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Attorney Docket No. 77974

ACOUSTIC BOLT REMOVAL

STATEMENT OF GOVERNMENT INTEREST

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

(1) Field of the Invention

This invention generally relates to a method and apparatus for removal of bolts which are "frozen" due to rust, corrosion, over-tightening or other reasons. More particularly, the invention relates to a method and apparatus for removal of frozen bolts using a frequency-specific acoustic transducer.

(2) Description of the Prior Art

In the art of removing bolts or mechanical connections which have become "frozen" due to rust, corrosion, over-tightening or the like, it is known to apply a direct mechanical force such as with a hammer to the bolt to loosen the same.

The following patents, for example, disclose applying a direct hit to the bolt, a vibrational shock to the bolt or other similar force, but do not disclose a frequency specific method and apparatus for ultrasonically loosening a stuck bolt.

U.S. Patent No. 4,864,902 to Doorley;

U.S. Patent No. 4,913,234 to Bodine;

U.S. Patent No. 5,029,480 to Kibblewhite;

U.S. Patent No. 5,220,839 to Kibblewhite;

U.S. Patent No. 5,499,540 to Whaley et al.;

U.S. Patent No. 5,675,087 to MacLauchlan et al.; and

U.S. Patent No. 5,526,722 to Limehouse

Specifically, the patent to Doorley discloses a striking tool device formed of a cylindrical metal shaft having, at one end, a square bore for mating with the drive tang of a ratchet wrench and at the other end, a square shank for mating with a socket, and an arm member attached to the cylindrical metal shaft extending substantially at right angles thereto. The arm member has an anvil-like end portion of slightly larger diameter. The end portion has two flat striking surfaces on opposite sides for allowing striking by a hammer. Such striking crates a sufficient shock impulse to loosen a "frozen" nut or bolt. Clearly, Doorley does not use an acoustic transducer for loosening a stuck bolt according to the present invention.

Bodine discloses a screw-type sonic oscillator for insertion in a stuck section of a drill pipe. The oscillator vibrates to loosen the material about the stuck drill pipe. More specifically, the oscillator having a screw shaped rotor and stator is lowered down by means of a cable within a section of drill pile which has become stuck in a bore hole. The rotor of the oscillator is rotatably driven by means of a liquid stream at a speed such as to generate vibrational energy in the oscillator housing at a sonic frequency. The cable from which the oscillator is suspended has swivel bearings installed therein to permit the oscillator housing to rotate from the cable. The vibrational energy generated in the oscillator housing causes the housing to rotate precessionally around the inside wall of the stuck section of drill pipe to thus generate amplified lateral quadrature vibrational energy in the drill pipe to shake it loose from the bore hole.

The patent to Kibblewhite '480 disclose a bolt having an ultrasonic load indicating member such as a transducer coupled to its head. The transducer is used to indicate load on the bolt. The load indicating member includes a shank having at least one groove and an ultrasonic transducer coupled to a load indicating member so that an ultrasonic wave is directed to the groove. A surface can be formed adjacent to one longitudinal end of the shank and the ultrasonic transducer

can be coupled to this surface. Further, the ultrasonic transducer can be coupled to the surface so that the ultrasonic wave is also directed to the other longitudinal end of the shank which is remote from the surface. The groove may be located on the shank at a predetermined distance from the surface for identification of the member. Moreover, the surface can have a recess, with the ultrasonic transducer being located in the recess. The groove can be an annular groove or the groove can be comprised of threads disposed on the shank. Also, the shank can have two or more annular grooves. These grooves can be located on the shank at a predetermined distance apart for identification of the load indicating member. Preferably, the ultrasonic transducer is a piezoelectric film transducer. Additionally the preferred load indicating member is a fastener.

Kibblewhite '839 discloses an ultrasonic bolt load measuring device formed as a part of a socket wrench. A transducer is attached to the bolt head. Specifically, the load indicating device and method of using a load indicating device for monitoring the deformation in and imparting torque to a load bearing member are disclosed. An ultrasonic transducer, grown on one surface of a load bearing member, such as a fastener, is used to determine the length, stress, or other tensile load dependent characteristics of the member using ultrasonic techniques.

Whaley et al. disclose a socket wrench/load measuring tool. An ultrasonic transducer is contained within the socket for transmitting ultrasonic waves into the bolt. As explained therein, a device is provided for measuring a load on a part such as a bolt, and comprises a socket having walls defining an interior space wherein the socket engages the bolt for transmitting a load to the bolt. An electromagnetic acoustic transducer comprising a magnet and a coil is located in the interior space of the socket near the bolt. The coil provides a current while the magnet provides a magnetic field such that the magnet and the coil generate an ultrasonic signal within the bolt. A detector is used to detect and measure a change in the ultrasonic signal at the bolt. Thus, although an acoustic transducer is provided in the head of a wrench and in contact with a bolt, the purpose of the assembly is only to measure load on the bolt. There is no teaching or suggestion that the acoustic transducer could be used at a specific frequency for loosening stuck bolts as occurs in the present invention.

MacLauchlan et al. disclose a socket wrench/load measuring tool. The device includes a socket having walls defining an interior space wherein the socket engages the bolt for transmitting a load to the bolt. An electromagnetic acoustic transducer comprising a magnet and a coil is located in the interior space of the socket near the bolt. The coil

provides a current while the magnet provides a magnetic field such that the magnet and the coil generate an ultrasonic signal within the bolt. A detector is used to detect and measure a change in the ultrasonic signal at the bolt for measuring the load on the bolt and for detecting any flaws in the bolt. MacLauchlan clearly does not teach the use of a frequency-specific acoustic transducer for loosening stuck bolts.

The patent to Limehouse discloses an impact tool for removing stuck bolts. The impact tool includes an axially aligned impact section, torque section and shaft. The shaft is configured to extend though a socket to abut a bolt head when the socket is in operative communication with the bolt head. The shaft is additionally configured such that a torque applied to the shaft is transferred to the socket. The shaft defines a shaft face that abuts the bolt head. The impact section defines an impact face on the opposite end of the tool from the shaft face. The torque section is configured such that a torque applied thereto is transferred to the shaft. Accordingly, a blow to the impact face transfers an axial force of the bolt at the interface between the bolt head and the shaft face. Such an axial force may tend to break a corrosive bond between the treads of the bolt and the receiving surface. Thus, axial blows to the tool in combination with torque applied to the torque section may tend

to loosen and remove frozen bolts. A system according to the patent additionally includes an impact instrument, a torque instrument and a socket.

It should be understood that the present invention would in fact enhance the functionality of the above patents by eliminating the need to impart a forceful blow to a stuck bolt or the like in an effort to loosen the same. Instead, the present invention utilizes an acoustic transducer applied to a bolt head at a specific frequency, thereby easily and effectively loosening the bolt.

SUMMARY OF THE INVENTION

Therefore it is an object of this invention to provide a method and apparatus for acoustic bolt removal.

Another object of this invention is to provide a method and apparatus for acoustic removal of a bolt corroded or otherwise frozen in a corresponding bolt hole.

Still another object of this invention is to provide a method and apparatus for acoustic removal of a bolt corroded or otherwise frozen in a corresponding bolt hole by providing an acoustic transducer on the head of the bolt.

A still further object of the invention is to provide a method and apparatus for acoustic removal of a bolt in which an acoustic transducer provided on the head of the bolt

receives a frequency specific resonance at a high amplitude to correspondingly excite the bolt.

Yet another object of this invention is to provide a method and apparatus for acoustic removal of a bolt which is simple to manufacture and easy to use.

In accordance with one aspect of this invention, there is provided a method and apparatus for acoustically removing a frozen bolt from a metal structure having a bolt hole formed therein. The bolt includes a head and a shank portion depending from the head, the shank of the bolt being inserted into the bolt hole of the metal structure. A material inhibiting removal of the bolt from the bolt hole of the metal structure substantially surrounds the shank of the bolt, and an acoustic transducer is removably mounted to the head of the bolt, the acoustic transducer being responsive to a frequency specific resonance applied thereto at a predetermined amplitude. A socket wrench head surrounds the acoustic transducer and the head of the bolt, the socket wrench head applying torque to the head of said bolt and confining the acoustic transducer to the head of the bolt. The frequency specific resonance applied to the acoustic transducer at the predetermined amplitude correspondingly excites the bolt at that frequency specific resonance and predetermined amplitude, thereby loosening the bolt from the bolt hole.

BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims particularly point out and distinctly claim the subject matter of this invention. The various objects, advantages and novel features of this invention will be more fully apparent from a reading of the following detailed description in conjunction with the accompanying drawings in which like reference numerals refer to like parts, and in which:

The figure is a side view of a corroded bolt screwed into a threaded bolt hole according to a preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In general, the present invention is directed to a method and apparatus for removing bolts which are "frozen" due to corrosion or other reasons. The present invention is especially useful when the bolt is so badly corroded that a pneumatic wrench may not be used without breaking the bolt.

Referring to the figure, a bolt 10 is screwed into a threaded bolt hole 12. The bolt 10 generally includes a bolt head 14, and a shank portion 16 depending from the bolt head 14. The shank portion 16 may be threaded or smooth, depending upon the application of the bolt or the type of structure to which it is applied.

Several conditions may occur to the bolt 10 threaded into the bolt hole 12, including corrosion over time, over-tightening, rust, or the like. In the figure, there is illustrated a considerable amount of corrosion 18 between the threads of the shank 16 and the bolt hole 18.

By way of further explanation, the bolt hole 12 is shown formed in a metal structure 20 since the problems of rust, corrosion, and over-tightening generally occur in a metal to metal contact as will occur between the bolt shank 16 and the surrounding metal 20 of the bolt hole 12.

The frozen bolt 10 is removed by first placing an acoustic transducer 22 on the exposed head 14 of the bolt 10. The acoustic transducer is held down with a specially designed socket wrench head 24. The socket wrench head in effect surrounds the head 14 of the bolt 10 and encapsulates the acoustic transducer 22 therein. The acoustic transducer 22 is then driven at a frequency which matches a lowest breathing mode frequency of bolt 10. The breathing mode frequency can be cataloged in a look-up table for most common bolts. The breathing mode frequency can also be determined directly with the acoustic transducer 22 by driving it with an impulse and receiving the lowest resonant frequency of the bolt. This frequency can be recorded and then used at any time.

The apparatus described and the method for using it can be accomplished in one of two ways. First, the acoustic transducer 22 drives the bolt 10 at its lowest resonant frequency (which corresponds to the determined breathing mode) at a high amplitude. In the determined breathing mode, the bolt 10 will expand and contract. If the driving amplitude is high enough, the bolt 10 should contract enough so that it will sufficiently loosen itself from the encapsulating corrosion 18 or the like so that the bolt 10 can be easily removed from the bolt hole 12 with an ordinary wrench.

Alternatively, a torque is applied to the bolt 10 to loosen it from the surrounding corrosion 18 or the like while the bolt 10 is being excited at its resonant frequency. In this manner, the loosening torque applied to the bolt 10 and the contractions of the bolt 10 as a result of being excited at its resonant frequency will act together to maximize the probability of removing the bolt 10 from the corrosion 18 and the bolt hole 12.

While the surface area of the acoustic transducer 22 is shown to be coextensive with the surface area of the exposed bolt head 14, there is no requirement that this be the case. Instead, it is contemplated that the determined resonant frequency at a sufficiently high amplitude applied to the bolt 10 is the determining factor in the expansion and contraction of the bolt 10 and thus the loosening of the bolt 10. If

smaller or larger acoustic transducer is needed to accomplish the outcome described, then such an acoustic transducer is within the scope of the present invention.

The resonant frequency of the bolt 10 will not be significantly affected by the metal structure 20 surrounding the bolt hole 12 since a total contact area of the threads on the shank 16 of the bolt 10 against the corrosion 18 or bolt hole 12 is minimal. Therefore, there will be a weak acoustic coupling between the shank 16 of the bolt 10 and the surrounding metal structure 20. If there is any corrosion 18, the coupling will be even weaker, because the corrosion 18 will, in general, not have an impedance matching that of the bolt 10.

By the present invention, a method and apparatus are provided for removing a "frozen" bolt or the like from a corresponding bolt hole in a more efficient manner than previously achieved in the art. Specifically, the invention utilizes an acoustic transducer removably mounted to the head of the bolt and a frequency-specific resonance applied to the acoustic transducer at a high amplitude to ultrasonically loosening the bolt.

This invention has been disclosed in terms of certain embodiments. It will be apparent that many modifications can be made to the disclosed apparatus without departing from the invention. Therefore, it is the intent

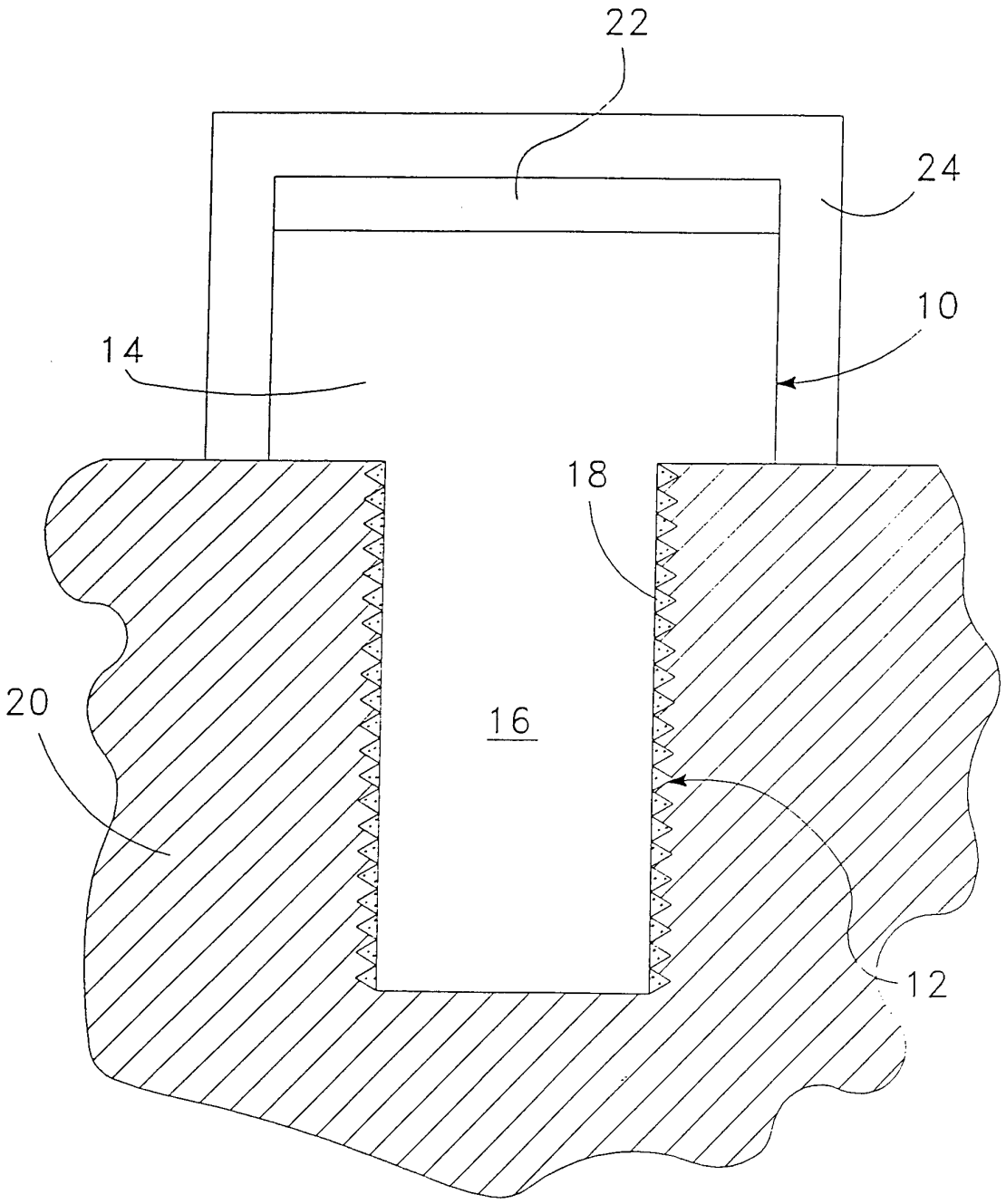
to cover all such variations and modifications as come within the true spirit and scope of this invention.

Attorney Docket No. 77974

ACOUSTIC BOLT REMOVAL

ABSTRACT OF THE DISCLOSURE

A method and apparatus for acoustically removing a frozen bolt from a metal structure having a bolt hole formed therein. The bolt includes a head and a shank portion depending from the head, the shank of the bolt being inserted into the bolt hole of the metal structure. A material inhibiting removal of the bolt from the bolt hole of the metal structure substantially surrounds the shank of the bolt, and an acoustic transducer is removably mounted to the head of the bolt, the acoustic transducer being responsive to a frequency specific resonance applied thereto at a predetermined amplitude. A socket wrench head surrounds the acoustic transducer and the head of the bolt, the socket wrench head applying torque to the head of said bolt and confining the acoustic transducer to the head of the bolt. The frequency specific resonance applied to the acoustic transducer at the predetermined amplitude correspondingly excites the bolt at that frequency specific resonance and predetermined amplitude, thereby loosening the bolt from the bolt hole.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