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Case No. 8864/20

PATENT APPLICATION TRANSMITTAL LETTER

To the Commissioner for Patents:

Transmitted herewith for filing is the patent application of: Griffith D. Neal for : STATOR ASSEMBLY MADE FROM A PLURALITY OF TOROIDAL CORE ARC SEGMENTS ANDMOTOR USING SAME. Enclosed are:

- ☒ Six (6) sheet(s) of drawings, twenty-four (24) pages of application (including title page), and the following Appendices : _____.
- ☒ Declaration.
- ☒ Power of Attorney.
- ☐ Verified statement to establish small entity status under 37 CFR §§ 1.9 and 1.27.
- ☒ Assignment transmittal letter and Assignment of the invention to : Encap Motor Corporation.
- ☐ _____.

JC996 U.S. PTO 09/798511 03/02/01

Claims as Filed	Col. 1	Col. 2	Small Entity			Other Than Small Entity	
For	No. Filed	No. Extra	Rate	Fee	or	Rate	Fee
Basic Fee				$ 355	or		$ 710
Total Claims	29-20	9	x$9=	$81	or	x$18=	$
Indep. Claims	5-3	2	x$40=	$40	or	x$80=	$
Multiple Dependent Claims Present			+$135=	$	or	+$270=	$
			Total	$516	or	Total	$

*If the difference in col. 1 is less than zero, enter "0" in col. 2.

- ☐ Please charge my Deposit Account No. 23-1925 in the amount of $: _____. A duplicate copy of this sheet is enclosed.
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  - ☐ The issue fee set in 37 CFR § 1.18 at or before mailing of the Notice of Allowance, pursuant to 37 CFR § 1.311(b).

Date 3/2/01

Sailesh Patel
Sailesh K. Patel
BRINKS HOFER GILSON & LIONE
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Our Case No. 8864/20

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
APPLICATION FOR UNITED STATES LETTERS PATENT

INVENTOR: GRIFFITH D. NEAL

TITLE: STATOR ASSEMBLY MADE FROM A PLURALITY OF TOROIDAL CORE ARC SEGMENTS AND MOTOR USING SAME

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STATOR ASSEMBLY MADE FROM A PLURALITY OF TOROIDAL CORE SEGMENTS AND MOTOR USING SAME

FIELD OF THE INVENTION

The present invention relates generally to a stator assembly used in a motor. It relates particularly to a spindle motor such as used in a hard disc drive, and to the construction and arrangement of a stator assembly made from a plurality of arc segments.

BACKGROUND OF THE INVENTION

Computers commonly use disc drives for memory storage purposes. Disc drives include a stack of one or more magnetic discs that rotate and are accessed using a head or read-write transducer. Typically, a high speed motor such as a spindle motor is used to rotate the discs.

In conventional spindle motors, stators have been made by laminating together stamped pieces of steel. These stamped pieces of steel are generally circular in nature, but also have "poles" extending either inwardly or outwardly, depending on whether the rotor is on the inside or surrounds the stator. The stamped pieces are laminated together and then coated with insulation. Wire is then wound around the poles to form stator windings.

An example of a conventional spindle motor 1 is shown in FIG. 1. The motor 1 includes a base 2 which is usually made from die cast aluminum, a stator 4, a shaft 6, bearings 7 and a disc support member 8, also referred to as a hub. A magnet 3 and flux return ring 5 are attached to the disc support member 8. The stator 4 is separated from the base 2 using an insulator (not shown) and attached to the base 2 using a glue. Distinct structures are formed in the base 2 and the disc support member 8 to accommodate the bearings 7. One end of the shaft 6 is inserted into the bearing 7 positioned in the base 2 and the other end of the shaft 6 is placed in the bearing 7 located in the hub 8. A separate electrical connector 9 may also be inserted into the base 2.

Each of these parts must be fixed at predefined tolerances with respect to one another. Accuracy in these tolerances can significantly enhance motor performance.

In operation, the disc stack is placed upon the hub. The stator windings are selectively energized and interact with the permanent magnet to cause a defined rotation of the hub. As hub 8 rotates, the head engages in reading or writing activities based upon instructions from the CPU in the computer.

Manufacturers of disc drives are constantly seeking to improve the speed with which data can be accessed. To an extent, this speed depends upon the efficiency of the spindle motor, as existing magneto-resistive head technology is capable of accessing data at a rate greater than the speed offered by the highest speed spindle motor currently in production. The efficiency of the spindle motor is dependent upon the dimensional consistency or tolerances between the various components of the motor. Greater dimensional consistency between components leads to a smaller gap between the stator 4 and the magnet 3, producing more force, which provides more torque and enables faster acceleration and higher rotational speeds.

The conventional method of forming stators has a number of drawbacks. First, most steel is manufactured in rolled sheets and thus has a grain orientation. The grain orientation has an effect on the magnetic flux properties of the steel. In circular stamped pieces of steel, the grain orientation at different points around the circle differs. Compared from the radius line of the circle, the grain orientation is sometimes aligned along the radius, sometimes transverse to it, and mostly at a varying angle to the radius. The un-aligned grain structure of conventional stators causes the magnetic flux values to differ in parts of the stator and thus the motor does not have consistent and uniform torque properties as it rotates.

Another drawback with using circular steel pieces is that, especially for inward facing poles, it has been difficult to wind the wire windings tightly because of the cramped space to work inside of the laminated stator core. The cramped working space creates a lower limit on the size of the stator and thus the motor. The limited working space also results in a low packing density of wire. The packing density of wire coiled around the poles affects the amount of power generated by the motor. Increasing packing density increases the power and thus the efficiency of the spindle motor.

An important factor in motor design is to reduce stack up tolerances in the motor. Stack up tolerances reduce the overall dimensional consistency between the components. Stack up tolerances refer to the sum of the variation of all the tolerances of all the parts, as well as the overall tolerance that relates to the alignment of the parts relative to one another. One source of stack up tolerances is from the circular stator body. Generally, the thickness of rolled steel is not uniform across the width of the roll. Sometimes the edges are thicker or thinner than the center. In a stator made from circular stamped pieces, the thickness of individual laminations are thus different from one side to the other. When stacked together, this creates a stack up tolerance problem. Furthermore, the circular stampings leave a lot of wasted steel that is removed and must be recycled or discarded.

Another important factor in motor design is the lowering of the operating temperature of the motor. Increased motor temperature affects the electrical efficiency of the motor and bearing life. As temperature increases, resistive loses in wire increase, thereby reducing total motor power. Furthermore, the Arhennius equation predicts that the failure rate of an electrical device is exponentially related to its operating temperature. The frictional heat generated by bearings increases with speed. Also, as bearings get hot they expand, and the bearing cages get stressed and may deflect, causing non-uniform rotation reducing bearing life. This non-uniform rotation causes a further problem of limiting the ability of the servo system controlling the read/write heads to follow data tracks on the magnetic media. One drawback with existing motor designs is their limited effective dissipation of the heat, and difficulty in incorporating heat sinks to aid in heat dissipation. In addition, in current motors the operating temperatures generally increase as the size of the motor is decreased.

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