

Memory with moving parts Drives

The earliest forms of digital data storage involving moving parts was that of the punched paper card. Joseph Marie Jacquard invented a weaving loom in 1780 which automatically followed weaving instructions set by carefully placed holes in paper cards. This same technology was adapted to electronic computers in the 1950's, with the cards being read mechanically (metal-to-metal contact through the holes), pneumatically (air blown through the holes, the presence of a hole sensed by air nozzle backpressure), or optically (light shining through the holes).

An improvement over paper cards is the paper tape, still used in some industrial environments (notably the CNC machine tool industry), where data storage and speed demands are low and ruggedness is highly valued. Instead of wood-fiber paper, mylar material is often used, with optical reading of the tape being the most popular method.

Magnetic tape (very similar to audio or video cassette tape) was the next logical improvement in storage media. It is still widely used today, as a means to store "backup" data for archiving and emergency restoration for other, faster methods of data storage. Like paper tape, magnetic tape is sequential access, rather than random access. In early home computer systems, regular audio cassette tape was used to store data in modulated form, the binary 1's and 0's represented by different frequencies (similar to FSK data communication). Access speed was terribly slow (if you were reading ASCII text from the tape, you could almost keep up with the pace of the letters appearing on the computer's screen!), but it was cheap and fairly reliable.

Tape suffered the disadvantage of being sequential access. To address this weak point, magnetic storage "drives" with disk- or drum-shaped media were built. An electric motor provided constant-speed motion. A movable read/write coil (also known as a "head") was provided which could be positioned via servo-motors to various locations on the height of the drum or the radius of the disk, giving access that is almost random (you might still have to wait for the drum or disk to rotate to the proper position once the read/write coil has reached the right location).

The disk shape lent itself best to portable media, and thus the *floppy disk* was born. Floppy disks (so-called because the magnetic media is thin and flexible) were originally made in 8-inch diameter formats. Later, the 5-1/4 inch variety was introduced, which was made practical by advances in media particle density. All things being equal, a larger disk has more space upon which to write data. However, storage density can be improved by making the little grains of iron-oxide material on the disk substrate smaller. Today, the 3-1/2 inch floppy disk is the preeminent format, with a capacity of 1.44 Mbytes (2.88 Mbytes on SCSI drives). Other portable drive formats are becoming popular, with IoMega's 100 Mbyte "ZIP" and 1 Gbyte "JAZ" disks appearing as original equipment on some personal computers.

Still, floppy drives have the disadvantage of being exposed to harsh environments, being constantly removed from the drive mechanism which reads, writes, and spins the media. The first disks were enclosed units, sealed from all dust and other particulate matter, and were definitely *not* portable. Keeping the media in an enclosed environment allowed engineers to avoid dust altogether, as well as spurious magnetic fields. This, in turn, allowed for much closer spacing between the head and the magnetic material, resulting in a much tighter-focused magnetic field to write data to the magnetic material.

The following photograph shows a hard disk drive "platter" of approximately 30 Mbytes storage capacity. A ball-point pen has been set near the bottom of the platter for size reference:



Modern disk drives use multiple platters made of hard material (hence the name, "hard drive") with multiple read/write heads for every platter. The gap between head and platter is much smaller than the diameter of a human hair. If the hermetically-sealed environment inside a hard disk drive is contaminated with outside air, the hard drive will be rendered useless. Dust will lodge between the heads and the platters, causing damage to the surface of the media.

Here is a hard drive with four platters, although the angle of the shot only allows viewing of the top platter. This unit is complete with drive motor, read/write heads, and associated electronics. It has a storage capacity of 340 Mbytes, and is about the same length as the ball-point pen shown in the previous photograph:



While it is inevitable that non-moving-part technology will replace mechanical drives in the future, current state-of-the-art electromechanical drives continue to rival "solid-state" nonvolatile memory devices in storage density, and at a lower cost. In 1998, a 250 Mbyte hard drive was announced that was approximately the size of a quarter (smaller than the metal platter hub in the center of the last hard disk photograph)! In any case, storage density and reliability will undoubtedly continue to improve.

An incentive for digital data storage technology advancement was the advent of digitally encoded music. A joint venture between Sony and Phillips resulted in the release of the "compact audio disc" (CD) to the public in the late 1980's. This technology is a read-only type, the media being a transparent plastic disc backed by a thin film of aluminum. Binary bits are encoded as pits in the plastic which vary the path length of a low-power laser beam. Data is read by the low-power laser (the beam of which can be focused more precisely than normal light) reflecting off the aluminum to a photocell receiver.

The advantages of CDs over magnetic tape are legion. Being digital, the information is highly resistant to corruption. Being non-contact in operation, there is no wear incurred through playing. Being optical, they are immune to magnetic fields (which can easily corrupt data on magnetic tape or disks). It is possible to purchase CD

"burner" drives which contain the high-power laser necessary to write to a blank disc.

Following on the heels of the music industry, the video entertainment industry has leveraged the technology of optical storage with the introduction of the *Digital Video Disc*, or DVD. Using a similar-sized plastic disc as the music CD, a DVD employs closer spacing of pits to achieve much greater storage density. This increased density allows feature-length movies to be encoded on DVD media, complete with trivia information about the movie, director's notes, and so on.

Much effort is being directed toward the development of a practical read/write optical disc (CD-W). Success has been found in using chemical substances whose color may be changed through exposure to bright laser light, then "read" by lower-intensity light. These optical discs are immediately identified by their characteristically colored surfaces, as opposed to the silver-colored underside of a standard CD.

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