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(54) **MAGNETIC HARD DISK STORAGE DEVICE**

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(52) **U.S. Cl.** .... **310/67 R**; 310/42; 310/90; 310/156
(58) **Field of Search** .... 310/67 R, 42, 310/90, 156

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(57) **ABSTRACT**

In order to reduce the cost of producing **[**an in-hub**]** *a magnetic hard disk storage device having a* motor, which consists of a hub and the motor which is located in this hub and which contains magnets, magnetic yokes, coils, and shieldings, the hub (**2**) made of magnetizable steel is coated at least on the outer surface (**20**) with a noncorrosive coating which is reduced by means of final machining in the completed state of the motor.

21 Claims, 2 Drawing Sheets

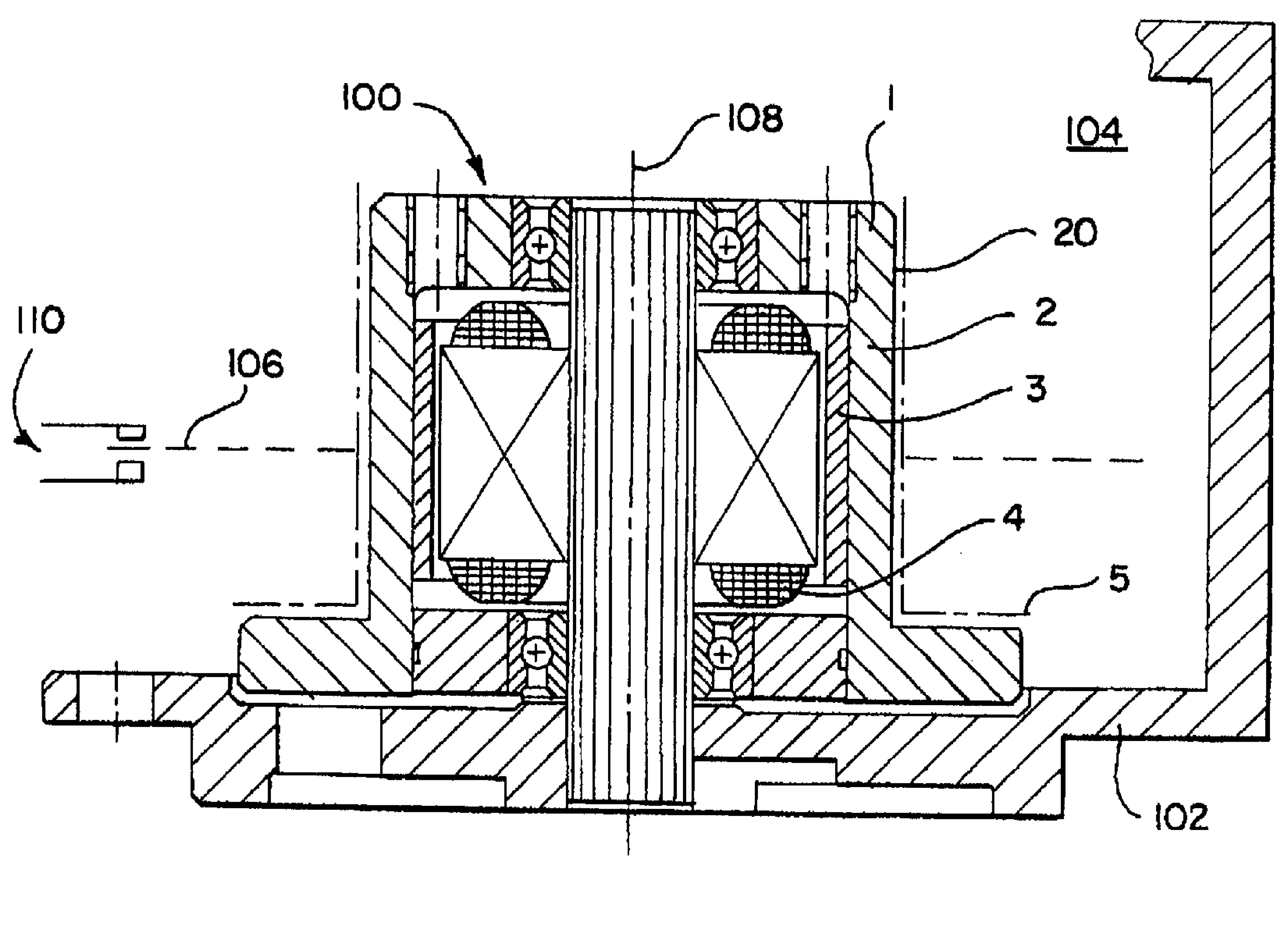


FIG. 1
PRIOR ART

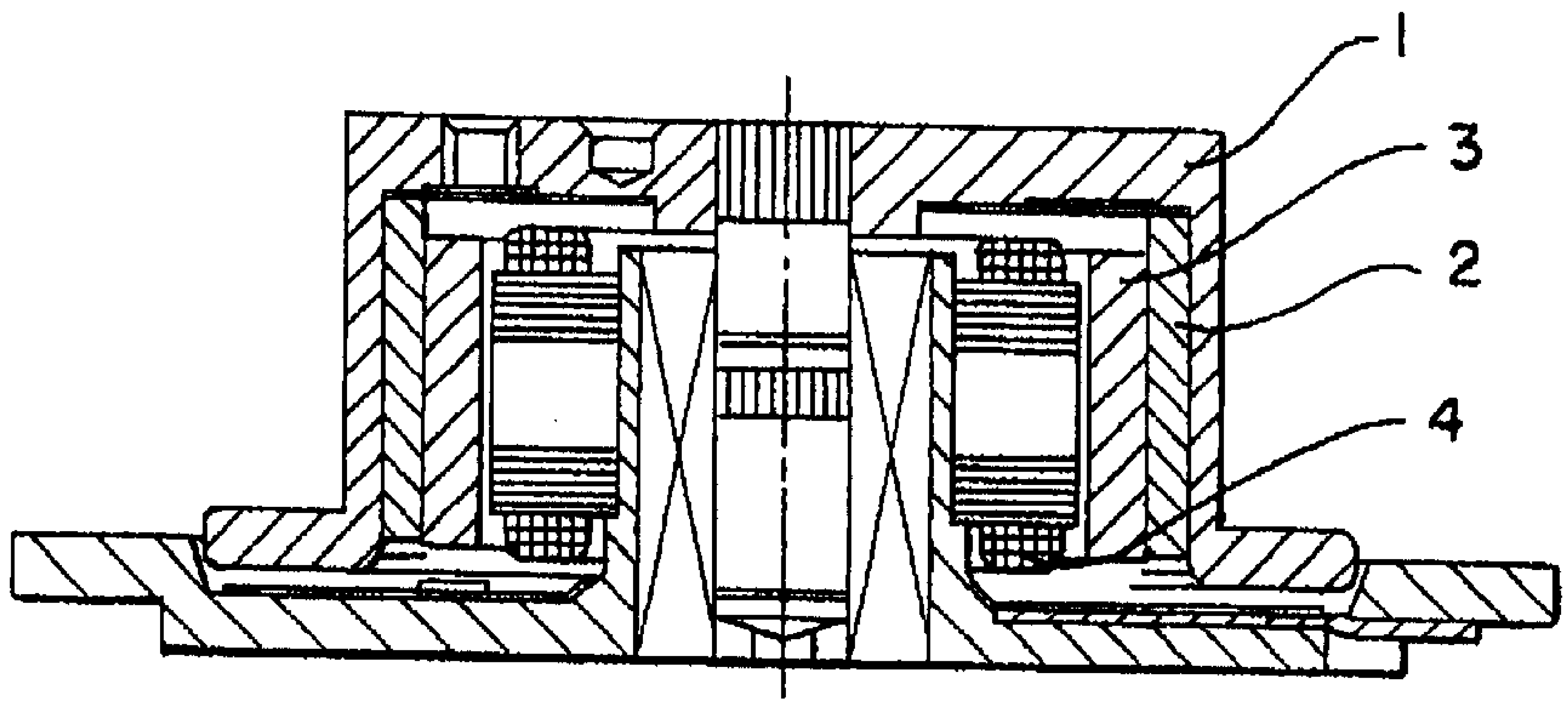


FIG. 2

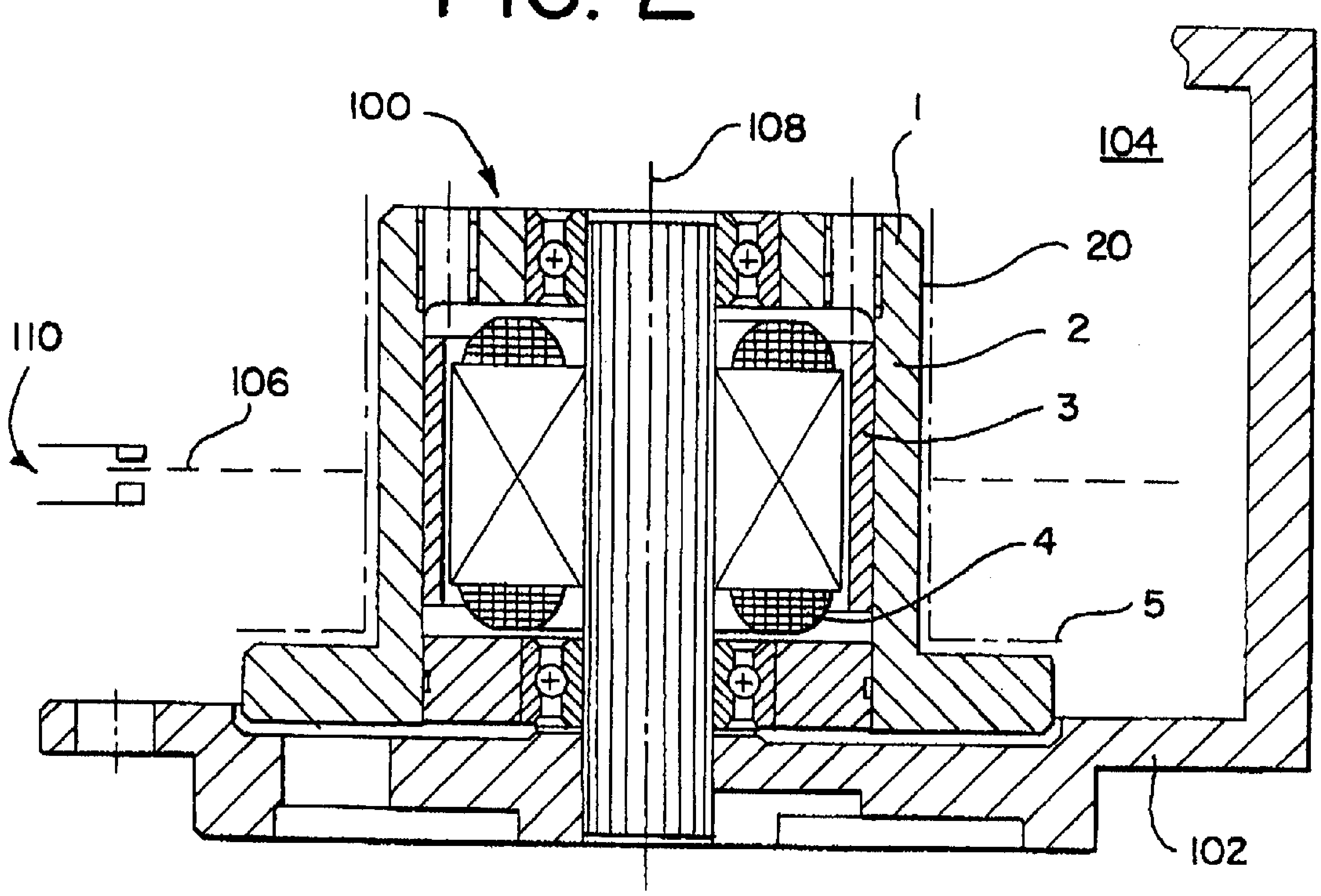
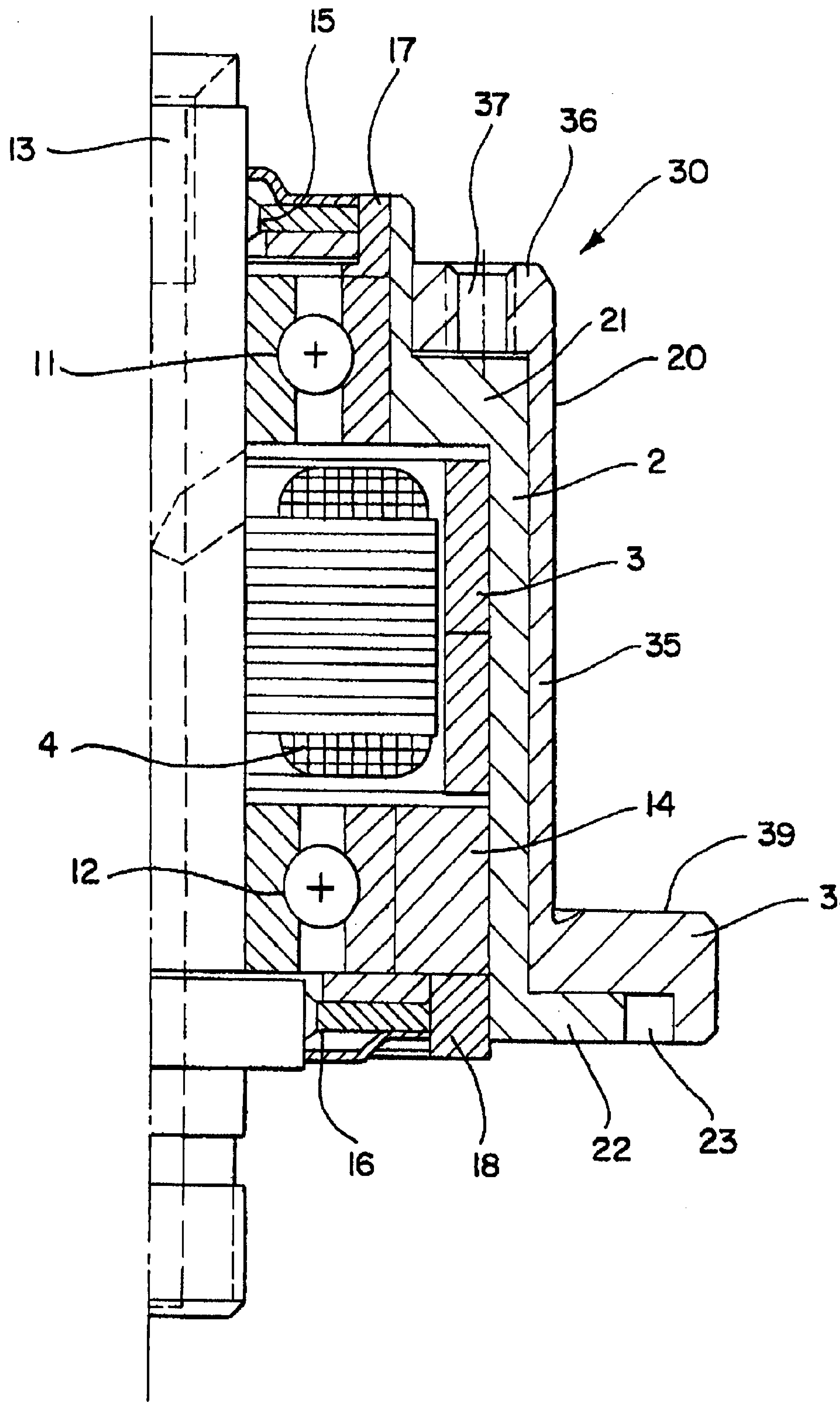


FIG. 3



MAGNETIC HARD DISK STORAGE DEVICE

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

This application is a continuation of application Ser. No. 200,654 filed May 31, 1988.

BACKGROUND OF THE INVENTION

The invention concerns an in-hub motor.

In-hub motors, as found, for example, in Winchester mechanisms in data processing, have been developed to provide a particularly high degree of freedom with respect to radial and axial eccentricity. Among other things, this freedom is obtained by giving the aluminum vat, which forms the hub and in which the magnetic yokes and magnets are secured, its fine machining, i.e., grinding or stripping, on the finished motor.

In the case of motors with a large ratio of torque to volume, the magnetic yoke and the plate hub are constructed as one piece and consist of magnetizable steel, which must have a rustproof coating. This rustproof coating prevents any machining of the hub in the finished motor, thus requiring that the hub be manufactured with very high precision before installation.

It must be borne in mind that the eccentricity tolerance of the finished motor should be the result of the sum of the eccentricity tolerances of the constituent parts so that, for example, the ball bearings, the plate hub itself, and the joining accuracy required at the time of assembly must remain below 5 μ.

The rustproof coating must lie within these tolerance limits. On the other hand, it is not possible to avoid such a rustproof coating by the use of stainless steel because this steel would not exhibit those magnetic properties that are particularly necessary in this type of motor.

Thus, the expenditure of time and money in the production of this type of motor is very high due to grinding, honing, or polishing. This production expenditure cannot be reduced even if large quantities of the motor are produced.

The objective, therefore, should be to reduce this production expenditure as much as possible.

SUMMARY OF THE INVENTION

The solution to this problem is to coat the hub, which consists of magnetizable steel and which has the form of a yoke body, with a noncorrosive coating at least on the outer surface, which is reduced by final processing in the completed state.

In order to bond the noncorrosive coating to the hub, all currently known joining techniques, such as shrink coating, dipping, sputtering, or bonding of caps or casings on the hub, may be employed.

Particularly during the use of galvanically deposited aluminum, a considerable reduction in production expenditure results based on the high adhesive strength and excellent machinability.

Other materials, which adhere excellently to the iron core of the hub, are also appropriate. This suitability is even greater when the specific weights of the hub and the coating are identical.

An additional improvement can be obtained if the entire hub, both inside and outside, is covered with the noncorrosive coating. This results primarily in a long-term constancy of the minimum radial and axial eccentricity obtained after final forming. In addition, the temperature profile of shaft, ball bearing, and rotor is mutually adjusted so that eccentricity variations are minimized during operation.

The following are advantages of the process described above: the production expenditure is significantly reduced, instances of corrosion no longer occur, long- and short-term variations in eccentricity are minimized, and the mechanical stability of the rotor is improved.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing which further illustrates the invention, shows

FIG. **1** illustrates a motor of standard design;

FIG. **2** illustrates an initial application example of a motor according to the invention; and

FIG. **3** illustrates a second application example of a motor according to the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

In FIG. **1**, hub **1**, consisting of aluminum supports a magnetic yoke in the form of yoke body **2** on which magnets **3** are arranged: stator coils **4** drive hub **1**. The final machining of the hub takes place in the completed state of the motor and includes the usual methods for material removal, such as finish turning by machining of the outer surfaces of hub **1**. *Motor 100 is mounted on a baseplate 102 which forms part of a hard disk drive housing and encloses a clean room 104. At least one magnetic hard storage disk 106 is mounted on hub 1 for rotation about axis 108 as diagrammatically illustrated in FIG. 2. At least one read/write head 110 is mounted on clean room 104 for movement in operative relation to the disks 106 to allow information to be stored on and retrieved from disks 106.*

In order to reduce the volume, in the motor, as shown in FIG. **2**, the yoke body **2** is designed as a ringlike support and supports magnets **3**. Stator coils **4** also drive the hub here. Yoke body **2** consists of magnetizable steel.

The conventionally employed noncorrosive coating **5**, which is at least applied to the outer surface **20** of hub **1**, however, is no longer only a few μ thick, but instead has a range in thickness of from 15 μ to approximately 200 μ. Thus, it is no longer just a protection against corrosion but a mechanically machinable component which can be primarily used to reduce radial eccentricity, particularly by means of final finishing of the built-in shaft.

The coating can consist of plastic or metal and should adhere very tightly to hub **1**.

FIG. **3** shows a cross section of a second application example, which, as already described in FIG. **2**, contains magnetic yoke body **2** with an upper flange **21** and which, designed as hub **30**, is made of magnetizable material. Yoke body **2** supports magnets **3**. Coils **4** drive hub **30** as described in the preceding application examples. This hub **30** contains yoke body **2** which is made of magnetizable steel and which is designed as a ring-shaped support. This steel forms the magnetic yoke. Casing **35** made of aluminum is fastened to the core by means of shrink coating. The upper end (as viewed in FIG. **3**) of casing **35** contains thickened rim **36**, with mounting boreholes **37**, with this rim turning radially toward, the inside. The lower end of casing **35** is equipped with flange **38**, which, projects radially toward the outside and has planar surface **39**. For the purpose of final machining, the assembled and mounted motor is put into operation, and surfaces **20** and **39** are given their final shape, for example, by means of precision turning. Bearings **11** and **12** are, on the one hand, fastened to shaft **13**, and, on the other hand, to the inside of yoke body **2**. Upper bearing **11** is directly installed into the yoke body **2**. Lower bearing **12** is surrounded by spacer ring **14** in order to arrive at similar positions in the case of predetermined dimensions. Ferrofluid seals **15** and **16** are provided axially outwardly of each of bearings **11** and **12** and seal the motor compartment from the surrounding environment. Ferrofluid seals **15** and **16** are surrounded by eccentric rings **17** and **18** on their outside diameters. The insertion of axial mounting boreholes **37** in (thickened rim **36** of) the casing leads to a further simplification of yoke body **2**, as the yoke body is simplified to a pure swivel part, since the upper and lower edges of the noncorrosive coating, which is made of easily machinable material and which is designed as casing, ensure, it is true, slightly higher material costs, but lead to a further reduction in cost due to the improved machinability.

Conventional joining techniques, such as shrink coating of a cap or casing, bonding of such elements, or coating by dipping, sputtering, or galvanization, can be used to create the coating. On the one hand, the coating should be applied so as to be sufficiently thick to ensure satisfactory handling during assembly of the motor and, on the other hand, thin enough so that it can be reduced at minimum cost during the final machining procedure on the shaft.

A relatively modern shrink-coating process uses the dynamic effect of electromagnetic parts at high pulse-like currents. This so-called magnetic molding process is particularly suited for aluminum casing **35**, which is to be tightly applied to the underlying steel core of the hub, thus forming a disk storage hub.

Thin coatings of aluminum up to a thickness of 0.2 mm can be applied most effectively by means of evaporation, thus giving a uniform thickness to the entire surface.

The invention can be used advantageously particularly in hard-disk storage devices with a disk diameter of 5.25 inches or less.

Magnetic yoke body **2** as well as casing **35**, preferably made of aluminum, each have a Z-shaped cross section with parts of the casing **35** and yoke body **2**, respectively, lying adjacent and parallel to each other. The radial outer ends of lower flanges **22** and **38** are designed in such a way as to form surrounding groove **23** into which metal ballast can be axially inserted (or removed).

What is claimed is:

[1. In-hub motor comprising:

a fixed shaft extending axially of the motor;

a stator mounted on the fixed shaft;

a pair of ball bearings mounted on the fixed shaft axially spaced apart from each other on either axial end of the stator;

a rotor mounted over and at least foundationally supported by both said axially spaced apart ball bearings to rotate around the stator and be separated therefrom by a cylindrical air gap, the rotor including

a yoke body of magnetic material having a cylindrical inner surface and a cylindrical outer surface and formed to axially span both said spaced apart ball bearings in support of the rotor and

ring shaped permanent magnets mounted on the inner surface of the yoke body opposite the stator and defining an extent of the air gap; and

a coating of machinable noncorrosive material applied to the outer surface of the yoke body, said coating being of a predetermined thickness to provide a surface capable of being machined to reduce radial eccentricity in a finished motor.]

[2. Motor according to claim **1**, wherein said predetermined thickness of the coating of machinable noncorrosive material is within a range of from 15 μ to approximately 200 μ.]

[3. In-hub motor comprising:

a fixed shaft extending axially of the motor;

a stator mounted on the fixed shaft;

a pair of ball bearings mounted on the fixed shaft axially spaced apart from each other on either axial end of the stator;

a rotor mounted over and at least foundationally supported by both said axially spaced apart ball bearings to rotate around the stator and be separated therefrom by a cylindrical air gap, the rotor including

a yoke body of magnetic material having a cylindrical inner surface and a cylindrical outer surface and formed to axially span both said spaced apart ball bearings in support of the rotor and

ring shaped permanent magnets mounted on the inner surface of the yoke body opposite the stator and defining an extent of the air gap; and

a casing of noncorrosive material of predetermined thickness having two axially opposing ends, one of which is for securing the casing to the yoke body of the rotor, the casing being made to conform to the outer surface of the yoke body and being nested over the outer surface of the yoke body providing a machinable surface for reducing radial eccentricity in a finished motor.]

[4. Motor according to claim **3**, wherein the casing of noncorrosive material further has at its mounting end a thickened rim with a mounting borehole therethrough, the rim turning radially toward the inside of the motor.]

[5. Motor according to claim **3**, wherein the casing of noncorrosive material further has at its end opposite its mounting end a flange with a planar surface which turns radially outwardly of the motor and terminates in a radially outer end.]

[6. Motor according to claim **5**, wherein the yoke body also includes a radially outwardly extending flange terminating in a radially outer end, the yoke body flange extending in parallel to the casing flange at the casing end opposite its mounting end and further including a surrounding groove with an axial recess provided between the radial outer ends of the two flanges.]

[7. Motor according to claim **4** wherein the yoke body includes a radially inwardly extending flange in parallel to the thickened rim, the flange mounting directly on an adjacent bearing and supporting the thickened rim.]

[8. Motor according to claim **3**, wherein said predetermined thickness of said casing is within a range of from 15 μ to 2 mm.]

[9. Motor according to claim **3**, wherein the noncorrosive material is aluminum.]

10. A disk storage device, comprising:

a clean room having an internal mounting surface;

at least one hard magnetic storage disk provided in said clean room for rotation about an axis, said at least one disk having a central opening;

at least one read/write head mounted in said clean room for movement in operative relation to said at least one disk;

a motor mounted on the internal mounting surface of said clean room for rotating said at least one disk about said *axis, said motor including a stator and a bearing and shaft assembly, said assembly including a shaft extending axially of the motor and bearings surrounding said shaft, said motor further including a rotor which is rotatable via said bearings about said axis, said rotor including a cylindrical yoke body of magnetic material and a plurality of ring-shaped permanent magnets connected to said yoke body such that a cylindrical air gap is defined between adjacent surfaces of said permanent magnets and said stator, said motor further including a coating of a machinable noncorrosive material applied to a cylindrical outer surface of said rotor which extends through the central opening of and thereby supports said at least one disk, said coating being of a predetermined thickness to provide a surface capable of being machined to generally reduce radial eccentricity in a finished motor.*

11. The disk storage device of claim 10 wherein said motor comprises an in-hub motor.

12. The disk storage device of claim 10 further comprising at least one seal for generally sealing the motor compartment from clean room.

13. The disk storage device of claim 12 wherein said at least one seal comprises at least one magnetic fluid seal.

14. The disk storage device of claim 10 wherein said coating is applied to the outer surface of said rotor by means of a chosen from the group consisting of: dipping, sputtering, galvanization, and evaporation.

15. The disk storage device of claim 10 wherein the predetermined thickness of said coating is within a range of from about 15μ to about 2 mm.

16. The disk storage device of claim 10 wherein said coating is aluminum.

17. The disk storage device of claim 10 wherein said magnetic material comprises steel.

18. A disk storage device, comprising:

a clean room having an internal mounting surface;

at last one hard magnetic storage disk provided in said clean room for rotation about an axis, said at least one disk having a central opening;

at least one read/write head mounted in said clean room for movement in operative relation to said at least one disk;

a motor mounted on the internal mounting surface of said clean room for rotating said at least one disk about said axis, said motor including a stator and a bearing and shaft assembly, said assembly including a shaft extending axially of the motor and bearings surrounding said shaft, said motor further including a rotor which is rotatable via said bearings about said axis, said rotor including a cylindrical yoke body of magnetic material and a plurality of ring-shaped permanent magnets connected to said yoke body such that a cylindrical air gap is defined between adjacent surfaces of said permanent magnets and said stator, said motor further including a machinable noncorrosive casing of a predetermined thickness applied to a cylindrical outer surface of said rotor which extends through the central opening of and thereby mounts said at least one disk, said casing having two axially opposing ends, one of which is for securing said casing to the cylindrical outer surface of said rotor, said casing being made to conform to and be nested over the cylindrical outer surface of said rotor to provide a machinable surface for generally reducing radial eccentricity in a finished motor.

19. The disk storage device of claim 18 wherein said motor comprises an in-hub motor.

20. The disk storage device of claim 18 further comprising at least one seal for generally sealing the motor compartment from clean room.

21. The disk storage device of claim 20 wherein said at least one seal comprises at least one magnetic fluid seal.

22. The disk storage device of claim 18 wherein said coating is applied to the outer surface of said rotor by means of a chosen from the group consisting of: dipping, sputtering, and galvanization.

23. The disk storage device of claim 18 wherein the predetermined thickness of said coating is within a range of from about 15μ to about 2 mm.

24. The disk storage device of claim 18 wherein said casing is aluminum.

25. The disk storage device of claim 18 wherein said magnetic material comprises steel.

26. The disk storage device of claim 18 wherein said casing of non-corrosive material has a mounting end secured to an axial end of said cylindrical yoke body, said mounting end including a thickened rim with a mounting borehole therethrough, said rim turning radially toward the inside of said motor.

27. The disk storage device of claim 18 wherein said casing of noncorrosive material further has at its end opposite its mounting end a flange with a planar surface which turns radially outwardly of the motor and terminates in a radially outward end.

28. The disk storage device of claim 27 wherein said yoke body includes a radially outwardly extending flange terminating in a radially outer end, said yoke body flange extending in parallel to said coating flange at the coating end opposite its mounting end, said yoke body further including a surrounding groove with an axial recess provided between the radial outer ends of the two flanges.

29. The disk storage device of claim 26 where said yoke body includes a radially inwardly extending flange in parallel to the thickened rim, the flange mounting directly on an adjacent bearing and supporting the thickened rim.

30. The disk storage device of claim 18 wherein said casing is applied to the cylindrical outer surface of said rotor by means of a technique chosen from the group consisting of: shrink coating, bonding, and magnetic molding.

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