

DESCRIPTION**«APPARATUS AND METHOD FOR CHECKING COMPONENT PARTS OF A MECHANICAL PIECE»**

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Technical Field

The present invention relates to an optoelectronic system for checking relative attitude of component parts of a mechanical piece including a base; a reference system, connected to the base and adapted to refer the mechanical piece in a predetermined position, the reference system including a stationary support which defines a reference plane and is adapted to cooperate with positioning surfaces of the mechanical piece; an optoelectronic detection system; and a processing unit adapted for receiving and processing signals of the optoelectronic detection device. The present invention also relates to a method for checking relative attitude of component parts of a mechanical piece by means of an optoelectronic system, including the steps of referring a first component part of the mechanical piece in a reference system; and locking the mechanical piece to be checked at a checking position.

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Background art

There are known hard disk storage units, or "hard disks", for storing and recalling data, that are employed in electronic systems such as computers. Hard disks typically include one or more magnetic read/write heads that are connected to sliders and are placed near a surface of a rotating magnetic disk. When the magnetic disk is driven into rotation, a thin air cushion forms between the disk and the slider, enabling the latter to "float" over the disk at a distance which is in the range of a few tens of nanometers, or even less, in the current hard disks. In the course of the disk rotation, the magnetic read/write

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elements can be utilized to read/write bits of data along a magnetic track on the magnetic disk.

It is known that the heads employed in the known hard disks are very complex and delicate and thus are checked before
5 the assembly in the hard disks.

Generally, the heads are checked once they have been assembled in "Head Gimbal Assembly" (HGA) or one or more HGA have been assembled in a "Head Stack Assembly" (HSA). Typically, the HGA includes a head with an associated
10 slider, and a resilient thin plate to which the head is connected by means of a joint. Each of the thin plates has one end, opposite with respect to the end carrying the head, which is connected to a E-shaped support or "E-block" having a plurality of mutually parallel wings. The assembly
15 of the E-block and the HGAs is called HSA and is utilized for reading or writing on one face or both the faces of one or more magnetic disks. The HSA also includes a bearing which couples the HSA to stationary component parts of the hard disk and enables the former to rotate under the
20 control of a motor of the VCM ("Voice Coil Motor") type, for moving the magnetic heads on the magnetic disks.

Checking operations carried out on the HSA, before the latter is assembled in the hard disk, typically include dimensional and attitude checking of the heads, of the
25 associated sliders as well as of the E-block wings. Such checking operations are carried out by dedicated systems that typically comprise a rest structure, reference and locking devices of the HSA to be checked for referring and locking the HSA in the rest structure, checking devices for
30 checking the conformity of the dimensions and the attitude ("roll" angle and "pitch" angle) of the HSA with the project specifications, and displacement devices of the HSA for rotating and/or translating the HSA with respect to the checking devices.

35 European patent No. EP 1029219 B1 discloses an optoelectronic apparatus for checking position and/or form deviation of mechanical pieces, for example HSA sliders,

which includes, among other things, a base, a locking and reference system for the E-block of the HSA to be checked, detection devices with an optoelectronic system for providing signals indicative of the position of the piece
5 component parts, a processing unit for processing signals provided by the detection devices, and a rotation system enabling mutual rotations between the piece and the optoelectronic system. In the course of mutual rotations between the HSA and the optoelectronic system, signals
10 indicative of the spatial position of the sliders are detected by means of the optoelectronic system. Once processed, said signals provide information concerning the dimension and/or the attitude of the sliders with respect to a reference plane, which is defined by the base.

15 The international patent application published with No. WO 2006/097445 discloses an optoelectronic apparatus which can check dimensions and attitude of mechanical pieces, in particular HSA sliders, having smaller dimensions than those checked with the apparatus illustrated in the patent
20 No. EP 1029219 B1.

The optoelectronic apparatus disclosed in patent publication No. WO 2006/097445 includes a base, a locking and reference system for the E-block of the HSA to be checked, a translation system, and a rotation system
25 enabling mutual translations and rotations between the piece and the optoelectronic system, in the course of which an optoelectronic device provides signals indicative of the position of the sliders of the HSA to be checked. Such an apparatus provides remarkable standards of metrological
30 performance and can provide measures related to height and attitude of the sliders that are referred to a locating plane defined by the base.

In the apparatuses disclosed in the previously mentioned patent documents, the sliders attitude is detected in a
35 checking condition and is influenced by the HSA E-block, since the arrangement of the parts to be checked is

established by the connection of the E-block to the locking and reference system.

The attitude of the HSA sliders in a working condition, which means once the HSA has been assembled in the associated hard disk, generally differs from the attitude that has been previously checked, owing to the influence applied not only by the E-block attitude but also by the bearing attitude, which couples to a suitable seat of the hard disk and thus determines the whole attitude of the HSA in the working condition. That is, whether attitude of the sliders is checked with reference to the E-block, the working conditions of the HSA are not taken into consideration, and this can introduce errors. In other words, sliders having an attitude according to the project specifications in a checking condition, could have an attitude differing from the project specifications in a working condition, and vice-versa.

Disclosure of the invention

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Object of the present invention is to provide a checking apparatus and relevant method for HSAs of hard disks which overcome the disadvantages of the known apparatuses and methods.

25 This and other objects are achieved by an optoelectronic system and a checking method of the static type according to claim 1 and claim 6, respectively.

The optoelectronic checking system according to the present invention enables to check attitude characteristics of HSA component parts, such as for example the bearing, that are essential for evaluating the arrangement of the sliders and thus of the read/write heads with extremely high accuracy.

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Brief Description of the Drawings

The invention is now described with reference to the enclosed sheets of drawings, given by way of non limiting

examples, wherein:

figure 1 is a perspective view of a checking system according to the present invention, with some elements omitted for the sake of simplicity;

5 figure 2 is a perspective view of a component part of the checking system shown in figure 1;

figure 3 is a longitudinal cross-section along the plane XZ of the component part of figure 2.

10 Best Mode for Carrying Out the Invention

An optoelectronic checking system **1** according to the present invention, for an HSA that is shown in simplified way in figure 1, includes a base **2** carrying a reference system **40** for an E-block **29** of the HSA to be checked, a locking system **4** and a detection system. The locking system **4** may be of a known type having a rod **5** which carries a floating ball **6** for locking the E-block **29** to a stationary support, in particular a reference nosepiece **3**. The detection device may be for example of the optoelectronic shadow casting type, which is per se known and thus illustrated in a very simplified way with the blocks **A, B** representing an emitter and a receiver, respectively. A processing unit **C** is connected to the optoelectronic system, in particular to the receiver **B**, for processing the signals provided by the latter.

The reference system **40** includes the reference nosepiece **3**, a floating device **10**, a ball **12**, a thrust element **13**, and a reference plane surface **27** (figures 2 and 3). The reference nosepiece **3**, defining a reference system XYZ, is connected to the base **2** and is substantially cylindrically shaped with a longitudinal through hole **7** defining the direction Z, two side openings **8, 9** and a reference annular surface **25** for the E-block of the HSA to be checked. The reference nosepiece **3** also includes a lower opening **14** wherein the ball **12** is housed and can slide along the direction Z. More specifically, the ball **12** is arranged between - and in

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contact with - the thrust element **13**, for example a pneumatic cylinder, and the floating device **10**, which is partly housed in the through hole **7** and can float within the nosepiece **3**. The floating device **10** includes a floating
5 element **11** defining an adjustable plane and is locked by a not illustrated screw between a rest element **15** and a floating nosepiece **16** having a rest surface **26**. The floating element **11** is suitably shaped, as it will be hereinafter disclosed in detail, and mostly extends along a
10 direction transversal to the direction Z.

The floating element **11** protrudes from the side openings **8**, **9** of nosepiece **3** and includes a first shaped end portion **17** featuring two longitudinal plane surfaces **18**, **19** being mutually convergent and defining an edge **20** at a
15 substantially middle longitudinal section of the floating element **11**. The end portion **17** also includes a checking portion **21** with a decreasing thickness which defines a suitable sloping plane surface **31**, for example with a slope of less than 10° , with respect to the adjustable plane
20 defined by the whole floating element **11**. An end portion **22** of the floating element **11**, which is longitudinally opposed to the first end portion, includes a slot **23** for a guide pin **24** connected to the base **2**.

The optoelectronic checking system **1** enables to check the
25 roll and pitch angles of the bearing of a HSA in a static way, said angles being defined as rotated arrangements of the bearing about directions X and Y perpendicular to the direction Z.

The operation of the optoelectronic checking system **1** is
30 herein disclosed in more detail.

In a preliminary calibration phase, an HSA sample **32**, which is partly visible in figure 3, is checked for determining a sample attitude to which the subsequent attitude checkings carried out on the bearing of the HSA will make reference.
35 An HSA sample does not typically includes the bearing but it is shaped so as to include an external surface **33** reproducing the theoretical arrangement of a working

surface of the bearing, said working surface defining in turn the working attitude of the HSA. Hence, the HSA sample **32** is located and referred at positioning surfaces **34** of a first component part, in particular of the associated E-block, on the reference surface **25** of the reference nosepiece **3**, and locked by the floating ball **6** of the locking device **4** at a predetermined checking position, in such a way that the thin plates of the HSA are arranged substantially parallel to the floating element **11**, aligned with the end portion **17**. Once locked the HSA sample **32** in the predetermined checking position, the pneumatic piston is actuated for urging the ball **12** against the rest element **15** of the floating device **10**, which is in turn urged to contact a second component part of the HSA sample **32**, in particular the above-mentioned external surface **33**. Thus, the rest surface **26** of the floating nosepiece **16** fully rests on the external surface **33** of the HSA sample **32** and reproduces the attitude of the latter. As the floating element **11** is integral with the floating nosepiece **16**, the former takes the same attitude of the HSA sample **32**, too. It should be noted that, although the E-block is referred to the reference nosepiece **3**, the floating element **11** contacts the external surface **33** of the HSA sample **32** which reproduces the bearing and takes the attitude of the latter regardless of the E-block attitude.

The utilized optoelectronic detection device is, as hereinbefore said, of the known shadow casting type and includes an emitter **A** emitting infrared beams (shown in simplified form by broken lines in figure 1 and identified by reference number **28**) that travel towards a receiver **B** including a plurality of photodetectors. A mechanical piece located between the emitter **A** and the receiver **B** partly intercepts the emitted beams **28** and, as a consequence, just a part of the emitted beams **28** is detected by the receiver **B**. The part of emitted beams **28** that are detected by the receiver **B** provides information about the dimensions of the mechanical piece in a per se known way.

The optoelectronic device is arranged in such a way that the emitted beams **28** lay substantially on a plane YZ perpendicular to the direction X and the floating element **11** is arranged between the emitter **A** and the receiver **B**.

5 The floating element **11** thus intercepts the beams **28** emitted by the emitter **A** and determines a shadow area upon the receiver **B**. In particular, at a determined transversal section, the optoelectronic device detects a thickness dimension or "virtual" thickness of the floating element
10 **11**, which corresponds to the length along the direction Z of the projection of the considered section of the floating element **11**.

At a transversal section of the checking portion **21**, the "virtual" thickness detected by the optoelectronic device
15 depends on the slope of the plane surface **31** with respect to the plane XY. Such a slope depends on both the geometric characteristics and the attitude of the floating element **11**, which is determined by the roll angle of the external surface **33** of the HSA **32**, as hereinbefore explained. During
20 the calibration phase carried out with the HSA sample **32**, there is assumed that the thickness dimension of the floating element **11**, detected at a determined transversal section of the checking portion **21**, corresponds to a zero value of a roll angle.

25 By virtue of the slope of the plane surface **31** with respect to the adjustable plane defined by the floating element **11**, it is possible, for limited values of the roll angle, to detect whether variations of the roll angle are positive or negative. If otherwise the plane surface **31** were parallel
30 to the adjustable plane, rotations occurring in both directions would cause an increasing of the detected thickness dimension. On the contrary, when the plane surface **31** is suitably sloping, the amount of the virtual thickness depends on the rotation direction of the floating
35 element **11**. By way of example, it should be noted that, with reference to the view of figure 2, when the floating element **11** rotates about the direction X in a clockwise

direction, the virtual thickness increases; whereas in the case of rotations of the floating element **11** in a counterclockwise direction, the virtual thickness decreases.

5 It is also possible to check the height and the pitch angle of the floating element **11**, and thus of the external surface **33** of the HSA sample **32**, by checking - by means of the optoelectronic detection device - the height and inclination on plane XZ of the edge **20**. It is to be noted
10 that, for limited variations of the roll angle, the edge **20** defines the upper end of the virtual thickness of the floating element **11** at the considered transversal section and is not eclipsed by other points of the end portion **17**. An height reference value can be associated to the height
15 of the edge **20** at a determined transversal section with reference, for instance, to the reference plane surface **27**. The pitch angle can be checked by repeating the height checking of the floating element **11** at at least one different transversal section including the edge **20**, and
20 processing the achieved results in a known way. In this case too, it is possible to associate a value equal to zero to the height and pitch value which is detected when the HSA sample **32** is assembled.

Once finished the preliminary calibration phase, it is
25 possible to proceed with the real check and replace the HSA sample **32** with an HSA to be checked.

Similarly to what has been previously disclosed, the HSA is referred to the annular reference surface **25** by means of suitable positioning surfaces of the E-block **29**, and is
30 locked in a predetermined checking position by the locking device **4**. Once the checking position of the HSA is defined, the pneumatic piston **13** is actuated for urging the floating device **10** to contact suitable working surfaces of the HSA bearing. Hence, the floating element **11** and relevant
35 adjustable plane take the attitude of the working surfaces of the HSA bearing, in terms of height and roll and pitch angles, that generally differ from the previous case

relating to the HSA sample **32**.

In practice, the height and the roll and pitch angles of the HSA bearing are obtained, by means of processing carried out in the unit **C** of the signals provided by the receiver **B**, by comparing them with the values of the height and the roll and pitch angles detected in the calibration phase with the HSA sample **32**.

The optoelectronic checking system can be modified, without departing from the scope of protection of the present invention. Component parts that are differently shaped or have different dimensions from those hereinbefore described, can be employed as well. In particular, the floating element **11** can be differently shaped, and, for example, the edge **20** and the abutment plane **21** thereof can be reversely arranged or have different slopes.

CLAIMS

1. Optoelectronic system for checking relative attitude of component parts of a mechanical piece including:
- 5 - a base **(2)**;
- a reference system **(40)**, connected to the base **(2)** and adapted to refer the mechanical piece in a predetermined position, the reference system including a stationary support **(3)** which defines a reference
- 10 plane (XY) and is adapted to cooperate with positioning surfaces **(34)** of the mechanical piece,;
- an optoelectronic detection device **(A,B)**; and
- a processing unit **(C)** adapted for receiving and processing signals of the optoelectronic detection
- 15 device **(A,B)**;
- characterised in that said reference system **(40)** further includes a floating device **(10)** which floats with respect to the stationary support **(3)** and is adapted to cooperate with a working surface **(33)** of a component
- 20 part the relative attitude thereof is checked, said floating device **(10)** including a floating element **(11)** which defines an adjustable plane adapted to cooperate with the optoelectronic detection device **(A,B)**.
- 25 2. The optoelectronic system according to claim 1, wherein the optoelectronic detection device **(A,B)** is adapted to provide signals indicative of the position and/or the dimensions of portions **(17, 21)** of said floating element **(11)**, and said processing unit **(C)** is adapted to provide
- 30 information concerning the relative attitude of said component parts of the mechanical piece to be checked.
3. The optoelectronic system according to any one of claims 1 to 2, wherein said floating element **(11)** includes a
- 35 checking portion **(21)** having a plane surface **(31)** which is sloping with respect to said adjustable plane.

4. The optoelectronic system according to any one of claims 1 to 3, wherein said floating element **(11)** includes two longitudinal plane surfaces **(18,19)** that are convergent so as to form an edge **(20)** at a substantially middle longitudinal section of the floating element **(11)**.
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5. The optoelectronic system according to any one of the preceding claims, wherein the floating device **(10)** includes a floating nosepiece **(16)** integral with the floating element **(11)** which defines a rest surface **(26)** and is adapted to cooperate with said working surface **(33)** of the component part of the mechanical piece.
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6. Method for checking relative attitude of component parts of a mechanical piece by means of an optoelectronic system **(A,B)**, including the steps of:
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- referring a first component part of the mechanical piece to a reference system **(40)**; and
 - locking the mechanical piece to be checked at a checking position;
- 20
- characterised by
- bringing a floating device **(10)** including a floating element **(11)** to contact a second component part of the piece; and
 - carrying out dimensional and positional checkings of portions **(17, 21)** of the floating element **(11)** by means of the optoelectronic system **(A,B)**.
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7. The method according to claim 6, wherein said mechanical piece to be checked is a head stack assembly (HSA) including an E-block and a bearing, said first component part corresponding to the E-block and said second component part corresponding to the bearing.
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8. The method according to any one of claims 6 and 7, wherein said step of carrying out dimensional and positional checkings of component parts **(31,20)** of the
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floating element **(11)** includes the step of checking thickness dimensions of the floating element **(11)** at a transversal section.