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(54) Apparatus for generating magnetic fields

(57) Apparatus for generating a magnetic field comprises a plurality of bobbins 14 arranged in a predetermined configuration. Each bobbin carries first and second current carrying coils (20, 21). By appropriately energising the coils a magnetic field can be produced which can be switched between a first direction and a second direction. In another mode of operation the coils can be energised to produce a magnetic filed which rotates.

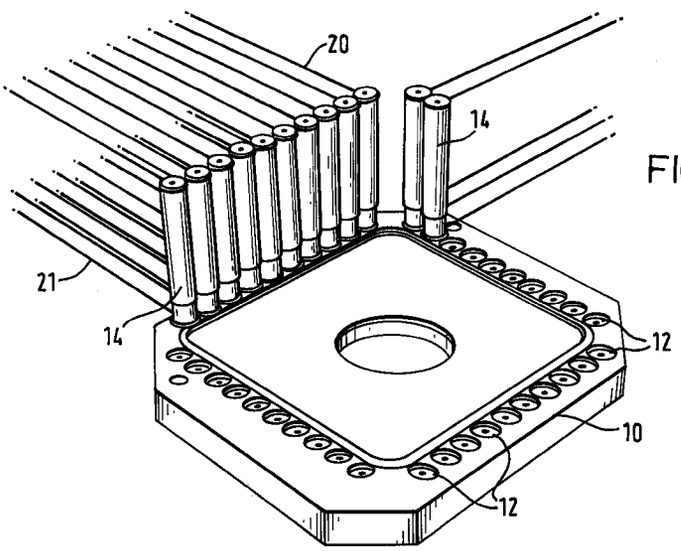

FIG. 2

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Description

[0001] This invention relates to apparatus for generating magnetic fields. The apparatus has been designed for use in the manufacture of the so-called hard disks of computers, but its use is not limited to such an application.

[0002] Modem computers use what are known as hard disks as the bulk data storage medium. Such disks are typically round and have a diameter of approximately 15cm and a thickness of about 1mm. During the manufacture of such disks magnets are used to create magnetic fields in the material of the disks. Typically such magnets create magnetic fields of 100 Gauss in the plane of the disk and such fields have a uniformity of about +/- 10% over the volume of the disks. That is to say if B_y is the main direction of the magnetic field then B_y may vary by +/- 10% and B_x and B_z are each less than 10% of B_y. This is illustrated diagrammatically in Figure 1 of the drawings.

[0003] Recent developments in the manufacture of these hard disks has lead to a requirement for magnetic field generating apparatus which is capable of producing two independent and orthogonal magnetic fields. That is to say there is a requirement for a magnetic field which can be switched between two states expressed as follows:

$$90<B_y<110 \text{ Gauss with } B_x \ \& \ B_z<0.1B_y$$

$$90<B_x<110 \text{ Gauss with } B_y \ \& \ B_z<0.1B_x$$

[0004] Such a requirement is not readily achievable by conventional magnetic field generating apparatus. Magnets exist which can produce a uniform field in a single direction and such magnets are well known. However to produce a magnetic field which can be switched between two different directions requires mechanical machinery to physically rotate the magnet or the disk being magnetised. There are significant problems with such a method in this particular application. Firstly, mechanical machinery is relatively expensive and bulky. It can also be unreliable and needs regular servicing. Furthermore, the magnet has to be integrated into a complex piece of machinery within a high vacuum vessel and this leads to difficulties in servicing. Furthermore, the machinery tends to produce particular matter and this can contaminate the disk being produced.

[0005] An object of the present invention is to provide a magnetic field generating apparatus, which does not suffer from such problems.

[0006] According to the present invention there is provided apparatus for generating a magnetic field, said apparatus comprising a plurality of elongate members, each formed of magnetic or magnetisable material and arranged in a predetermined configuration relative to a volume within which the magnetic field is to be produced, each elongate member carrying first and second current carrying coils, the arrangement being such that when said first current carrying coils are energised, a magnetic field is produced in a plane generally orthogonal to the axis of the elongate members, said magnetic field being in a first direction, and when said second coils are energised a magnetic field is produced in said plane, said magnetic field having a second direction different from said first direction.

[0007] Thus by appropriately energising the first and second current carrying coils, a magnetic field can be produced, which field can be switched between a first direction and a second direction.

[0008] Typically, but not necessarily, the first and second directions will be generally orthogonal.

[0009] With such an arrangement it is possible to produce two independent and orthogonal magnetic fields simply by electrically switching between the first and second groups of current carrying coils. Such an arrangement is far simpler and more reliable than the mechanical arrangements referred to above. The first current carrying coils may be connected in series and the second current carrying coils may also be connected in series. The apparatus may include means for controlling the switching of the first and second sets of coils to produce the appropriate field direction.

[0010] The elongate members may have a uniform length. Alternatively the elongate members may have different lengths.

[0011] The elongate members may be mounted upon a base plate. The base plate may be profiled in such a way as to enhance one or more characteristics of the magnetic field.

[0012] Each elongate member may carry a further current carrying coil or coils, which are energisable to enhance a characteristic or characteristics of the magnetic field being generated.

[0013] The apparatus may also include additional soft or permanent magnetic materials so arranged as to enhance a characteristic or characteristics of the magnetic fields.

[0014] In addition to being able to produce a magnetic field which can be switched between a first direction and a second direction, the present apparatus can also be used to produce a magnetic field which rotates. In this alternative mode of operation a sinusoidal signal is applied to the first ad second current carrying coils such that the signal applied to the first coils is 90° out of phase relative to the signal applied to the second coils. This arrangement produces a magnetic field which rotates.

[0015] The invention will be described now by way of example only, with particular reference to the accompanying drawings. In the drawings:

Figure 1 illustrates the magnetic fields configuration used in the production of magnetic computer storage disks,

Figure 2 illustrates schematically an apparatus for generating a magnetic field in accordance with the present invention,

Figures 3a and 3b are side and perspective views respectively of a bobbin with two coils wound thereon, and

Figure 4 illustrates the connection of the coils to a power supply unit.

[0016] Referring to Figure 2, magnetic field generating apparatus in accordance with a embodiment of the present invention comprises a square base plate 10. The perimeter portion of the base plate 10 is configured to define a plurality of circular recesses 12, which can receive the lower end of a corresponding plurality of upright bobbins 14. These Bobbins are elongate pin-like members and formed from magnetic or magnetisable materials such as magnetic steel. In the particular embodiment forty such bobbins are employed, ten along each side of the square, but it will be appreciated that this number can vary widely.

[0017] Each bobbin carries a first current carrying coil and second current carrying coil. The first current carrying coils will be referred to as the X coils and the second current carrying coils as the Y coils. All the X coils are connected in series and similarly all the Y coils are connected in series. The arrangement is such that when the X coils are energised the apparatus generates a magnetic field whose flux lines extend in the Z=0 plane along the B_x direction. By carefully optimising the number of turns or current density within each of the coils it is possible to generate a magnetic field which is uniform over a useful volume.

[0018] A wound bobbin is shown in more detail in Figures 3a and 3b. The bobbin has two coils wound thereon each formed from copper wire which has an insulating coating formed from for example enamel. Tthe two coils are both wound in the same sense around the body and each has two layers of windings. The start tail of the first coil 20 is shown at TS1 and the finish tail of the first coil is shown at TF1. The start tail of the second coil 21 is shown at TS2 and the finish tail of the second coil is shown at TF2.

[0019] When the Y coils are energised and the X coils de-energised the arrangement then produces a magnetic field in the B_y direction which is orthogonal to the B_x direction, but still parallel to the Z=0 plane. Again by optimising the number of turns within the coils and the current densities, it is possible to produce a uniform magnetic field over a useful volume.

[0020] Thus it will be seen that the arrangement described can produce two independent ad orthogonal fields. A change from one field to the other can be achieved simply by electrical switching.

[0021] The manner in which the coils 20, 21 are connected to a power supply is illustrated in Figure 4. In Figure 4 a power supply unit is shown at 22. The coils along each side of the square are shown as two groups marked A to E. The coil tails marked "1" in Figure 4 correspond to the tails TS1 and TF1 of Figure 3 and the tails marked "2" correspond to the coil tails TS2 and TF2 of Figure 3. The + and - signs signify opposite ends of each coil.

[0022] The connection of coils shown in Figure 4 produces a magnetic field B_y in a plane coplanar with the upper surface of the bobbins. To produce a field in the direction B_x the connections are changed so that the other set of coils or each limb is energised.

[0023] Tests show that the following can be achieved by the apparatus shown in Figure 2.

X coil current (Ix)	9.0A(dc)	0
Y coil current (Iy)	0	9.0A(dc)
B_x @ Z=0	+86.9 to +112.7 Gauss	-4.9 to +4.9 Gauss
B_y @ Z=0	-4.9 to +4.9 Gauss	+86.9 to +112.7 Gauss
B_z @ Z=0	-10.5 to +10.5 Gauss	-10.5 to +10.5 Gauss

[0024] This shows that the predominant field components B_x and B_y produced in each case are relatively homogenous varying by +/- 12.5%. Also the effect of field components in other directions are relatively small being only 5% and 10.5% of the main component.

[0025] As can be seen the arrangement described uses forty bobbins located around the edges of a square. It will be appreciated that many other configurations of bobbins can be used. It is not necessary, for example, that the bobbins form a continuous perimeter of a regular shape such as a square. Also the bobbins shown in the drawings are of uniform length. It may be appropriate in certain instances to use bobbins of different lengths in order to achieve the required magnetic field characteristics.

[0026] Other variations which are possible are to provide additional current carrying coils on the pins, again to pro-

duce particular magnetic field characteristics. Magnetic field characteristics can also be adjusted by appropriately profiling the base plate 10. Enhancements to the magnetic field can also be generated by providing additional soft or permanent magnets in the vicinity of the bobbins.

[0027] In the embodiment described above the current carrying coils are energised in such a way as to produce a magnetic field which can be switched between a first direction and a second direction.

[0028] The apparatus can be used other ways. For example it is possible to produce a rotating magnetic field by applying a first sinusoidal current to the first set of current carrying coils and a second sinusoidal current, 90° out of phase relative to the first current, to the second set of coils. If $I_x = I_o \sin(wt)$ is applied to the x-axis set of coils and

$$I_y = I_o \sin(wt + \frac{\Pi}{2})$$

is applied to the y-axis set of coils a magnetic field of constant intensity is produced and this field rotates about the Z-axis at a frequency

$$f = (\frac{w}{2\Pi}) H_z$$

The apparatus can operate in this way because the two sets of current carrying coils produce independent and orthogonal magnetic fields.

Claims

1. Apparatus for generating a magnetic field, said apparatus comprising a plurality of elongate members, each formed of magnetic or magnetisable material and arranged in a predetermined configuration relative to a volume within which the magnetic field is to be produced, each elongate member carrying first and second current carrying coils, the arrangement being such that when said first current carrying coils are energised, a magnetic field is produced in a plane generally orthogonal to the axis of the elongate members, said magnetic field being in a first direction, and when said second coils are energised a magnetic field is produced in said plane, said magnetic field having a second direction different from said first direction.

2. Apparatus according to claim 1, wherein the first and second current carrying coils are so energised as to produce a magnetic field which can be switched between a first direction and a second direction.

3. Apparatus according to claim 1, wherein a first sinusoidal current is applied to the first current carrying coils, and a second sinusoidal current, 90° out of phase relative to the first current, is applied to the second current carrying coils so as to produce a magnetic field which rotates.

4. Apparatus according to claim 2, wherein the first and second directions are generally orthogonal.

5. Apparatus according to any preceding claim, wherein the first current carrying coils are connected in series and the second current carrying coils are also connected in series.

6. Apparatus according to claim 2, claim 4 or claim 5, including means for controlling the switching of the first and second sets of coils to produce the appropriate field direction.

7. Apparatus according to any preceding claim, wherein the elongate members have a uniform length.

8. Apparatus according to any one of claims 1 to 6, wherein the elongate members have different lengths.

9. Apparatus according to any preceding claim, wherein the elongate members are mounted upon a base plate.

10. Apparatus according to claim 9, wherein the base plate is profiled in such a way as to enhance one or more characteristics of the magnetic field.

11. Apparatus according to any preceding claim, wherein each elongate member carries a further current carrying coil

or coils, which are energisable to enhance a characteristic or characteristics of the magnetic field being generated.

12. Apparatus according to any preceding claim including additional soft or permanent magnetic materials so arranged as to enhance a characteristic or characteristics of the magnetic fields.

FIG. 1

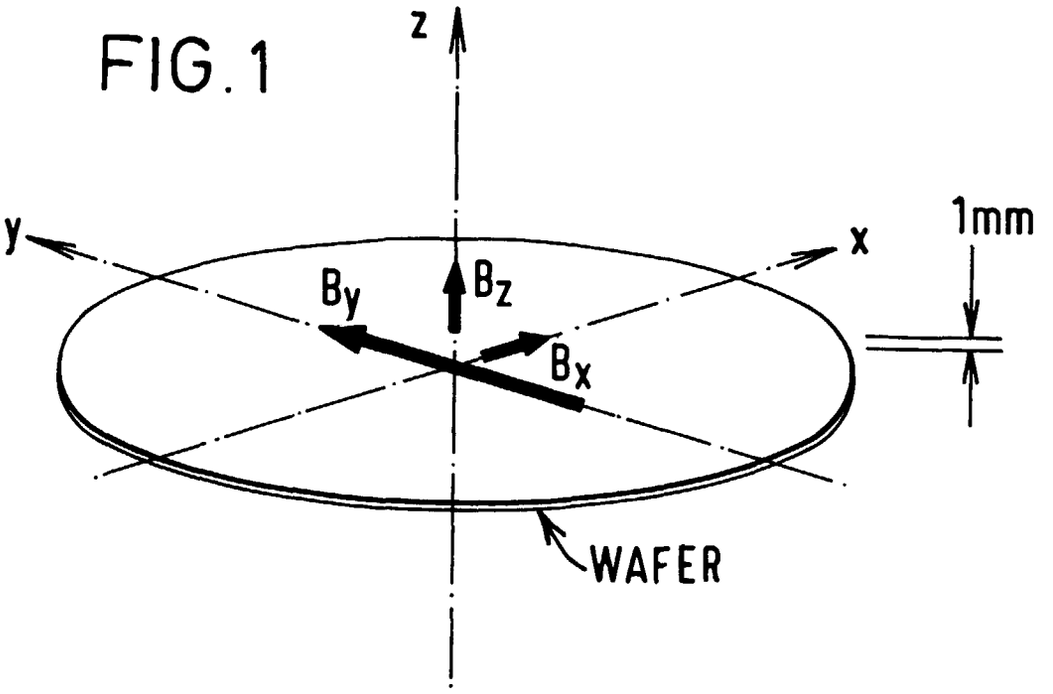

FIG. 3a

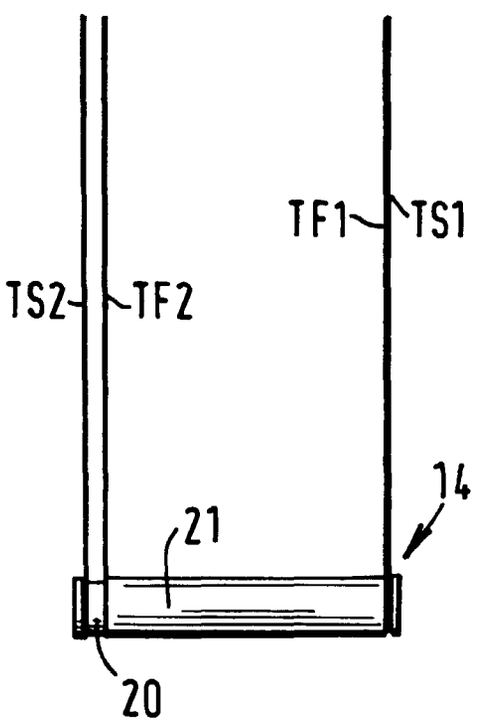

FIG. 3b

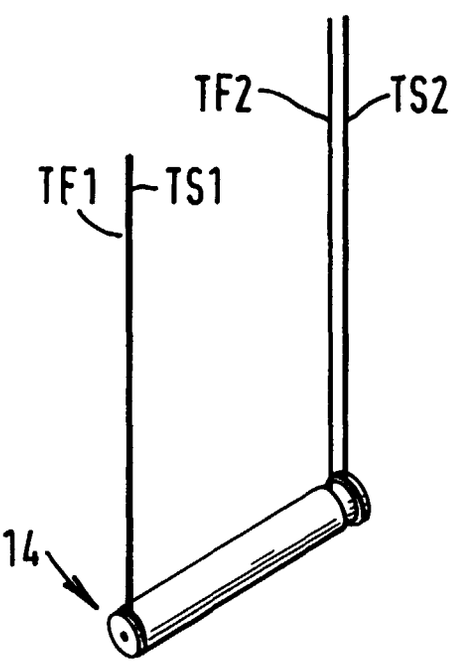

FIG. 2

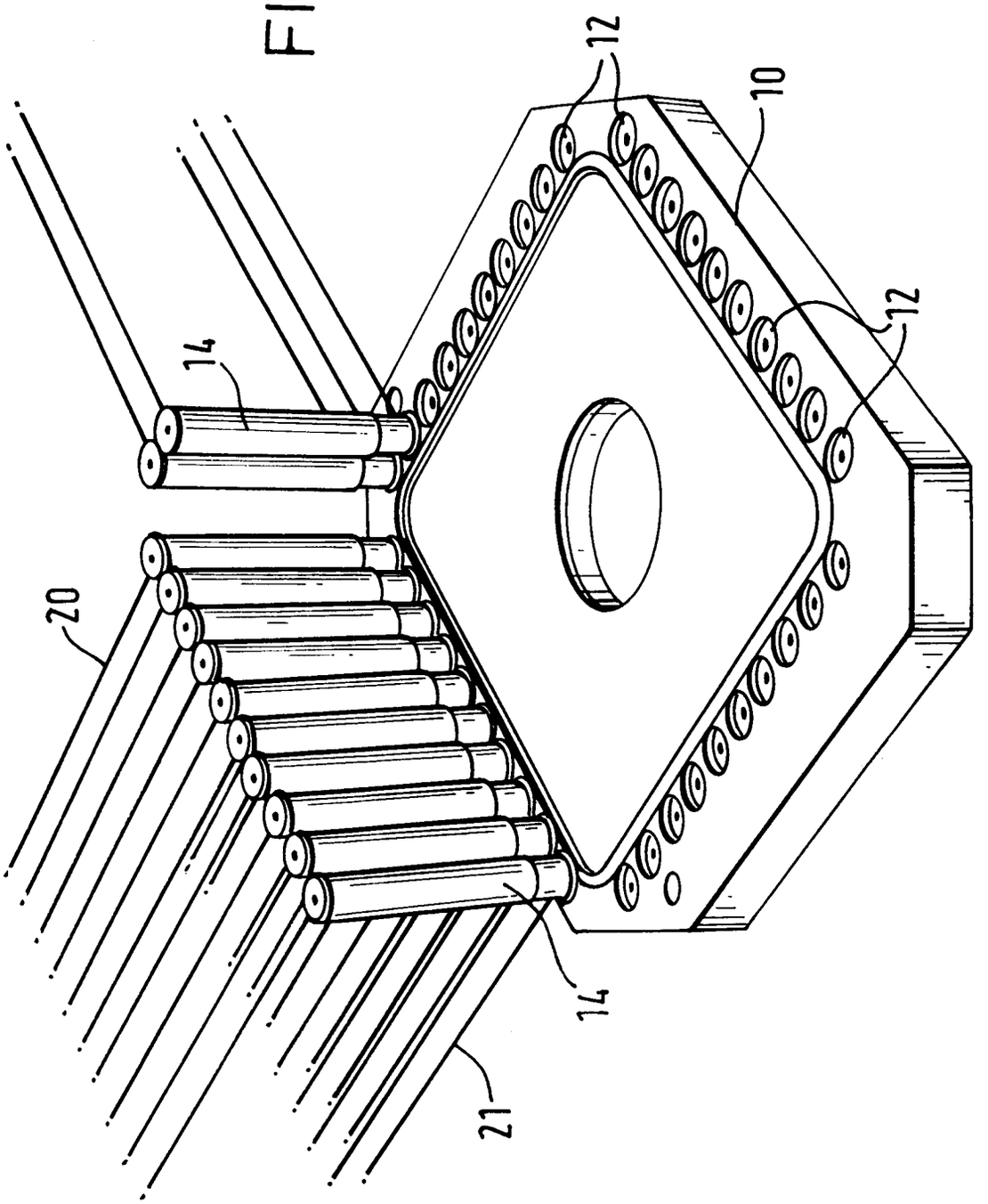

FIG. 4