PORTABLE RAPID AND QUIET DRILL

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ABSTRACT

A hand-held drilling device, and method for drilling using the device, has a housing, a transducer within the housing, with the transducer effectively operating at ultrasonic frequencies, a rotating motor component within the housing and rigid cutting end-effector rotationally connected to the rotating motor component and vibrationally connected to the transducer. The hand-held drilling device of the present invention operates at a noise level of from about 50 decibels or less.
PORTABLE RAPID AND QUIET DRILL

STATEMENT AS TO FEDERALLY-SPONSORED RESEARCH

The invention described herein was made in the performance of work under a NASA contract, and is subject to the provisions of Public Law 96-517 (U.S.C. 202) in which the Contractor has elected not to retain title.

BACKGROUND OF THE INVENTION

1. Field of the Invention
The present invention relates to a hand-held drilling device, and method of drilling, for quiet drilling operations.

2. Description of the Related Art
Drilling includes rotation of long pointed pieces of metal, held in a machine, rotated at high speed to produce boreholes in hard substances such as masonry, concrete or rock. In many instances, noise resulting from drilling operations becomes problematic because of the drilling location or time of operations. Drilling operations done during the night present a particularly bothersome noise to the local community. Additionally, the use of hearing protection in the high noise areas of drilling operations may be difficult, if not impossible, to use, such as within a restricted space, in high hazard areas, and the like.

Accordingly, there is a need in the art to provide a portable and quiet drilling device. The present invention addresses this and other needs.

SUMMARY OF THE INVENTION

The present invention provides a portable, quiet drill for industrial applications, such as concrete drilling. As seen in FIG. 1, the present invention includes a hand-held drilling device 10 having a housing 20, a transducer component within the housing, with the transducer operating at ultrasonic frequencies, a rotating motor component within the housing, rigid cutting end-effector rotationally connected to the rotating motor component and vibrationally connected to the transducer.

The present invention also includes a method for drilling comprising the steps of providing a hand-held drilling device having a housing, a transducer within the housing, with the transducer operating at ultrasonic frequencies, a rotating motor component within the housing, rigid cutting end-effector rotationally connected to the rotating motor component and vibrationally connected to the transducer and initiating the transducer and rotating motor component effective for ultrasonic drilling.

Additionally, the present invention includes a silent drilling product produced by operation of the hand-held drill of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates component parts of the quiet, portable drilling device of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides a portable, quiet drill for industrial applications, such as concrete drilling.

As seen in FIG. 1, the present invention includes a hand-held drilling device 10 having a housing 20 that contains the working mechanisms of the device 10, with the housing 20 preferably including a composite or plastic composition, or other like materials, that resist the transmission or production of noise thereby therethrough or therein. However, the composition of the housing 20 retains a sufficiently resilient structure for withstanding compressional forces generally incurred with drilling operations of a hard surface or work surface 100, as detailed herein.

Within the housing 20, the drilling device 10 further includes a transducer or actuator 30. The transducer 30 operates at ultrasonic frequencies during drilling. The transducer 30 includes an ultrasonic transducer capable of quiet operations, preferably operating at frequencies from about 10-kHz to about 50-kHz, more preferably from about 20-kHz to about 30-kHz, and most preferably at about 25-kHz. The actuator 30 is preferably made of a piezoelectric transducer, generally having a piezoelectric stack, backing layer 36, stress bolt 38 and horn 37 allowing for the formation of a central borehole therethrough for dust removal. The horn 37 may be solid or allow for a hole therethrough. Representative sizes of the horn 37 may include from about 1 to about 2 inches in length, with weights of from about 0.1 lb to about 2 lbs. The transducer 30 preferably includes a piezoelectric transducing stack as a means for mechanical longitudinal stroke from the housing 20 which amplifies and transmits the amplified mechanical axial stroke to a rigid cutting end-effector 50, detailed below.

The backing layer 36 and stress bolt 38 provide structural integrity to the piezoelectric stack within the housing 20. The actuator 30 preferably includes multiple piezoelectric rings 34 and electrodes 39, with ceramic piezoelectric transducers preferred, although other piezoelectric devices may be used. The multiple piezoelectrics and electrodes preferably include 2 or more piezoelectrics and electrodes, more preferably from about 2 to 5 piezoelectrics and about 2 to 5 electrodes, with various other configurations determinable by those skilled in the art in building low power, small and lightweight drills for particular drilling devices 10. The size and number of piezoelectrics useful in the present invention is determined by the control voltage that can be applied to the device and the desired range of the ultrasonic operating frequency. The rigid cutting end-effector 50 is rigidly connected to the transducer 30 allowing transmission of the ultrasonic stress wave to pass from the transducer 30 onto the rigid cutting end-effector 50 through the coupling therewith.

A rotating motor component 40 within the housing 20 provides rotational movement of the rigid cutting end-effector 50. The rotating motor component 40 includes a rotating mechanism, such as a disk, arm or other like mechanisms that is mechanically attached to, and imparting the rotation to, the rigid cutting end-effector 50. The rotating motor component 40 is effectively secured to the housing 20, fixed at a particular location therein, to remain stable during operations and impart a consistent and powerful force onto the attached rigid cutting end-effector 50. As the rotating motor component 40 rotates within the housing 20, imparting the rotational movement onto the rigid cutting end-effector 50 (once the drilling device 10 is activated), the piezoelectric transducer 30 imparts axial movement to the rigid cutting end-effector 50, providing the rigid cutting end-effector 50 with concurrent rotational and axial movement. Rotational movement may include uni-directional or bi-directional rotation, i.e., either or both clockwise and counter-clockwise directions, as needed. Uni-directional rotation of the rotating motor component 40 provides a set means for accomplishing a drilling methodology onto the hard surface 100, and use of the counter bi-directional direction further aides in the drilling of the hard surface 100 in with an additional counter drilling methodology that further enhance the effect of the drill on the hard surface 100. The rotating motor component 40 preferably provides high torque at lower rpm (revolutions per
A drilling device is constructed having a total weight of less than 5 lbs. The drilling device has a transducer with 4 piezoelectric elements and 4 electrodes, with each piezoelectric element having a weight of about 2 ounces and a diameter of about 1.5 inches, and each electrode having a weight of less than 1 ounce and a diameter of about 1 inch. The drill bit is made of reinforced steel, with a carbide crown. The actuator includes an input of up to 200 watts. The transducer operates at a frequency of about 25 kHz and a rotation speed of about 100 rpm. The drilling device imparts axial stresses onto the work piece of about 65 MPa. The noise level of the drill device, in operation, is about 45 decibels.

**EXAMPLE 2**

A drilling device is constructed having a total weight of 7.5 lbs. The drilling device has a transducer with 6 piezoelectric elements and 5 electrodes, with each piezoelectric element having a weight of about 4 ounces and a diameter of about 2 inches, and each electrode having a weight of less than 1 ounce and a diameter of about 2 inches. The drill bit is made of reinforced steel. The actuator includes an output of up to 300 watts. The transducer operates at a frequency of about 20 kHz and a rotational speed of about 85 rpm. The drilling device imparts stresses onto the work piece of about 75 MPa. The noise level of the drill device, in operation, is about 50 decibels.

**EXAMPLE 3**

A drilling device is constructed having a total weight of up to 4.5 lbs. The drilling device has a transducer with 3 piezoelectric elements and 3 electrodes, with each piezoelectric element having a weight of about 3 ounces and a diameter of about 1.5 inches, and each electrode having a weight of less than 1 ounce and a diameter of about 1 inch. The drill bit is made of carbide, with a diamond-bit crown. The actuator includes an output of up to 150 watts. The transducer operates at a frequency of about 50 kHz and a speed of about 50 rpm.
The drilling device imparts stresses onto the work piece of about 50 MPa. The noise level of the drill device, in operation, is about 40 decibels.

EXAMPLE 4

A drilling device is constructed having a total weight of up to 9 lbs. The drilling device has a transducer with 8 piezoelectric elements and 7 electrodes, with each piezoelectric element having a weight of about 4 ounces and a diameter of about 1.5 inches, and each electrode having a weight of less than 1 ounce and a diameter of about 1 inch. The drill bit is made of reinforced steel, with a carbide crown. The actuator includes an output of up to 300 watts. The transducer operates at a frequency of about 12 kHz and a motor speed of about 500 rpm. The drilling device imparts stresses onto the work piece of about 100 MPa. The noise level of the drill device, in operation, is about 50 decibels.

EXAMPLE 5

A drilling device is constructed having a total weight of up to 3.0 lbs. The drilling device has a transducer with 2 piezoelectric elements and 2 electrodes, with each piezoelectric element having a weight of about 1 ounce and a diameter of about 1 inch, and each electrode having a weight of less than 1 ounce and a diameter of about 1 inch. The drill bit is made of reinforced steel having a diamond-bit crown. The actuator includes an output of 50 watts. The transducer operates at a frequency of about 35 Hz and a speed of about 45 rpm. The drilling device imparts stresses onto the work piece of about 30 MPa. The noise level of the drill device, in operation, is about 30 decibels.

The foregoing summary, description, examples and drawings of the invention are not intended to be limiting, but are only exemplary of the inventive features which are defined in the claims.

What is claimed is:
1. A hand-held drilling device, comprising:
   a housing constructed of materials that resist transmission or production of noise therethrough;
   a transducer within the housing which operates at ultrasonic frequencies from about 20 kHz to about 30 kHz;
   a rotating motor within the housing; and,
   a rigid cutting end-effector rotationally connected to the rotating motor and vibrationally connected to the transducer, wherein the hand-held drilling device operates at a noise level comprising about 50 decibels or less.
2. The device of claim 1, wherein the transducer comprises multiple piezoelectric elements and electrodes.
3. The device of claim 2, comprising 2 or more piezoelectric elements and about 2 or more electrodes.
4. The device of claim 1, wherein the ultrasonic transducer is capable of operating at about 25-kHz.
5. The device of claim 1, wherein the rotating motor rotates at a speed of from about 1 rpm to about 400 rpm.
6. The device of claim 1, wherein the rigid cutting end-effector includes a drill bit.
7. The device of claim 6, wherein the drill bit forms a thin auger on an outer surface for the removal of accumulating dust through rotation of the bit.
8. The device of claim 6, wherein the drill bit forms a central borehole.
9. The device of claim 8, further comprising a gas supply communicatively connected to the formed central borehole effective for imparting positive gas pressure through the central borehole.

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