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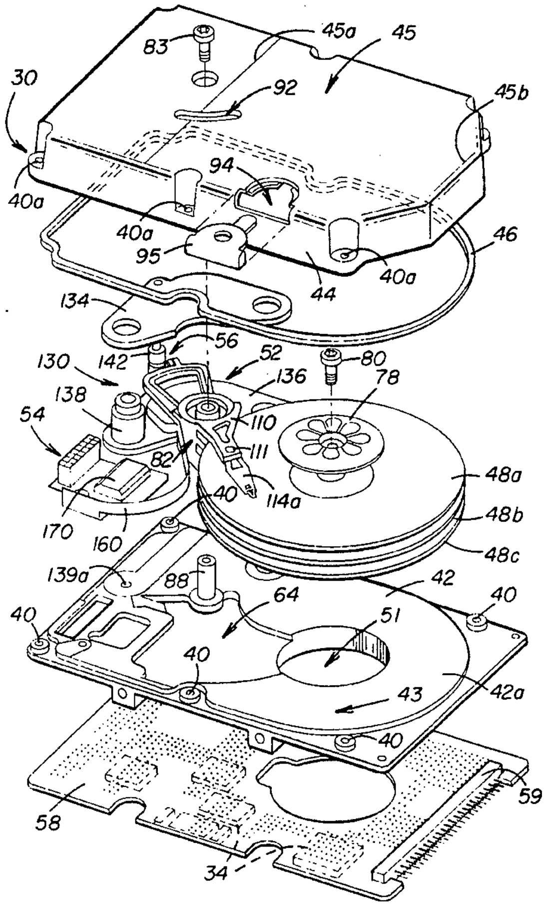
(54) Title: HIGH CAPACITY TWO AND ONE-HALF INCH DISK DRIVE

(57) Abstract

A two and one-half inch form factor disk drive comprises a base (42), a cover (44) attached to the base (42), and at least three storage disks (48a-c) in a height of about three-quarters of one inch. The disk drive includes read/write heads attached at the end of head suspension (114a) for reading and writing information to the disks (48a-c). Actuator assembly (52) selectively positions the heads with respect to the disks (48a-c). Control circuitry (34) is mounted on a printed circuit board (58) which is adjacent to the bottom of the base (42) for controlling the actuator assembly (52) and the read/write heads.



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HIGH CAPACITY TWO AND ONE HALF INCH DISK DRIVE

CROSS-REFERENCE TO RELATED APPLICATIONS AND PATENTS

ARCHITECTURE FOR SEALED DISK DRIVE, Serial No. 664,659, filed March 5, 1991, which is a divisional of U.S. Patent No. 5,029,026, which is a divisional of Serial No. 056,584, filed May 29, 1987 now abandoned.

DISK DRIVE SYSTEM CONTROLLER ARCHITECTURE, U.S. Patent No. 4,979,056.

DISK DRIVE SOFTWARE SYSTEM ARCHITECTURE, Serial No. 488,386, filed February 23, 1990, which is a continuation of Serial No. 057,806, filed June 2, 1987, now abandoned.

DISK DRIVE SYSTEM CONTROL ARCHITECTURE UTILIZING EMBEDDED REAL-TIME DIAGNOSTIC MONITOR, U.S. Patent No. 4,979,055.

LOW-POWER HARD DISK DRIVE ARCHITECTURE, Serial No. 564,693, filed August 7, 1990, which is a continuation of Serial No. 152,069, filed February 4, 1988, now abandoned.

DISK DRIVE SYSTEM EMPLOYING ADAPTIVE READ/WRITE CHANNEL CONTROLS AND METHOD OF USING SAME, Serial No. 420,371, filed October 12, 1989.

DISK DRIVE SYSTEM USING MULTIPLE EMBEDDED QUADRATURE SERVO FIELDS, Serial No. 386,504, filed July 27, 1989.

ARCHITECTURE FOR 2-1/2 INCH DIAMETER SINGLE DISK DRIVE, U.S. Patent No. 5,025,335.

Each of these Related Applications and Patents are assigned to the Assignee of this subject Patent and are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to hard disk drives; more particularly, to hard disk drives which have reduced size and weight and increased storage density.

Description of the Related Art

Data storage technology follows a continuing trend towards increasing storage density, and reducing device weight, size, and power consumption. One factor motivating these trends is the increasing use of lap-top, notebook, palm-top, and other portable and/or battery-powered computers. Portability requires reduced size (physical dimensions) and weight. Increased storage density is necessary so that a disk drive having a reduced physical size can provide the same storage capacity as a physically larger drive.

The dimensions of disk drives have generally become standardized around certain so-called "form factors." Eight inch (8") disk drives were followed by the five and one-quarter inch (5¼") disk drives. The length of a 5¼" drive is approximately the width of an 8" drive and the width of a 5¼" drive is approximately one-half of the length of an 8" drive. This same size relationship applies to the relationship between so-called three and one-half inch (3½") drives and 5¼" drives (a 3½" drive is approximately one half the size of a 5¼" drive), and to the relationship between two and one-half inch (2½") drives and 3½" drives (a 2½" drive is approximately one half the size of a 3½" drive).

In addition, the heights of disk drives have changed. Initially, this relationship followed a trend similar to form factors, full height 5¼" drives were reduced to half-height 5¼" drives (a height of approximately 1.625"). The half-height form factor was the starting point for 3½" drives, which were later reduced to a one inch (1.0") height form factor and lower. For 2½" form factor disk drives, a typical height is in the range of 0.7" - 0.75", generally depending on whether the drive has one or two disks. With the increasing popularity of portable and notebook computers, the thrust toward reduced size and increased capacity remains extremely strong.

Typically, Winchester-type hard disk drives incorporate a storage medium or disk, read-write transducers or "heads" to transfer information to and from the disks, a spin motor for rotating the disks, an actuator assembly for positioning the heads with respect to the disk, and control electronics (usually on a printed circuit board) incorporating means for communicating with a host computer, means for controlling data transfer functions to and from the disk, and means for controlling the integral components of the disk drive. A number of Winchester-type hard disk drive designs incorporate the disk, heads, actuator assembly and spin motor within a controlled environment, isolated from ambient atmospheric conditions. Generally, the controlled environment is provided in the hard disk assembly (HDA) portion of the drive which, along with the control electronics, may comprise an integrated mechanical assembly substantially (or totally) defining the desired form factor.

The HDA generally comprises: a base, on which the disk, heads, actuator assembly, spin motor, and connectors are mounted; and a cover, which forms an intersecting fit with the base and encloses the components in the drive, thereby creating the controlled environment between the base and cover. A gasket may be provided between the cover and the base to ensure a seal therein between. Typically, such drives can withstand pressure changes in a range of 200 feet below sea level to 10,000 feet above sea level.

The inventors of the disk drive which is the subject of this patent has realized that improvements in the specific components of a disk drive having a 2½" form factor were necessary to provide increases in disk drive capacity within standard form factor sizes, where the drive has power consumption levels suitable for use in notebook computers. In redesigning components of a disk drive having a 2½" form factor, consideration is given to maintaining or decreasing the physical area occupied by the drive, while improving the techniques utilized to manufacture the drive.

As the footprint of the disk drives has decreased, so has the amount of board space available for the circuit components necessary to operate the disk drive. It is conventional to provide a hole in the printed circuit board to accommodate the spin motor in disk drives having an overall height of less than one inch. However, each hole in the printed circuit board reduces the amount of space available for circuit components. The reduced size of disk drives having a form factor of 2½" or less places a premium on printed circuit board space, and thus any further reduction in board space is undesirable.

Because of the sensitivity of the components contained within the controlled environment, contamination is a major cause of drive failure. The prevention of contamination within the drive is thus a specific and important design goal. As the overall size of the disk drives has decreased, so has the volume within the controlled environment surrounding the contaminant sensitive elements of the drive. In two and one-half inch form factor drives, the reduced size of the controlled environment has resulted in contamination problems resulting from outgassing, e.g. the tendency of certain materials used in manufacturing the drive to exude gasses within the controlled environment over the life of the drive. Outgassing causes a buildup within, and eventual release of pressure from, the controlled environment. Such a release allows contamination to enter the drive, which may thereby compromise data integrity.

Materials known to cause outgassing problems are pressure sensitive adhesives. Adhesives, such as Part No. Y-9460 pressure sensitive adhesive, manufactured by Minnesota Mining and Manufacturing (3M) Company, St. Paul, Minnesota, are typically used at various stages in drive manufacture. Such pressure sensitive adhesives re used in a number of sub-assemblies in the controlled environment. For example, in an actuator assembly, which typically consists of an actuator body, having read/write heads coupled thereto, and a bearing cartridge, which allows the actuator body to rotate (generally about a post) on the base plate, adhesives are used to secure the bearing cartridge to the actuator body. In another aspect, adhesives are used in prior art drives to secure the spin motor to the base plate. Further, many drives incorporate flex circuits to carry data from the printed circuit board to the actuator and to the spindle motor. The flex circuit has one end coupled to the actuator and another end coupled to a bracket and header, which couples the circuit to the PCB. In such applications, adhesives are used in securing both ends of the flex circuit.

During initial disk drive fabrication, a typical storage disk will be provided with the plurality of data storage tracks. During drive fabrication, the necessary servo information is written into the data tracks of the storage disk. This process is sometimes referred to as "pack writing".

Generally, pack-writing is performed before the drive is sealed. Conventionally, this meant that pack writing took place before the cover portion of the drive was in place. However, this process had the disadvantage of allowing prolonged exposure of the media to contaminants and it was possible that some distortion of the mechanical structure of the drive could take place once the drive cover was secured in place.

SUMMARY OF THE INVENTION

It is therefore, an object of the present invention to provide a high capacity hard disk drive having a two and one-half inch (2½") form factor with a height equal to or less than substantially three-quarters (0.75) inch.

An additional object of the invention is to provide the above object in a two-and-one-half-inch form factor disk drive wherein the control electronics for the drive are positioned adjacent to the HDA, and the total assembled height of the drive does not exceed substantially three-quarters (0.75) inch.

A further object of the present invention is to reduce the amount of outgassing and resultant contamination found in two and one-half inch form factor disk drives.

It is a further objective of the present invention to provide a two and one-half inch form factor, reduced height disk drive, using fewer adhesives to generate fewer contaminants in the hard disk assembly (HDA) portion of the drive.

A further object of the invention is to provide a disk drive which is easy to manufacture in substantial quantities, and thus to provide a novel method for manufacturing the drive.

A further object of the invention is to provide the above objects in a disk drive utilizing at least 3 disks to achieve a storage capacity of at least 250 MBytes.

These and other objects are provided in a two and one-half inch form factor disk drive, comprising a base having a top and a bottom, a cover attached to the base, and at least three storage disks in a height of about three-quarters of one inch. The drive includes a spin motor supporting the disks on the top of the base and interactive read/write heads for reading information from and writing information on the disks. An actuator assembly, supported on the base and responsive to control signals, selectively positions the heads with respect to the disks. The base and cover enclose the disks, the interactive means, and the actuator means to form a controlled environment thereinbetween. Control circuitry, mounted on the head-disk assembly on a printed circuit board (PCB) so that the (PCB) is adjacent to the bottom of the base, generates control signals to control the actuator assembly and heads to write and read data on the disks.

In a further embodiment, the disk drive includes four storage disks in the same height factor. The spin motor assembly may be provided in a low-profile arrangement under a hub assembly, the hub assembly having a disk mounting surface for mounting the disks thereon. In one embodiment, the motor includes a base portion, and the total height of the motor defined from the base to the disk mounting surface is about 0.270 inch; further the height of the disk mounting surface above a portion of the base adjacent the disk mounting surface is no greater than about 0.028 inch.

In yet another aspect a header assembly is provided including plurality of pins cast into a mounting body, the mounting body press fit into the base plate and secured on the exterior of the controlled environment by an adhesive.

In a further aspect, the actuator includes an actuator arm rotatively positioned about an axis of rotation, having the interactive means mounted at one end thereof and a coil mounted at a second end thereof, and further including a magnet assembly positioned so that a current in the coil in the presence of the magnetic field provided by the magnet assembly creates a force to move the actuator arm. The coil may be mounted to the actuator arm by a molded plastic coil mounting assembly.

In a still further aspect, a latch assembly is provided which utilizes the magnetic force of the actuator magnet assembly to latch the actuator arm during parking.

In yet another aspect, the actuator arm has a rotational axis and the heads have a recording gap therein, and the distance from the gap to the axis is about 1.44 inches. In such embodiment, where the disks include a plurality of concentric tracks, the skew angle of the gap with respect to the tracks on the disk is in a range of about 0.0° to 18.50°.

The cover may include a sloped portion overlying the disks to provide room for a connector underlying the disks to maintain the total overall height of the drive at about 0.75 inch.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be described with respect to the particular embodiments thereof. Other objects, features, and advantages of the invention will become apparent with reference to the specification and drawings in which:

Figure 1 is an exploded, perspective view of a disk drive in accordance with the present invention.

Figure 2 is a partial cutaway, plan view of a disk drive in accordance with the present invention.

Figure 3 is a cross-sectional, side view of a disk drive in accordance with the present invention.

Figures 4A-4C are perspective, plan, and side views, respectively, of a pack writing port cover for use with the disk drive in accordance with the present invention.

Figure 5 is an exploded, partial perspective view of an actuator arm and bearing assembly in accordance with the present invention.

Figure 6 is a cross-sectional view of the bearing actuator cartridge assembly for use in accordance with the disk drive of the present invention.

Figure 7 is a plan view of the actuator arm assembly used in accordance with the disk drive of the present invention.

Figure 8 is a partial perspective exploded view of an actuator arm assembly and magnet assembly.

Figure 9 is a partial plan view of the latch assembly and magnet assembly for use in accordance with the disk drive of the present invention.

Figure 10 is a partial cross-sectional view of the magnet assembly showing the latch post and magnet structure.

Figure 11 is a view along line 11-11 in Figure 2 showing the motion of the latch assembly with respect to the motion of the coil assembly of the actuator of the present invention.

Figure 12 is a cross-sectional view of the latch post for use in accordance with the magnet structure of the present invention.

Figure 13 is a perspective view of the actuator arm body and coil for use in accordance with the disk drive of the present invention.

Figure 14 is a perspective view of the actuator arm body, coil, and plastic molded coil mounting assembly for use in accordance with the disk drive of the present invention.

Figure 15 is a cross-sectional view along 15-15 in Figure 14.

Figure 16 is a reverse perspective view of the actuator arm assembly and the attachment of the actuator flex circuit thereto.

Figure 17 is an exploded, perspective view of the header assembly in accordance with the present invention.

Figure 18 is a bottom plan view of the hard disk assembly portion of the disk drive of the present invention.

Figure 19 is a cross-sectional view along line 19-19 in Figure 18.

Figure 20 is an exploded cross-sectional view of the header bracket installed in the base of the disk drive of the present invention.

Figure 21 is a cross-sectional view of the disk spin motor and hub assembly for use in accordance with the disk drive of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A disk drive according to the present invention will be described with reference to Figs. 1-21. The disk drive described herein includes, for example, three magnetic storage disks such as a single hard disk with a magnetic coating and utilizing Winchester technology; however, the disk drive may utilize various numbers of disks, and is specifically designed to incorporate up to four disks in the same height as a 3-disk embodiment (and a corresponding number of heads, usually one per disk surface, i.e., two (2) heads per disk) and other types of disks, for example, optical disks, and other read/write technologies, for example, lasers.

Form Factors (Footprint and Height)

The form factor selected for the disk drive of the present invention is a two-and-one-half inch (2½") form factor. The range of dimensions of the disk drive of the present invention are: length (L) 4.00 inches; width (W) 2.75 inches; and height (H) 0.75 inch. The height dimension relates to both a three-disk and a four-disk embodiment of disk drive 30.

Disk drive 30 is ideal for use in lap-top, notebook, palmtop, or other portable or other battery-powered computers due to the reduced form factors and the small power consumption. Power consumption for various modes at 5.0 volts is as follows: Read/Write Mode 400ma; Seek Mode 400ma; Idle Mode 280ma; Standby Mode 60ma; Sleep Mode 20ma; and Spin-Up Mode 1.2a.

Overall Drive Architecture

As shown in Figs. 1-3, a disk drive 30 in accordance with the present invention includes two main components, a head-disk-assembly (HDA) 32 and control electronics 34 which provide control signals to the HDA 32, receive data signals form and transmit data signals to the HDA 32, and interface the disk drive 30 with a host system. The host system may be, for example, a portable or laptop computer.

HDA 32 includes a base 42 and a cover 44. A gasket 46 is provided between base 42 and cover 44 to establish a sealed (or controlled) environment between base 42 and cover 44. Cover 44 is secured to base 42 by a plurality of socket head screws (not shown) secured through bores 40a in cover 44 into threaded bores 40. Disk drive 30 does not utilize a breather filter, and the seal provided by gasket 46 isolates the sealed environment from ambient atmospheric conditions and pressures. The seal provided by gasket 46 is stable at pressures experienced at altitudes from 200 feet below sea level to 15,000 feet above sea level during operation of the disk drive.

The components provided in the controlled environment established by HDA 32 include a disks 48a, 48b and 48c, a spin motor 50 for rotating disks 48a-48c, an actuator assembly 52 for reading data from and writing data to disks 48a-48c, a header assembly 54 for transferring electronic signals to and from the controlled environment established in HDA 32, and a latch assembly 56 for parking actuator assembly 52.

Control electronics 34 are provided on a printed circuit board (PCB) 58. Electronics elements 34 are provided on the bottom surface 58b of PCB 58. The control electronics 34 control the operation of spin motor 50, the operation of actuator assembly 52, and the transfer of data to and from disk 48. PCB 58 is mounted to base 42 and electrically grounded to the HDA 32. The dimensions of disk drive 30 are shown in Figs. 2 and 3 and Table 1. In accordance with the present invention, the component height of electronics elements 34 on PCB 58 should not exceed 0.091" and is nominally 0.086".

The above-described basic structure of disk drive 30 provides protection from shock and vibration. In particular, disk drive 30 will withstand nonoperating shocks on the order of 300g's and operating shocks, without nonrecoverable errors, of 10g's. Nonoperating vibration of 5.0g's in the range of 0-400 Hz is the specified tolerable limit. Operating vibration, without nonrecoverable data, is specified at 0.5g's for the range of 0-400 Hz.

Media

The storage media utilized in drive 30, comprising disks 48a-c, will be described with reference to Fig. 2. The disk has an outside disk diameter of approximately 2.56 inches and an inside disk diameter of approximately 0.788 inches. Each disk 48 has a data band 62, shown in Fig. 16, having an inside data diameter ID of approximately 0.710" and an outside data diameter OD of approximately 1.220". Each disk 48 is generally manufactured from an aluminum substrate, and has a plated or sputtered magnetic coating exhibiting a magnetic intensity of 1500 Oe.

Spin Motor

Spin motor assembly 50 supports and rotates disks 48a-48c. A unique feature of disk drive 30 is the low profile design of spin motor assembly 50 which allows the mounting of three or four disks between the upper surface 42a of cover 42 and cover 44. A further unique aspect of motor 50 is the manner in which motor assembly 50 is installed in base 42.

As shown in Figs. 3 and 21, spin motor 50 is mounted in a bore 51 in base 42. Motor assembly 50 includes a motor 50a which is an under-the-hub, rotating shaft-type motor and hub assembly 74. With reference to

Fig. 21, first and second bearings 66, 67 are mounted in a housing 68. Housing 68 is glued in a bore 69a in a washer-like support 69. Support 69 also supports stator 70 (including a stator lamination and windings). Shaft 72 is rotatively mounted on bearings 66, 67, and hub 74 is mounted on shaft 72. Hub 74 has a disk mounting surface 76 which supports disks 48a-48c, and spacers 75a, 75b. Cover 44 has an interior height in region 45 of about 0.355 inch between the base and the interior surface of cover 44. Spacers have a vertical height d as great as 0.118 inch, separating respective disks 48a-48c. In a four-disk embodiment, spacers have a thickness d' of 0.180 inch. Hub 74 is formed of aluminum. A clamp ring 78 is secured to the shaft assembly 72 by a screw 80 and functions to secure disks 48a-48c and spacers 75a,75b to hub 74. Motor 50a includes rotor 80, including a multi-pole magnet 81 having a ring-like structure, mounted on hub 74 so that the rotor 80 is adjacent to and concentric with stator 70. Magnet 81 has a skewed magnetization to eliminate the detent torque of motor 50 and to increase the start-up torque of motor 50. Further, the skewed magnetization decreases the back emf generated by motor 50.

The use of a rotating shaft motor, opposed to a stationary shaft motor, reduces the friction attributable to the bearings 70, 72, since the rotation of the inner race of each bearing 70, 72 as opposed to the outer race causes fewer rotations of the ball bearings between the inner and outer races.

The low profile design of motor assembly 50 is achieved through the use of an integral motor assembly which allows the assembled motor to be press fit into a bore 51 in base 42. Support 69 includes a notched end 69a which interfaces with a lip 65 in the wall of bore

51. Motor assembly 50 is pre-assembled and inserted into bore 51 from the lower surface 42b toward the top surface 42a of base 42. Support 69 is press fit into bore 51 and achieves a pressure fit requiring 20 lbs. of force to remove motor assembly 50 in the opposite direction to that of installation. Subsequently, an adhesive 73, such as Fusor 310, is applied to the bottom surface 42b of base 42, and the assembly cured at 60°C for 1 hour. The elimination of a motor support surface in bore 51 as a cast part of base 42 allows the stator assembly 70 to be positioned as close as possible to support 69, and disk mounting surface 76 to be as low as possible with respect to the portion 43 of upper surface 42a of base 42 adjacent disk 48c, while still allowing motor 50 to be preassembled apart from base 42, and allowing for a motor design with a stator having area sufficient to provide 4500 rpm with 3 or 4 disks. In addition, motor assembly 50 allows for the reduction in the use of adhesives to attach motor assembly 50 to base 40 since support 69 is press fit into base bore 51 and adhesive 73 is secured to the lower surface 42b around the interface region between support 69 and bore 51. The low profile of motor 50a means that the lowermost disk mounted on hub 74 is approximately .025" from a region 43 (Fig. 1) of the upper surface 42a of base 42 adjacent to disk 48c. In addition, such low profile allows for up to four disks to be provided in the disk stack between disk mounting surface 76 and the interior surface of cover 44.

The total height H_1 of motor 50a is .270 inch defined from the bottom of support 69 to the top of mounting surface 76. A metal seal 71 is secured in bore 69a in support 69 to prevent external contaminants from entering the controlled environment. Metal seal 71 may be secured with an adhesive on the exterior thereof to further seal motor 50.

Actuator Assembly

Actuator assembly 52 (Figs. 5-16) performs the function of positioning heads 60a-b, 61a-b and 62a-b with respect to disks 48a-48c. An actuator arm 82 supports heads 60a-b, 61a-b, 62a-b, mounted via head suspensions at a first end 82a of actuator arm 82, and an actuator coil 86, mounted at a second end 82b of actuator arm 82. Actuator arm 82 is mounted on base 42 on an actuator post 88 and a bearing cartridge 90, which is slipped over actuator post 88 and secured to cover 44 by a set screw 83 provided through bore 84 in cover 44 to post 88. Actuator post 88 has a post base 92; both are cast as a feature of base 42. Casting of post 88 as a portion of base 42 eliminates one interface where adhesives have been conventionally used in prior art drive designs to affix an actuator post into a boss in the base. The central axis 89 of actuator post 88 is approximately 1.88" from the rotational axis of disk 48.

As shown in Figs. 5-6, bearing cartridge 90 includes inner member 96, bearings 104,106, outer member 102 and lock ring 123. Inner member 96 slips over actuator post 88 and has a mounting surface 98 which interfaces with top surface 100 of post base 92. Outer member 102 of bearing cartridge 90 is rotatably mounted about inner member 96 by first and second bearings 104, 106.

Inner member 96 and outer member 102 are generally manufactured from 300 Series stainless steel. Bearings 104,106 are lubricated with a 40 micron Nigace filtered grease, and the inner rail thereof is affixed to the inner member 96 the application of a high strength cured adhesive, such as Locktite 661N. It is important that no uncured adhesives be used since such uncured adhesives result in additional outgassing within the controlled environment between the base and the cover, which in turn releases contamination into the controlled environment. Outer member 104 includes a ledge 103 around the circumference thereof which is utilized to secure the assembled bearing cartridge 90 in bore 109 of arm body 110 after bearing cartridge 90 is press fit into bore 108. A lock collar 123 secures actuator bearing cartridge 90 into arm body 110. As shown in Fig. 6, ledge member 103 engages a boss portion 119 in mounting hole 108, and lock collar 123 is press fit into boss 119 to secure ledge 103 against lip 122 of bore 108, and sandwiches ledge 103 between collar 123 and lip 122. A well region 64 is provided in base 42 to allow for maximum stiffness of base 42 but provide sufficient clearance for arm 114 and head 62b on the lower surface of disk 48c.

With reference to Figs. 5 and 8, actuator arm 82 includes arm body 110 having arms 111, 112, 113 and 114 supporting head suspensions 115a-b, 116a-b, 117a-b, respectively, to which read/write heads 60a-b, 61a-b, and 62a-b are mounted. Arm body 110 is generally comprised of aluminum. Actuator coil 86 is supported by a molded plastic coil assembly 107, which is molded directly to coil 86 and arm body 110. Arm body 110 includes two tabs 118a,118b to which the molded coil assembly 107 are secured. The provision of a plastic molded actuator assembly 107 further reduces the use of adhesives in the controlled environment. Conventionally, an actuator coil would be secured to a portion of the actuator arm body by an adhesive. A mounting bore 108 for engaging outer member 102 of bearing cartridge 90 is also included in arm body 110.

Load beams 115a-b, 116a-b and 117a-b are secured by staking to arms 111, 112, 113 and 114 as shown in Figs. 5, 8 and 16. Load beams 115, 116 and 117 are, for example, Part Nos. PR79108 or PR79416 "Type 16" Suspensions manufactured by Hutchinson. A flexure on each suspension, shown by example as flexure 120 in Fig.7, supports respective ones of heads 60, 61 on each respective ones of suspensions load beams 115-117.

As shown in Fig. 7, the length of the actuator arm assembly 82, from the center, rotational axis 89, to the recording gap of heads 60, 61 and 62 over the disk surface, has been appreciably increased over conventional actuators in 2½" form factor disk drives. In the preferred embodiment, the length L_1 of the arm with load beam is 1.44 inch. The length L_2 from the center point of the load beam staking area to the gap is 0.751 inch. The position of the gap in head 60 is represented by the line GAP in Fig. 8A. It was determined that increasing the length of the actuator arm over prior art 2½" form factor drives improves the performance of heads 60-62.

Heads 60-62 may be comprised of so-called 50% sliders, thin film, air bearing read/write heads, such as are available from ReadRite Corporation, Milpitas, California. Such sliders are designed to "fly" over the surface of the disks on a cushion of air which is generated by rotation of the disks. Numerous slider designs have developed which attempt to create a stable, constant flying height platform to carry the recording coil of the head. These designs are most efficient when the direction of the airflow is directly incident on the front of the head. When the disks cease spinning, the heads are directed to a non-data area of the disk so that, when rotation of the disks ceases, the heads land on this "landing zone". Generally, when the disk begins rotation, the head lifts away from the disk surface. It has been determined that due to the fact that the velocity of the disk surface toward the outer diameter is greater than the velocity at the inner diameter during rotation, an air bearing head tends to travel a greater flying height (head gap to disk spacing) at the outer diameter than at the inner diameter.

As will be generally understood by those skilled in the art, an air bearing recording head with a generally rectangular shaped recording gap as a defined "skew angle" between the head and the data tracks on the disk. The skew angle is generally understood to be defined as the angle between the length of the gap and a line tangential to the data track at the point where the gap crosses the track. Generally, drives are designed so that heads have 0° of skew when the actuator positions the heads in the approximate center of the data zone (between the ID and OD of the disk).

In disk drive 30, the increased gap/pivot axis length results in a drive which has no negative skew angle between the gap and the drive tracks. In drive 30, the skew angle between heads 60 and tracks on disk 48 ranges from approximately 0.0° at the inner diameter to 18.0° at the outer diameter. This relatively high skew angle (18°) at the outer diameter compensates for the normally increased flying height at the outer diameter of the disk. Because the slider is skewed with respect to the direction of the disk and the airflow generated thereby is not directly incident on the head, the head does not fly as efficiently as it would if the airflow were directly incident on the front of the head. Normally, this would result in the head flying lower, assuming a constant disk velocity. With increased speed at the OD, flying height at the OD in the drive of the present invention remains relatively constant. Thus, the increased airflow velocity at the OD is offset by the increased skew. When, as in drive 30, landing zone 150 is provided at the ID, the byproduct of this skew angle range is the fact that improved start/stop performance is yielded because heads 60-62 "take off" much more quickly upon rotation of the disk.

The force necessary to pivot actuator arm 82 is created by a voice coil motor including coil 86 and a magnet structure 130 shown in Figs 2 and 8. Magnet structure 130 includes two bipolar magnets 132,133, top and bottom plates 134, 136, support posts 138,140 and latch post 142. Bipolar magnets 132,133 are secured to top and bottom plates 134,136, respectively. First and second support posts 138, 140 and a bifurcated latch post 142, support top and bottom plates 134,136. Top and bottom plates 134,136 are manufactured from 12L14 steel with an electroless nickel finish. Bores 126 and 128 are provided in each of top plates 134 and bottom plate 136 which allow support posts 138,140 to be secured therein. Support post 138 is manufactured from AISI 17-4 stainless steel, but has a passivate finish. Support post 140 is manufactured from 12L14 steel, with an electroless nickel finish, with 5-8% phosphorous; latch post 42 is likewise manufactured from 17-4 stainless steel. Thus, posts 140 and 142 are magnetically permeable and function as returns for the magnetic fields provided by magnet 132, while post 138 is not magnetically permeable and does not form part of the magnetic circuit of the magnetic structure 136. It is important that there are no air gaps between support posts 140, 142 and top and bottom plates 134, 136; any air gap would create a discontinuity in the return, greatly reducing the strength of the magnetic fields. This combination of magnetically permeable material in top plate 134, bottom plate 136, support posts 140, and latch post 142 creates a magnetic circuit flux path through these elements that allows efficient utilization of the magnetic field of magnets 132,133 to latch the actuator during parking, as described below.

Magnet structure 130 and actuator coil 86 are arranged so that coil 86 is placed in the magnetic fields created by magnet 132. Currents passing in coil 86 create torques so that actuator arm 82 may be pivoted to position heads 60, 61, 62 at selected locations with respect to disk 48.

An additional feature of magnetic structure 130 is the ease with which this magnetic structure may be preassembled and inserted into, or removed from, disk drive 30 without detaching actuator arm body 110 and bearing cartridge 90 from base 42. Specifically, the assembled magnet assembly may be rotated about post 87 cast in base 42 as depicted by arrow 100 in Fig. 2. Support posts 138 and 140 are press fit between top plate 134 and bottom plate 136, into bores 126a-b and 128a-b, respectively, therein. Likewise, latch post 142 is press fit between bores 127a-b in top plate 134 and bottom plate 136. Support post 138 includes bore with a shelf to allow screw 131 to secure bore 139 into a threaded bore in base 42. Support post 140 also includes an inner bore 141, similar to bore 139, to support screw 131b which secures post 140 to post 87 on base 42.

It should be noted that bore 141 has a substantially shallower depth than bore 139, as such depth is only that necessary to secure support post 140 in base post 87. A second bore (not shown) in post 140 is sized to fit over post 87 on base 42 so that the magnet structure 130 may be slid over post 143 when assembled. Screw 131b thereafter screws into the threaded bore 87a in post 87. Magnet structure 130 may rotate about post 143 to a position where post 138 and bore 139 therein are positioned over threaded bore 139a (Fig. 1) in base 42 such that screw 131a secures post 138 and magnet assembly 30 in base 42. Likewise, removal of screw 131a allows the magnet structure 130 to be swung and rotated clockwise around post 87 to remove magnet structure 130 from base 42 without removing the assembled actuator and coil assembly from the base 42.

Actuator arm 82, including all of the components attached thereto, is precisely balanced, i.e., equal amounts of weight are provided on either side of pivot axis 89 so that the pivoting of actuator arm 82 to position heads 60a-b, 61a-b and 62a-b has a low susceptibility to linear shock and vibration. Actuator assembly 52 provides average access times of less than 20 milliseconds, and averaging 12ms, due to the high power-to-mass ratio and the small moment of inertia of actuator arm 82.

An outer diameter crash stop is provided to limit the pivoting movement of actuator arm 82 so that heads 46 travel only between the landing zone 150 and outside data diameter OD of each disk 48a-c. A landing zone (or non-data area) 150 (shown in Fig. 2 with respect to disk 48a) is located, e.g., adjacent to the inside diameter ID, and actuator assembly 52 positions the heads 60, 61, 62 over landing zone 150 during parking. The landing zone 150 may be any selected portion of the disk; however, a portion of the disk adjacent to the ID or OD is usually selected.

The outside diameter crash stop is provided by an O-ring 152 of burtyl rubber which fits over actuator post 140 in a groove (not shown) formed therein. When the pivoting motion of actuator arm 82 places heads 60, 61, 62 at the OD of disk 48, the edge of coil assembly 107 contacts O-ring 152 serving as the outside diameter crash stop. The inside diameter crash stop is provided by the latch mechanism and is described below.

A latch mechanism is utilized to lock actuator arm 82 in a position where heads 60, 61, 62 are located over landing zone 150 of disks 48a-c and will be described with reference to Figs. 2 and 8-12. The latch assembly includes a latch pin 174, mounted in a bore 105 molded into plastic coil assembly 107, an O-ring 176, and latch post 142.

As described above with respect to magnet assembly 130, the flux generated by actuator magnets 132,133 is directed in a magnetic circuit which includes latch post 142. Latch post 142 includes a slot 144 defined between portions 144a and 144b of post 142 which causes the flux incident from magnets 132,133 to be directed therethrough and causes a fringing effect (shown at reference number 180) in the magnetic flux about slot 144. This fringing effect 180 extends a distance B_1 out from post 142. The distance B_1 is defined by the width Z of slot 144 and the area of center portion 144c of post 142. In one embodiment Z = 0.024 inch and the diameter of outer portion 144c is about 0.074 inch. Latch pin 174 is manufactured from type 17-4 stainless steel. Pin 174 contains a detent region 174a so that only the outer circumference 174b of the pin face engages post 142. When pin 174 is brought into contact with post 142, this fringing flux 180 passes through pin 174 and secures pin 174 to post 142 as pin 174 becomes part of the magnetic circuit formed by latch post 142, top plate 134, bottom plate 136, and support post 138. This interaction force is sufficient to restrain movement of actuator assembly 52 under the environmental conditions specified below to ensure an adequate latching force. In the prior art, latch pins were required to squarely engage a latch body so that no air gaps existed between the face of the pin and the magnetic returning body. In the latch of drive 30, the rounded shape of post 142 eliminates the concern over the squareness of the engagement between pin 174 and post 142. There is sufficient contact region that latch mechanism secures the actuator assembly under the conditions as specified below. An additional feature of this latch assembly is that no additional latch magnet is required to restrain the actuator in the latch position. The power of the voice coil motor assembly is sufficient to overcome a latching force when a strong current is applied to coil 86.

Header Assembly

With reference to Figs. 1, 2, and 17-20, the header assembly 54 will be hereafter described. Header assembly 54 couples PCB 58 to the internal components of drive 30 in the controlled region between base 42 and cover 44. Header assembly 54 also includes a flex circuit 160 to provide electrical connections to heads 60, 61, 62 and actuator coil 86 mounted on rotating actuator arm 82.

The main components of header assembly 54 are header 162, a flex circuit bracket 164 and flex circuit 160. Header 162 includes connector pins 166 molded to a plastic base 167. Header 162 is press fit into socket 168 in base 42 in the direction from the lower surface 42b toward the upper surface 42a thus sealing the adhesive outside of the drive's internal atmosphere. Base 167 of header includes a lip 166a which allows an adhesive 169 to be applied to the lower surface 42b of base 42 and header 162 on the lower surface 42b of base 42, outside the controlled environment between base 42 and cover 44. Bracket 164 has a base portion 168a and an arm portion 168b which secures a chip 170 and flex circuit 160.

As shown in Figs. 8, 16 and 17, flex circuit 160 is a reverse flex circuit and is secured to actuator body 110 with a set screws 162a in bore 162b to further reduces the adhesive necessary in drive 20. Pins 166 engage corresponding pin holes (not shown) on PCB 58.

A spin motor flex circuit is also provided to transfer motor control signals from PCB 58 to spin motor 50. Unlike prior drive designs, spin motor flex circuit 190 is mounted on the exterior of the controlled environment, on the lower surface 42b of base 42. Flex circuit 190 is secured to four of pins 166 on the bottom surface 42b of base 42 as shown in Figs. 18 - 20. A first end 192 of circuit 190 rests in detent region 193 of base 42 to provide maximum clearance for PCB 58 on the lower surface 42b of base 42. A second end 198 of flex circuit 190 is coupled to the spin motor leads 196 on the bottom surface of mounting flange 69 in a detent region 195 of flange 69. Flex circuit 190 is secured to base 42 by screw 194.

Plug-In Connector

A connector 59, shown in Fig. 1, is provided on PCB58 to couple the drive to a host computer. In disk drive 30, data is stored in a data track band on each surface of disks 48a-48c defined by an outer (OD) and inner (ID) track diameter. Actuator assembly 52, including one head 60, 61, 62 per data surface, is utilized to transfer data with respect to concentric data tracks. The primary control aspects of the electronics 34 include controlling the spin rate of the spindle motor 50 and the control of the actuator assembly 52 in positioning of the heads 60, 61 for the transfer of data with respect to selected data tracks.

PCB 58 includes a connector 59 which may be a standard, dual row, right angle 50-pin connector for SCSI interface applications in a low profile surface mount construction. Connector 59 has a vertical height of approximately 0.147". Because of the highly compact nature of drive 30, the height and position of connector 59 requires modification of cover 44 of disk drive 30 to enable disk drive 30 to meet the total overall drive height of 0.75". As shown in Figs. 1 and 2, the area of the cover substantially overlying the area occupied by disks 48a-48c, designated at reference number 45 between line 45a and edge 45b of cover 44 a negative slope of approximately .020" between line 45a and edge 45b. This slope is indicated in Fig. 3 in greatly exaggerated form as the distance "S" in Fig. 3.

Disk drive 10 also provides for improved writing of embedded servo information on disks 48a-48c. As shown in Figs. 1 and 4a-4c, cover 44 includes two ports 92,94 to allow embedded servo information to be written onto disks 48a-48c while cover 44 is secured to base 42. The provision for through the cover writing of embedded servo information in a disk drive results in reduced mechanical off-tracking errors that may result from torquing of the drive mechanics subsequent to writing of the servo information with the cover off and improvements in overall production yields for the drives.

In the preferred servo writing process of the present invention, a step member (not shown) is inserted through port 92 to engage the side of arm 82 of actuator assembly 52. Port 94 allows a clock read/write head, mounted on a transport arm, to access one of disks 48a-48c to determine the speed of rotation of disks 48a-48c during the writing process. To pack write the drive, an external control system is linked to header assembly 54 via pins 166. The pack write control system provides write control signals to heads 60, 61 and 62 to utilize actuator assembly 52 to write the servo information on disks 48a-48c. In addition, the control system provides current to actuator assembly 52 to provide a reverse bias against the step member engaged with arm 82. The pack-write control system also provides current to spindle motor 50 to rotate disks 48a-48c during the writing process.

The clock read/write head initially writes a clock track outside the usable data field of disks 48a-48c, preferably at the outermost diameter track of the disks. To accomplish this function, the step member engaged with bore 79 moves actuator arm 82 to the outermost diameter of the disk and forces the actuator to compress the rubber o-ring surrounding post 140. As disks 481-48c are rotated, the clock head continuously reads the clock track to determine the precise rotational velocity of disks 48a-48c. The pack write control system determines the precise number of sectors to be utilized per track and direct actuator means 50 to write servo information to each sector in accordance with the desired servo control scheme.

The step member, also under control of the pack write control system, controls movement of actuator assembly 52 at the desired rate to provide the servo information on each track as desired.

Operation of the stepper member and the write process may be coordinated on any number of direct formats to utilize any number of closed-loop schemes.

Ports 92 and 94 are sealed by a seal strip of .002 inch silver metalized Mylar over port 92, and by port cover 95, which is secured in bore 93 by a second seal strip of .002 inch silver metalized Mylar.

The electronic architecture of the present invention is described in detail in the above-identified co-pending related applications.

Tables 1 and 2 below specify certain characteristics of disk 48.

Table 1

Number of Disks	3	
Number of Data Surfaces	6	
Number Data Cylinders (Tracks per surface)	1319	cylinders
Sectors per Track	42-72	sectors
Bytes per Sector	666	bytes
Data Bytes per Sector	512	bytes
Data Capacity per Data Surface (formatted)	42.16	Mbytes
Total Data Capacity (formatted)	253	Mbytes

Table 2

Disk Data Outside Diameter	1.27	inch
Disk Data Inside Diameter	0.55	inch
Data Track Band Width	.72	inch
Track Density	2611	tracks/inch
Bit Density (max)	43,684	fci
Head Width	7.5	microns
Track Width	10.8	microns
Gram Load	3.0±.5	grams

The characteristics shown in Tables 1 and 2 are based on the utilization of standard 50% sliders having thin-film heads.

The many features and advantages of the disk drive of the present invention will be apparent to those skilled in the art from the Description of the Preferred Embodiments and the Drawings. Thus, the following claims are intended to cover all modifications and equivalents falling within the scope of the invention.

CLAIMS

1. A two and one-half inch form factor disk drive, comprising:

a base having a top and a bottom;

at least three storage disks;

a spin motor supporting the disks on the top of the base;

interactive means for reading information from and writing information on the disks;

actuator means, supported on the base and responsive to control signals, for selectively positioning the interactive means with respect to the disks;

a cover attached to the base, the base and cover enclosing the disks, the interactive means, and the actuator means to form a controlled environment thereinbetween; and

control means, mounted on the head-disk assembly so that the control means is adjacent to the bottom of the base, for generating control signals to control the actuator means and for providing and receiving information signals, the disk drive having an overall maximum height equal to or less than substantially three quarters of one inch (.75 inch).

2. The disk drive of claim 1 wherein the drive includes four storage disks.

3. The disk drive of claim 1 wherein the spin motor is provided in a low-profile arrangement under a hub assembly, the hub assembly having a disk mounting surface for mounting the disks thereon.

4. The disk drive of claim 3 wherein the motor includes a base portion, and the total height of the

motor defined from the base to the disk mounting surface is about 0.270 inch.

5. The disk drive of claim 3 wherein the height of the disk mounting surface above a portion of the base adjacent the disk mounting surface is no greater than about 0.028 inch.

6. The disk drive of claim 1 including a header assembly, the header assembly including plurality of pins cast into a mounting body, the mounting body press fit into the base plate and secured on the exterior of the controlled environment by an adhesive.

7. The disk drive of claim 1 wherein the actuator means includes an actuator arm rotatively positioned about an axis of rotation, having the interactive means mounted at one end thereof and a coil mounted at a second end thereof, and further including a magnet assembly positioned so that a current in the coil in the presence of the magnetic field provided by the magnet assembly creates a force to move the actuator arm.

8. The disk drive of claim 7 wherein the actuator coil is mounted to the actuator arm by a molded plastic coil mounting assembly.

9. The disk drive of claim 7 further including a latch assembly, the latch assembly including a latch pin coupled to a portion of the actuator arm, and a bifurcated latch post, having a circular cross-section and a first and second major portions, forming an integral part of the magnet assembly and forming a portion of a magnetic circuit defined by the magnet assembly.

10. The disk drive of claim 8 wherein the magnet assembly includes a first and a second bipolar magnets, a top and a bottom plate having the first and second permanent bipolar magnets mounted thereon, and a first and second support members, the first support member being magnetically permeable, the second support member being non-magnetically permeable, and the latch post.

11. The disk drive of claim 1 wherein the actuator means includes an actuator arm mounted for rotation about an axis perpendicular to the base, the arm having the interactive means mounted at one end, the interactive means comprising at least one read/write head having a recording gap therein, the distance from the gap to the axis being about 1.44 inches.

12. The disk drive of claim 1 wherein the disks include a plurality of concentric tracks, and the interactive means comprises at least one read/write head having a read/record gap, wherein the skew angle is defined as the angle made between a line formed by the axis and the recording gap and a line tangential to any concentric track on the disk is in a range of about 0.0° to 18.50°.

13. The disk drive of claim 1 wherein the cover includes a sloped portion overlying the disks and the printed circuit board includes a connector underlying the disks, wherein the total overall height of the drive is about 0.75 inch.

14. The disk drive of claim 1 wherein the control means is mounted on a printed circuit board, the drive

further including a connector, mounted on the printed circuit board and coupled to the control means.

15. The disk drive of claim 14 wherein the cover includes a sloped portion, substantially overlying the storage disks and an area of the base adjacent the connector.

16. The disk drive of claim 15 wherein the slope of the cover is 0.020 inch. with respect to the base.

17. A disk drive, comprising:

three data storage disks;

a hub for supporting the disks;

a spin motor positioned under the hub for rotating the hub and disks;

a plurality of read/write heads, at least one head per disk;

an actuator for supporting and positioning the heads;

a housing, including a base and a cover, for maintaining the disks, hub, motor, heads and actuator in a controlled environment; and

control means provided on a printed circuit board adjacent the base for controlling the spin motor and the actuator, and including a connector for electrically interconnecting the disk drive with a host computer, the housing and the control means having an overall maximum height equal to or less than substantially three-quarters (0.75) inch and a footprint having a length of substantially four (4) inches and a width of substantially two and one-half (2.5) inches, wherein the cover includes a sloped portion overlying the disks and the connector.

18. The disk drive of claim 17 wherein the sloped portion of the cover has a slope of about 0.020 inch.

19. The disk drive of claim 17 further including a magnetic latch means for securing the heads in a non-data region over the disks during parking of the heads.

20. The disk drive of claim 19 wherein the disk drive further includes a magnet assembly positioned adjacent the actuator, the magnet assembly including a first and a second bipolar magnets, and a magnet housing, wherein the latch means is formed from a part of the magnet housing and utilizes magnetic flux provided by the first and second bipolar magnets in a magnetic circuit formed by portions of the housing to latch the actuator.

21. The disk drive of claim 20 wherein the magnet housing comprises a top plate, a bottom plate, a first support post, a second support post and a latch post, wherein the first and second bipolar magnets are coupled to the top and bottom plates, respectively.

22. The disk drive of claim 21 wherein the top plate, bottom plate, first support post and latch post are formed of magnetically permeable material; the second support post is not magnetically permeable; and the latch post is bifurcated to create a region of fringing flux adjacent thereto.

23. A two and one-half inch form factor disk drive, comprising:

a housing, the housing having a bore;

at least three data storage disks having a plurality of tracks for storing data;

a spin motor assembly mounted in the bore, the spin motor assembly having a base support forming a pressure fit with a portion of the bore, the spin motor assembly supporting the disk and rotating the disk;

a plurality of read/write heads for interacting with the disk to read data from and record data on the tracks;

actuator means for supporting the read/write heads adjacent to the disk and positioning the head; and

a printed circuit board including circuitry for controlling the actuator means to position the read/write heads over selected ones of the tracks and for controlling the spin motor assembly, the printed circuit board being mounted on the housing; and

a connector, mounted on the printed circuit board adjacent a portion of the housing, for interfacing the disk drive with a host computer; the housing, the printed circuit board, and the connector having an overall, maximum height equal to or less than substantially three-quarters of one inch (0.75 inch).

24. The disk drive of claim 23 wherein the housing comprises a base and a cover, the disks forming at least one plane substantially parallel with a portion of the base underlying the disks, and the cover is sloped with respect to the plane at a region of the cover substantially overlying the disks.

25. The disk drive of claim 23 wherein the actuator includes an actuator arm, having a first end supporting the read/write heads and a second end supporting a coil.

26. The disk drive of claim 25 wherein each of the read/write heads includes a recording gap, the actuator

arm rotates about a rotational axis, and the distance from the rotational axis to the gap is about 1.44 inches.

27. The disk drive of claim 25 wherein each of the read/write heads includes a recording gap, the actuator arm rotates about a rotational axis such that the heads form an arcuate path with respect to each disk surface, and the skew angle of the gap with respect to the tracks is in a range of about 0.0° to 18.5°.

28. The disk drive of claim 25 wherein the actuator means further includes a magnet structure, the magnet structure including a magnet housing supporting first and second bipolar magnets arranged so that currents in the coil induce rotational forces on the actuator arm to position the heads with respect to the disk.

29. The disk drive of claim 28 wherein the magnet structure further includes a top plate, a bottom plate, a first support post, a second support post, and a latch post, the first, second and latch posts being positioned between the top and bottom plates, the first and second support post being secured to the base, the first support post being positioned over a mounting post such that the magnet structure is free to rotate about the mounting post when the second post is un-secured to the housing.

30. A disk drive responsive to a host system, comprising:

a housing;

at least three magnetic disks;

a hub assembly supporting the disks;

a spin motor positioned under the hub assembly, responsive to control signals, for rotating the disks and the hub assembly;

means for reading information from and recording information on the disks;

means for supporting and positioning the means for reading and recording information relative to the disks;

means for generating control signals to control the spin motor, means for reading and recording and means for supporting and positioning; and

means for electrically interconnecting the disk drive with a host system.

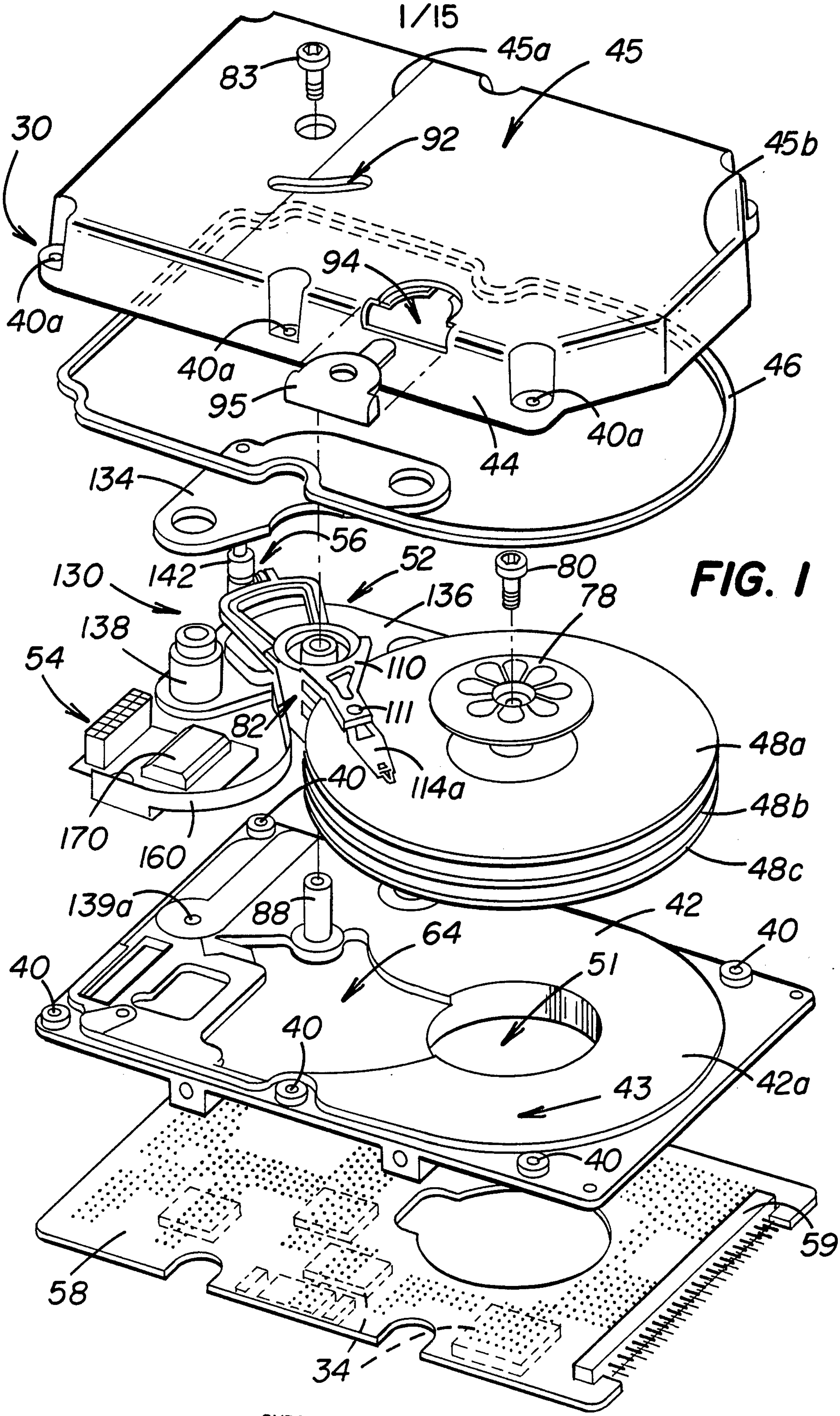
31. The disk drive of claim 30 having at least four disks.

32. The disk drive of claim 30 wherein the means for supporting and positioning comprises an actuator assembly, the actuator assembly including an actuator arm mounted for rotation about a post on the housing by a bearing cartridge, the bearing cartridge being secured in a bore in the actuator arm by a lock ring.

33. The disk drive of claim 31 wherein the actuator arm has a rotational axis, the means for reading and recording comprise magnetic recording heads having recording gaps, and the distance from the rotational axis to the recording gaps is about 1.44 inches.

34. The disk drive of claim 30 wherein the housing includes a base and a cover which are mated to form a controlled environment thereinbetween, the disks are mounted in the controlled environment under a portion of the cover, and the portion of the cover has

a slope with respect to a plane defined by any one of the disks.



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45b
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94
40a
95
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78
138
54
110
111
82
48a
40
114a
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FIG. 1

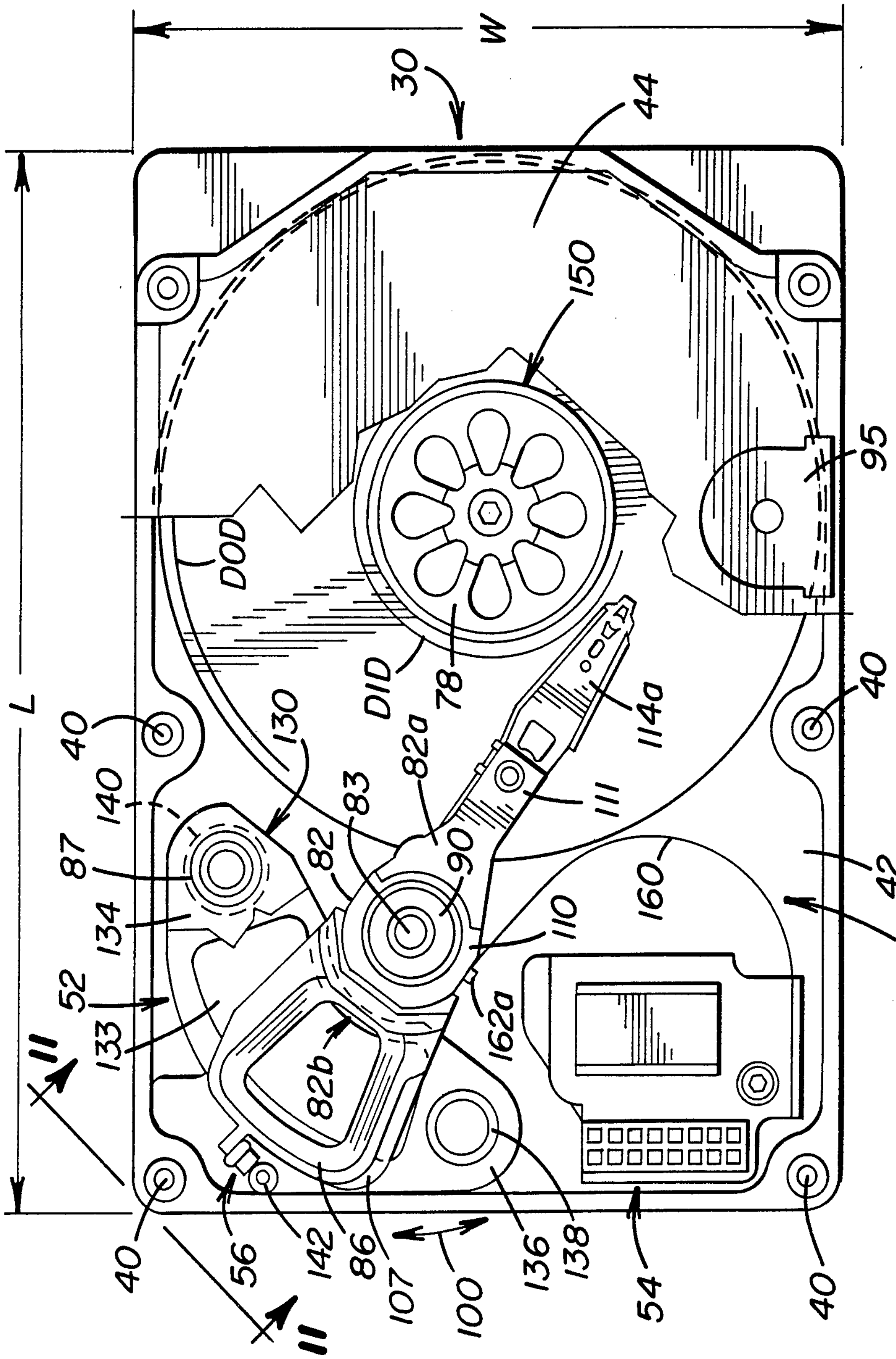
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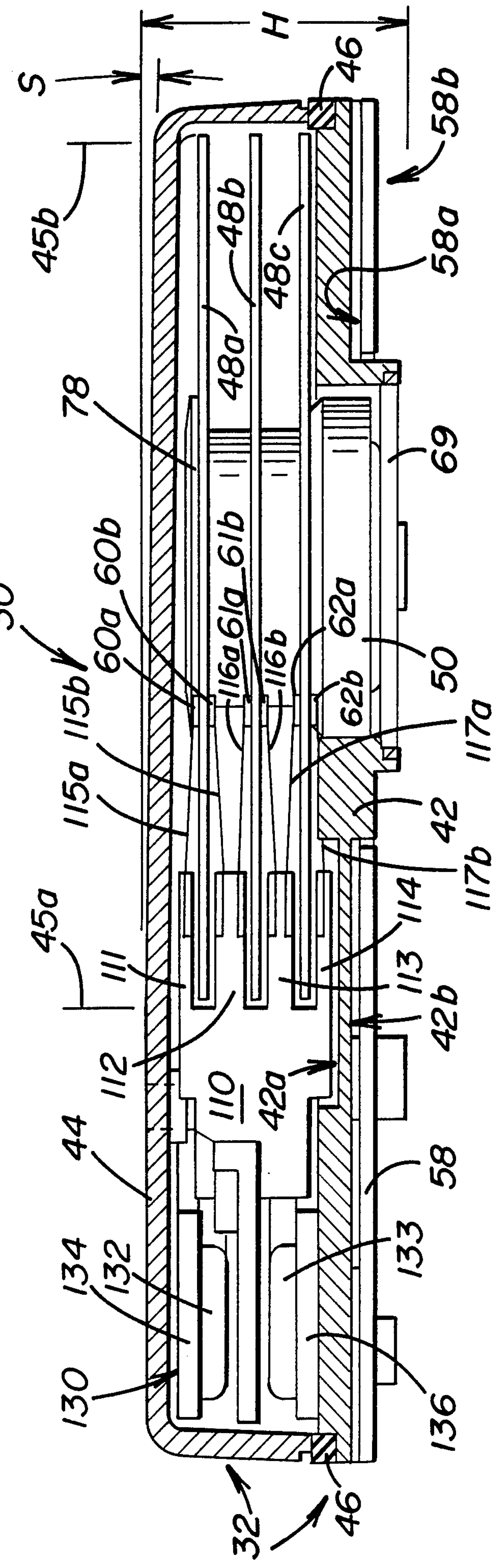
FIG. 2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116b
62a
62b
50
117a
115a
42
117b
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42a
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136
32
46

FIG. 3

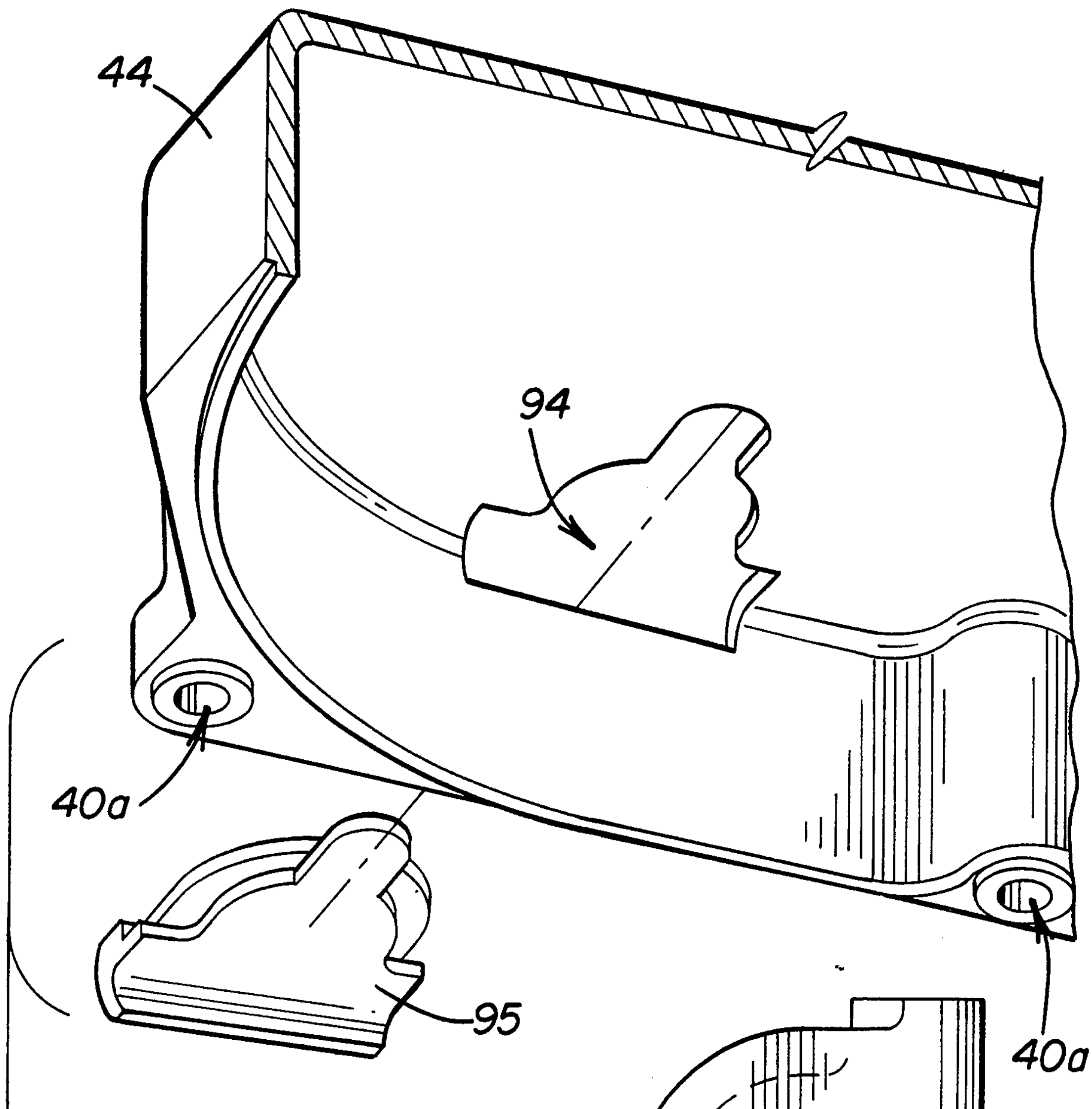


FIG. 4A

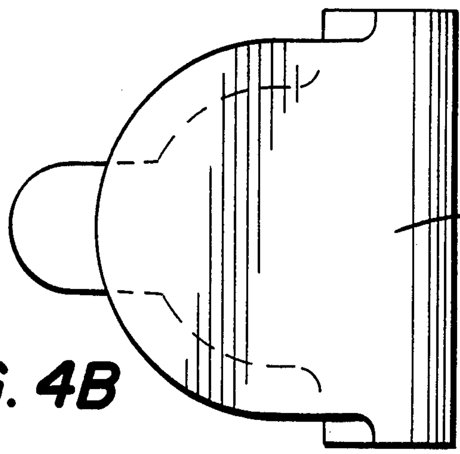


FIG. 4B

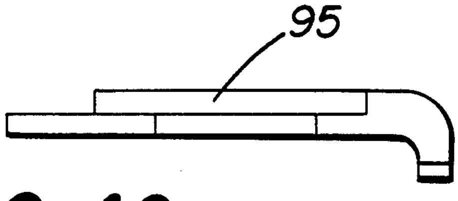
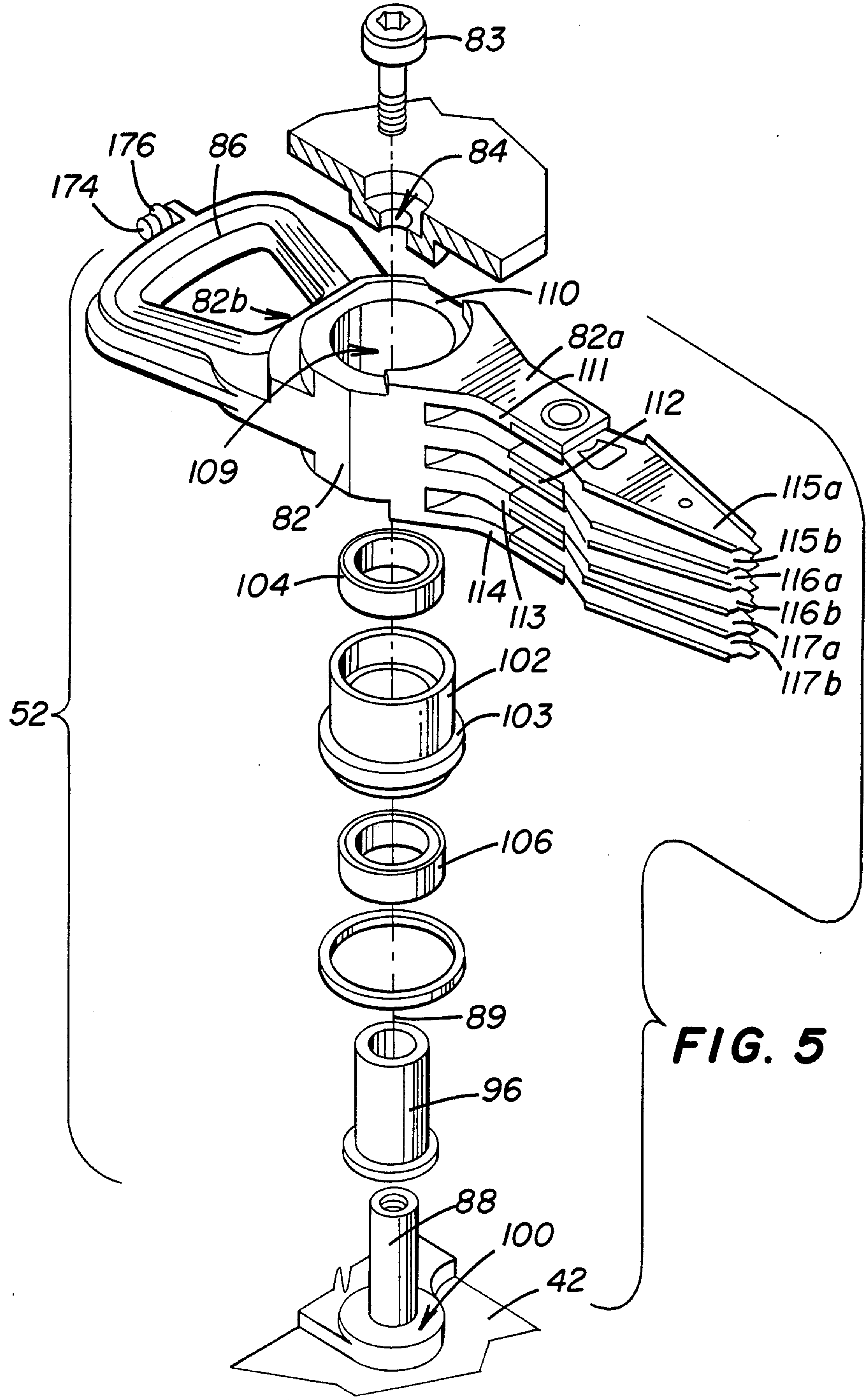


FIG. 4C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110
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112
109
82
115a
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116a
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117b
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114
113
102
103
52
106
89
96
88
100
42

FIG. 5

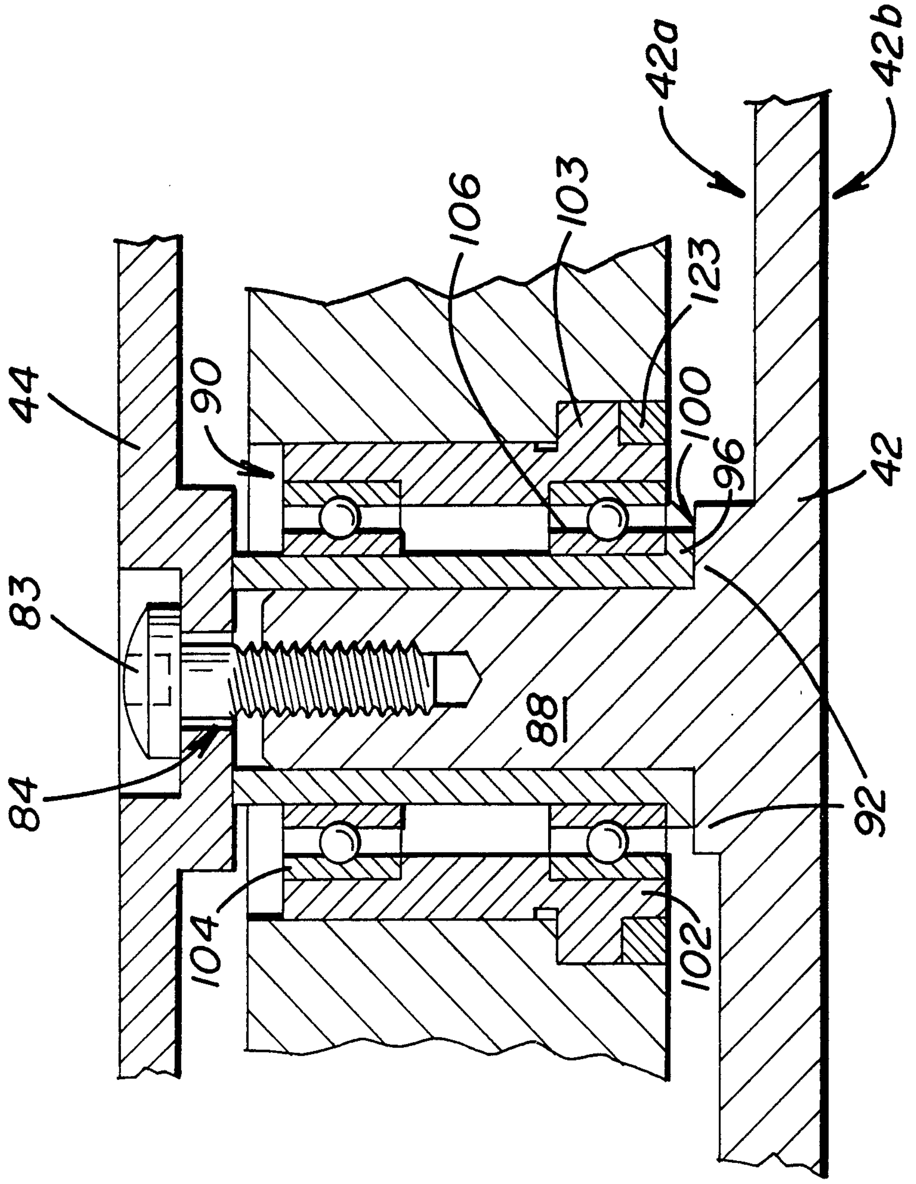
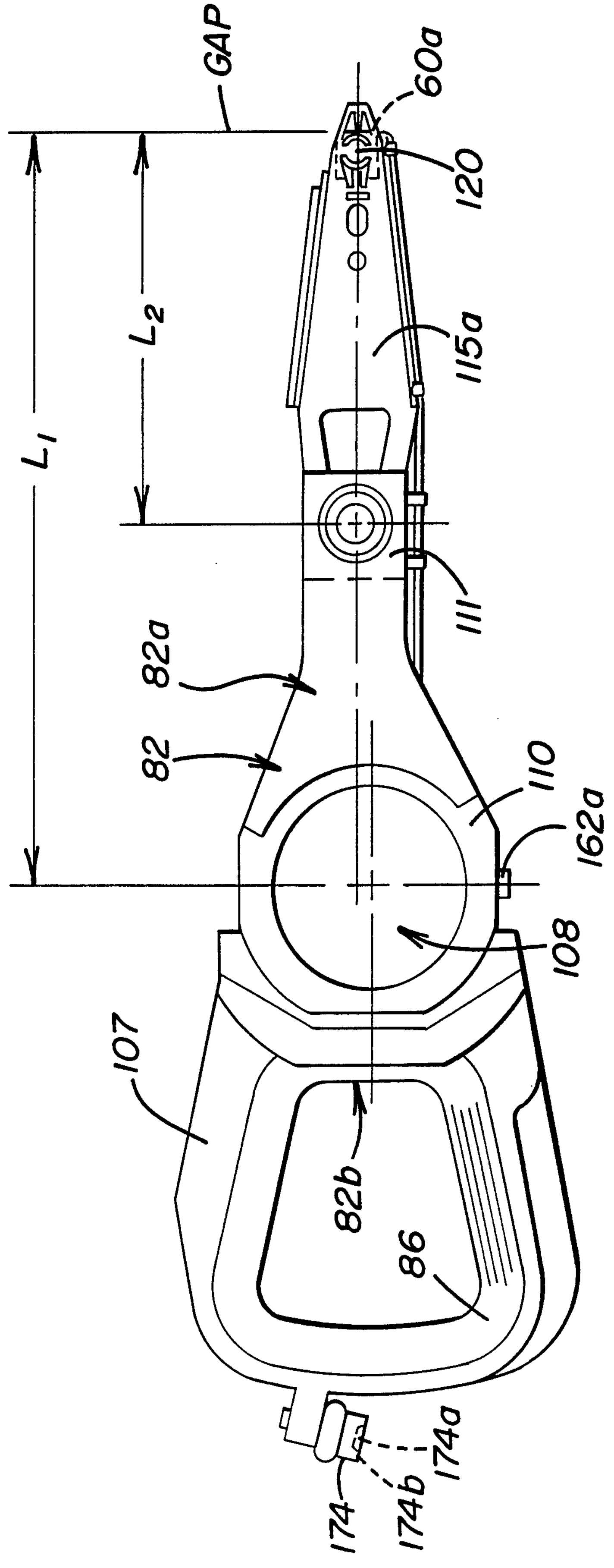


FIG. 6


GAP
60a
120
L2
L1
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111
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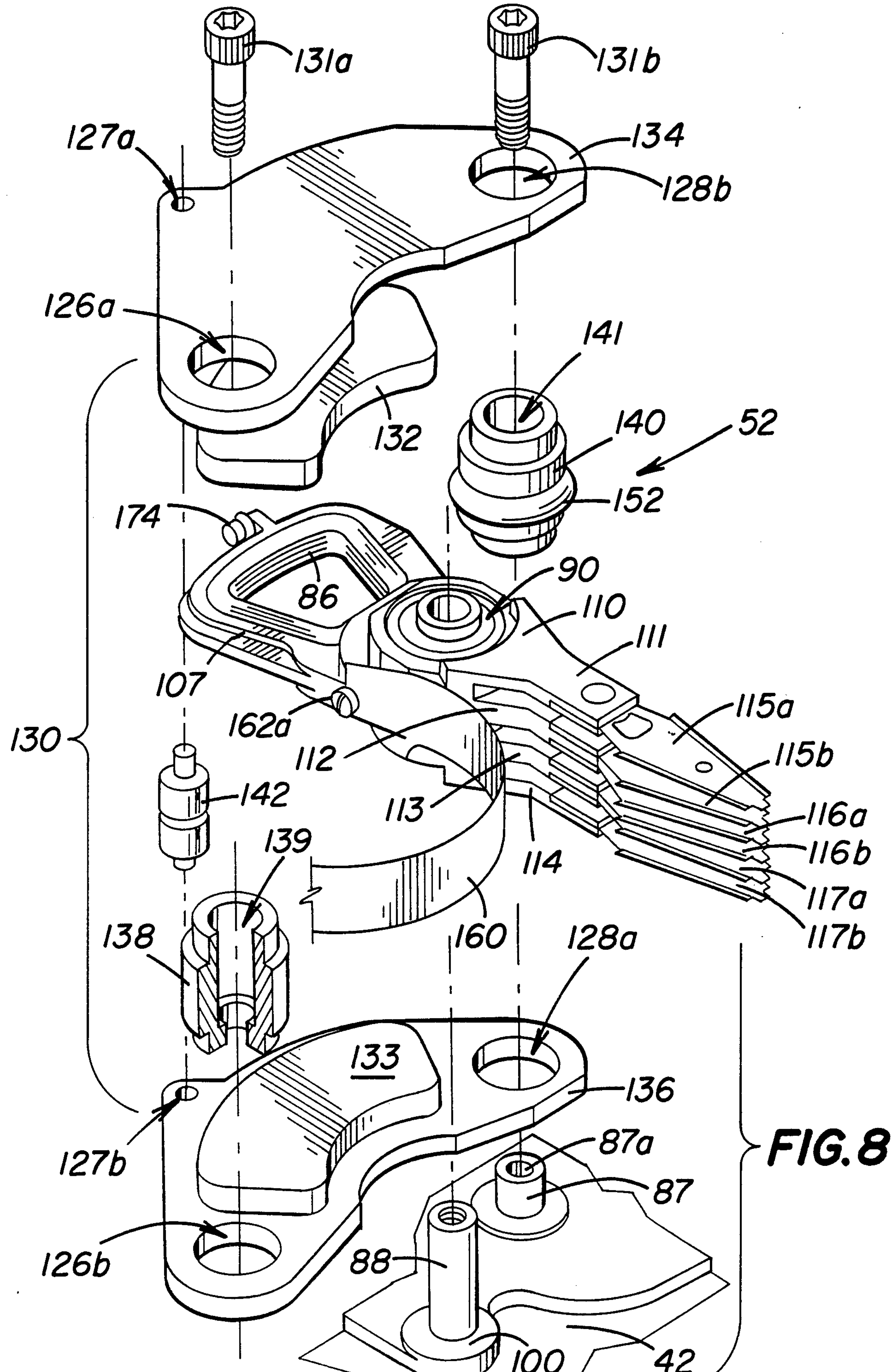
82
110
162a
108
107
82b
86
174a
174b
174

FIG. 7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131b
127a
134
128b
126a
141
132
140
52
152
174
90
86
110
111
107
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130
112
115b
142
113
116a
116b
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88
126b
100
42

FIG.8

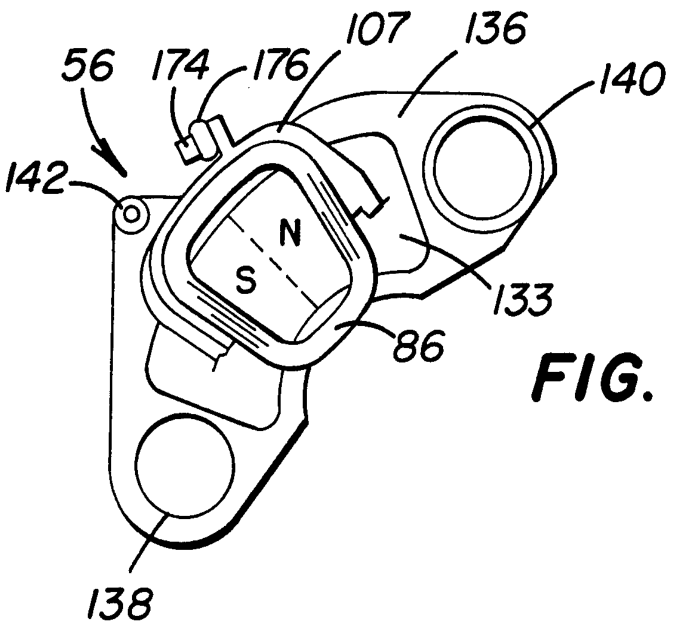


FIG. 9

FIG. 10

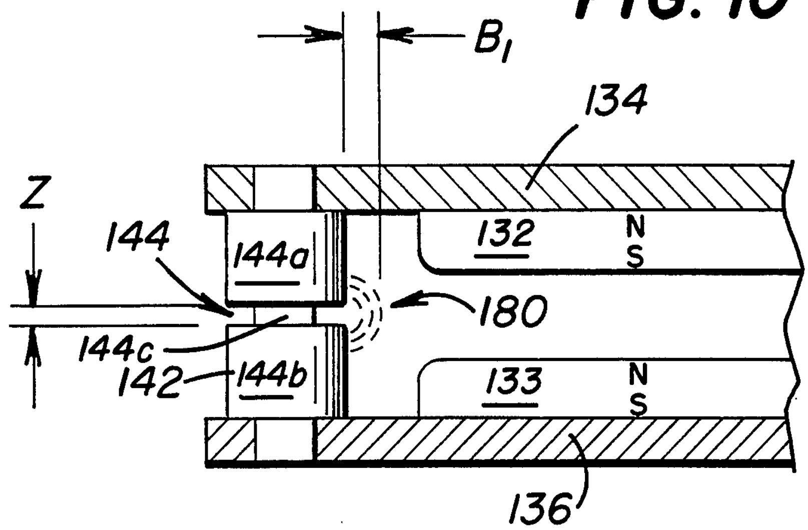
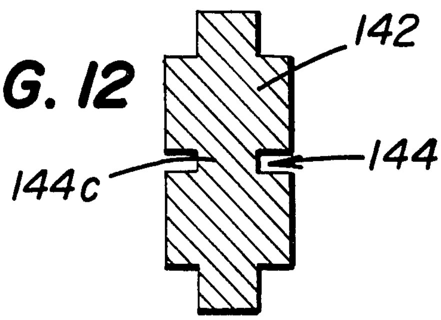
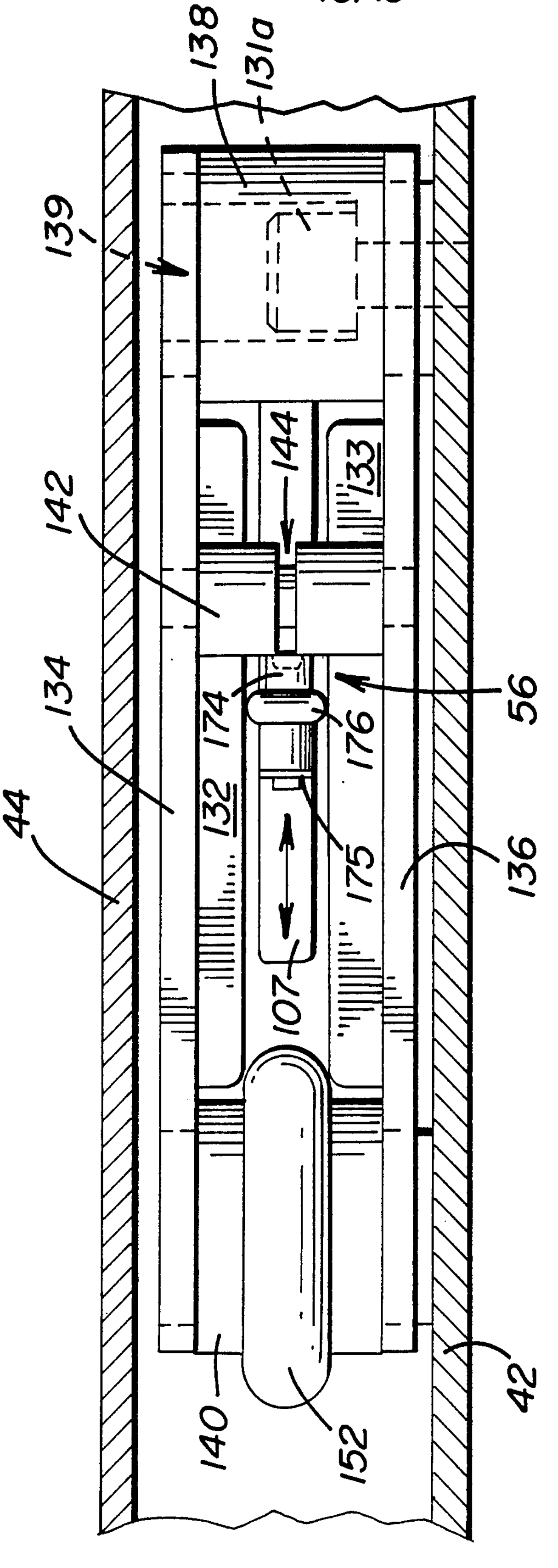


FIG. 12

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131a
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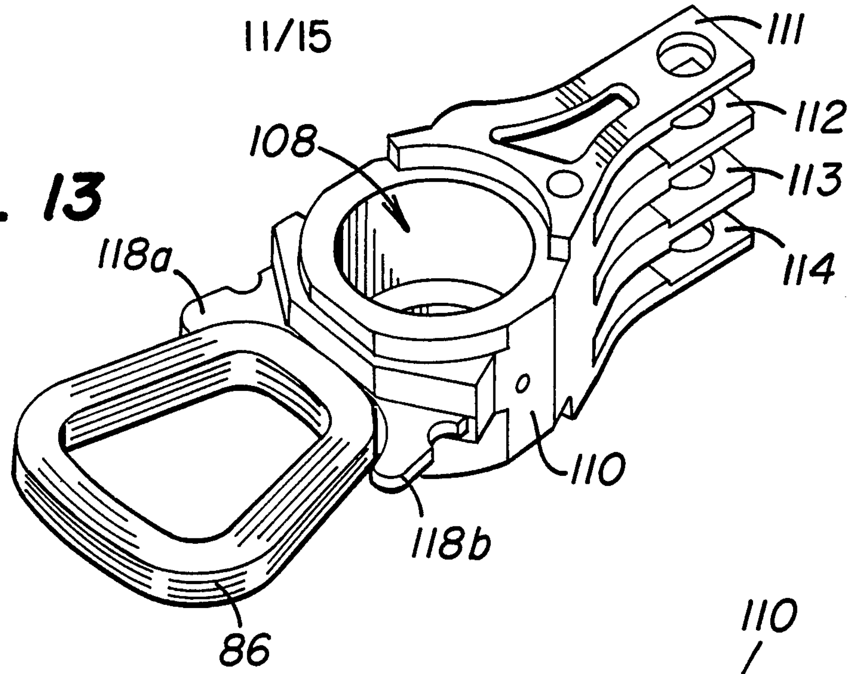
42

FIG. 11

FIG. 13



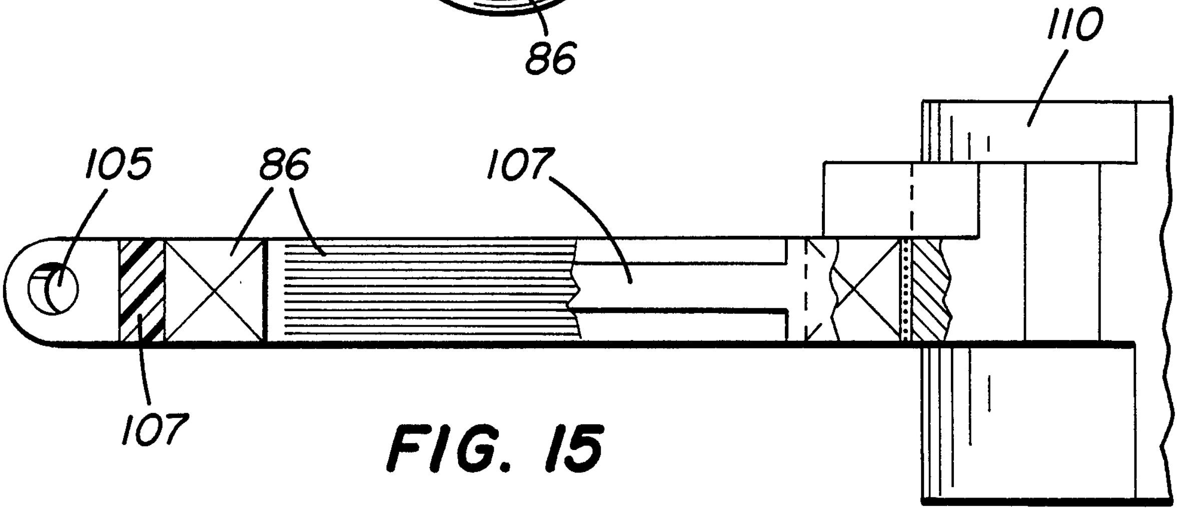
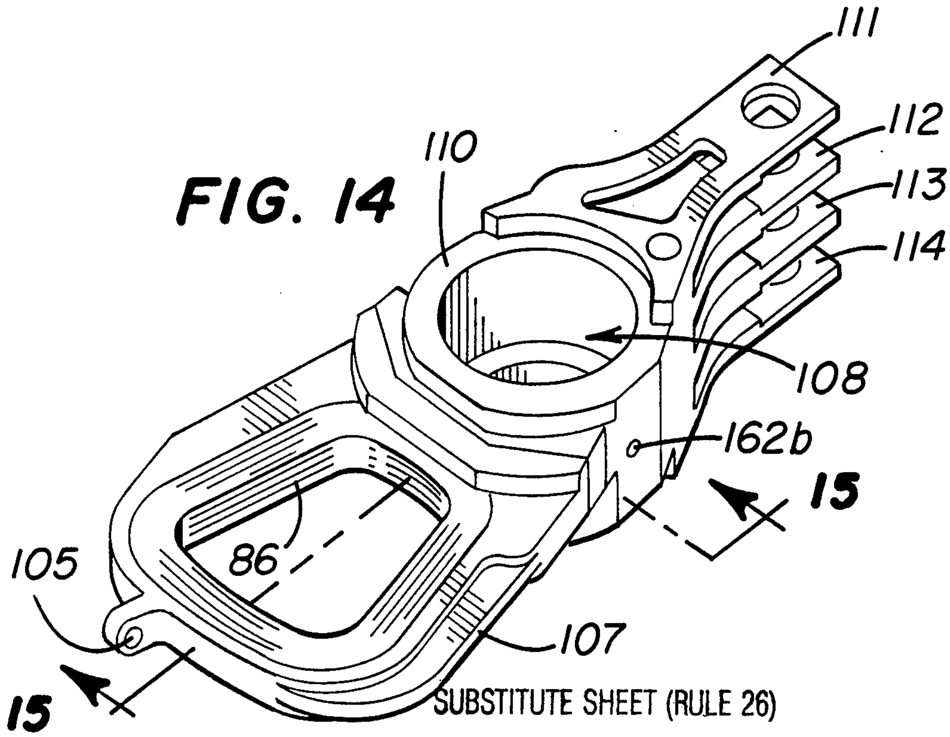


FIG. 15

FIG. 14



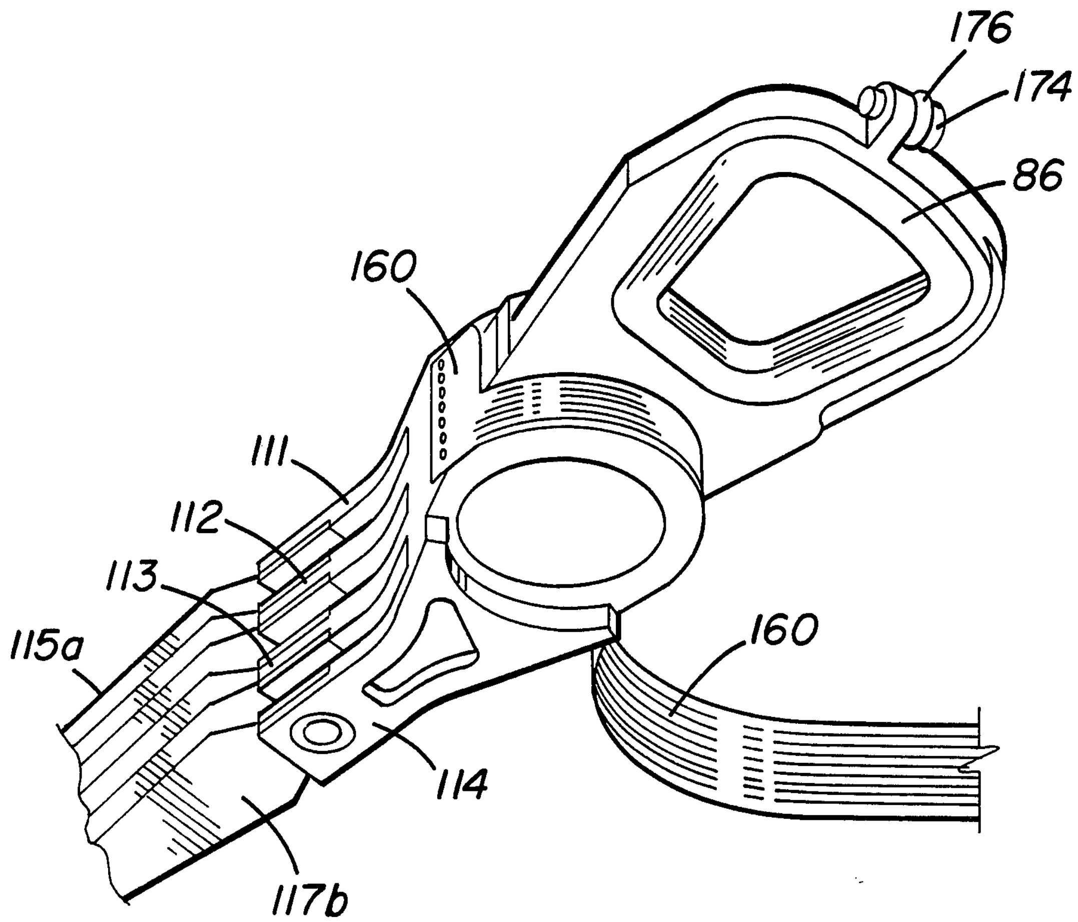


FIG. 16

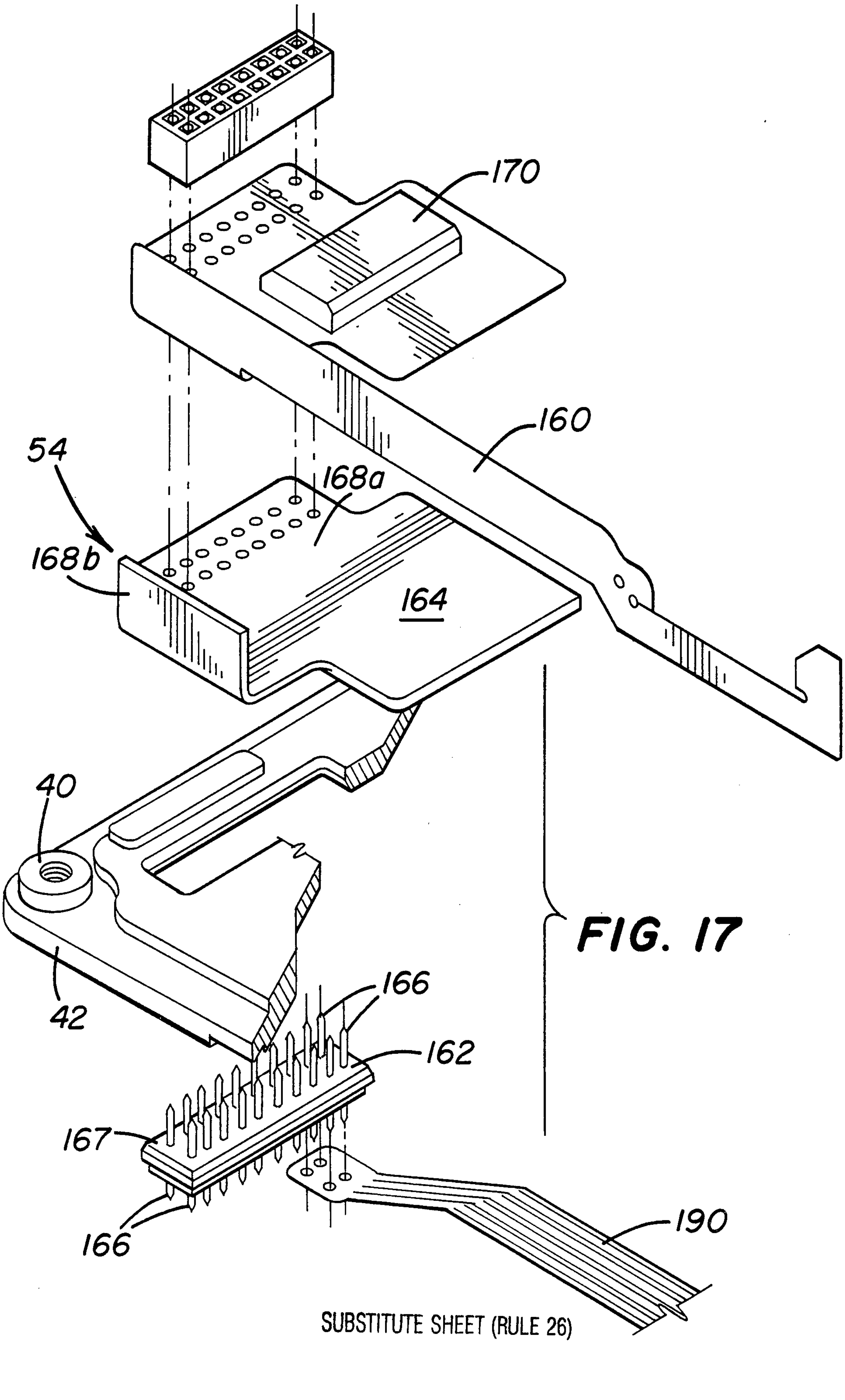


FIG. 17

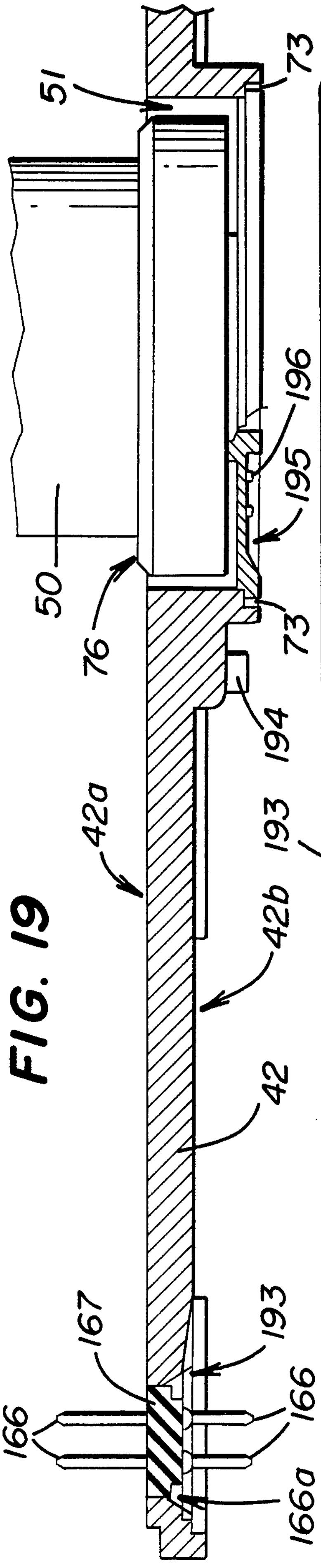


FIG. 19

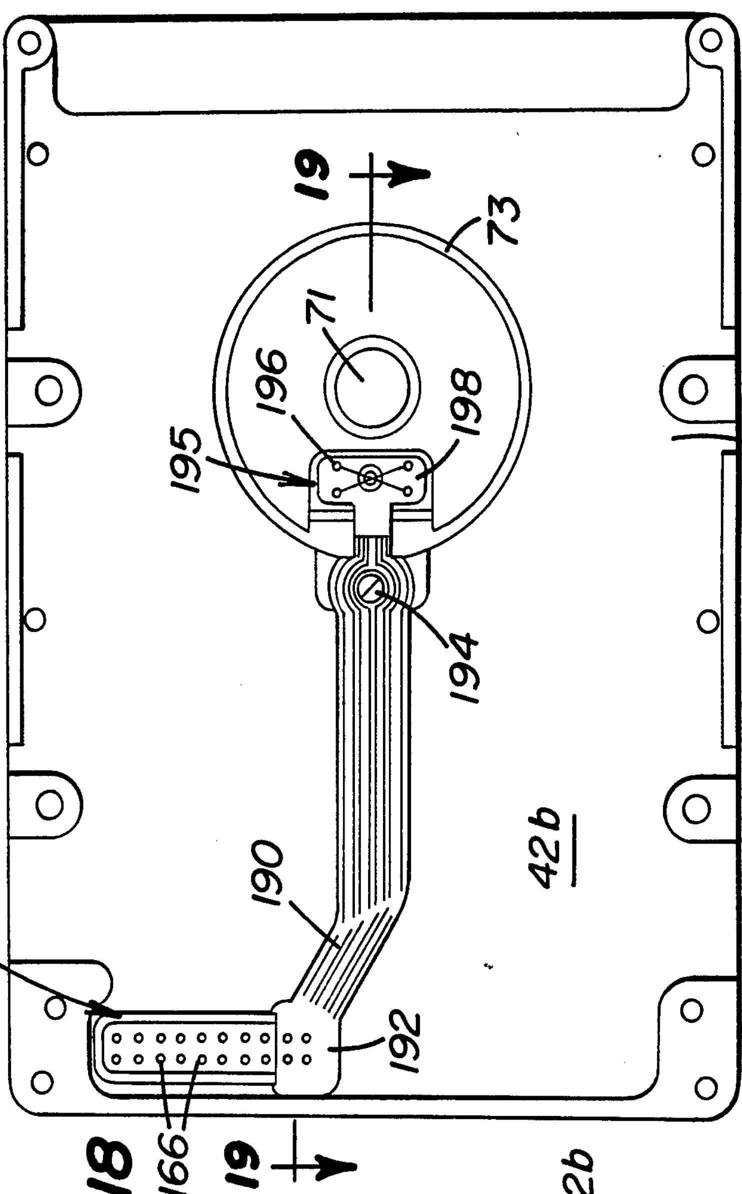


FIG. 18

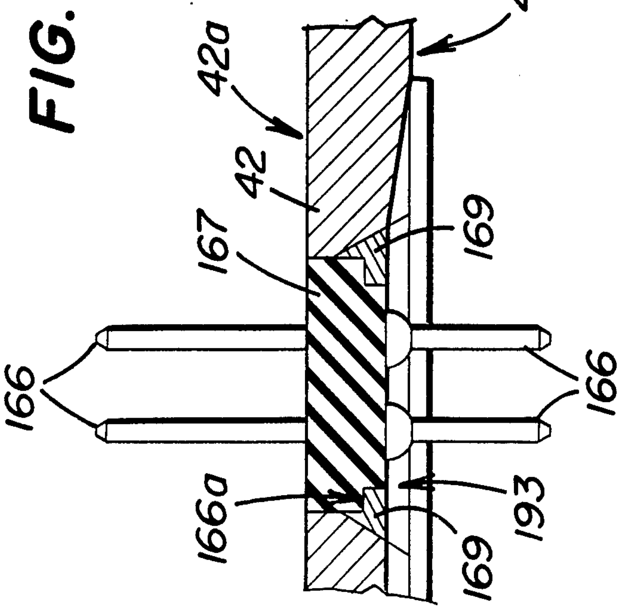
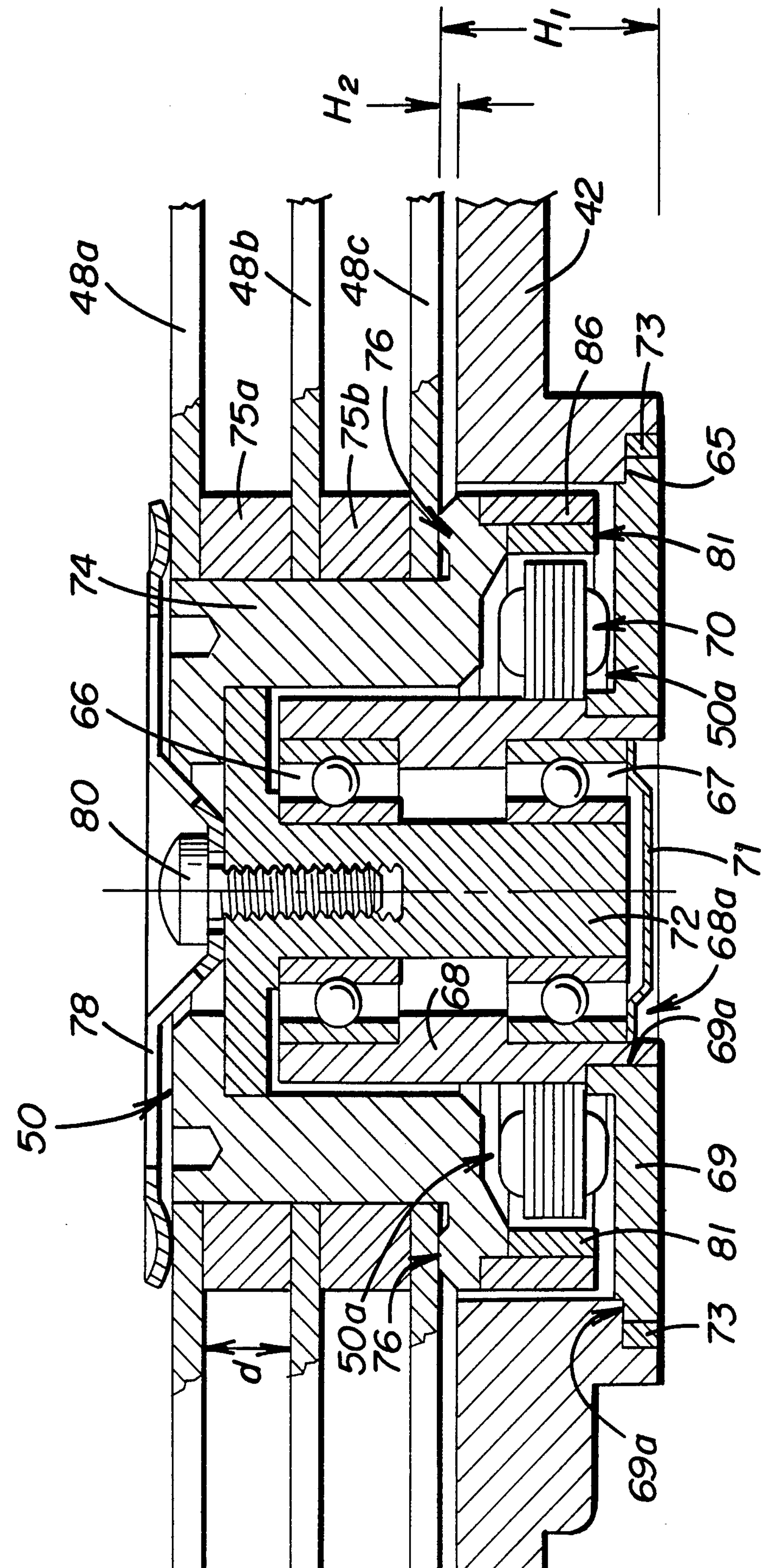


FIG. 20



H1
H2
48a
48b
48c
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76
75a
75b
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65
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74
70
50a
66
67
80
71
72
68a
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69a
78
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81
50a
76
73
d
69a

FIG. 21

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02428

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) : G11B 5/012, 5/55
US CL : 360/97.01, 105
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 360/97.01, 105, 104, 106, 97.02, 97.03

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS; search terms: disc#, disk#, drive, actuator, plastic, coil, cover, top, lid, slope#, 1.44, magnet?, latch, magnetic latch

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ------ Y	US, A, 5,025,335 (Stefansky) 18 June 1991, see Figures 1-4, cols. 5-11.	1-7, 11-15, 17, 19, 23-27, 30, 31, 33, 34 ---------------- 8-10, 16, 18, 20-22, 28, 29
Y	US, A, 4,965,684 (Stefansky) 23 October 1990, see Figure 3, col. 5, lines 12-15.	16, 18
Y,P	US, A, 5,216,662 (Stefansky et al) 1 June 1993, see Figures 6-18, cols. 11 and 12.	9, 10, 20-22, 28, 29

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be part of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 18 April 1994	Date of mailing of the international search report 25 APR 1994
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3594	Authorized officer DAVID OMETZ Telephone No. (703) 308-1296

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/02428

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,027, 241 (Hatch et al) 25 June 1991, see Figure 2, col. 10, lines 56-61.	8, 10
A	US, A, 5,025,336 (Morehouse et al) 18 June 1991, see Figures 1-3, col. 7, lines 24-56.	1, 3, 7, 11