DISK STORE DRIVE

The invention relates to a disk store drive with a brushless drive motor having a stator provided with a winding, and an external rotor coaxially surrounding the stator and spaced therefrom by a substantially cylindrical air gap, said rotor having a permanent magnetic motor magnet and a soft magnetic yoke; and a hub concentric to the yoke, said hub being connected to the rotor for rotation therewith and having a disk support portion with a cylindrical circumferential surface, which can be passed through a central opening of a storage disk for receiving at least one storage disk.

In the case of a known disk store drive of this type (Figs. 3 and 4 of DE-OS 31 35 385) there is a hub or armature sleeve for receiving the storage disk or disks in the form of a relatively solid body, which is provided with axially directed bearing webs in the vicinity of the disk support portion and which is connected in non-rotary manner to a shaft via a bearing bush cast or pressed into the hub and which with the disk support portion extends over a smaller part of the axial dimension of the magnetically active stator and rotor parts, i.e. the stator winding and the motor magnet cooperating therewith.

In the case of disk stores, there is an increasing need for reducing the space requirement for the store. Thus, the problem of the invention is to provide a disk store drive, which takes up particularly little space and consequently allows a minimization of the disk store dimensions, especially in the axial direction.

According to the invention this problem is solved in that at least half the axial dimension of the stator winding and the motor magnet cooperating therewith are housed within the area surrounded by the disk support portion of the hub and the disk support portion wall is thinner than the yoke wall.

The major part of the magnetically active parts of the drive motor in this construction is located within the space which is in any case necessary for holding the storage disks, particularly magnetic rigid storage disks, but also storage disks of other types, e.g. optical storage disks.

Preferably, at least two thirds of the axial dimension of the stator winding and the motor magnet cooperating therewith are housed in the space surrounded by the disk support portion. A particularly space-saving overall arrangement is obtained if the magnetically active stator and rotor parts are substantially completely located with this space.

The diameter of the central opening of the storage

disks, e.g. magnetic rigid storage disks, is standardized and consequently its size is limited to a fixed value. However, the application of the drive energy requires a certain motor size. The conditions are particularly critical in the case of known small storage disks with a central opening diameter of e.g. only 25 mm. In order to provide maximum space for the magnetically active motor parts in the diametrically limited area of the storage disk central opening, the wall thickness of the disk support portion of the hub is minimized to the extent that this is possible in view of the mechanical strength. The wall thickness of the disk support portion is smaller than the wall thickness of the part of the magnetic yoke which is concentric thereto.

The disk support portion preferably has a cylindrical outer peripheral surface, i.e. a peripheral surface free from the known bearing webs or ribs, because this also contributes to providing a maximum cross-section, whilst taking account of the fixed diameter of the central opening of the storage disks as well as the necessary mechanical strength of the hub for the magnetically active motor parts.

At least those surface parts of the hub located in the clean area or room of a disk store in which the disk(s) are housed must not give off into the latter,

even during prolonged use of the disk store drive, significant quantity of dirt particles, e.g. due to oxidation processes. Preferably the hub is made from a material which, even after cutting, is suitable for use in a clean area i.e. a material which following cutting and without a corrosion-inhibiting treatment following the same meets the strict cleanness conditions necessary with disk stores in the clean area receiving the storage disks. Such a construction makes it possible to finish, e.g. grind or turn to size the outer peripheral surface of the disk support portion after assembly of the hub and the drive motor with respect of the centricity with the rotation axis.

Such metal finishing of the installed hub is frequently necessary in order to fulfil the extreme demands in connection with disk stores with respect of accuracy of rotation or minimization of inaccuracy of the hub. It is particularly appropriate to have a hub made from light metal, preferably aluminium or an aluminium alloy. Light metal hubs can be used in clean areas without further treatment, even after cutting has taken place. For example using a diamond tool, and whilst respecting the necessary precision, such hubs can be turned, which is less expensive than grinding, particularly in the case of a disk support portion with a cylindrical outer circumferential surface. The hub

is preferably extruded or cast and is pressed hot on to the magnetic yoke. However, in principle, other possibilities for joining hub and yoke exist, e.g. a bonding together of the two parts.

In per se known manner, the magnetic yoke can have a cup or pot-shaped construction. However, it is more advantageous to provide an annular magnetic yoke, whilst appropriately inserting a magnetic shield ring in the hub and which extends radially inwards substantially from the clean area axial end of the annular magnetic yoke. As a result of both these features the necessary guidance of the magnetic flux and an efficient magnetic shielding of the storage disks with respect to the drive motor are achieved. The combination of yoke ring and shield ring can be produced less expensively than a cup or pot. The shield ring can be relatively thin, so that the overall axial size of the drive can be further reduced or, for a constant axial size, more space provided for a hub end wall at the closed end of the subassembly comprising the hub, magnetic yoke and motor magnet. The magnetic yoke can be appropriately constructed as a rolled ring, particularly a steel ring, or as a tube portion.

The rotor and the hub can be fixed to a shaft which is supported in a bearing arrangement at least partly housed within the drive motor stator. A bearing

bush receiving the shaft can be shaped onto the yoke, if the latter is constructed in cup-shaped manner, or preferably on the hub. This obviates a separate component of the bush. The rotor and the hub can, according to a modified construction, be mounted in rotary manner via a bearing arrangement on a fixed shaft, the leads of the stator winding passing through the fixed shaft to the outside of the drive.

A control magnet, e.g. in the form of a control magnet ring is preferably connected to the unit comprising a rotor and the hub, and said magnet cooperates with a stationary magnetic field-sensitive rotation position sensor arrangement, whose function is to produce commutating control signals and optionally additional control signals, e.g. a pulse for a given rotor reference position. The control magnet is appropriately located on the axially open end of the unit comprising the rotor and hub. It can be axially aligned with the motor magnet. The motor magnet can optionally serve as the control magnet. The rotation position sensor arrangement is advantageously placed on a printed circuit board, which axially faces the axially open end of the unit comprising the rotor and hub.

The invention is described in greater detail hereinafter relative to preferred, but non-limitative,

embodiments and the attached drawings. In the drawings:-

Fig.1 is a section through a disk store drive according to the invention along line I-I of Fig. 2;

Fig. 2 is a diagrammatic section along line II-II of Fig. 1;

Fig. 3 is a section similar to Fig. 2 for a modified embodiment;

Fig. 4 is an axial section through a disk store drive according to a further modified embodiment of the invention;

Fig. 5 is an axial partial section for a further modified embodiment;

Fig. 6 is an axial partial section for an embodiment with a magnetic yoke ring and separate axial shield ring;

Fig. 7 is an axial partial section through a further modified embodiment of the disk store drive with a fixed shaft; and

Fig. 8 is a partial section corresponding to Fig. 7 for an embodiment with a fixed shaft.

In Figs. 1 and 2, the drive motor 18 has a stator 19 with a stator lamination bundle 10. The latter is radially symmetrical with respect to a central rotation axis 10A and is provided with an annular central portion 10B. The stator laminations 10 form six stator

poles 11A to 11F, which, in the plan view according to Fig. 1, have a substantially T-shaped configuration and are positioned with a reciprocal angular distance of 60°. A sintered iron core can be provided in place of a bundle of laminations. Pole shoes 12A to 12F of the stator poles, together with a permanent magnetic motor magnet 13, define a substantially cylindrical air gap 14. In the manner indicated in Fig. 1, motor magnet 13 is radially magnetized in quadripolar manner in the circumferential direction, i.e. it has four portions 13A to 13D and on the inside of the annular motor magnet 13 facing air gap 14 are provided in alternating sequence two magnetic north poles and two magnetic south poles 15, 16. In the represented embodiment, poles 15 and 16 have a width of substantially 180° el (corresponding to 90° physical). Thus, an approximately rectangular or trapezoidal magnetization is obtained in the circumferential direction of air gap 14.

Motor magnet 13 is fitted in a soft magnetic material external rotor cup or pot 17 serving as a magnetic yoke and has a magnetic shield, e.g. it is bonded thereinto. Pot 17 and magnet 13 together form an external rotor 30. The external rotor pot 17 has an end wall 17A and a cylindrical circumferential wall 17B. In the case of motor magnet 13, it can in

particular be a rubber magnet, or a plastic-bonded magnet. In place of a one-part magnet ring, dish-shaped magnet segments can be bonded or in some other way fixed into pot 17. Particularly suitable materials for the magnet ring or segments are magnetic material in a synthetic binder, a mixture of hard ferrite and elastomeric material, ceramic magnetic material or samarium cobalt. Whilst in the represented embodiment, each of the poles extends over substantially 180° el, it is also possible to work with narrower poles. However, the rotor pole width should be at least 120° el in order to obtain a high motor output.

Together stator poles 11A to 11F define six stator slots 20A to 20F, in which is placed a three-strand stator winding. Each of the three strands comprises two 120° el-chord coils 21, 22; 23, 24; and 25, 26; whereof each is wound round one of the stator poles 11A to 11F. The two coils in series of each strand diametrically face one another, as shown in Fig. 1. In a not illustrated manner, the coils are preferably wound in bifilar manner. As can be seen from the diagrammatic representation of Fig. 1, any overlap between coils 21 to 26 is avoided and in this way particularly short coil winding heads 27 (Fig. 2) are obtained. The slot openings 28A to 28F can be between

3° el and 30° el. In the present stator winding configuration, slots 20A to 20F can be excellently filled. There is generally no need to provide caps for the slot openings 28A to 28F.

The present motor design makes it possible to obtain a relatively large hole 29 within the stator, because the depth of the stator slots 20A to 20F can be kept relatively small. It is easy to obtain ratios between the diameter I of internal hole 29 and the stator external diameter E in the vicinity of pole shoes 12 of at least 0.35. Preferably the I/E value is in the range 0.4 to 0.7. The L/E ratio between the axial length L of the stator iron and the stator external diameter E is preferably equal to or smaller than 1. These dimensioning ratios are of particular significance in connection with a stable mounting of the rotor. This is of particular importance in connection with drives for disk store systems. In addition, the overall resistance of the stator winding is kept particularly small.

For the purpose of the mounting of rotor 30, according to Fig. 2, in the centre of the external rotor pot 17 is fixed a stub shaft 32 via a bearing bush 31 shaped on to said pot, said shaft being supported via axially spaced ball bearings 33 in a cylindrical sleeve 34, which carries the stator laminations 10 and is fixed to an assembly flange 35.

A preferably light metal hub 37 (not shown in Fig. 1) of a rigid disk store and provided with a cylindrical disk support portion 36 is placed, e.g. by shrinking on to the external rotor pot 17. One or more rigid storage disks 39, preferably magnetic disks are placed on the disk support portion 36, the latter passing through a central opening 40 in storage disks 39, which are reciprocally axially spaced by spacers 41 and are fixed with respect to hub 37 by per se known clamping device. In the case of the embodiment shown in Fig. 2, somewhat more than 2/3 of the axial dimension of the magnetically active stator and rotor parts of drive motor 18, i.e. motor magnet 13 and stator winding 21 to 26 project into the area 46 surrounded by the disk support portion 36. The wall thickness of the disk support portion 36 of hub 37 is smaller than the wall thickness of the cylindrical circumferential wall 17B of cup 17 forming the magnetic yoke, so that a maximum cross-section is made available for parts 13, 17, 37 in the predetermined central opening 40. In particular, the wall thickness of the disk support portion 36 is made as small as possible consistent with mechanical strength requirements. In order to increase the dimensional stability of hub 37, in the vicinity of the open end of the unit comprising hub 37, external rotor pot 17 and motor magnet 13, said

hub carries a thickened, outwardly radially projecting flange 47, which simultaneously axially supports the rigid storage disk 39 closest to the flange.

Hub 37, together with the storage disks 39 supported thereon is located in a clean area 49 which, in per se known, not shown manner, is defined by disk store casing parts. The assembly flange 35 forms part of the clean area boundary towards the lower side in Fig. 2. The upper bearing 33 in Fig. 2 is located between a shoulder 51 on sleeve 34 and a spacing ring 52, whose side remote from bearing 33 engages on the bottom surface of bearing bush 31. Stub shaft 32 is convex at its lower end 53 and is appropriately mounted in a not shown axial bearing. Close to the lower end 53, a fastening ring 55 is arranged in an annular slot 54 of shaft 32 and against the upper surface of said ring bear two cup springs 56, which engage on an intermediate ring 57. The lower ball bearing 53 is positioned between intermediate ring 57 and a further shoulder 58 of sleeve 34.

Assembly flange 35 carries a circuit board 38, which can optionally carry the commutating electronics and/or other circuit components, e.g. for speed regulation purposes. The circuit board 38 more particularly carries three rotation position sensors 42, 43, 44 and in the represented embodiment they are

magnet field sensors, e.g. Hall generators, field plates, magnetic diodes and the like. Bistable-switching Hall IC's are particularly advantageous. The use of 180° el wide rotor poles 15, 16 make it possible to use motor magnet 13 as the control magnet for position sensors 42, 43, 44. The embodiment according to Fig. 2 shows the rotation position sensors 42, 43, 44 axially facing the magnet 13 controlling them. It is also e.g. possible to arrange the rotation position sensors in the manner indicated in broken line form in Fig. 2, so that they radially face the magnet 13 controlling them. The rotation position sensors 42, 43 and 44 are appropriately so peripherally positioned with respect to coils 21 to 26 that changes to the sensor switching states substantially coincide with the zero crossings of the associated coil voltages. In the embodiment according to Fig. 1 this is achieved in that the rotation position sensors are displaced by 15° mech with respect to the centre of the slot openings 28A, 28B, 28C.

The embodiment according to Fig. 3 essentially differs from that according to Fig. 2 in that a control magnet 45 separate from motor magnet 13 is provided for energizing the rotation position sensors 42, 43, 44. Control magnet 45 is located radially outside motor magnet 13 on the bottom of a flange 17C, which projects

radially outwards from peripheral wall 17B of external rotor pot 17, on its open end. The external rotor pot 17 and hub 37' terminate in flush manner at the open end in the case of the embodiment of Fig. 3. At 59 is indicated a connection of one of the coils 21, 26, to a contact of the printed circuit board 38 from which a connecting cable 60 extends outwards through an opening 61 in assembly flange 35.

Fig. 4 illustrates another embodiment of the disk store drive in which, diverging from the embodiment of Figs. 2 and 3, hub 64 corresponding to hub 37 has an end wall 64A engaging on end wall 17A of external rotor pot 17 and on it is shaped a bearing bush 65 for shaft 32. On the end of the disk support portion 66 of hub 64 remote from end wall 64A is located a radially outwardly bent flange 67, which has a circumferential wall 68 concentric to the disk support portion 66 and having a larger diameter than the latter. Circumferential wall 68 engages radially and externally over flange 17C of pot 17. The junction between flange 17C and circumferential wall 68 is sealed in the manner indicated at 69 by varnish, adhesive or the like. Thus, as in Fig. 3, it is ensured that dirt particles are not passed radially outwards from flange 17C and into the clean area 49. Control magnet 45 cooperating with the rotation position sensors (whereof only sensor

42 is shown in Fig. 4) is axially aligned with motor magnet 13 and is fitted to the end of magnet 13 remote from end wall 17A. External rotor pot 17 is drawn down to such an extent in Fig. 4 that it surrounds the control magnet 45. The space left free between end wall 17A and the end of magnet 13 facing said wall is filled with an adhesive or some other filling material 70. The bearing arrangement for shaft 32 formed by the two ball bearings 33 is sealed with respect to the inner area of the motor and consequently with respect to the clean area 49 by means of a magnetic fluid seal 72, which comprises two annular pole pieces 73,74, a permanent magnet ring 75 located between these pole pieces, and a not shown magnetic fluid, which is introduced into an annular clearance 76 between ring 75 and a portion 77 of shaft 32. Seals of this type are known under the term "ferro-fluidic seals". Seal 72 effectively prevents the passage of dust particles from the bearing arrangement into the clean area 49. Seal 72 is adjacent to, but axially spaced from, bearing bush 65, which ensures that magnetic fluid is not drawn by capillary action out of seal 72.

As can be gathered from Fig. 4, the magnetically active stator and rotor parts are substantially completely housed within the space enclosed by the disk support portion 66. Fig. 4 also shows an axial bearing

79 located on a spring clip 80, which is in turn placed on a cover 81 introduced into the end of a sleeve 82 remote from the clean area 49. In a similar way to sleeve 34 of the embodiment according to Figs. 2 and 3, sleeve 82 receives the bearings 33, but is connected in one piece with assembly flange 83 corresponding to assembly flange 35.

In the same way as spring clip 80, axial bearing 79 is preferably electrically conducting. This makes it possible to eliminate electrostatic charges of shaft 32 via bearing 79 in spring clip 80.

Circuit board 38 is connected to assembly flange 8 via an adhesive coating 84, which is located in a slot 85 of assembly flange 83. In order to further reduce the overall axial height of the disk store drive, in the vicinity of the rotation position sensors circuit board 38 is provided with openings 86 and the rotation position sensors are introduced into slot 85 and openings 86. In the vicinity of the engagement point between upper pole piece 73 and the inner circumferential wall 87 of sleeve 82, an additional seal by means of coating lacquer or the like is provided at 88.

The embodiment according to Fig. 5 is largely similar to that of Fig. 4. However, in this case the bearing bush 31 is shaped on to the end wall 17A of the

external rotor pot 17 and which acts as a magnetic shield. End wall 17A contains three threaded holes 90, which are circumferentially displaced from one another 120°. Holes 90 are used to receive threaded bolts for fitting a not shown clamping device for the rigid storage disks 39 (Fig. 2). Under end wall 17A is located to cover ring 91 which, in the vicinity of the threaded holes 90, seals the inner area of the motor relative to clean area 49. Most of the axial length of the magnetically active stator and rotor parts of the drive motor are once again located in area 46, which is surrounded by the disk support portion 36' of hub 37', which in this case corresponds to that of Fig. 3.

Fig. 6 shows a further modified embodiment of the invention, which essentially differs from the previous constructions in that the external rotor pot 17 is replaced by a soft magnetic yoke ring 94 and a separate, but also soft magnetic shield ring 95. The latter extends from the clean area-side axial end 96 of yoke ring 94 in a radially inwards direction. The wall thickness of shield ring 95 can be much less than that of the yoke ring 94. Threaded holes 97 functionally corresponding to the threaded holes 90 of Fig. 5 are formed in the end wall 98 of a hub 99, on which is shaped the bearing bush 100 for shaft 32. In the vicinity of threaded holes 97, shield ring 95 is

provided with depressions 101, which permit the use of the full thread length of the threaded holes 97. Filling material 70 is provided in the region between the upper end of the motor magnet 13 in Fig. 6, end 96 of the yoke 94 and the radially outer part of the shield ring 95. the magnetically active rotor and stator parts are more than 2/3 located in the area surrounded by the cylindrical disk support portion 102 of hub 99.

Yoke ring 94 can be a rolled ring particularly a steel ring, or a tube portion. Manufacture is simplified compared with the use of an external rotor pot 17. In addition, additional axial length is saved, because on the one hand the wall thickness of the shield ring 95 can be kept small, and because on the other hand no space is lost, in the way in which it is required when using pot 17 for its unavoidable radius r (Fig. 5) at the transition point between circumferential wall 17B and end wall 17A. The axial construction space which has been made available can be used to give end wall 98 a greater thickness and consequently increase the length of threaded holes 97.

Whereas in the case of the embodiment according to Figs. 1 to 6, shaft 32 rotates in operation, Figs. 7 and 8 illustrate embodiments with a stationary shaft 105. According to Fig. 7, the latter is fitted in not

shown manner in the disk store. By means of the first ball bearing 106, a hub 107 is mounted in rotary manner on shaft 105. Hub 107 has an end wall 108 with a shaped-on bearing bush 109, a disk support portion 110 and on the side remote from end wall 108 a radially outwardly projecting reinforcing flange 111. Hub 107 is connected to a soft magnetic yoke ring 94. The soft magnetic shield ring 95 engages on the inside of end wall 108. The circuit board 38 with the rotation position sensors, whereof only sensor 42 is shown in Fig. 7, is in this case suspended by means of supports 112 (Fig. 8) on the stator laminations 10. A motor cover 114 is mounted by means of a second ball bearing 113 on shaft 105, said cover tightly sealing the motor on the axial end remote from end wall 108. A magnetic fluid or ferro-fluidic seal 72 or 72' discussed in detail relative to Fig. 4, is provided on each of the outsides of bearings 106, 113. Seals 72, 72' ensure a sealing of the bearing arrangement with respect to clean area 49, so that the complete drive motor can be located in said clean area. The connections of the stator winding and/or the electronic components mounted on circuit board 38 can be led out by means of a cable 115, which is placed in an axial slot 116 of shaft 105.

The embodiment of Fig. 8 differs from that of Fig. 7 substantially in that in place of the shield ring 95 and the yoke ring 94 there is a one-piece soft magnetic material pot 117 with end wall 117A and circumferential wall 117B corresponding to pot 17.

In the embodiments according to Figs. 7 and 8, the magnetically active stator and rotor parts of the drive motor are located within the area surrounded by the disk support portion 110.

Embodiments of the disk store drives described and illustrated herein are also described and claimed in the following copending applications divided out of this application, namely in Nos. 2217522 (8910359.2), (8910360.0), and in (8910559.7).

CLAIMS

1. A disk store drive with a brushless drive motor having a stator provided with a winding, and an external rotor coaxially surrounding the stator and spaced therefrom by a substantially cylindrical air gap, said rotor having a permanent magnetic rotor magnet and a soft magnetic yoke; and a hub concentric to the yoke, said hub being connected to the rotor for rotation therewith and having a disk support portion with a cylindrical external circumferential surface, which can be passed through a central opening of a storage disk for receiving at least one storage disk, at least half of the axial longitudinal dimension of the stator winding and the motor magnet cooperating therewith being housed within the disk support portion of the hub, wherein the disk support portion wall is thinner than said yoke wall.

2. A disk store drive as claimed in Claim 1, wherein the hub has an outwardly radially projecting flange at its outer end.

3. A disk store drive as claimed in any one of the preceding claims, wherein at least two thirds of said axial longitudinal dimension is housed within the disk support portion of the hub.

4. A disk store drive as claimed in Claim 3, wherein the stator winding arrangement and the motor magnet

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cooperating therewith are substantially completely housed within the disk support portion.

5. A disk store drive as claimed in any one of the preceding claims, wherein the hub is made from a material which is still suitable for clean area use after cutting.

6. A disk store drive as claimed in Claim 5, wherein said material is light metal.

7. A disk store drive as claimed in any one of the preceding claims, wherein the external circumferential surface of the disk support portion, following assembly of hub and drive motor, is finished with respect to centricity with the rotation axis.

8. A disk store drive as claimed in Claim 7, wherein said surface is ground or turned to size.

9. A disk store drive as claimed in any one of the preceding claims, wherein the hub is extruded or cast.

10. A disk store drive as claimed in Claim 9, wherein the hub is pressed hot on to the magnetic yoke.

11. A disk store drive as claimed in any one of the preceding claims, wherein the magnetic yoke is annular.

12. A disk store drive as claimed in Claim 11, wherein a magnetic shield ring is placed in the hub and extends radially inwards substantially from outer axial end of the annular yoke.

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13. A disk store drive as claimed in any one of the preceding claims, wherein the rotor and the hub are fixed to a shaft, which is rotatably supported in a bearing arrangement at least partly housed within the drive motor stator.

14. A disk store drive as claimed in Claim 13, wherein a bearing bush receiving the shaft is shaped on to the hub or the magnetic yoke.

15. A disk store drive as claimed in any one of Claims 1 to 12, wherein the rotor and the hub are rotatably mounted by means of a bearing arrangement on a fixed shaft.

16. A disk store drive as claimed in Claim 15, wherein leads for the stator winding pass through the fixed shaft or a slot therein to the outside of the drive.

17. A disk store drive as claimed in any one of Claims 13 to 16, wherein the bearing arrangement is sealed by means of at least one magnetic fluid seal.

18. A disk store drive as claimed in any one of the preceding claims, wherein a control magnet is connected to the unit comprising the rotor and hub, and cooperates with a stationary, magnetic field-sensitive rotation position sensor arrangement, which is mounted on a printed circuit board, which axially faces the side of the unit comprising the rotor and hub, which is open in the axial direction.

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19. A disk store drive as claimed in any one of the preceding claims, wherein the ratio of inner and outer diameters of the stator is at least 0.35.

20. A disk store drive as claimed in Claim 19, wherein said ratio is 0.4 to 0.7.

21. A disk store drive as claimed in any one of the preceding claims, wherein the ratio of axial length to external diameter of the stator is at most 1.

22. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figures 1 and 2.

23. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 3.

24. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 4.

25. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 5.

26. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 6.

27. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 7.

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28. A disk store drive as claimed in Claim 1 and substantially as hereinbefore described with reference to Figure 8.

29. A disk store comprising a disk store drive as claimed in any one of the preceding claims having one or more disks received on the hub and located in a clean area defined within a housing of the store.

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