the ultrasonic forming technology, curve B changes to curve C. As can be easily seen from Fig. 2, a similar deformation rate D 1 requires a deformation force F2 which is much smaller than in the previous non-ultrasonic case where the deforming force F1 is applied. Likewise, the area under the curve is much smaller, indicating that much less strain energy is required for obtaining a predetermined deformation rate. Similarly, by using the ultrasonic oscillations and the same deformation force F1, a significant increase in deformation is obtained, see e.g. D2 in the ultrasonic case versus D 1 in the non-ultrasonic case. Without being bound by any theory, the physical effect can be explained using different theories, such as acoustic plasticity, strain energy or stress superposition approaches. Further, the amount of acoustic energy in relation to the total deformation energy can vary from application to application, e.g. ranging from approximately 1% or 2% to 10% or almost 100%.

[0035] In short, the application of ultrasonic oscillations decreases the process time, reduces the deformation energy consumption, increases the degree of deformation while applying a particular mechanical deforming force or pressure, and enables workpiece deformation processes that would otherwise be difficult to perform in practice by using mechanical forces only, e.g. due to the use of a relatively thick metal layer in the workpiece or relatively rigid materials requiring too much energy, or because of the risk that cracks or other damages of the workpiece may be caused. Furthermore, increase of the inner diameter of a casing of about 25% or more can be achieved without damaging the casing.

[0036] Optionally, an intermediate medium is applied between the transducer or transformer, such as the expansion cone 3, and the workpiece, such as the casing of the borehole 5. The intermediate medium may comprise a fluid, such as oil or other liquid. By employing the intermediate medium the ultrasonic oscillations are more efficiently coupled into the workpiece.

[0037] Further, the inner side of the borehole 5 can be subjected to a pretreatment for cleaning purposes, e.g. by means of a mechanical wiping arrangement, such as a wiper, by means of a heating element, such as heated oil, or by driving electrical currents into the metal borehole, thereby heating the casing. In the heating process, dirty particles can lose contact with the inner part of the casing, so that the borehole is cleaned. After cleaning, the surface is less rough, yielding improved direct contact with the expansion cone 3.

[0038] It is noted that the method of deforming a metal workpiece is not limited to deforming workpieces made of casing members of a borehole, but is also applicable to workpieces made of other metal tubular pipes, such as steel tubular pipes.

[0039] In another embodiment according to the invention, the method of deforming a workpiece is applied for bending and forming other types of workpieces, such as metal plates, e.g. for nautical, aeronautical or other applications, or other workpieces, such as profile elements in which a local radius is to be changed. A substantially flat plate is bent by exerting a mechanical force on a section of the metal plate using a stamp or die. According to the invention, ultrasonic energy is transferred to the section of the metal plate to facilitate the bending process. Preferably, the ultrasonic energy is introduced into the metal plate on the outer side of the bending curve in order to avoid cracks being generated by concentrated local strain forces in this area.

[0040] The invention is not limited to the embodiments described herein. Many variants are possible.

[0041] Instead of piezoelectric transducers or magnetostrictive transducers also electromagnetic means can be used, such as a laser apparatus or means by which Lorenz forces are applied.

[0042] Such variants will be obvious to one skilled in the art and are considered to lie within the scope of the invention as formulated in the following claims.

Claims

1. A method of deforming a metal workpiece, comprising:

   exerting a mechanical force on the workpiece; and
   exerting ultrasonic oscillations on the workpiece.

2. The method according to claim 1 further comprising the steps of exerting the mechanical force and exerting the ultrasonic oscillations occurring substantially simultaneously.

3. The method according to claim 1, wherein the metal workpiece comprises a casing member residing in a borehole, the method further comprising:

   exerting the mechanical force on an operative portion of the casing having a first diameter to expand the operative portion of the casing to a larger, second diameter, the mechanical force being radially outwardly oriented with respect to the geometrical axis of the borehole; and
   exerting the ultrasonic oscillations to the opera-

tive portion of the casing member substantially simultaneously to exerting the mechanical force.

4. A method according to claim 3 further comprising exerting the radially outwardly oriented mechanical force using an expansion tool comprising an expansion cone, the expansion tool being located above or inside the borehole near the operative portion of the casing member having the first diameter, the expansion cone of the expansion tool being subjected to a downwardly oriented mechanical force.

5. A method according to claim 3, wherein the operative portion of the casing to which the ultrasonic oscillations are exerted is of annular shape.

6. The method according to claim 3, wherein exerting the ultrasonic oscillations on the operative portion of the casing vibrates the operative portion of the casing with an amplitude of at least 40 micrometer.

7. The method according to claim 3 , wherein ultrasonic oscillations of at least one of a longitudinal mode and a radial mode are exerted on the workpiece.

8. The method according to claim 1, wherein the ultrasonic oscillations are exerted on the workpiece by converting electrical energy to the ultrasonic oscillations using at least one of a piezoelectric transducer and a magnetostrictive transducer.

9. The method according to claim 1 further comprising exerting the ultrasonic oscillations on the metal workpiece via an intermediate medium.

10. A tool for deforming a metal piece work, comprising:

a deformer configured to exert a mechanical force on the workpiece sufficient to deform the shape of the workpiece; and
an ultrasonic means for exerting ultrasonic oscillations on the workpiece.

11. The tool according to claim 10, wherein the deformer comprises an expansion cone and driving means operatively associated with the expansion cone for driving the expansion cone.

12. The tool according to claim 10, wherein the ultrasonic means comprises at least one of a piezoelectric transducer and a magnetostrictive transducer.

13. The tool according to claim 10, wherein the ultrasonic means comprises a piezoelectric transducer comprising a high strength high wear plate.

14. The tool according to claim 11 wherein the workpiece comprises a casing having a first diameter and the expansion cone has a major diameter greater than the first diameter, the expansion cone being axially received within the casing, the driving means driving the expansion cone axially of the casing, whereby the expansion cone applies a radial force to the casing enlarging the first diameter of the casing.

15. A casing member of a borehole made by a process comprising:

exerting ultrasonic oscillations on the casing member having a first diameter; and
exerting a mechanical force on the casing member, the mechanical force producing a deformation between the first and a second diameter increasing the inner diameter at least about 25%.

16. A method of extracting hydrocarbons from a subterranean hydrocarbon deposit wherein a borehole comprising a casing having a first diameter is in fluid communication with the hydrocarbon deposit, the method comprising:

exerting a mechanical force on an operative portion of the casing having the first diameter to expand the operative portion of the casing to a larger, second diameter, the mechanical force being radially outwardly oriented with respect to a geometrical axis of the borehole; and
exerting ultrasonic oscillations to the operative portion of the casing member substantially simultaneously to exerting the mechanical force.

17. A method according to claim 16 further comprising exerting the radially outwardly oriented mechanical force using an expansion tool comprising an expansion cone, the expansion tool being located above or inside the borehole near the operative portion of the casing member having the first diameter, the expansion cone of the expansion tool being subjected to a downwardly oriented mechanical force.

18. A method according to claim 16, wherein the operative portion of the casing to which the ultrasonic oscillations are exerted, is of annular shape.

19. The method according to claim 16, wherein exerting the ultrasonic oscillations on the operative portion of the casing vibrates the operative portion of the casing with an amplitude of at least 40 micrometer.

20. The method according to claim 16, wherein ultrasonic oscillations of at least one of a longitudinal mode and a radial mode are exerted on the workpiece.

21. The method according to claim 16, wherein the ultrasonic oscillations are exerted on the workpiece by converting electrical energy to the ultrasonic oscilla-

tions using at least one of a piezoelectric transducer and a magnetostrictive transducer.

22. The method according to claim 16 further comprising exerting the ultrasonic oscillations on the metal workpiece via an intermediate medium.

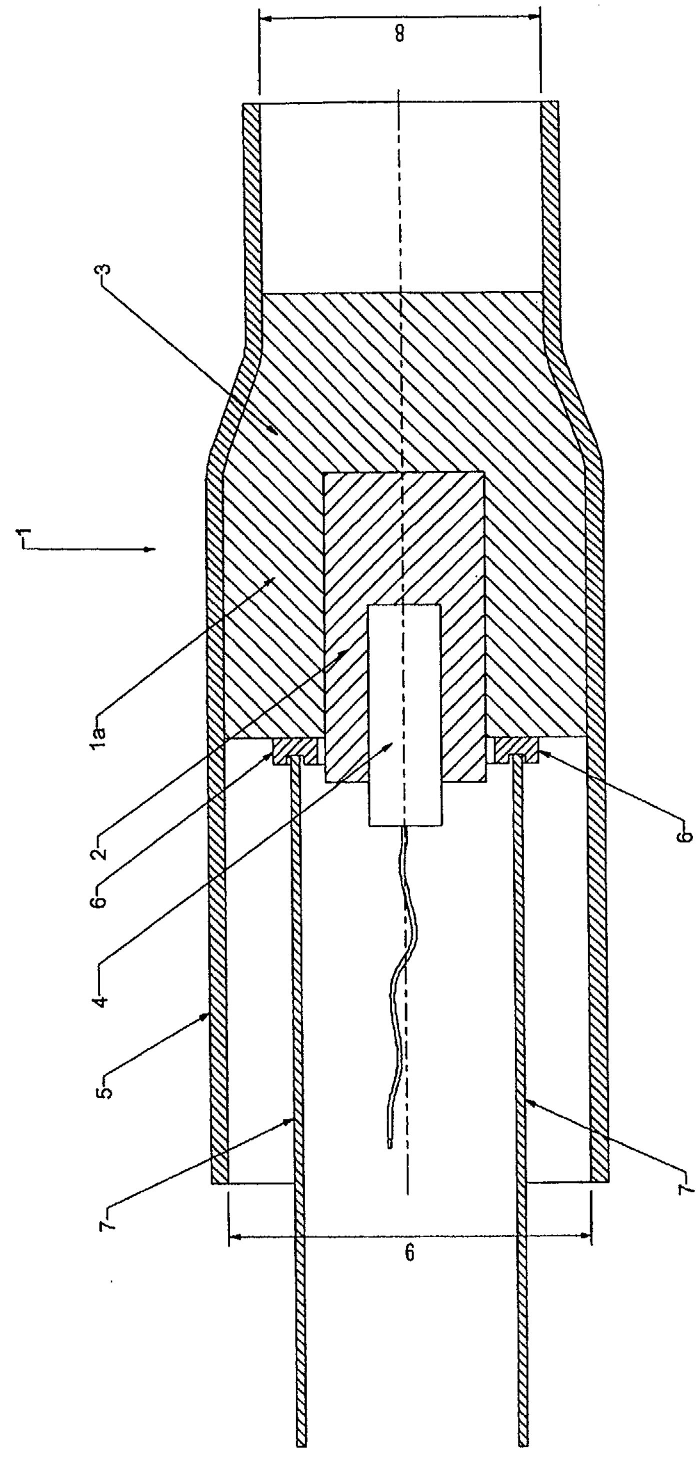

Figure 1

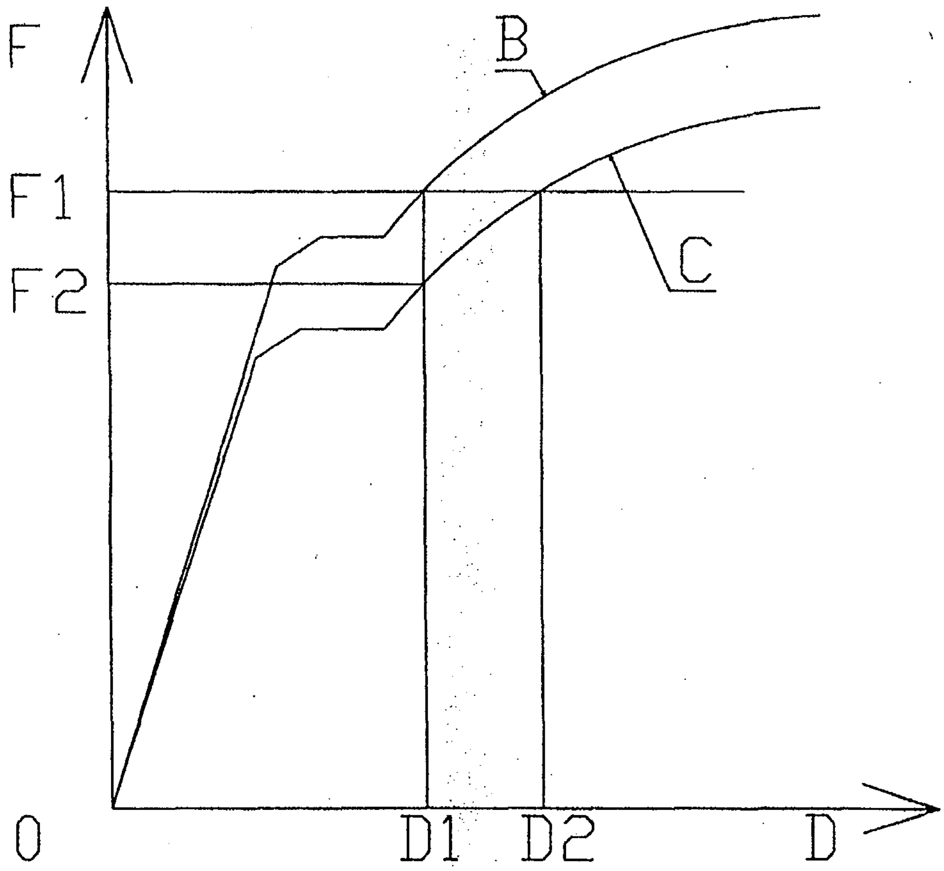

FIGURE 2

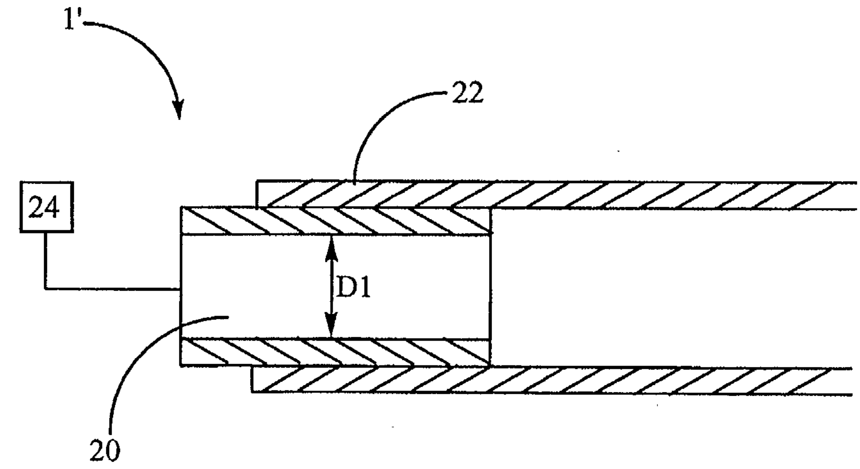

Fig. 3A

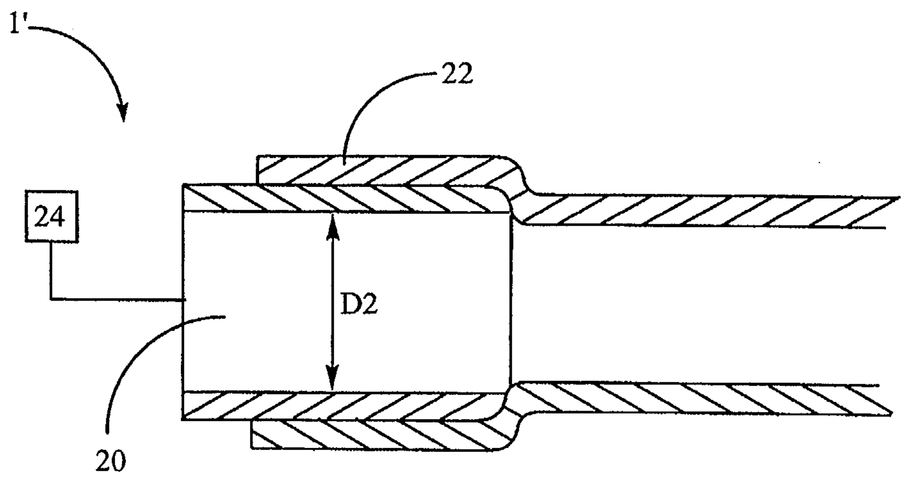

Fig. 3B

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 04 07 6930

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X,D	US 2003/051885 A1 (ADAMS GRANT ET AL) 20 March 2003 (2003-03-20) * paragraphs [0018], [0047] * * claim 1 * * figure 2 *	1-22	E21B43/10 E21B4/12
X	WO 2004/026017 A (ENVENTURE GLOBAL TECHNOLOGY ; RING LEV (US); SHUSTER MARK (US)) 1 April 2004 (2004-04-01) * paragraph [0027] * * figure 4 *	1,2,10, 11,14	
X	DE 41 31 775 A (OERTEL BERND ; SCHAFFER WILHELM (DE); LUEBCKE HANS ULRICH (DE)) 25 March 1993 (1993-03-25) * abstract *	1,2,10	
A	WO 03/064813 A (BURGE PHILIP MICHAEL ; E2TECH LTD (NL)) 7 August 2003 (2003-08-07) * abstract *	1,10,15, 16	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	WO 03/080994 A (EDDISON ALAN MARTYN ; ANDERGAUGE LTD (GB); LATIMER RICHARD (GB)) 2 October 2003 (2003-10-02) * page 8, lines 27,28 *	1,10,15, 16	E21B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 December 2004	Schouten, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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3

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 04 07 6930

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15-12-2004

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2003051885 A1	20-03-2003	CA 2455518 A1	27-12-2002
		WO 02103150 A2	27-12-2002
		GB 2394975 A	12-05-2004
		US 2004154808 A1	12-08-2004
WO 2004026017 A	01-04-2004	WO 2004026017 A2	01-04-2004
DE 4131775 A	25-03-1993	DE 4131775 A1	25-03-1993
WO 03064813 A	07-08-2003	CA 2472347 A1	07-08-2003
		WO 03064813 A1	07-08-2003
		GB 2401134 A	03-11-2004
WO 03080994 A	02-10-2003	WO 03080994 A1	02-10-2003

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82