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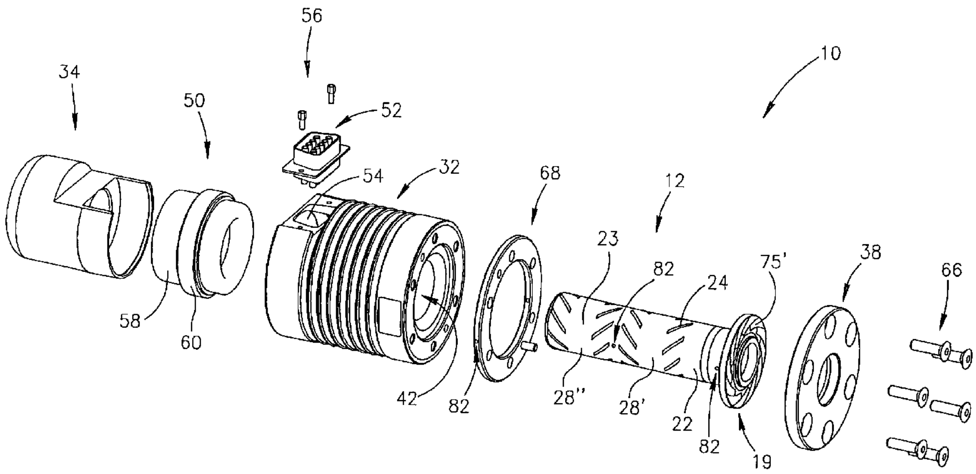

(57) Abstract: A spindle motor having an annular stator mounted in a housing. The stator and the housing having a joint hole lined by a thin layer of glue forming a cylindrical through bore. A rotor having a cylindrical rotor shaft is rotatably retained in the cylindrical through bore with the stator around and in operating relationship with the rotor shaft. A radial bearing is located between the rotor and the stator.

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SPINDLE MOTOR

FIELD OF THE INVENTION

This invention relates to spindle motors utilizing static or dynamic pressure bearings.

BACKGROUND OF THE INVENTION

Spindle motors typically have a stator with a stator coil for generating a magnetic field and a rotor provided with rotor magnets for interacting with the magnetic field causing the rotor to rotate. Such spindle motors have, either dynamic pressure bearings, static pressure bearings or combinations thereof. These bearings can be either air bearings, i.e., aerostatic or aerodynamic or they can be fluid bearings, i.e., hydrostatic or hydrodynamic. In the following description and claims a bearing in general will be defined by two surfaces being in spaced opposed relationship with each other with a bearing support member therebetween. Hence, in ball bearings the bearing support member is a ball, in air bearings the support member is air and in fluid bearings the support member is a fluid.

Spindle motors are used in a variety of applications, for example, in hard and floppy disk drives in computers, in various optical and magnetic disk apparatuses, in scanners, and in tools for internal grinding, dicing and printed circuit board drilling. Spindle motors utilizing static or dynamic pressure bearings allow higher rotational accuracy, higher speed operation and a reduction in vibrations in comparison with conventional spindles utilizing ball bearings. Various spindle motors are known in the prior art. U.S. Patent No. 5,127,744 discloses a spindle assembly consisting of a stationary shaft and a rotating hub assembly that is supported in rotation by air bearings formed between adjacent axial and radial surfaces of the shaft and hub assemblies. A motor stator assembly is fitted to the end of a stationary shaft of the shaft assembly and a magnetic rotor assembly is fitted to the inside surface of a rotating hub adjacent the stator. In such an arrangement the shaft has a region in which the air bearings are formed and a region which is required in order to facilitate the motor stator -rotor assembly. This makes the shaft relatively long, thereby making it more susceptible to vibrations. U.S. Patent No. 5,994,803 discloses a spindle motor using a hydrodynamic bearing. A shaft is rotatably retained in a stationary sleeve and a stator is arranged around the sleeve. The top end of the shaft is coupled to a cap-shaped rotor, thus being rotatable along with the rotor. A cylindrical magnet is attached to the inner surface of the rotor's sidewall around the stator, thus forming a motor. The hydrodynamic bearing is formed between the shaft and the sleeve. Hence, in this arrangement the motor stator-rotor assembly is external to the sleeve-shaft assembly, thereby increasing the diameter of the spindle motor.

There is an ongoing demand for spindle motors with minimal vibrations along with size and weight reduction and reduction in manufacturing costs.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a spindle motor utilizing static or dynamic pressure bearings that is capable of high-speed operation and high rotational accuracy, reduced overall dimensions and reduced vibrations and manufacturing costs.

To achieve this object, the present invention provides a spindle motor utilizing static or dynamic pressure bearings in which the bearings are located between, or partially incorporated with, a motor rotor-stator assembly.

In accordance with the present invention, there is provided a spindle motor comprising:

a rotor having an axis of rotation, comprising a cylindrical rotor shaft having an outer peripheral surface, a generally disk-like thrust plate having two axially facing surfaces extending outwardly in a radial direction from a section of the outer peripheral surface;

a housing having a longitudinal axis and having an annular stator mounted therein, the stator comprising a stator coil and lamellae, the stator and the housing having a joint hole, at least a section of the joint hole being lined by a thin tubular member forming a cylindrical through bore having an inner peripheral surface;

a disk-like chamber extending outwardly in a radial direction from a section of the cylindrical through bore;

wherein the rotor is rotatably retained in the cylindrical through bore with the thrust plate located in the disk-like chamber and the lamellae are located around the rotor shaft, so that during operation of the spindle motor a uniform radial gap exists between the rotor shaft and the cylindrical through bore and axial gaps exists adjacent the two axially facing surfaces of the thrust plate, the radial and axial gaps containing a medium, the two axially facing surfaces of the thrust plate, the medium contained in the axial gaps and surfaces of the housing adjacent the axial gaps defining axial bearings, and at least one radial bearing being defined by the inner and outer peripheral surfaces and the medium therebetween along at least a section of the rotor and the shaft.

In accordance with a preferred embodiment of the present invention, the tubular member comprises a thin layer of glue, the thin layer of glue forming the cylindrical through bore, the radial gap being formed between the inner peripheral surface of the cylindrical bore and the outer peripheral surface of the rotor shaft and the axial gap being formed between the two axially facing surfaces of the thrust plate and layers of glue lining the surfaces of the housing adjacent the axial gaps.

Typically, the tubular member comprises a thin layer of epoxy.

Further typically, the radial thickness of the tubular member is in the range of one-tenth to one millimeter.

In accordance with a preferred embodiment of the present invention, the rotor shaft further comprises a cylindrical rotor sleeve mounted thereon, with rotor magnets retained around the cylindrical rotor shaft along a given length thereof between the cylindrical rotor shaft and a cylindrical rotor sleeve, with the lamellae in operating relationship with the rotor magnets, and with at least a portion of the at least one radial bearing being located between the rotor magnets and a radially inner face of the lamellae.

By one specific application of the present invention, the medium is air and the at least one radial and axial bearings form radial and axial aerodynamic bearings, respectively.

By another specific application of the present invention, the medium is a fluid and the at least one radial and axial bearings form radial and axial hydrodynamic bearings, respectively.

Generally, the at least one radial bearing is generated by a given radial bearing groove configuration provided on the rotor sleeve.

Typically, the given radial bearing groove configuration on the rotor sleeve is in the form of herringbone shaped grooves.

Generally, the axial bearings are generated by a given axial bearing groove configuration provided the axially facing surfaces of the thrust plate.

Further typically, the given axial bearing groove configuration on the axially facing surfaces of the thrust plate is in the form spiral grooves.

By yet another specific application of the present invention, the medium is compressed air fed under pressure from an external source and conveyed via air channels and nozzles to the radial and axial gaps and the at least one radial and axial bearings form radial and axial aerostatic bearings, respectively.

In accordance with on application, the generally disk-like thrust plate extends outwardly in a radial direction from an end of the outer peripheral surface of the rotor shaft and the disk-like chamber extends from an end of the cylindrical through bore.

Preferably, a section of the housing opposite one side of the thrust plate is formed by a disk-like thrust cover fixedly attached to the housing.

There is further provided in accordance with the present invention, a spindle motor comprising:

a housing having an annular stator mounted therein, the stator and the housing having a joint hole lined by a thin layer of glue forming a cylindrical through bore;

a rotor comprising a cylindrical rotor shaft rotatably retained in the cylindrical through bore with rotor magnets mounted on the rotor shaft and with the stator around the rotor shaft and with lamellae of the stator in operating relationship with the rotor magnets; and

at least one radial bearing having at least a portion thereof located between the rotor magnets and a radially inner face of the lamellae.

In accordance with the present invention, the at least one radial bearing is defined by an inner peripheral surface of the cylindrical through bore and an outer peripheral surface of a rotor sleeve mounted on the rotor shaft and a medium located in a radial gap between the inner and outer peripheral surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 is a schematic cross sectional view of the spindle motor in accordance with the present invention with aerodynamic or hydrodynamic bearings;

Fig. 2 is an axially exploded view of the spindle motor shown in Fig.1;

Fig. 3 is an axially exploded view of the rotor of the spindle motor shown in Fig.1;

Fig. 4 is a first detail of the spindle motor shown in Fig.1;

Fig. 5 is a second detail of the spindle motor shown in Fig.1; and

Fig. 6 is a partial cross sectional view of the spindle motor with in accordance with the present invention with aerostatic bearings.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Attention is drawn to the drawings. The spindle motor **10** in accordance with the present invention has a rotor **12** having an axis of rotation **A** and comprises a cylindrical rotor shaft **14** having an outer peripheral surface **16** with rotor magnets **18** mounted around the peripheral surface **16** along a given length **L** in the axial direction. A generally disk-like thrust plate **19**, having a central aperture **20**, extends outwardly in a radial direction typically from an end of the outer peripheral surface **16** of the rotor shaft **14**. The thrust plate **19** has two oppositely facing axially facing surfaces **21**. A cylindrical rotor sleeve **22**, having a rotor sleeve peripheral surface **23**, is mounted on the rotor shaft **14**. The rotor sleeve **22** prevents the rotor magnets **18** from flying off the rotor shaft **14** when the rotor **12** rotates at a high speed and it also facilitates the provision of radial bearing grooves **24** of a given configuration on the rotor sleeve peripheral surface **23** for generating radial bearings **26**. The preferred groove configuration on the rotor sleeve is in the form of herringbone shaped grooves **28** (**28'**, **28''**). A first set of herringbone shaped grooves **28'** is located at one end of the rotor **12** close to the thrust plate **19** and a second set of herringbone shaped grooves **28''** is located at the other end of the rotor **12** distal to the thrust plate **19**.

The spindle motor **10** has a housing **30**, having a longitudinal axis **B**, comprising a main housing member **32**, which is bound by a rear housing member **34** at a rear end **36** of the spindle motor **10**, and by an annular disk-like thrust cover **38** at a front end **40** of the spindle motor **10**. Although the rear house member is shown in the figures to have a particular geometrical form, it will be appreciated, that the form chosen is simply one of design and that other designs are possible. If desired, the main housing member **32** could be designed to extend to adjacent the rear end **36** of the spindle motor **10**, in which case, the rear house member **34** would take on a form similar to the form of the disk-like thrust cover **38**. Further if desired, the main housing member **32** could be designed to extend to adjacent the rear end **36** of the spindle motor **10** without using the rear house member **34**. The main housing member **32** has a central hollow **42** having a disk-like chamber **44** extending outwardly in a radial direction and adjacent the front end **40** of the spindle motor **10**. The disk-like chamber **44** merges with a generally cylindrical front portion **46** of the central hollow **42**, which in turn merges, with generally cylindrical rear portion **48** of the central hollow **42**. The generally cylindrical rear portion **48** has a larger radial dimension than that of the generally cylindrical front portion **46**. An annular stator **50** is mounted in the cylindrical rear portion **48** adjacent the cylindrical front portion **46**. The rear-housing member **34** is mounted in the cylindrical rear portion **48** thereby confining the stator **50** within the housing **30**. The stator **50** receives electricity from an electricity supply via a connector **52**, which is mounted in an opening **54** in the main housing member **32**. The connector **52** is secured to the main housing member **32** by means of connector screws **56**.

The stator **50** comprises a stator coil **58** and lamellae **60**. The stator **50** and the housing **30** having a joint hole **61**. The joint hole **61** is lined by a thin tubular member **62**, forming cylindrical through bore **64** having a longitudinal axis that coincides with the longitudinal axis **B** of the housing **30**. In accordance with a preferred embodiment of the present invention, the tubular member **62** comprises a thin layer of glue. Typically, the glue used is epoxy. The thickness of the thin tubular member **62** is typically in the range of 0.1 to 1 millimeter. The rotor **12** is rotatably retained in the cylindrical through bore **64** with the thrust plate **19** located in the disk-like chamber **44**. The thrust cover **38** is secured to the main housing member **32** by means of cover screws **66** with an annular axial spacer **68** interposed between the thrust cover **38** and the main housing member **32**, thereby forming the boundary of the disk-like chamber **44**. During operation of the spindle motor **10** a uniform radial gap **70** exists between the rotor sleeve **22** and the tubular member **62** (see Fig. 5), along the whole length of the tubular member **62**, and an axial gap **72** exists on either side of the thrust plate **19**, between the axially facing surfaces **21** of the thrust plate **19** and the housing **30**. On one side of the thrust plate **19** a first axial gap is formed between the thrust plate **19** and the thrust cover **38**. On the other side of the thrust plate **19** a second axial gap is formed between the thrust plate **19** and the main housing member **32**. As will be described in greater detail below, if glue is used for the thin tubular member **62**, then the axial gaps **72** are formed between the thrust plate **19** and the glue. The radial and axial gaps are filled with a medium. As will be described in greater detail below, the medium on either side of the thrust plate **19** together with the surfaces opposing the thrust plate on either side thereof, form axial bearings **74**. Typically, the axial bearing **74** is generated by a given axial bearing groove configuration **75** provided on either side of the thrust plate. The given axial bearing groove configuration **75** on the axially facing surfaces **21** on either side of the thrust plate **19** is typically in the form sets of spiral grooves.

A first axial bearing **74'** is formed between a first set of spiral grooves **75'** on the thrust plate **19** and the thrust cover **38** and a second axial bearing **74"** is formed between a second set of spiral grooves **75"** on the thrust plate **19** and the main housing member **32**. Similarly, a first radial bearing **26'** is formed between the first set of herringbone shaped grooves **28'** on the rotor sleeve peripheral surface **23** and the tubular member **62**, and a second radial bearing **26"** is formed by the between the second set of herringbone shaped grooves **28"** on the rotor sleeve peripheral surface **23** and the tubular member **62**. In accordance with one specific application of the present invention, the medium in the radial and axial gaps is air and the radial bearing is a radial aerodynamic bearing and the axial bearing is an axial aerodynamic bearing. In accordance with another specific application of the present invention, the medium in the radial and axial gaps is a fluid and the radial bearing is a radial hydrodynamic bearing and the axial bearing is an axial hydrodynamic bearing.

As stated, in the preferred embodiment of the present invention, the tubular member comprises a thin layer of glue such as epoxy. The tubular member **62** has an inner peripheral surface **76** (see Fig. 5). As will be described in greater detail below, when the tubular member **62** is formed of glue, the inner peripheral surface **76** can be manufactured to be smooth without requiring any internal machining, which is a costly process. Furthermore, the glue also fills in various spaces, such as spaces **78** between the stator coil **58** and the rear housing member **34**, between the thrust plate **19** and the thrust cover **38**, between the thrust plate **19** and the main housing member **32** and around the connector **52**. This is another of the advantages of forming the thin tubular member **62** from glue. Hence, the glue filled spaces **78** and the thin tubular member **62** form an integral entity.

Another advantage is found in using glues having good thermal conduction so that heat generated by the spindle can easily be conducted from within the spindle to the surroundings. Yet another advantage in using a glue such as epoxy is that it is not a ferromagnetic material and therefore does not interact electromagnetically with the stator. The glue not only lines the cylindrical through bore **64** with a thin coating having a smooth inner peripheral surface **76**, but it also affixes the stator **50** firmly to the housing **30**. As seen in Figs. 4 and 5 the lamellae **60** are aligned to form a generally continuous radially inner face **80**, which is located at a slightly different radial location than the stator coil. Therefore, the radial thickness of the glue, which forms the thin tubular member **62**, varies in the axial direction whilst its inner peripheral surface **76** remains smooth. This is another advantage of using glue to line the cylindrical through bore **64**. If a thin ceramic sleeve were be used to line cylindrical through bore **64**, instead of using a thin layer of glue, it would only make contact with the radially most inner portions of the cylindrical through bore **64** such as the lamellae, leaving gaps between it and other portions such as the stator coil **58**.

The lamellae **60** are located around the rotor magnets **18** and are in operating relationship therewith. As seen in Figs. 4 and 5, radially inner face **80** of the lamellae is directly opposite the rotor magnets **18**, with only three thin intervening layers between them, the rotor sleeve **22**, the radial gap **70** (filled with air or any other required medium, in accordance with the specific application used) and the layer of glue (tubular member **62**). The tubular member **62** in the form of a thin layer of glue can be made by inserting an oiled smooth cylinder in the cylindrical through bore **64**. The smooth cylinder should have a diameter slightly larger than that of the rotor **12** leaving a space between the smooth cylinder and the cylindrical bore **64**. Glue, such as epoxy, or any other convenient medium, is then injected into the space between the smooth cylinder and the cylindrical through bore **64**. After the glue has hardened, the smooth cylinder can be removed leaving a thin layer of glue forming the tubular member **62** with a smooth inner peripheral surface **76**. If the smoothness of the inner peripheral surface **76** of the so formed tubular member **62** is not sufficient, it can always be machined. However, in general this will not be necessary. Clearly, since the smooth cylinder has a diameter slightly larger than the diameter of the rotor then when the rotor is placed in the cylindrical through bore **64** the radial gap **70** is formed between the rotor **12** and the inner peripheral surface **76** of the cylindrical through bore **64**. In order to produce the axial gaps **72** between a layer of glue and the thrust plate **19**, the smooth cylinder has a smooth disk-like plate, of slightly larger dimensions that the thrust plate **19**, attached at one of its ends. In this way the surfaces of the glue facing the thrust plate **19** are manufactured to be smooth. Before any glue is introduced into the spindle motor **10**, the smooth cylinder is inserted into the central hollow **42** with the disk-like plate located in the disk-like chamber **44**, and glue is injected into the spaces in the spindle motor **10**. Prior to injecting the glue, all the glue filled spaces indicated by the reference numeral **78** will be air spaces.

There are various essential features relating to spindles that are not described with respect to the present invention, but that are required for the operation of the spindle motor **10**. These features and their function are well known in the art. For example, for the preferred embodiment, there are air inlets **82** in the rotor shaft **14**, in the rotor sleeve **22** and in the axial spacer **68**. Clearly for hydrodynamic bearings these will function as fluid inlets.

Although the present invention has been described to a certain degree of particularity, it should be understood that various modifications and alterations can be made without departing from the spirit or scope of the invention as hereinafter claimed. For example, the invention has been described with respect to aerodynamic and hydrodynamic bearings. It will be apparent that, the invention is by no means restricted to such bearings and that by suitably modifying the spindle described herein, the invention can be equally well applied to aerostatic bearings. Fig. 6 shows a partial cross sectional view of the spindle motor in accordance with the present invention with aerostatic bearings. Only half of the cross section is shown, illustrating the essential modifications required for operating the present invention with aerostatic bearings. All the reference numbers that have been described above have the same meaning with respect to Fig. 6. Compressed air fed under pressure from an external source (not shown) through an air intake **84** and conveyed via air channels **86** and radial and axial nozzles **88**, **90** to the radial and axial gaps **70**, **72** thereby forming radial and axial aerostatic bearings **92**, **94** respectively.

It will be appreciated that whereas the invention has been described with respect to a synchronous spindle motor, however, it applies equally well to asynchronous spindle motor, e.g., an inductive motor.

CLAIMS:

1. A spindle motor (10) comprising:

a rotor (12) having an axis of rotation (A), comprising a cylindrical rotor shaft (14) having a outer peripheral surface (16), a generally disk-like thrust plate (19), having two axially facing surfaces (21), extending outwardly in a radial direction from a section of the outer peripheral surface (16);

a housing (30) having a longitudinal axis (B) and having an annular stator (50) mounted therein, the stator (50) comprising a stator coil (58) and lamellae (60), the stator (50) and the housing (30) having a joint hole (61), at least a section of the joint hole (61) being lined by a thin tubular member (62) forming a cylindrical through bore (64) having an inner peripheral surface (76);

a disk-like chamber (44) extending outwardly in a radial direction from a section of the cylindrical through bore (64);

wherein the rotor (12) is rotatably retained in the cylindrical through bore (64) with the thrust plate (19) located in the disk-like chamber (44) and the lamellae (60) are located around the rotor shaft (14), so that during operation of the spindle motor (10) a uniform radial gap (70) exists between the rotor shaft (14) and the cylindrical through bore (64) and axial gaps (72) exist adjacent the two axially facing surfaces of the thrust plate (19), the radial and axial gaps (70, 72) containing a medium, the two axially facing surfaces (21) of the thrust plate (19), the medium contained in the axial gaps (72) and surfaces of the housing adjacent the axial gaps defining axial bearings (74), and at least one radial bearing (26) being defined by the inner and outer peripheral surfaces (76, 16) and the medium therebetween along at least a section of the rotor (12) and the rotor shaft (14).

2. The spindle motor according to claim 1, wherein the tubular member (62) comprises a thin layer of glue, the thin layer of glue forming the cylindrical through bore (64), the radial gap (70) being formed between the inner peripheral surface (76) of the cylindrical through bore (64) and the outer peripheral surface (16) of the rotor shaft (14) and the axial gap (72) being formed between the two axially facing surfaces (21) of the thrust plate (19) and layers of glue lining the surfaces of the housing (30) adjacent the axial gaps (72).

3. The spindle motor according to claim 2, wherein the glue is epoxy.

4. The spindle motor according to claim 3, wherein the thin layer of epoxy has a radial thickness in the range of one-tenth to one millimeter.

5. The spindle motor according to claim 4, wherein the rotor shaft (14) further comprises a cylindrical rotor sleeve (22) mounted thereon, with rotor magnets (18) retained around the cylindrical rotor shaft (14) along a given length (L) thereof between the cylindrical rotor shaft (14) and a cylindrical rotor sleeve, with the lamellae (60) in operating relationship with the rotor magnets (18), and with at least a portion of the at least one radial bearing (26) being located between the rotor magnets (18) and a radially inner face (80) of the lamellae (60).

6. The spindle motor according to claim 5, wherein the medium is air and the at least one radial and axial bearings (26, 74) are radial and axial aerodynamic bearings, respectively.

7. The spindle motor according to claim 5, wherein the medium is a fluid and the at least one radial and axial bearings (26, 74) are radial and axial hydrodynamic bearings, respectively.

8. The spindle motor according to either claim 6 or claim 7, wherein the at least one radial bearing (26) is generated by a given radial bearing groove configuration (24) provided on the rotor sleeve (22).

9. The spindle motor according to claim 8, wherein the given radial bearing groove configuration (24) on the rotor sleeve (22) is in the form of herringbone shaped grooves (28).

10. The spindle motor according to claims 6 and 7, wherein the axial bearing (74) is generated by a given axial bearing groove (75) configuration provided on the axially facing surfaces (21) of the thrust plate (19).

11. The spindle motor according to claim 10, wherein the given axial bearing groove configuration (75) on the axially facing surfaces (21) of the thrust plate (19) is in the form spiral grooves.

12. The spindle motor according to claim 1, wherein the generally disk-like thrust plate (19) extends outwardly in a radial direction from an end of the outer peripheral surface of the rotor shaft (14) and the disk-like chamber (44) extends from an end of the cylindrical through bore (64).

13. The spindle motor according to claim 12, wherein a section of the housing opposite one of the axially facing surfaces (21) of the thrust plate (19) is formed by a disk-like thrust cover (38) fixedly attached to the housing (30).

14. The spindle motor according to claim 1, wherein the medium is compressed air fed under pressure from an external source and conveyed via air channels (86) and nozzles (88, 90) to the radial and axial gaps (70, 72) and the radial and axial bearings form radial and axial aerostatic bearings (92, 94), respectively.

15. A spindle motor comprising:

a housing (30) having an annular stator (50) mounted therein, the stator (50) and the housing (30) having a joint hole (61) lined by a thin layer of glue forming a cylindrical through bore (64);

a rotor (12) comprising a cylindrical rotor shaft (14) rotatably retained in the cylindrical through bore (64) with rotor magnets mounted on the rotor shaft and with the stator (50) around the rotor shaft (14) and with lamellae of the stator in operating relationship with the rotor magnets; and

at least one radial bearing (26) having at least a portion thereof located between the rotor magnets (18) and a radially inner face of the lamellae.

16. The spindle motor according to claim 15, wherein the at least one radial bearing (24) is defined by an inner peripheral surface (76) of the cylindrical through bore (64) and an outer peripheral surface (16) of a rotor sleeve mounted on the rotor shaft (14) and a medium located in a radial gap (70) between the inner and outer peripheral surfaces.

17. The spindle motor according to claim 16, wherein the rotor (12) has an axis of rotation (A) and further comprises a generally disk-like thrust plate (19) extending outwardly in a radial direction from a section of the outer peripheral surface (16).

18. The spindle motor according to claim 17, wherein the glue is epoxy.

19. The spindle motor according to claim 18, wherein the thin layer of epoxy has a radial thickness in the range of one-tenth to one millimeter.

20. The spindle motor according to claim 19, wherein the rotor magnets (18) are retained around the cylindrical rotor shaft (14) along a given length (L) thereof between the cylindrical rotor shaft (14) and the cylindrical rotor sleeve.

21. The spindle motor according to claim 20, wherein the medium is air and the at least one radial bearing (26) is an aerodynamic bearing generated by a given radial bearing groove configuration (24) provided on the rotor sleeve (22).

22. The spindle motor according to claim 20, wherein the medium is a fluid and the at least one radial bearing (26) is an hydrodynamic bearing generated by a given radial bearing groove configuration (24) provided on the rotor sleeve (22).

23. The spindle motor according to either claim 21 or claim 22, wherein the given radial bearing groove configuration (24) on the rotor sleeve (22) is in the form of herringbone shaped grooves (28).

24. The spindle motor according to claim 23, wherein axial bearings (74) are generated by a given axial bearing groove (75) configuration provided on axially facing surfaces (21) of the thrust plate (19).

25. The spindle motor according to claim 24, wherein the given axial bearing groove (75) configuration is in the form spiral grooves.

26. The spindle motor according to claim 25, wherein the axial bearings (74) comprise axial gaps (72) adjacent the two axially facing surfaces (21) of the thrust plate (19), containing a medium.

27. The spindle motor according to claim 26, wherein the medium is air and the axial bearings (74) are axial aerodynamic bearings.

28. The spindle motor according to claim 26, wherein the medium is a fluid and the axial bearings (74) are axial hydrodynamic bearings.

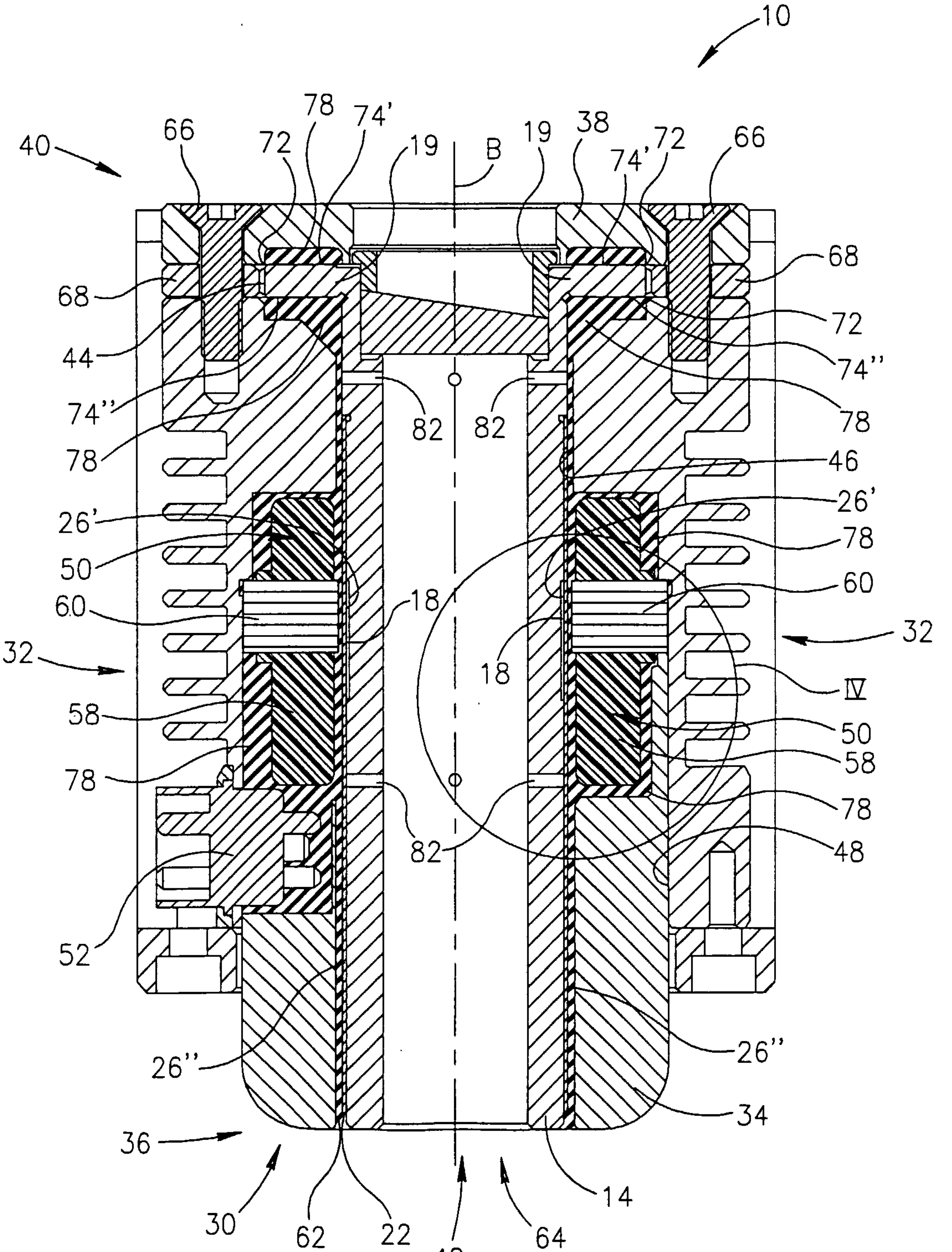
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FIG.1

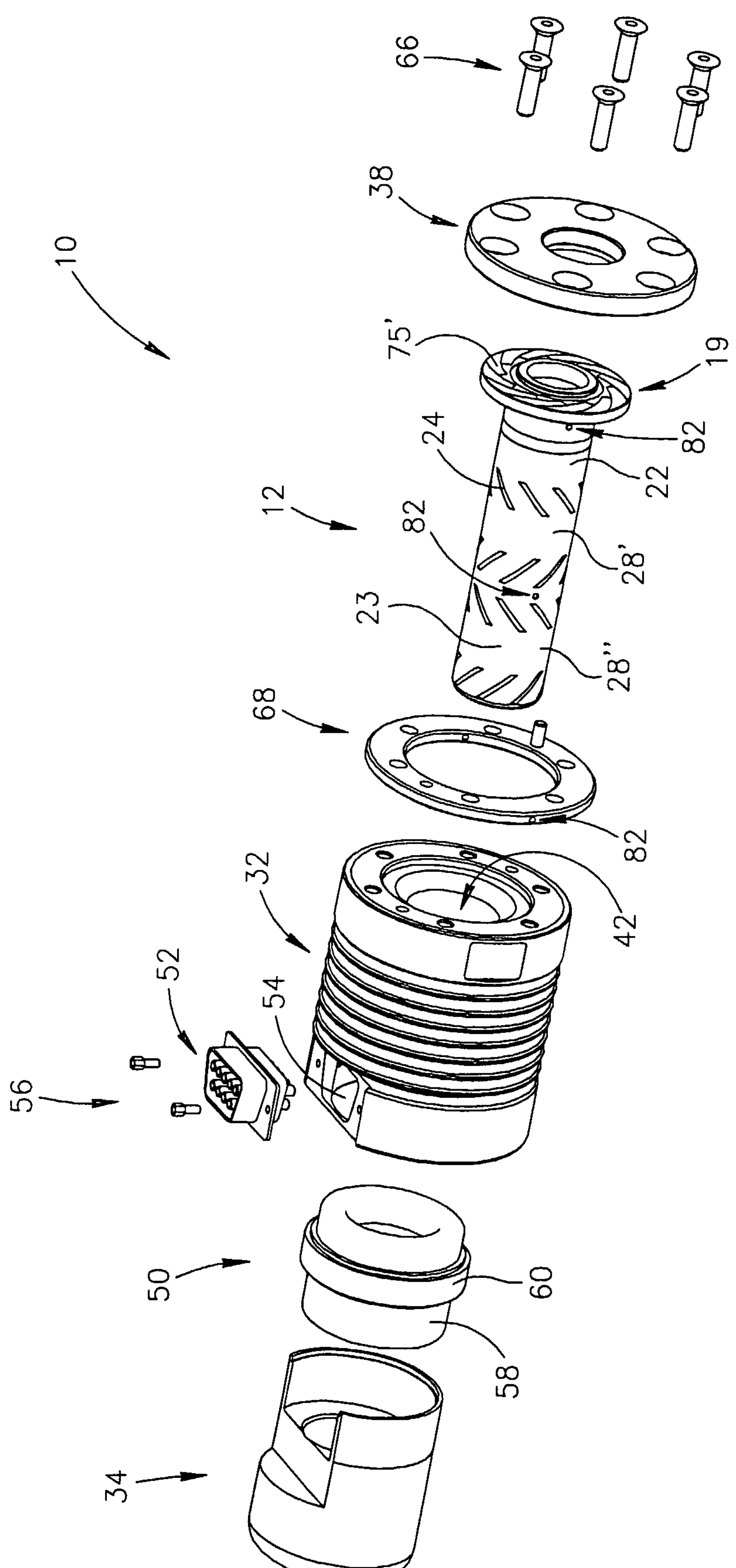

FIG.2

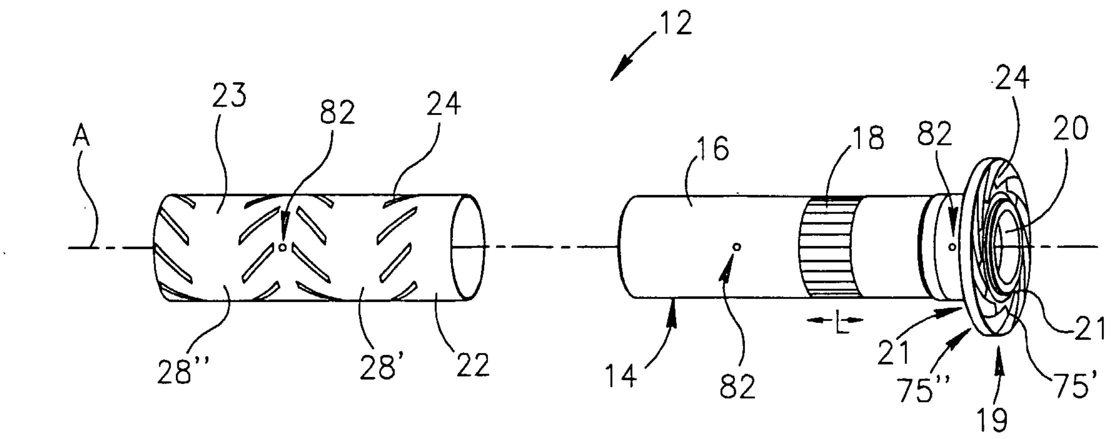

FIG.3

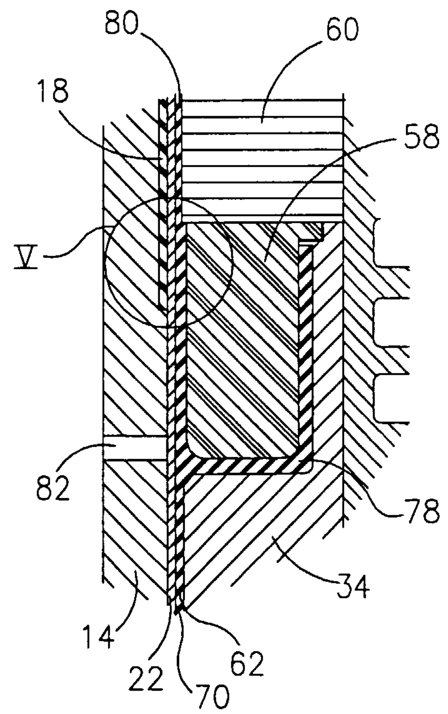

FIG.4

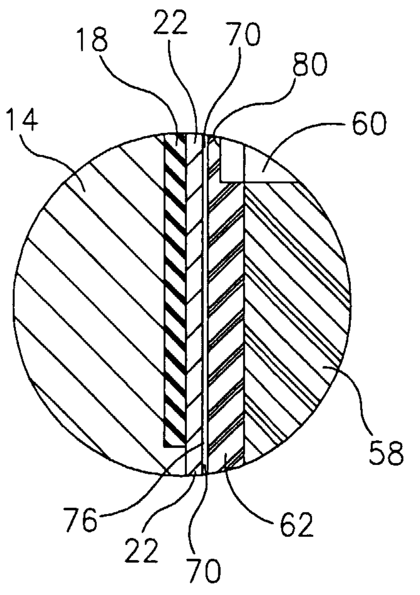

FIG.5

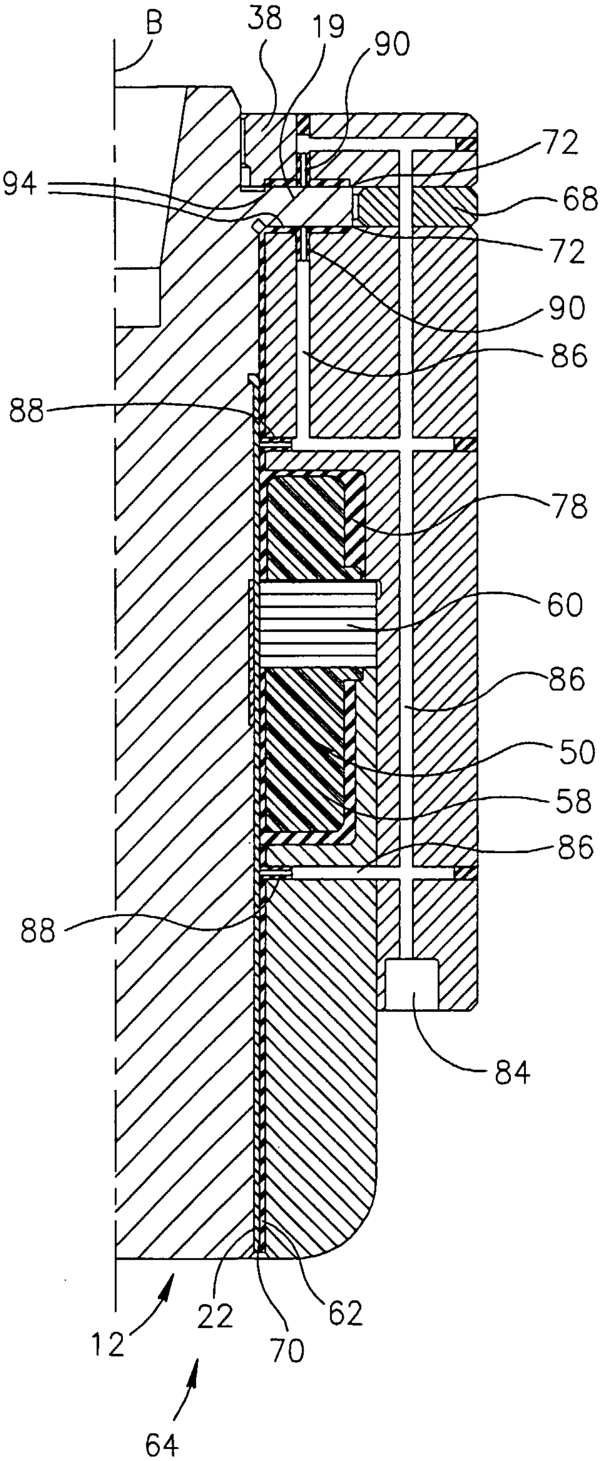

FIG.6