PROBE FOR NON-DESTRUCTIVE TESTING

Field of invention.

The present invention relates to a probe for use in the non-destructive testing of materials, and, particularly, but not exclusively, to a probe for use in the non-destructive testing (NDT) of structures and composite materials.

Background of the invention.

Non-destructive testing (NDT) is used to test a number of materials, in particular composite materials, such as utilised to manufacture aircraft and other items. It is not feasible to test items such as an aircraft for damage by disassembling the aircraft first. The testing needs to be non-destructive. Generally, but not exclusively, acoustic and near ultrasonic frequencies are used for NDT.

A typical NDT system is the pitch/catch system, employing a pitch/catch probe. A schematic cross-section through a typical pitch/catch probe showing the fundamental elements of such a probe is illustrated in figure 4. The pitch/catch probe 20 includes first 21 and second 22 probe assemblies. The probe assemblies include respective contact tips 23 and 24 which are spring loaded by springs 25 and 26 to contact a test sample 27. Each probe assembly 21 and 22 is equipped with a transducer 28, 29 such that one can act as a driver and the other as a detector (the operation may be interchangeable). The available drive frequency range is wide, typically 5 to 70 kHz. The drive signal is generally a short wave train, up to 6 cycles of sinusoid at a user selected frequency within the above range. The drive signal may alternatively be impulse or step excitation. The detector measures a response of the test sample 27 at its contact point. The theory is that the propagation of the disturbance from the drive to the detector is influenced

by the nature of the intervening structure and in particular, by any damage or anomaly in this region.

A return signal detected from a damaged test sample is compared with that from a "good" test sample (to give a reference signal) to determine the extent of any damage to the test sample. In conventional systems, complex electronic hardware is utilised to process the signals and provide a display of the return signal to enable determination of the damage. These systems are often expensive and the equipment is usually bulky.

In operation, testing will actually be carried out in situ on the item being tested (for example, an aeroplane). The pitch/catch probe is passed over the surface of the panels of the item being tested, and readings are taken from a plurality of points across the panel. Typical pitch/catch probes are hand held and move from one place to another over material being tested whilst viewing the result on a graphical readout.

Often, a reference frame is required so that positional information can be obtained from the probe. In the prior art systems, this positional information is acquired by attaching a part of a track or gantry to the item being tested, to which the probe can be attached and which provides a readout of the measuring position. The attachment of such gantry apparatus to the surface of an item such as an aircraft is difficult and time consuming.

It would be desirable to provide a probe for non-destructive testing which can provide positional information without requiring any separate frame of reference to be implemented such as a gantry arrangement.

Summary of the invention.

In accordance with a first aspect of the present invention, there is provided a probe for non-destructive testing of items, the probe being movable over a surface of a test item and including a receiver for receiving a return signal from the non-destructive testing of the item

and including displacement sensor means for providing a displacement signal indicative of the spatial displacement of the probe over the test item as the probe is moved over the test item.

Preferably, the displacement means includes a sensor mounted to the probe and being capable of providing the displacement signal.

Preferably, the displacement signal is also arranged to provide orientation information. The orientation information preferably provides information on the rotational position of the probe. This information can be used to compensate for any rotation of the probe (which may occur naturally as the user moves the probe over the test item) from effecting the displacement information.

Preferably, the sensor is similar to sensors provided in computer "mice" for driving the computer graphical user interface (GUI). Preferably, two sensors are provided to enable provision of the orientation information. The sensor may be any type of mouse sensor, but is preferably an optical sensor (as used in so-called "optical mice").

In a preferred embodiment, a pair of optical sensors are utilised in the probe. The pair of optical sensors are arranged to provide the orientation information.

A probe in accordance with the present invention advantageously has no need of a separate gantry or reference frame to enable the provision of positional information to an NDT processing system.

In another preferred embodiment the probe comprises non-destructive-testing (NDT) data acquisition, processing and analysis electronics in one housing. The probe, together with a computer for data storage and data display, preferably forms a complete NDT system. The probe preferably is operatively connectable with the computer using a single universal serial bus (USB) cable. In this case the USB cable may also be used to supply electrical power. Alternatively, the probe may be operatively connectable with the computer using a radio USB

connection. This embodiment has a significant commercial advantage, as the probe is readily connectable to a typical standard computer. No modifications of the computer are required and the computer does not need to be equipped with any special cards such as data acquisition cards. The probe may be connected to any typical standard PC computer via a USB port which has a significant commercial advantage. Further, the probe may be given a compact design similar to that of a computer mouse which has additional practical advantages.

As a variation of this embodiment, the probe may also comprise a computer memory for data storage in one housing. In this case a connection to an external computer may only be required for data transfer. The probe may also comprise a display and may form a complete NDT system.

In an alternative embodiment of the present invention a system is provided for processing the signals provided by the probe. The system may be similar to the graphical user interface systems which are provided for processing positional information from computer mice.

In accordance with a second aspect of the present invention, there is provided an apparatus for processing a signal from a NDT probe as discussed above, to provide data on the position of the probe as it moves over a test surface.

The apparatus preferably includes a suitable computing system programmed with suitable software to implement the probe position processing.

From a third aspect, the present invention provides a non-destructive testing system comprising a probe as discussed above in combination with an apparatus for processing the probe signal as discussed above.

From a fourth aspect, the present invention provides a probe for non-destructive testing of items, the probe comprising data acquisition, processing and analysis electronics in one housing and the probe forming, in combination with a typical standard computer, a useable

NDT system.

Brief description of the drawings.

Features and advantages of the present invention will become apparent from the following description of an embodiment thereof, by way of example only, with reference to the accompanying drawings, in which;

Figure 1 is a schematic diagram of a system in accordance with an embodiment of the present invention;

Figure 2 is a cross-sectional view through a NDT probe in accordance with an embodiment of the present invention;

Figure 3 is a schematic diagram of a probe in accordance with an embodiment of the present invention, and

Figure 4 is a cross-section through a prior art pitch/catch probe for NDT testing.

Detailed description of preferred embodiment.

Referring to figure 1, there is illustrated a non-destructive testing apparatus in accordance with an embodiment of the present invention, generally designated by reference numeral 1.

The apparatus includes a NDT probe 2 in accordance with an embodiment of the present invention. The probe 2 is arranged to be passed over a test sample 3 and to provide an acoustic vibration signal of a drive frequency within the range of 5 to 70 kHz to the sample 3 and receive a return signal to be processed by the computing system 8 to provide data on any faults in the test sample 3.

In operation, the test sample will usually be a part of equipment being tested, such as an aeroplane, for example.

Referring to figure 2, the probe 2 comprises a pitch/catch arrangement 30. The pitch/catch arrangement 30 includes pitch/catch assemblies 31 and 32 which are

equivalent to the pitch/catch assemblies 21 and 22 which are described in the preamble with reference to figure 4. The operation of the pitch/catch arrangement 30 of the probe 2 is the same as that of the prior art pitch/catch arrangement and no further description will be given.

In addition to the pitch/catch arrangement 30, the probe 2 also mounts displacement means 33 and 34. In this embodiment, the displacement means 33 and 34 comprise two optical systems 33 and 34 which are equivalent to those used in the so-called "optical" computer mouse. These optical systems operate by continuously forming an image of a small area of the test surface 3 beneath the probe 2. As the image is updated two-dimensional cross correlation is calculated using the natural "texture" of whatever is in the image. The result of this is a number which expresses how far the probe has moved between images. By utilising two of the optical systems 33 and 34 a vector for the movement of the probe 2 can be calculated. A computer 4 (see later) calculates this vector from the displacement signal provided by the optical systems. Because there are two optical systems, orientation information is provided enabling the vector to be calculated.

Note that the probe provides displacement information and that the processing to provide the positional information takes place in computing system 3 (to be described later).

The probe 2 also has "mouse buttons" 2A and 2B. These are associated with sensors so that when the buttons 2A, 2B are actuated a signal is sent back to computing system 8.

In use, a user of the probe 2 sets a "datum" on the test sample 3 from which all dimensional information may be mapped. The probe 2 can then be moved anywhere and the NDT reading taken, or the readings can be taken continuously as the probe is moved (these various options can be implemented using the probe buttons). If the probe

2 is lifted off the test piece 3 clicking on the datum re-establishes the co-ordinate system. The calculation of a vector rather than simply the distance the probe 2 has moved means that the user can rotate the mouse without distorting the co-ordinate system.

The data may comprise a reflective detector spot or a number of reflective detector spots on the panel and an LED/detector on the probe. Reflective spot provides point of reference. The spot may be matt, depending upon whether the panel has a shiny surface.

Note that normal mouse function is retained in mouse 7 connected to the computing system, and control can be switched back and forth between the probe 2 and the mouse 7 according to user demand.

As well as the probe 2 the system also includes a computing system 8 including a computer 4, display 5, keyboard 6 and mouse 7. Software is provided for the computing system 8 to process the signals from the optical sensors 33 and 34 and also the signals from the pitch/catch probe arrangement 30.

The computing system 8 may process the signals from the pitch/catch probe 30 in any conventional way known in the prior art, to provide information on defects within the test sample 3 as the probe 2 is passed over the test sample. Preferably, however, the signals are processed in accordance with the method of the invention described in the applicants co-pending application entitled "Method and Apparatus for Carrying Out Non-Destructive Testing of Materials", filed on the same day as the present application, and the disclosure of which is incorporated herein by reference.

Preferably, software is provided to control a computing system 8 to process the displacement signals from the optical systems 33 and 34 to provide position information as discussed above. This position information is preferably stored in the computer along with the result of the processing of the pitch/catch signals, so that a

positional map of the sample may be provided showing any defects therein, on display 5.

Referring to figure 3, there is illustrated a non-destructive testing (NDT) system in accordance with an embodiment of the present invention. The system includes a NDT probe 40 and a PC computer 41. The probe 40 comprises all NDT data acquisition, processing and analysis electronics in one housing. The PC computer 41 functions to store and display data. The probe is operatively connected with the computer using a single USB cable 42. The probe can be connected to any typical standard PC computer via a USB port which gives the probe a significant commercial advantage. In this case the USB cable may also be used to supply electrical power.

In operation, the test sample will usually be a part of equipment being tested, such as an aeroplane, for example.

In the above description, the probe utilised incorporates a pitch/catch arrangement. It will be appreciated that the present invention is not limited to use of a pitch/catch arrangement. Any NDT sensor arrangement which can be incorporated in the probe may be utilised (e.g. ultrasonic pulse echo, eddy current, mechanical impedance).

The particular embodiment of the probe described above utilises optical arrangements for providing positional information. It will be appreciated that the present invention is not limited to optical arrangements, and any sensor arrangement which enables the provision of positional information from motion of the probe may be utilised.

The probe described above is particularly suitable for use in non-destructive testing. The probe is not limited to the NDT field, however. Any process or system which requires the input of positional information from a probe could utilise the probe of the present invention.

It will be appreciated by persons skilled in the art

that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. For example, no cable may be required to connect the probe to the computer. The probe may be operatively connectable with the computer using a radio USB connection. Alternatively, the probe may also comprise the computer memory for data storage in one housing. In this case a connection to an external computer may only be required for data transfer. The probe may also comprise a display and may form a complete NDT system.

The present embodiments are to be considered in all respects as illustrative and not restrictive.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A probe for non-destructive testing of items, the probe being movable over the surface of a test item and including a receiver for receiving a return signal from the non-destructive testing of the item and including displacement means for providing a displacement signal indicative of the spatial displacement of the probe over the test item as the probe is moved over the test item.

2. The probe as claimed in claim 1, wherein the displacement means includes a sensor mounted to the probe and being capable of providing the displacement signal.

3. The probe as claimed in claims 1 or 2, wherein the displacement means is also arranged to provide information on the rotational orientation of the probe.

4. The probe as claimed in claims 2 or 3, wherein the sensor is equivalent to sensors provided in computer mice.

5. The probe as claimed in claim 4, wherein the sensor is an optical sensor similar to those utilised in computer mice.

6. The probe as claimed in claim 5, including a pair of optical sensors for providing orientation information.

7. The probe as claimed in any one of the preceding claims comprising non-destructive testing (NDT) data acquisition, processing and analysis electronics in one housing.

8. The probe as claimed in claim 7 wherein the probe, together with a computer for data storage and data display, forms a complete NDT system.

9. The probe as claimed in claim 7 wherein the probe is operatively connectable with the computer using a single USB cable.

10. The probe as claimed in claim 8 wherein the probe is operatively connectable with the computer using a radio USB connection.

11. The probe as claimed in any one of claims 7 to 10 wherein the probe comprises computer memory for data

storage in one housing.

12. The probe as claim in claim 11 wherein the probe comprises a display in one housing and forms a complete NDT system.

13. An apparatus for processing a signal from a probe according to any one of claims 1 to 6 , to provide data on the position of the probe as it moves over a test surface.

14. A non-destructive testing system comprising a probe as claimed in any one of the claims 1 to 6 and an apparatus as claimed in claim 13.

15. A probe for providing positional information of displacement of the probe over an item, the probe being movable over the surface of the item and including a displacement sensor means for providing a displacement signal indicative of the spatial displacement of the probe over the test item, the displacement sensor means also being arranged to provide information on the rotational orientation of the probe.

16. A probe for non-destructive testing of items, the probe comprising data acquisition, processing and analysis electronics in one housing and the probe forming, in combination with a typical standard computer, a useable NDT system.