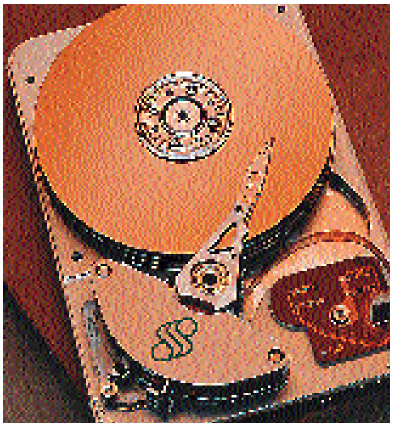
Keeping Magnetic Memory Ahead of the Curve

Over the past two decades, the basic storage requirements of personal computers have increased from kilobytes to megabytes, and then from megabytes to gigabytes. No matter how large the increase, however, the magnetic hard disk has kept pace, retaining its essential role as the primary storage device in computers.



Seagate Technology

The bit density on today's gigabyte hard disks ranges from about 600 Mb/in^2 to more than 1 Gb/in^2. Researchers at IBM's Almaden Research Center (San Jose, CA) have demonstrated storage of 5 Gb/in^2 and are working toward a density of 10 Gb/in^2. They note that if the data density of magnetic disks continues to increase at the same rate as in the past, the physical limits of magnetic storage—which are set by the capability of the read/write head as well as by the number of tracks on the disk—may be reached early in the next century. But other technologies may be capable of higher densities. Another research team at the Almaden center has developed a technique using a superconductor and scanning tunneling microscope to measure the magnetic properties of a single atom.

IBM introduced the first disk drive, the 305 Ramac, in 1956. The first commercial unit was bought by Crown Zellerbach for $50,000. It was the size of two refrigerators and held 5 MB on 50 24-in. disks. Twenty-three years later, a new company, Seagate Technology (Scotts Valley, CA), shipped the first Winchester hard drive for personal computers. The ST-506 could store 5 MB on a 5.25-in. disk, which had a data density of about 2 Mb/in^2.

Early hard disks used wire-wrapped inductive heads to read and write bits. Today's thin-film inductive read/write heads are fabricated using semiconductor technology. However, the bit density that inductive heads can read is limited, and they are being replaced by magnetoresistive (MR) heads. IBM introduced the first MR heads in 1991 and continues to lead the field. Today IBM combines an MR read element with a thin-film inductive write element in a single head that is capable of 1.44 Gb/in^2. Spin valves, which exhibit a "giant" MR effect and yet respond to minuscule switching fields, are most likely to be the basis of the next generation of recording heads from IBM.

Seagate, now the world's largest manufacturer of hard drives, has announced that nearly all of its drives will have MR heads by the end of this year. Unlike IBM, Seagate has chosen to incorporate two separate heads in its disk drives: a thin-film inductive head to write and an MR head to read.

Two other technologies—means of making thin films and data filtering—have contributed to the continuing dominance of magnetic disk storage. Hard disks are produced with thin-film techniques: the substrate is less than 1 mm thick and the magnetic layer can be as thin as 30 nm. Protective overcoats are about 10 to 20 nm. A filtering technique known as partial response maximum likelihood, which complements the response characteristics of the MR head, distinguishes bits from background noise.

Motion Sensor

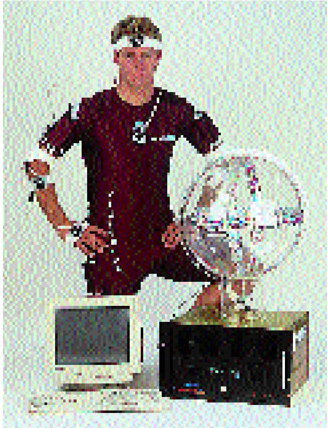
A magnetic motion sensor small enough to be used inside the human body has been introduced by Ascension Technology Corp. (Burlington, VT). Called the MiniBird tracker, the encapsulated device measures 18 × 8 × 8 mm. Smaller unencapsulated versions are available for inclusion in probes or instruments. A transmitter generates a dc magnetic field that passes unattenuated through the body, allowing the location of the microsensor inside the body to be determined instantaneously. The tracker makes 144 measurements per second and the accuracy of sensors within 30 in. of the transmitter is specified to be 1.7 mm for translational motion and 0.5° for rotation. Higher accuracies are possible with special calibration.

Dr. Roy Martin at the University of Washington Bioengineering Center (Seattle, WA) is using the microsensor in a transesophageal echo-cardiagraph probe to collect spatial data used to create accurate 3-D ultrasound images of the heart. With calibration, Martin is able to map the 3-D location of a point on an ultrasound image to within 1 mm. The microsensor is also being used to determine the position of biopsy needles and to monitor fetal movement during labor. Applications in internal medicine include simultaneous tracking of several instruments inside the body and obtaining accurate volume measurements by taking differential readings of anatomical structures.

Magnetic motion sensors, originally developed in the 1970s for military projects, such as helmet-mounted, line-of-sight target tracking and feedback loops in aircraft training simulators, are now being used in innovative ways in the commercial sector. Applications include choreographing realistic movements in 3-D animations, creating accurate 3-D mechanical simulations, mapping the exact shape of archeological specimens, and scientific visualization.

For the general public, however, perhaps the most interesting use of magnetic motion sensors is to provide feedback in virtual reality systems, updating the point of view as rapidly as the wearer turns his head. The magnetic motion detector consists of a tiny triad of electromagnetic coils arranged orthogonally. A transmitter—a larger triad of coils—generates a magnetic field that floods the local area. The magnetic field induces currents in the detector's coils when the detector moves, and these signals are sent to a computer, which calculates changes in position and orientation.

Two types of magnetic motion detectors are being marketed. Polhemus, Inc. (Colchester, VT), a subsidiary of Kaiser Aerospace and Electronics Corp., pioneered development of ac detectors for the military, and more recently Ascension Technology patented its dc detectors.


Polhemus

Until recently, magnetic motion detectors sent their signals via cables which could hamper freedom of movement. Last year, both Polhemus and Ascension introduced wireless magnetic motion systems that can be used to capture human motion for animations or special effects. Polhemus's system, called StarTrak, allows the wearer to move freely through an area 25 x 50 ft. The motion data is stored in memory modules and sent to the computer after a "performance." Ascension's MotionStar Wireless transmits sensor data directly to the computer in real time. The wearer must stay within a 10-ft. radius of the magnetic-field generator. In the future these systems should be able to track more detectors simultaneously, have a larger range, and transmit data more quickly. Ω

Patent Search

If you have a Web browser, direct it to www.ibm.com/patents, and you will be able to search IBM's comprehensive database of U.S. patents for the usual Internet price—namely, for free. This imaginative move by IBM is proving a boon to researchers, inventors, and attorneys, as well as to the just plain curious.

IBM, which holds more than 13,000 patents and files more patents than any other American company (1,867 in 1996), decided to open its patent database to the Internet public as a goodwill gesture and to demonstrate its prowess at handling large, high-volume databases on-line. Its patent database offers full-text search of more than 2 million U.S. patents issued after 1970. Page images of complete patents, including drawings, are also available. In addition, references in the patent abstracts are hyperlinks that provide direct access to relevant prior and subsequent patents. The renewal status of all patents can also be ascertained.

IBM's Almaden Research Center (San Jose, CA) initially developed the patent database for IBM employees worldwide. The Web site uses IBM's Net.Data software and RS/6000 and SP servers. The database currently stores 24 gigabytes of patent text. The page image repository consists of 1.3 terabytes stored on 3,000 CD ROMs. Page images of recent patents and patents issued before 1980 are continually added to the database.

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