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(54) Title: FLEXIBLE BOARD CONNECTING METHOD AND ULTRASONIC PROBE

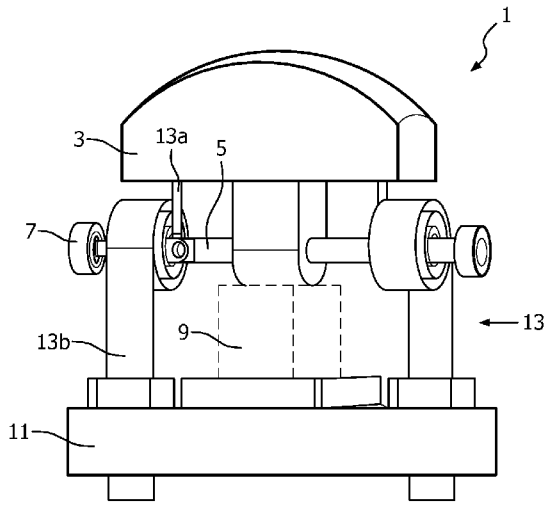

FIG. 1

(57) Abstract: The present invention provides a method of establishing a connection between a repeatedly rotating object and a stationary object by means of a flexible board, wherein the repeatedly rotating object is fixed to and rotates along with a rotating shaft, a first portion of the flexible board extends from the repeatedly rotating object to the rotating shaft, and a second portion of the flexible board extends from the rotating shaft to the stationary object, characterized in that, the first portion of the flexible board is arranged fixedly relative to the repeatedly rotating object and the rotating shaft, and the second portion of the flexible board is arranged so as to be wound around the rotating shaft in such a manner that it winds or unwinds along with the reciprocating rotation of the rotating shaft. The present invention also provides an ultrasonic probe. According to the present invention, the manner in which the flexible board is wound around the rotating shaft may cause the stressed area of the flexible board to increase substantially, thereby reducing the shearing force per unit area endured by the flexible board. The number of bending cycles of the flexible board may be increased considerably, thereby enhancing the reliability and prolonging the service life of the flexible board, and also further enhancing the reliability of the ultrasonic probe and the ultrasonic system and prolonging their service life.

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FLEXIBLE BOARD CONNECTING METHOD AND ULTRASONIC PROBE

Field of the Invention

The present invention relates to a flexible board, and especially to a method of establishing a connection between a repeatedly rotating object and a stationary object by means of a flexible board, and to an ultrasonic probe comprising such a connection.

Description of the Background Art

The flexible printed circuit board is a printed circuit formed of a flexible insulating substrate. The flexible printed circuit board can be freely bent, wound and folded, and it can be randomly arranged according to the spatial layout, and is randomly movable and telescopic in the three-dimensional space. As a result, the flexible printed circuit board has extensive applications. In many modern electronic integrated facilities, the flexible printed circuit board is widely used for establishing an electrical and/or signal connection between a repeatedly rotating object and a stationary object. Said board is typically used as a flexible printed circuit board disposed in an ultrasonic probe of an ultrasonic system, and as a flexible printed circuit board disposed between a camera of a monitoring system and its host. For example, in a 3D ultrasonic system for medical imaging and diagnosing, the connection between an acoustic head of the ultrasonic probe and the host can be established by means of the flexible printed circuit board and cables. In use, the acoustic head is driven to make a reciprocating scanning motion, and the flexible printed circuit board is bent to and fro along with the reciprocating scanning motion of the acoustic head. During bending, the flexible printed circuit board is subjected to a shearing force. As the number of bending cycles increase, the flexible printed circuit board will eventually break. During operation of the probe of the 3D ultrasonic system, the flexible printed circuit board generally is subjected to a number of 40 million of repeatedly occurring bending cycles. Obviously, a conventional design and mounting method of the flexible printed circuit board cannot meet the requirement of such a large number of bending cycles.

Therefore, it is necessary to provide a novel method of establishing a connection between

the repeatedly rotating object and the stationary object by means of the flexible board, and to provide an ultrasonic probe comprising such a connection.

Summary of the Invention

It is an object of the present invention to eliminate the above defects in the prior art, and to provide a method of establishing a connection between a repeatedly rotating object and a stationary object by means of a flexible board, and to provide an ultrasonic probe comprising such a connection.

According to one aspect of the present invention, a method of establishing a connection between a repeatedly rotating object and a stationary object must be provided by means of a flexible board, wherein the repeatedly rotating object is fixed to and rotates along with a rotating shaft, a first portion of the flexible board extends from the repeatedly rotating object to the rotating shaft, and a second portion of the flexible board extends from the rotating shaft to the stationary object, characterized in that the first portion of the flexible board is fixedly arranged relative to the repeatedly rotating object and the rotating shaft, and the second portion of the flexible board is arranged so as to be wound around the rotating shaft in such a manner that the second portion of the flexible board winds or unwinds along with the reciprocating rotation of the rotating shaft.

Preferably, the second portion is wound by at least one turn around the rotating shaft.

Preferably, the second portion is wound around the rotating shaft at the same position or helically.

Preferably, the flexible board is fixed to the rotating shaft at an interface between the first portion and the second portion.

Preferably, a groove is formed in the rotating shaft, and the flexible board is a snug fit at the flat bottom of the groove.

Preferably, at least two flexible boards are arranged between the repeatedly rotating object and the stationary object, and the second portions of the adjacent flexible boards are wound around the rotating shaft in opposite directions.

Preferably, the flexible board is a flexible printed circuit board.

Preferably, the repeatedly rotating object and the stationary object are an acoustic head of an ultrasonic probe and a stationary portion of the ultrasonic probe, respectively, or the repeatedly rotating object and the stationary object are a camera of a monitor and a housing of a host of the monitor, respectively.

According to another aspect of the present invention, an ultrasonic probe is to be provided comprising: an ultrasonic acoustic head, a rotating shaft to which the ultrasonic acoustic head is fixed and along with which the ultrasonic acoustic head rotates in a reciprocating manner, a drive mechanism for causing the rotating shaft to rotate, and a flexible printed circuit board provided between the ultrasonic acoustic head and a stationary portion of the ultrasonic probe, the flexible printed circuit board comprising a first portion extending from the ultrasonic acoustic head to the rotating shaft and a second portion extending from the rotating shaft through the stationary portion, characterized in that the first portion of the flexible printed circuit board is fixedly arranged relative to the ultrasonic acoustic head and the rotating shaft, and the second portion of the flexible printed circuit board is arranged so as to be wound around the rotating shaft in such a manner it winds or unwinds along with the reciprocating rotation of the rotating shaft.

Preferably, the second portion is wound by at least one turn around the rotating shaft.

Preferably, the second portion is wound around the rotating shaft at the same position or helically.

Preferably, the flexible printed circuit board is fixed to the rotating shaft at an interface between the first portion and the second portion.

Preferably, a groove is formed in the rotating shaft, and the flexible printed circuit board is a snug fit at the flat bottom of the groove.

Preferably, at least two flexible printed circuit boards are arranged between the ultrasonic acoustic head and the stationary portion, and the second portions of the adjacent flexible printed circuit boards are wound around the rotating shaft in opposite directions.

Preferably, the at least two flexible printed circuit boards are arranged on either side or on the same side of the ultrasonic acoustic head.

According to the present invention, the arrangement in which the flexible board is wound around the rotating shaft may substantially increase the stressed area of the flexible board, thereby reducing the shearing force per unit area endured by the flexible board. The number of bending cycles of the flexible board may be increased considerably, thereby enhancing its reliability and prolonging its service life, and further enhancing the reliability of the ultrasonic probe and the ultrasonic system and also prolonging their service life.

Brief Description of the Drawings

Fig. 1 schematically shows an ultrasonic probe of an ultrasonic system according to the present invention, in which the housing is removed to show clearly its interior configuration;

Fig. 2 is a partially enlarged view of Fig. 1, showing in detail the connection of the flexible printed circuit board according to the present invention; and

Fig. 3 is a side view showing the connection of the flexible printed circuit board according to the present invention.

Detailed Description of the Preferred Embodiments

Hereinafter, the present invention is described in detail with reference to the figures.

Fig. 1 schematically shows an ultrasonic probe of an ultrasonic system according to the present invention, in which the housing is removed so as to show clearly its interior configuration. As shown in Fig. 1, the ultrasonic probe 1 comprises an ultrasonic acoustic head 3, in which a plurality of ultrasonic transducer elements are arranged to generate an incident ultrasonic wave and receive a reflected ultrasonic wave. The ultrasonic probe 1 further comprises a rotating shaft 5 to which the ultrasonic acoustic head 3 is fixed and along with which the ultrasonic acoustic head 3 rotates (or swings) in a reciprocating manner. The rotating shaft 5 is rotatably fixed to a frame housing (not shown) by a bearing 7. The rotating shaft 5 can make the reciprocating rotation at high speed under the driving action of a drive mechanism 9 in any known suitable manner. The drive mechanism 9 preferably comprises a stepper motor. Besides the ultrasonic probe 1, the ultrasonic system further comprises a host that receives and processes signals from the ultrasonic probe 1 so as to acquire an ultrasonic image of the target to be detected. The host substantially has the same structure as the host of the conventional ultrasonic system, so that a detailed description of the host can be dispensed with.

A flexible printed circuit board 13 is arranged between the ultrasonic acoustic head 3 and a stationary portion 11 of the ultrasonic probe 1 for establishing an electrical and/or signal connection. According to the present invention, a first portion 13a of the flexible printed circuit board 13 is shown to extend from the ultrasonic acoustic head 3 to the rotating shaft 5 and is fixed to the rotating shaft 5 such that the first portion 13a of the flexible printed circuit board 13 does not move relative to the rotating shaft 5 during rotation of the rotating shaft 5. A second portion 13b of the flexible printed circuit board 13, which extends from the rotating shaft 5 to the stationary portion 11 of the ultrasonic probe 1, is arranged in such a way that it is wound around the rotating shaft 5 and extends continuously through the stationary portion 11. According to the requirements, the second portion 13b of the

flexible printed circuit board 13 may be wound by one or more turns around the rotating shaft 5. The second portion 13b may be wound spirally around the rotating shaft 5, but preferably the second portion 13b is wound around the rotating shaft 5 at the same position to reduce the required space.

The first portion 13a of the flexible printed circuit board 13, which is shown to extend from the ultrasonic acoustic head 3, is bent several times in the proximity of the rotating shaft 5, so that the first portion 13a is brought into contact with the rotating shaft 5 with a planar part of the first portion 13a. An aperture 15 is present in the flexible printed circuit board 13 between the first portion 13a and the second portion 13b, and a corresponding aperture 17 is present in the rotating shaft 5. A screw (not shown) passing through the apertures 15 and 17 secures the first portion 13a of the flexible printed circuit board 13 to the rotating shaft 5, as shown in Fig. 2. It is should be understood that other means, such as bonding, may be used to secure the first portion 13a of the flexible printed circuit board 13 to the rotating shaft 5. In order to facilitate securing the first portion 13a of the flexible printed circuit board 13 to the rotating shaft 5, a groove 19 is preferably formed in the rotating shaft 5 such that the flexible printed circuit board 13 is a snug fit at the flat bottom of the groove 19. The second portion 13b of the flexible printed circuit board 13, which is wound around the rotating shaft 5, is fixed at, and relative to, the stationary portion 11 of the ultrasonic probe 1, so that during the rotation of the rotating shaft 5, a part of the second portion 13b extending through the stationary portion 11 does not experience any movement relative to the stationary portion 11 or the housing of the ultrasonic probe.

In the shown embodiment, although one flexible printed circuit board 13 is arranged on either side of the ultrasonic acoustic head 3 so as to be symmetrical, one or more than two flexible printed circuit boards 13 may be arranged between the ultrasonic acoustic head 3 and the stationary portion 11 according to the requirements for establishing the electrical and/or signal connection. In the case that a plurality of flexible printed circuit boards 13 are arranged, they may be arranged on either side or on the same side of the ultrasonic probe 1.

In the case that one flexible printed circuit board 13 is arranged on either side of the ultrasonic acoustic head 3 so as to be symmetrical, the two flexible printed circuit boards 13 may be wound around the rotating shaft 5 in the same direction. When the second portion 13b of the flexible printed circuit board 13 winds or unwinds along with the reciprocating rotation of the rotating shaft 5, a force that resists or retards such winding or unwinding is generated on the rotating shaft 5. The two flexible printed circuit boards 13 preferably are wound around the rotating shaft 5 in opposite directions so that the forces generated by the two flexible printed circuit boards 13 on the rotating shaft 5 and resisting or retarding such winding or unwinding counteract each other, thereby reducing vibration of the rotating shaft 5 and kinetic energy consumption. In the case that more than two flexible printed circuit boards 13 are arranged between the ultrasonic acoustic head 3 and the stationary portion 11, the adjacent flexible printed circuit boards 13 may be wound around the rotating shaft 5 in the same direction, but preferably in opposite directions.

During operation of the ultrasonic probe 1, the rotating shaft 5 makes the reciprocating rotation at high speed under the driving action of the drive mechanism 9, causing the ultrasonic acoustic head 3 to swing at high speed so as to acquire the ultrasonic signal from the target to be detected. The ultrasonic signal is transmitted to the host through the flexible printed circuit board 13 and the cables (not shown) connected to the flexible printed circuit board 13 in order to acquire the ultrasonic image of the target to be detected. During the high-speed swinging of the ultrasonic acoustic head 3, the ultrasonic acoustic head 3, the first portion 13a of the flexible printed circuit board 13 and the rotating shaft 5 do not move relative to each other. Since the second portion 13b of the flexible printed circuit board 13 extends through the stationary portion 11 and is fixed at and relative to the stationary portion 11 or relative to the housing, only the second portion 13b rotates, between its fixed point on the rotating shaft 5 and the stationary portion 11, around an axis O of the rotating shaft 5 when the ultrasonic acoustic head 3 swings at high speed. Such rotation is converted into the winding up of the second portion 13b relative to the rotating shaft 5 in one direction A or the unwinding of the second portion 13b relative to the

rotating shaft 5 in the other direction B, as shown in Fig. 3. As can be seen from Fig. 3, compared with an arrangement in which the flexible printed circuit board 13 is not wound around the rotating shaft 5, the arrangement in which the flexible printed circuit board 13 is wound around the rotating shaft 5 allows a substantial increase of the stressed area of the flexible printed circuit board, thereby reducing the shearing force per unit area endured by the flexible printed circuit board. The number of bending cycles of the flexible printed circuit board may be increased considerably, thereby enhancing its reliability and prolonging its service life, and further enhancing the reliability of the ultrasonic probe and the ultrasonic system and prolonging their service life.

Although the present invention is described with reference to the figures, the present invention is not limited to the above preferred embodiments. For example, the flexible printed circuit board also may be arranged in the same way between the high-speed rotating camera of the monitor and its host. Furthermore, the present invention also may be used for arranging other flexible boards, i.e. other than the flexible printed circuit board between the repeatedly rotating object and the stationary object. It should be understood that a person skilled in the art may make various modifications to the present invention without departing from the scope of the claimed invention.

CLAIMS

1. A method of establishing a connection between a repeatedly rotating object and a stationary object by means of a flexible board, wherein the repeatedly rotating object is fixed to and rotates along with a rotating shaft, a first portion of the flexible board extends from the repeatedly rotating object to the rotating shaft, and a second portion of the flexible board extends from the rotating shaft to the stationary object, characterized in that the first portion of the flexible board is fixedly arranged relative to the repeatedly rotating object and the rotating shaft, and the second portion of the flexible board is arranged so as to be wound around the rotating shaft in such a manner that it winds or unwinds along with the reciprocating rotation of the rotating shaft.

2. The method according to claim 1, characterized in that the second portion is wound by at least one turn around the rotating shaft.

3. The method according to claim 1, characterized in that the second portion is wound around the rotating shaft at the same position or helically.

4. The method according to claim 1, characterized in that the flexible board is fixed to the rotating shaft at an interface between the first portion and the second portion.

5. The method according to claim 4, characterized in that a groove is formed in the rotating shaft, and the flexible board is a snug fit at the flat bottom of the groove.

6. The method according to claim 1, characterized in that at least two flexible boards are arranged between the repeatedly rotating object and the stationary object, and the second portions of the adjacent flexible boards are wound around the rotating shaft in opposite directions.

7. The method according to claim 1, characterized in that the flexible board is a flexible

printed circuit board.

8. The method according to claim 7, characterized in that the repeatedly rotating object and the stationary object are an acoustic head of an ultrasonic probe and a stationary portion of the ultrasonic probe, respectively, or the repeatedly rotating object and the stationary object are a camera of a monitor and a housing of a host of the monitor, respectively.

9. An ultrasonic probe comprising: an ultrasonic acoustic head, a rotating shaft to which the ultrasonic acoustic head is fixed and along with which the ultrasonic acoustic head rotates in a reciprocating manner, a drive mechanism for causing the rotating shaft to rotate, and a flexible printed circuit board provided between the ultrasonic acoustic head and a stationary portion of the ultrasonic probe, the flexible printed circuit board comprising a first portion extending from the ultrasonic acoustic head to the rotating shaft and a second portion extending from the rotating shaft through the stationary portion, characterized in that the first portion of the flexible printed circuit board is fixedly arranged relative to the ultrasonic acoustic head and the rotating shaft, and the second portion of the flexible printed circuit board is arranged so as to be wound around the rotating shaft in such a manner that it winds or unwinds along with the reciprocating rotation of the rotating shaft.

10. The ultrasonic probe according to claim 9, characterized in that the second portion is wound by at least one turn around the rotating shaft.

11. The ultrasonic probe according to claim 9, characterized in that the second portion is wound around the rotating shaft at the same position or helically.

12. The ultrasonic probe according to claim 9, characterized in that the flexible printed circuit board is fixed to the rotating shaft at an interface between the first portion and the second portion.

13. The ultrasonic probe according to claim 12, characterized in that a groove is formed in

the rotating shaft, and the flexible printed circuit board is a snug fit at the flat bottom of the groove.

14. The ultrasonic probe according to claim 9, characterized in that at least two flexible printed circuit boards are arranged between the ultrasonic acoustic head and the stationary portion, and the second portions of the adjacent flexible printed circuit boards are wound around the rotating shaft in opposite directions.

15. The ultrasonic probe according to claim 14, characterized in that the at least two flexible printed circuit boards are arranged on either side or on the same side of the ultrasonic acoustic head.

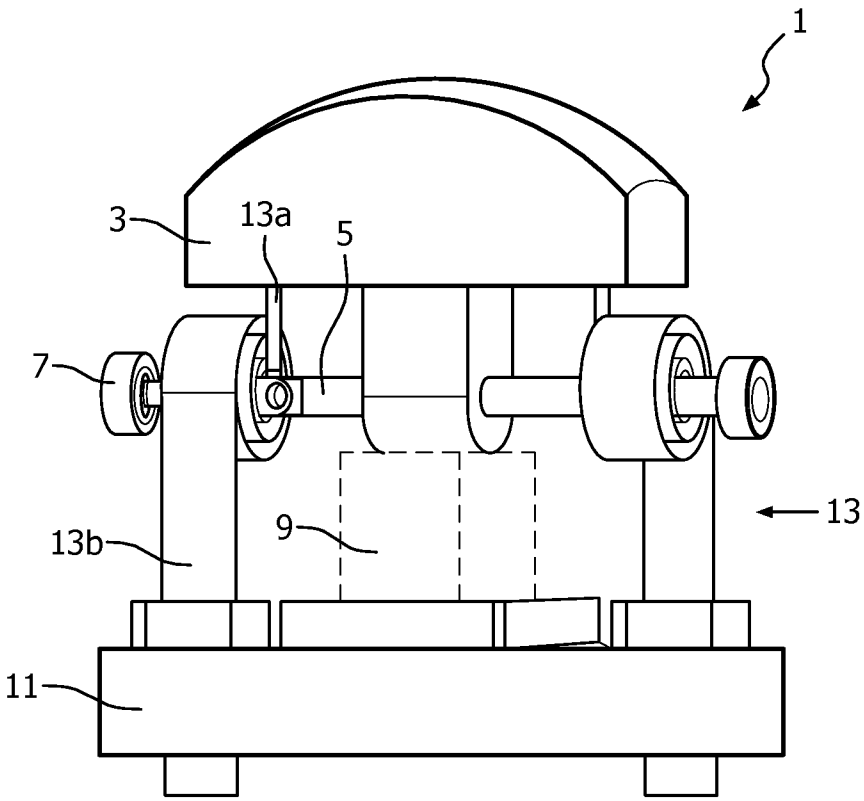

FIG. 1

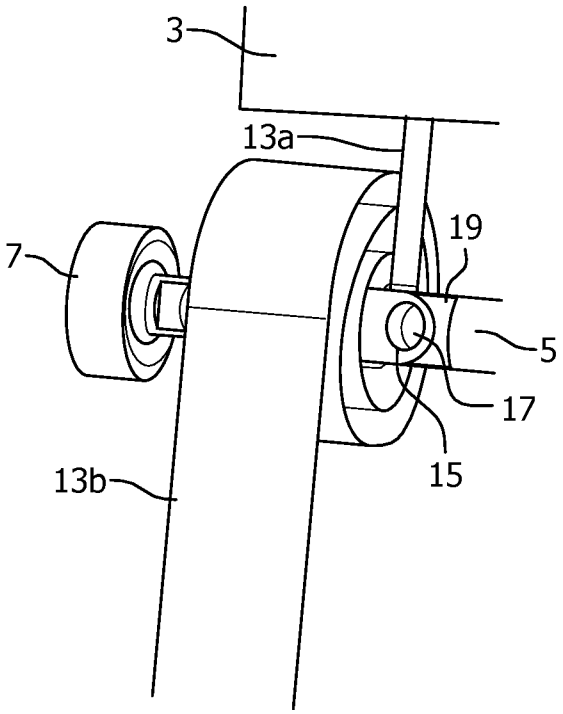

FIG. 2

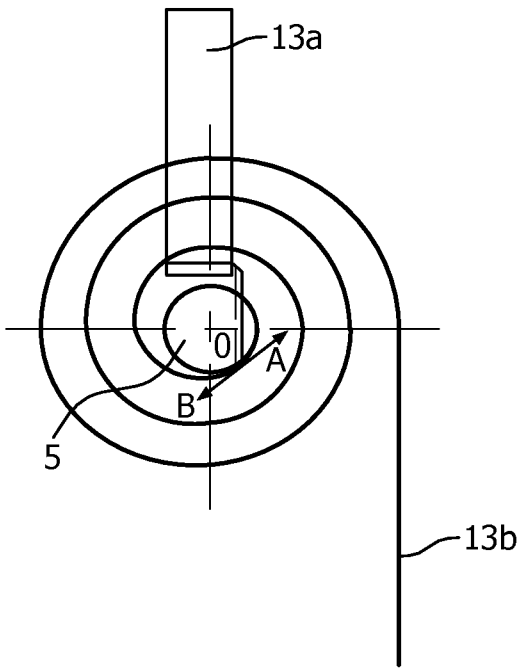

FIG. 3