

Description

This invention is directed generally to the field of disc drives and more particularly to an improved spindle motor construction for a disc drive.

This invention is especially useful in a spindle motor used in a rotary actuator of the type disclosed in US-A-5051855 and 4881140.

Disc drive machines record and reproduce information stored on concentric circular tracks on magnetic discs. These recording discs are driven at a constant rotational speed by a spindle motor, while a transducer is selectively positioned over locations on the disc where the information to be accessed is stored, in order to be able to rapidly and accurately access the information stored on the disc. Therefore it is important to provide a spindle motor capable of quickly bringing the discs up to their constant rotational speed, and which is also capable of maintaining that constant rotational speed for a significant period of time.

The difficulty of properly designing such a motor is compounded by the constant reduction in size of disc drives. Disc drives have an increasingly low profile, thereby necessitating the use of many innovative design techniques in achieving an efficient, low profile dc spindle motor. One answer to the problem of the need for such a motor has been the use of what is commonly termed a pancake motor. The common structural features of a pancake motor include a plurality of flat, axial coils of the air core type affixed to a printed circuit board to define the motor stator. The coils are regularly axially spaced about a motor shaft which extends through the printed circuit board. One end of the shaft is mounted on bearings to extend up through the disc drive base casting, the top of the shaft carrying a hub which supports one or more discs for constant rotation. The other end of the shaft supports a shallow, cup-shaped element containing an annular permanent magnet comprising the motor rotor. The rotor and stator operate in combination to provide a brushless dc motor particularly suited for a disc drive.

When the coils are energized in order, currents flowing therethrough interlink with magnetic flux from the permanent magnet so as to generate torque for rotating the motor shaft. In some such motors, it is known to provide a stationary magnetic return path annular on the opposite side of the coils from the flat, rotating magnet.

The use of such a stationary magnetic return path is already known in this technology. However, such stationary magnets are usually stamped from a sheet of magnetic steel. Because of the direction of magnetic flux in the steel runs perpendicular to the direction of lamination, high current losses are induced and represent a significant loss of power.

Such eddy currents occur in steel plate when the magnetic field is changed as a function of time. In cases of a motor such as the type described herein, when the field is reversed, which happens at a relatively high frequency, eddy currents are induced in the direction that produces a magnetic field to oppose the change. Thus, significant eddy current losses can occur.

Prior efforts to reduce eddy current losses have attempted to use a return path constructed out of powdered metal such as steel of 3% silicon. Some reduction in losses will occur; however, the powdered metal is difficult to manufacture in thin sheets, and material that has good high frequency performance tends to be brittle in such thin sheets.

In some such motors, it is known to provide a stationary magnetic return path annular on the opposite side of the coils for the flat, rotating magnet. JP-A-62 293959 discloses an example of such an arrangement.

It is an objective of this invention to provide an improved disc drive spindle motor which is inexpensive to manufacture and assemble.

This invention provides a spindle motor for use in a disc drive comprising a base casting for the drive, a shaft extending through said base casting and carrying a hub supporting one or more discs for rotation, said shaft being supported for rotation in said casting by one or more bearings, a flat rotor connected to the shaft and extending axially parallel to the base casting, said rotor comprising a magnet supported by a rotor support plate carried on an end of said shaft, a plurality of axially oriented air core coils disposed in a toroidal path around said shaft and in a plane parallel to said flat rotor and a toroidal magnetic return path element in the form of a wound coil of thinly sliced sheet steel to complete the magnetic circuit, disposed on the opposite side of said axially oriented coils from said rotor; wherein a single printed circuit board is provided mounted on the base casting with first and second surfaces of the board out of contact with the casting; said air coils being located on said first surface of the board and said magnetic return path element being supported on the second surface of the board.

The tape wound magnetic return path allows the magnetic flux to flow easily in a circumferential direction, while preventing eddy currents from flowing in a radial direction, thereby significantly reducing eddy current losses. In a preferred form, the steel would be 0.010 cms (.004") thick and 0.15 cms (.060") wide, and is formed by winding on a core to a suitable size. Such a tape wound coil is mechanically sound, and inexpensive to manufacture. By providing the coil on one side of a printed circuit board opposite to the side of the printed circuit board that supports the flat stator coils, and

by further designing the printed circuit board to include all necessary electronic components for commutation of the axial coils and rotor position sensing, a highly efficient spindle motor, inexpensive to manufacture and assemble, is achieved.

The features and advantages of this invention will be better understood with reference to the following drawings, wherein:

FIG 1 is vertical sectional view of a spindle motor incorporating this invention;

FIG 2 shows the single printed circuit board used to support both the coils and the magnetic return path of the disc drive;

FIG 3 illustrates the steel core coil that forms the magnetic return path of this invention;

FIGs 4A, 4B and 4C illustrate the improvement gained by this invention in reduction of eddy currents; and

FIGs 5A and 5B are a vertical sectional view and plan view, respectively, of the base casting as it supports the molded circuit board of the invention.

In order to facilitate understanding of this invention and the problems solved thereby, reference will first be made to FIG 1 in which a flat, brushless dc motor 10 of a type incorporating this invention is illustrated in vertical section. The low profile spindle motor 10 uses bearings 12, 14 incorporated directly into the disc drive base casting 16 to support the shaft 18 for rotation. A hub 20 supported on the top of the shaft 18 carries one or more discs 22 for rotation. Appropriate preload of the bearings 12, 14 is achieved and maintained with a spring 24 located between the bearings and arranged to produce a preload configuration known as DB in the art, which provides the greatest possible stability for the bearing system within the casting 16.

The motor electronics are provided mounted on a single printed circuit board 26 supported from the casting 16. Specifically, the casting 16 has shoulders 30 and 32 which define a central bore in which the bearings 12, 14 which support the shaft 18 are located. Located on the outer surface of the shoulder 32 is an opening that may be used to locate the inner end 36 of the printed circuit board 26 to the casting 16. The outer end 38 of the printed circuit board is similarly supported from the casting 16.

The outer end of the shaft 18 supports a shallow cup-shaped element 40 having an up-turned end 42 which forms the support for the motor rotor. The cup-shaped element 40 supports a motor rotor in the form of an annular permanent magnet 43 which is adhered to its inner surface. In a preferred embodiment, the annular magnet 43 is configured to have eight pie-shaped sectors of alternating magnetic polarities, facing the six flat axial air core

coils 44A-F, which are affixed to the printed circuit board as shown in FIG 2A. It can be seen from an inspection of FIG 1 that the coils 44 are aligned with and overlie the annular magnet 43 so that with selective sequential energization of the coils 44, a magnetic path is completed between a section of the magnet of one polarity, one of the coils, and returning to an oppositely polarized section of the magnet 43. Thus, by sequentially energizing the coils, rotation of the magnet and its rotor 43 and thus, the shaft 18, is achieved.

It is well known in this technology to provide a magnetic return path 50 to efficiently complete the magnetic circuit. However, as discussed above, such magnetic return paths have typically been formed of sheet steel or powdered metal, and thus have been subjected to significant eddy current losses. As more specifically shown in FIG 4A, the eddy currents illustrated by the arrows 52 in FIG 4A can be significant in solid steel return paths because there is nothing to block the current flow.

FIG 4B illustrates one form of this invention, in that the return path is formed of coarsely wound, i.e., relatively thick, steel spiral. Here, as illustrated by the arrows 54B, the eddy currents are significantly reduced, as there is only a limited place for current to flow. FIG 4C illustrates a more finely wound return path element, resulting in even more limited eddy currents, as indicated by arrows 54C.

In the preferred form of this invention illustrated in FIG 3, the return path is formed of wound steel tape 60 on the order of 0.010 cms (.004") thick and 0.15 cms (.060") wide. Because of the very limited path for current to flow, the eddy currents are very small (see FIG 4C). Therefore, with this breaking up of the eddy current paths, the eddy currents are significantly diminished, maximizing the efficiency and power of the motor design.

A further efficiency of the present design is illustrated and apparent from FIGs 2A and 2B. As shown in these figures, all the discrete and LSI type electronic components such as the drive speed control electronics for both the stepper motor 70 and spindle motor 10 (shown more clearly in FIG 5B) are mounted on a single molded printed circuit board 26. FIG 2A shows the front ("primary") side 59 of this printed circuit board 26 mounting in annular array the six air core axial coils 44A-F whose selective energization drives the rotor of the motor. Posts 61 are provided molded into the board surface 69 to maintain the shape of each coil 44 and its accurate alignment in the annular array.

The necessary Hall effect devices 64A-C to control selective energization of the coils of the motor are arrayed on the same printed circuit board surface 59, together with all the other electronic components necessary for control of the

stepper motor at electronics section 73 adjacent to the stepper motor region 75 and spindle motor electronics 77 adjacent to the region 79 for mounting the spindle motor. In this way, assembly of the motor is facilitated, and its overall structural integrity is maximized. The precise location of the Hall devices 64A-C relative to the assembled spindle motor is also achieved.

The other side 63 of the molded board (shown in FIG 2B) supports the coil 60 directly beneath the casting 16 shown in FIG 1. The casting 16 itself is shown in a vertical sectional view in FIG 5A, and in plan view in FIG 5B. This view illustrates the relative positions of the location 79 for the spindle motor and the location 75 for the stepper motor. The molded printed circuit board as shown in FIG 5B underlies the entire region allocated to the spindle motor, and lies adjacent to the region allocated to the stepper motor. The use of this board to support the coil 60, cores 44 and electronics 73, provides for quick assembly, precise alignment of all elements of the spindle motor and effective use of space in this disc drive.

Claims

1. A spindle motor for use in a disc drive comprising a base casting (16) for the drive, a shaft (18) extending through said base casting and carrying a hub (20) supporting one or more discs for rotation, said shaft being supported for rotation in said casting by one or more bearings (12, 14), a flat rotor (43) connected to the shaft and extending axially parallel to the base casting, said rotor comprising a magnet (43) supported by a rotor support plate (40) carried on an end of said shaft, a plurality of axially orientated air core coils (44A-F) disposed in a toroidal path around said shaft and in a plane parallel to said flat rotor and a toroidal magnetic return path element in the form of a wound coil of thinly sliced sheet steel to complete the magnetic circuit, disposed on the opposite side of said axially oriented coils from said rotor; characterised in that a single printed circuit board (26) is provided mounted on the base casting with first and second surfaces (59, 63) of the board out of contact with the casting said air coils (44A-F) being located on said first surface (59) of the board and said magnetic return path element (60) being supported on the second surface of the board.
2. A spindle motor as in Claim 1, characterised in that the magnetic return path (60) is formed of steel about 0.010 cms thick.
3. A spindle motor as in Claim 2, characterised in that the magnetic return path (60) is formed of steel about 0.15 cms wide.
4. A spindle motor as in any of Claims 1 to 3, characterised in that control electronics (64A to C) for controlling rotation of said shaft (18) are mounted adjacent to said coils (44A to F) on said printed circuit board.
5. A spindle motor as in any of Claims 1 to 4, characterised in that shaft (18) extends through a bore in said casting, said bore defining a shoulder (32) on the side of said casting opposite said disc for mounting and supporting said printed circuit board (26).
6. A spindle motor as in any of Claims 1 to 5, characterised in that the periphery (38) of said printed circuit board (26) is supported from said casting (16).
7. A spindle motor as in any of Claims 1 to 6, including a plurality of posts (61) molded in said surface (59) of said printed circuit board (26) in annular array, said coils (44A to F) being mounted adjacent to said posts to maintain the shape of the coils and their alignment in the annular array.
8. A spindle motor as in any of the Claims 1 to 7, characterised in that said base casting further comprises means (75) for supporting a stepper motor relative to the constantly rotating disc of said spindle motor.
9. A spindle motor as in any of Claims 1 to 8, characterised in that said single printed circuit board extends to be adjacent to the region allocated to said stepper motor, the control electronics for said spindle motor being mounted adjacent said spindle motor on said printed circuit, the control electronics for said stepper motor being mounted adjacent to said stepper motor on said printed circuit board.
10. A spindle motor as in any of Claims 1 to 9, characterised in that a plurality of posts are molded in the surface of said printed circuit board in annular array, said coils being mounted adjacent to said posts to maintain the shape of the coils and their alignment in the annular array.

Patentansprüche

1. Spindelmotor für den Gebrauch in einem Plattenlaufwerk

stepper motor at electronics section 73 adjacent to the stepper motor region 75 and spindle motor electronics 77 adjacent to the region 79 for mounting the spindle motor. In this way, assembly of the motor is facilitated, and its overall structural integrity is maximized. The precise location of the Hall devices 64A-C relative to the assembled spindle motor is also achieved.

The other side 63 of the molded board (shown in FIG 2B) supports the coil 60 directly beneath the casting 16 shown in FIG 1. The casting 16 itself is shown in a vertical sectional view in FIG 5A, and in plan view in FIG 5B. This view illustrates the relative positions of the location 79 for the spindle motor and the location 75 for the stepper motor. The molded printed circuit board as shown in FIG 5B underlies the entire region allocated to the spindle motor, and lies adjacent to the region allocated to the stepper motor. The use of this board to support the coil 60, cores 44 and electronics 73, provides for quick assembly, precise alignment of all elements of the spindle motor and effective use of space in this disc drive.

Claims

1. A spindle motor for use in a disc drive comprising a base casting (16) for the drive, a shaft (18) extending through said base casting and carrying a hub (20) supporting one or more discs for rotation, said shaft being supported for rotation in said casting by one or more bearings (12, 14), a flat rotor (43) connected to the shaft and extending axially parallel to the base casting, said rotor comprising a magnet (43) supported by a rotor support plate (40) carried on an end of said shaft, a plurality of axially orientated air core coils (44A-F) disposed in a toroidal path around said shaft and in a plane parallel to said flat rotor and a toroidal magnetic return path element in the form of a wound coil of thinly sliced sheet steel to complete the magnetic circuit, disposed on the opposite side of said axially oriented coils from said rotor; characterised in that a single printed circuit board (26) is provided mounted on the base casting with first and second surfaces (59, 63) of the board out of contact with the casting said air coils (44A-F) being located on said first surface (59) of the board and said magnetic return path element (60) being supported on the second surface of the board.
2. A spindle motor as in Claim 1, characterised in that the magnetic return path (60) is formed of steel about 0.010 cms thick.
3. A spindle motor as in Claim 2, characterised in that the magnetic return path (60) is formed of steel about 0.15 cms wide.
4. A spindle motor as in any of Claims 1 to 3, characterised in that control electronics (64A to C) for controlling rotation of said shaft (18) are mounted adjacent to said coils (44A to F) on said printed circuit board.
5. A spindle motor as in any of Claims 1 to 4, characterised in that shaft (18) extends through a bore in said casting, said bore defining a shoulder (32) on the side of said casting opposite said disc for mounting and supporting said printed circuit board (26).
6. A spindle motor as in any of Claims 1 to 5, characterised in that the periphery (38) of said printed circuit board (26) is supported from said casting (16).
7. A spindle motor as in any of Claims 1 to 6, including a plurality of posts (61) molded in said surface (59) of said printed circuit board (26) in annular array, said coils (44A to F) being mounted adjacent to said posts to maintain the shape of the coils and their alignment in the annular array.
8. A spindle motor as in any of the Claims 1 to 7, characterised in that said base casting further comprises means (75) for supporting a stepper motor relative to the constantly rotating disc of said spindle motor.
9. A spindle motor as in any of Claims 1 to 8, characterised in that said single printed circuit board extends to be adjacent to the region allocated to said stepper motor, the control electronics for said spindle motor being mounted adjacent said spindle motor on said printed circuit, the control electronics for said stepper motor being mounted adjacent to said stepper motor on said printed circuit board.
10. A spindle motor as in any of Claims 1 to 9, characterised in that a plurality of posts are molded in the surface of said printed circuit board in annular array, said coils being mounted adjacent to said posts to maintain the shape of the coils and their alignment in the annular array.

Patentansprüche

1. Spindelmotor für den Gebrauch in einem Plattenlaufwerk



- mit einem Basisgußstück (16) für das Laufwerk,
 - mit einer Welle (18), die sich durch das Basisgußstück erstreckt und eine Nabe (20) trägt, welche eine Platte oder mehrere Platten drehbar abstützt, wobei die Welle in dem Gußstück durch ein oder mehrere Lager (12, 14) drehbar gelagert ist,
 - mit einem flachen Rotor (43), der mit der Welle verbunden ist und sich axial parallel zu dem Basisgußstück erstreckt, wobei der Rotor einen Magnet (43) aufweist, der von einer an einem Ende der Welle getragenen Rotorstützscheibe (40) abgestützt ist,
 - mit mehreren axial ausgerichteten Spulen (44A-F) mit Luftkern, die ringförmig um die Welle und in einer zu dem flachen Rotor parallelen Ebene angeordnet sind, und
 - mit einem ringförmigen magnetischen Rückleitungselement in Form einer Wickelspule aus dünn geschnittenem Stahlblech zur schließung des magnetischen Kreislafs, das auf der dem Rotor gegenüberliegenden Seite der axial ausgerichteten Spulen angeordnet ist,
- dadurch gekennzeichnet, daß eine einzelne gedruckte Leiterplatte (26) auf dem Basisgußstück angebracht ist, wobei eine erste (59) und eine zweite Oberfläche (63) der Leiterplatte nicht mit dem Gußstück in Kontakt sind, wobei die Spulen (44A-F) mit Luftkern auf der ersten Oberfläche (59) der Leiterplatte und das magnetische Rückleitungselement (60) auf der zweiten Oberfläche der Leiterplatte gelagert ist.
2. Spindelmotor nach Anspruch 1, dadurch gekennzeichnet, daß die magnetische Rückleitung (60) aus Stahl von ungefähr 0,010 cm Dicke besteht.
 3. Spindelmotor nach Anspruch 2, dadurch gekennzeichnet, daß die magnetische Rückleitung (60) aus Stahl von ungefähr 0,15 cm Breite besteht.
 4. Spindelmotor nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß eine Steuer elektronik (64A bis C) zum Steuern der Drehung der Welle (18) angrenzend an die Spulen (44A bis F) auf der gedruckten Leiterplatte angebracht ist.
 5. Spindelmotor nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß die Welle (18)

sich durch eine Bohrung in dem Gußstück erstreckt, wobei die Bohrung eine Schulter (32) auf der der Platte gegenüberliegenden Seite des Gußstücks zum Anbringen und Abstützen der gedruckten Leiterplatte (26) bildet.

6. Spindelmotor nach einem der Ansprüche 1 bis 5, dadurch gekennzeichnet, daß der Umfang (38) der gedruckten Leiterplatte (26) von dem Gußstück (16) abgestützt ist.
7. Spindelmotor nach einem der Ansprüche 1 bis 6 mit mehreren Stiften (61), die in der Oberfläche (59) der gedruckten Leiterplatte (26) in ringförmiger Anordnung geformt sind, wobei die Spulen (44A bis F) angrenzend an die Stifte angebracht sind, um die Form der Spulen und ihre Ausrichtung in der ringförmigen Anordnung aufrechtzuerhalten.
8. Spindelmotor nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß das Basisgußstück ferner Einrichtungen (75) zum Abstützen eines Schrittmotors relativ zu der konstant rotierenden Platte des Spindelmotors aufweist.
9. Spindelmotor nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß die einzelne gedruckte Leiterplatte sich angrenzend an den dem Schrittmotor zugeordneten Bereich erstreckt, wobei die Steuerelektronik für den Spindelmotor angrenzend an den Spindelmotor auf der gedruckten Leiterplatte und die Steuerelektronik für den Schrittmotor angrenzend an den Schrittmotor auf der gedruckten Leiterplatte angebracht ist.
10. Spindelmotor nach einem der Ansprüche 1 bis 9, dadurch gekennzeichnet, daß eine Vielzahl von Stiften in der Oberfläche der gedruckten Leiterplatte in ringförmiger Anordnung geformt ist, wobei die Spulen angrenzend an die Stifte angebracht sind, um die Form der Spulen und ihre Ausrichtung in der ringförmigen Anordnung aufrechtzuerhalten.

Revendications

1. Moteur de pile de disques à utiliser dans une unité de disques comportant une pièce moulée (16) de base pour l'unité, un arbre (18) s'étendant à travers ladite pièce moulée de base et portant un moyeu (20) supportant un ou plusieurs disques pour les faire tourner, ledit arbre étant supporté de façon à tourner dans ladite pièce moulée par un ou plusieurs paliers (12, 14), un rotor plat (43) relié à l'arbre et s'étendant de façon à être parallèle axialement



à la pièce moulée de base, ledit rotor comportant un aimant (43) supporté par une plaque (40) de support de rotor portée sur une extrémité dudit arbre, plusieurs enroulements (44A-F) à noyau d'air orientés axialement, disposés en un trajet toroïdal autour dudit arbre et dans un plan parallèle audit rotor plat et un élément toroïdal de trajet de retour magnétique sous la forme d'un enroulement bobiné d'une feuille d'acier coupée en tranche mince pour compléter le circuit magnétique, disposé sur le côté opposé desdits enroulements orientés axialement par rapport audit rotor ; caractérisé en ce qu'une plaquette unique (26) à circuit imprimé est prévue et montée sur la pièce moulée de base de manière que des première et seconde surfaces (59, 63) de la plaquette ne soient pas en contact avec la pièce moulée, lesdits enroulements à air (44A-F) étant placés sur ladite première surface (59) de la plaquette et ledit élément (60) de trajet de retour magnétique étant supporté sur la seconde surface de la plaquette.

2. Moteur de pile de disques selon la revendication 1, caractérisé en ce que le trajet (60) de retour magnétique est formé d'acier d'une épaisseur d'environ 0,010 cm.

3. Moteur de pile de disques selon la revendication 2, caractérisé en ce que le trajet (60) de retour magnétique est formé d'acier d'une largeur d'environ 0,15 cm.

4. Moteur de pile de disques selon l'une quelconque des revendications 1 à 3, caractérisé en ce que des moyens électroniques (64A à C) de commande destinés à commander la rotation dudit arbre (18) sont montés à proximité immédiate desdits enroulements (44A à F) sur ladite plaquette à circuit imprimé.

5. Moteur de pile de disque selon l'une quelconque des revendications 1 à 4, caractérisé en ce que ledit arbre (18) passe dans un alésage de ladite pièce moulée, ledit alésage définissant un épaulement (32) sur le côté de ladite pièce moulée opposé audit disque pour le montage et le support de ladite plaquette (26) à circuit imprimé.

6. Moteur de pile de disques selon l'une quelconque des revendications 1 à 5, caractérisé en ce que la périphérie (38) de ladite plaquette (26) à circuit imprimé est supportée par ladite pièce moulée (16).

7. Moteur de pile de disques selon l'une quelconque des revendications 1 à 6, comprenant plusieurs colonnettes (61) venues de moulage dans ladite surface (59) de ladite plaquette (26) à circuit imprimé en une rangée annulaire, lesdits enroulements (44A à F) étant montés à proximité immédiate desdites colonnettes pour maintenir la forme des enroulements et leur alignement dans la rangée annulaire.

8. Moteur de pile de disques selon l'une quelconque des revendications 1 à 7, caractérisé en ce que ladite pièce moulée de base comporte en outre des moyens (75) pour supporter un moteur pas à pas par rapport au disque en rotation constante dudit moteur de pile de disques.

9. Moteur de pile de disques selon l'une quelconque des revendications 1 à 8, caractérisé en ce que ladite plaquette unique à circuit imprimé s'étend de façon à être adjacente à la zone affectée audit moteur pas à pas, les moyens électroniques de commande pour ledit moteur de pile de disques étant montés à proximité immédiate dudit moteur de pile de disques sur ledit circuit imprimé, les moyens électroniques de commande pour ledit moteur pas à pas étant montés de façon à être adjacents audit moteur pas à pas sur ladite plaquette à circuit imprimé.

10. Moteur de pile de disques selon l'une quelconque des revendications 1 à 9, caractérisé en ce que plusieurs colonnettes sont moulées dans la surface de ladite plaquette à circuit imprimé en une rangée annulaire, lesdits enroulements étant montés de façon à être adjacents auxdites colonnettes pour maintenir la forme des enroulements et leur alignement dans la rangée annulaire.

