Color photo courtesy Shugart Associates.

# MEMORY STORAGE
## *THE MEGABYTE WAY*

*How hard disks operate and what's needed
for backup and interfacing with small computers*

*By Stan Miastowski*

THE Winchester hard disk drive is the most powerful data storage peripheral available for microcomputers. It may also be the most economical system if you're a serious computer user who handles large amounts of data and needs the kind of high-speed access to them that multiple floppy disk systems cannot provide.

**What's a Winchester?** At one time, hard disk systems were huge in size. In its evolution, IBM developed smaller rigid disk drives with one fixed and one removable disk pack. Each held about 30 megabytes of data, so the model was dubbed "3030's," which according to legend soon became "Winchester" (as in 30 cal. Winchester rifle). Although IBM abandoned the name, it's commonly used today to identify hard disk drives for small computer systems.

Most Winchester hard disks share the following characteristics: 1) the disk(s), read/write heads, and the mechanism for moving heads across the surface of the disk are enclosed in a sealed environment in which air is continuously filtered and circulated; 2) the disk(s) spin at high speed (normally 3600 rpm) and the read/write heads do not actually touch the surface of the disks; 3) since the heads must rest on the surface of the disk when the drive is turned off, the disk surface is lubricated; 4) there is a very thin magnetic coating on the disk(s); and 5) the

media isn't removable (although this attribute is changing.)

Winchesters owe their large storage capacity to a number of factors, including the thin magnetic coating mentioned above. The thinner the coating, the more data that can be stored on it. In addition, the magnetic heads that read the data actually "fly" over the surface of a disk on a cushion of air created by the enormous speed at which the platter rotates. It's the same as the "ground effect" created when the wings of an aircraft come close to ground level. Continuing the aircraft analogy, when the disk stops turning, the head ends up on a special area of the disk known as the "landing zone." The usual flying height for today's typical Winchester is about 1.5 microns—a height considerably smaller than the diameter of a speck of dust or particle of smoke. This flying height is related to the bit density of the disc—the lower the height, the higher the density.

Owing to the microscopic tolerances involved, Winchesters require a climate-controlled environment. Any particle that gets in the way of the head can cause a "head crash"—a condition where the head actually touches the surface of the platter while it is moving. When this happens, the entire disk often becomes useless. To eliminate this problem, the platters and heads of a Winchester drive are enclosed in a sealed environment, with microscopic air filters that continually re-

circulate air (Fig. 1). The drives are also assembled in "clean rooms."

Positioning the head so that it's exactly over a track every time is crucial. There are primarily two ways of doing this: stepper motors and voice-coil positioners. The former is the most common method. The stepper motors are used in one of two ways. In the first the motor is attached to a lead screw. As the stepper motor moves back and forth, the screw turns and moves the read/write head from track to track. The more common method is to attach the read/write heads to metal bands, which move back and forth with the stepper motor as shown in Fig. 2. Bands are subject to less wear than a lead screw.

Unlike a stepper motor, a voice-coil head positioner is a closed-loop system that actually tells the system where the heads are positioned. A voice-coil positioner uses a linear motor which moves smoothly throughout its range, but can stop at any track. Each track contains magnetically coded information that tells the controller where the head is positioned. The controller uses the information to move the head until the right track is found.

Although a voice-coil head positioner is more accurate than a stepper motor, it's considerably more expensive to manufacture and requires a sophisticated (and more expensive) controller. Also, because the magnetic position information is permanently encoded on the disk,
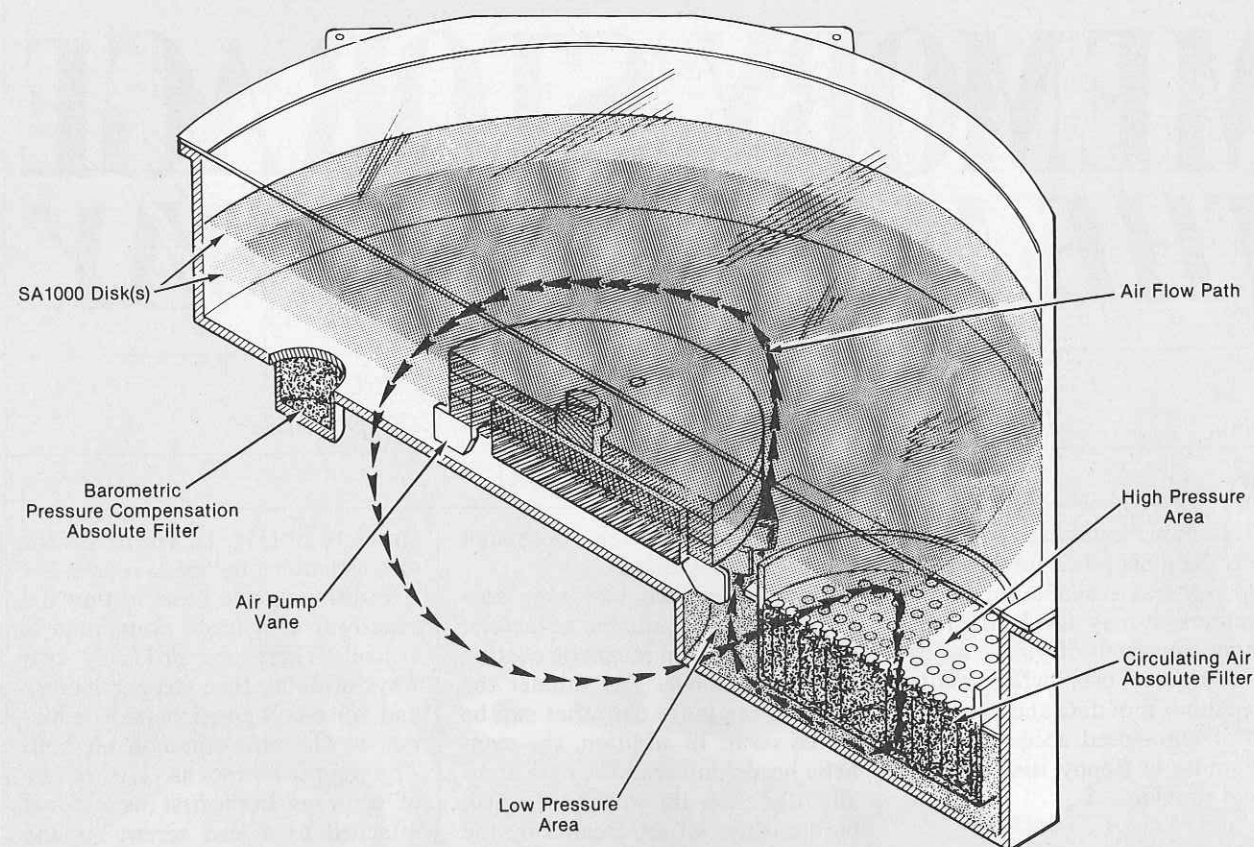
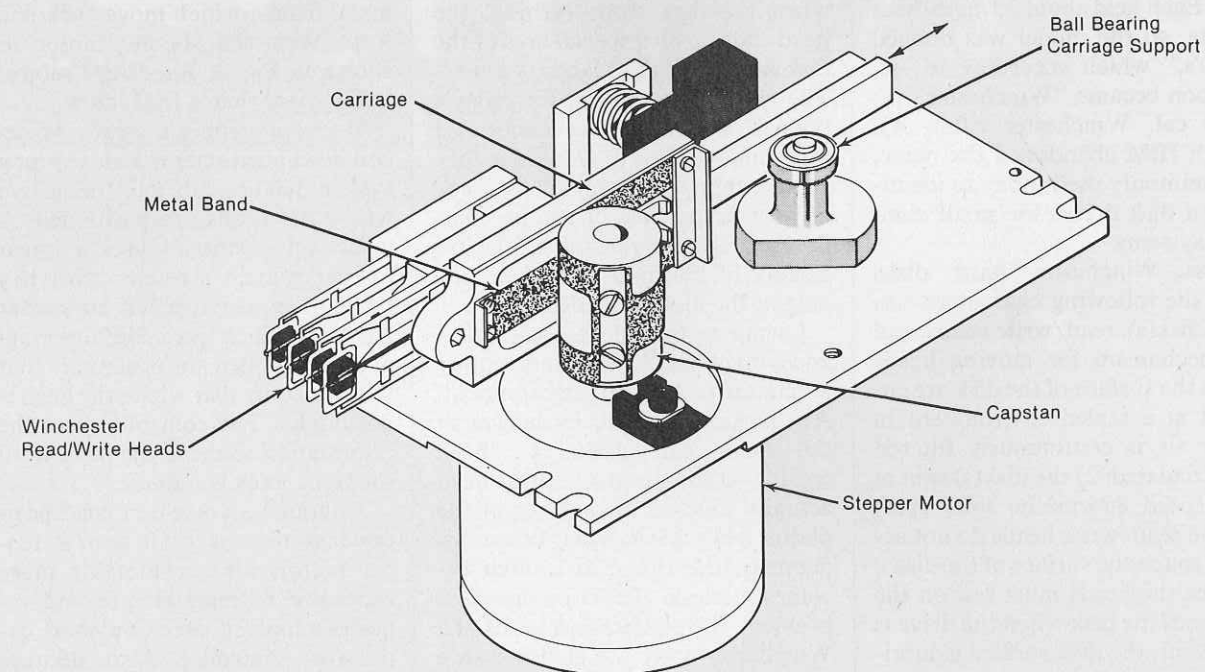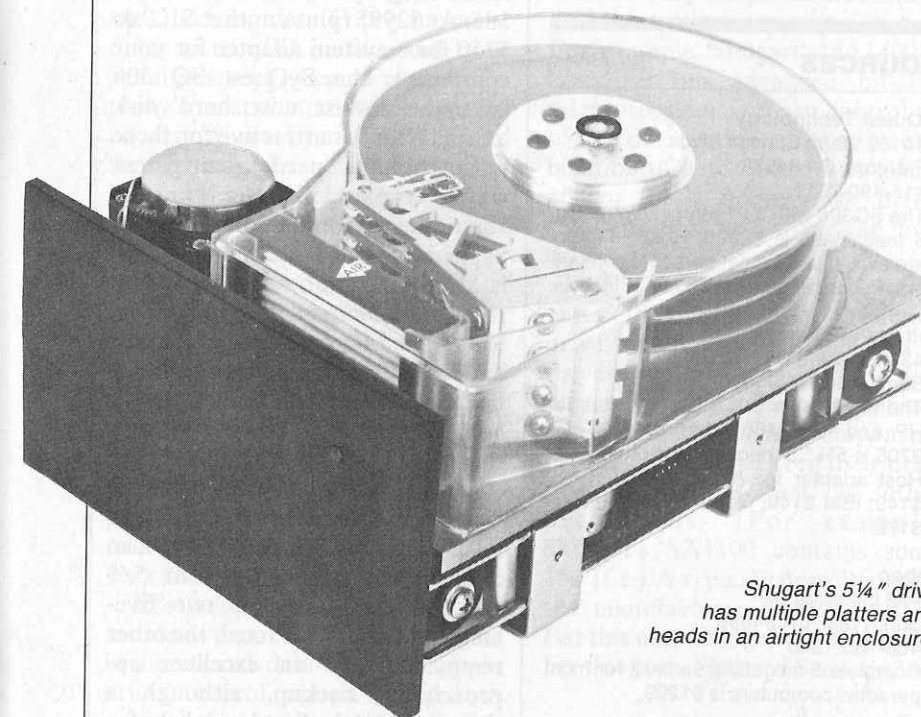Fig. 1. Air flow diagram of the Shugart SA1000 8" fixed disk system.

SA1000 Disk(s)

Air Flow Path

Barometric
Pressure Compensation
Absolute Filter

High Pressure
Area

Air Pump
Vane

Circulating Air
Absolute Filter

Low Pressure
Area



Fig. 2. Actuator assembly of the Shugart SA1000.

Ball Bearing
Carriage Support

Carriage

Metal Band

Capstan

Winchester
Read/Write Heads

Stepper Motor

The Syquest SQ306 hard disk drive uses removable 3.9" cartridges.



Shugart's 5¼" drive
has multiple platters and
heads in an airtight enclosure.
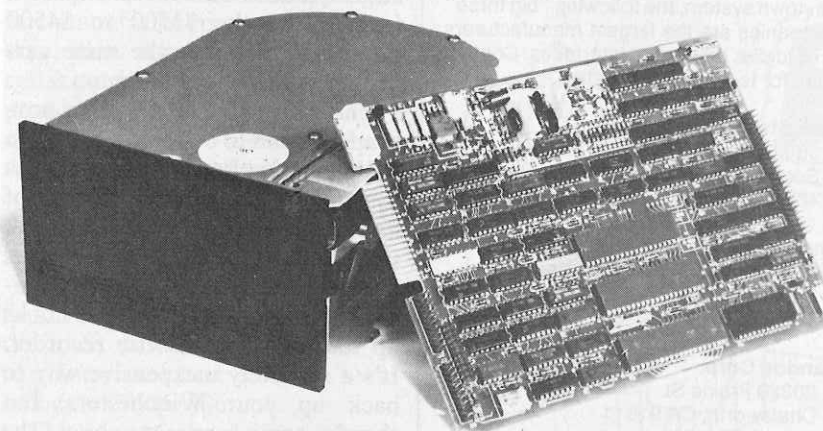


Xebec disk controller features an industry standard (SASI) host interface.

it takes up storage space. You'll find voice-coil head positioners on some 8" hard disks, but few 5¼" disks—at least at present.

**Why a Hard Disk?** No matter what you use your personal computer for, it doesn't take long for the limitations of even floppy disk storage to become evident. Although floppy drives are relatively fast and storage capacity on a double-sided, double-density, 5¼" disk has increased to nearly a megabyte (one million characters), any serious personal computer user soon collects a shelf full of the disks and has to keep swapping back and forth among them. If you're a professional and must use your computer for handling very large amounts of data (such as a list of accounts), you may have to purchase additional drives to have all the information you need "on line" at the same time. Not only is it expensive, but most personal computers can't handle more than four floppy disk drives. On the other hand, a single 5¼" Winchester hard disk normally stores 5 megabytes, with 10-megabyte units (using multiple platters) common.

Hard disks have another selling point—speed. Because the read/write head of a floppy disk actually touches the disk surface and because of the friction of the "envelope" all floppies are enclosed in, there's a speed limitation of about 300 rpm. Winchesters, however, spin at 3600 rpm. The speed of the disk dramatically decreases the speed required to find a specific point on the disk—known as seek time. While a floppy disk's seek time is between 1/10 second and 1 second, most small Winchesters can find specific data between 25 and 75 ms. This speed, coupled with the increased bit packing density of the disk, means data is transferred ten to twenty times faster. Most Winchesters designed for personal computer applications can transfer data at 600,000 to 900,000 bytes per second resulting in greatly increased efficiency in disk-intensive operations.

**Backing Up a Hard Disk.** Nearly everyone who uses a personal computer keeps backup copies of their

important programs and data in storage—usually on floppy disks. But backing up data on a Winchester is more of a problem because of the huge amounts involved.

Obviously, the most logical and least expensive way to back up Winchester data is to use floppy disks. The problem is that backing up all the data on a 5-megabyte Winchester can require changing disks as many as 20 times—a time-consuming and inconvenient process.

Floppy disks can be useful though, if you only back up part of the data, such as files you worked on that day. In that way, you can do a "rotating backup" where all the information on the Winchester is backed up every couple of weeks. One of the most popular backup devices, especially for Winchester users with large databases is the streaming tape drive. These drives use special tape cartridges and operate at relatively high speeds. They can copy a 10-megabyte disk in less than a minute. They copy data from the Winchester in a continuous stream, with no starting and stopping as each file is copied. Although streaming drives come in both ¼"

and ½" varieties, the ½" variety is often as expensive as low-priced Winchesters. The ¼" variety is still expensive though, costing about $1200. Individual tape cartridges cost only a couple of dollars, and hold over 20 megabytes of data.

Another backup method is to use a second Winchester drive. However, tying up several thousand dollars just to keep a backup of data isn't economical for most personal computer users. A developing trend is hard disk drives with removable media. SyQuest Technology (Fremont, CA) is offering a hard disk drive that has 3.9" removable cartridges. Each cartridge holds about seven megabytes and costs about $85. At $2995 (plus another $100 to $250 for a system adapter for your computer), the SyQuest SQ 306 isn't the lowest cost hard disk around. But it's attractive for those who absolutely need a convenient way to keep backup data.

Another manufacturer, DMA Systems Corp. (Santa Monica, CA) is also going the removable media route. The company has just started to ship the Micro Magnum 5, a 5¼" hard disk drive with removable cartridges. Although no final price has been set (the company is presently shipping to OEMs only), the drive is expected to cost $3000 to $4000, with each five-megabyte cartridge selling for about $200. DMA is also offering the Micro-Magnum 5/5 disk drive. It contains two five-megabyte disks, one fixed, the other removable. It's an excellent approach to backup, although a throwback to the first hard disks for large systems. The 5/5 is expected to retail in the $3500 to $4500 range, and will use the same cartridges as the Micro Magnum 5.

There are some other rather novel approaches to backing up data on a Winchester. For instance, Corvus Systems Inc. (San Jose, CA), one of the largest marketers of hard disk systems for personal computers, has a system called the Mirror™. It consists of an interface card that hooks up to any video cassette recorder. It's a relatively inexpensive way to back up your Winchesters, but there's some concern about the long-term reliability of data recorded on video tape.

## WINCHESTER SOURCES

If you're ready to buy a hard disk for your personal computer, the best place to start is with the company you purchased your computer from. Most companies including Apple, Commodore, Heath/Zenith, Radio Shack, and others offer some hard disk systems, although usually not for all models.

There are a number of companies that market ready-to-plug-in-and-run hard disk systems for most popular personal computers. Listed below are a few.

**Corvus Systems, Inc.**
2029 O'Toole Ave.
San Jose, CA 95131
408-946-7700
One of the largest integrators of hard disk systems for personal computers, Corvus offers 6-, 11-, and 20-megabyte systems for almost all popular computer systems. Prices start at about $3000.

**Data Peripherals**
965 Stewart Dr.
Sunnyvale, CA 94086
408-745-6500
The Lynx 8", 10.6 megabytes, with removable media is $5300 with Apple II interface.

**Laredo Systems**
2264 Calle deLuna
Santa Clara, CA 95050
800-538-5137 [orders]
408-980-1888 [technical help]
LS525 5¼", 5 megabyte is $1995. TRS-80 host adapter is $250.

**Percom Data Company, Inc.**
11220 Pagemill Rd.
Dallas, TX 75243
214-340-7081
PHD 5¼" 5 and 10-megabyte systems start at $2495. Direct interface to the TRS-80 Model III, Apple II, Heath/Zenith 89, and IBM Personal Computer.

**SyQuest Technology**
44160 Warm Springs Blvd.
Fremont, CA 94538
415-490-7511
The SQ306 with 3.9" removable media, 5 megabytes is $2995. Host adapters are available for most personal computers. Prices range from $99 to $300.

**United Peripherals**
432 Lakeside Dr.
Sunnyvale, CA 94086
The UP-9800 is 5-¼" 5 megabytes for HP and IEEE-488 interface and UP-9705 is 5¼" 5 megabytes, both $2995. Host adapter for Apple II $99; S-100 $149; IBM $149; Q-bus $299; Multibus $179.

**Xebec**
432 Lakeside Dr.
Sunnyvale, CA 94086
408-735-1340
Complete 5 megabyte semi-kit for most personal computers is $1299.

Finally, if you're interested in designing your own system, the following "big three" companies are the largest manufacturers of hard disk drives and interfaces. Contact them for technical information.

**Seagate Technology**
360 El Pueblo Rd.
Scotts Valley, CA 95066
408-438-6550

**Shugart Associates**
475 Oakmead Parkway
Sunnyvale, CA
408-733-0100

**Tandon Corp.**
20320 Prairie St.
Chatsworth, CA 91311
213-993-6644

**Hooking Up a Hard Disk.** In the past, hooking up a Winchester hard disk drive to your computer was a long and involved exercise that required intimate hardware and software knowledge and the patience of Job. Thankfully, most of today's Winchesters are specifically designed for a particular microcomputer system—plug in a board, turn on the power, and off you go. Interfacing has become simple because of standard controllers and host adapters.

As many of us tend to forget in the era of "plug-in-and-go" systems, moving data from your computer to the disk surface and back again is a sophisticated process. In today's most commonly used method, data flows from the computer through an interface, to the controller, and then to the disk.

The interface between the controller and the host computer is called a host adapter. It's specific to your computer system and plugs directly into the computer bus (for example, S-100, IBM-PC, TRS-80, etc.). Through the host adapter, the host computer "sees" the hard disk as just another logical device like a floppy disk. All that the host computer need do is send the interface a read or write address and the number of blocks to be read or written.

Host adapters are comparatively simple devices consisting of an 8-bit bi-directional data-bus and appropriate control signals adapted to your computer system's bus configuration. Because these adapters allow manufacturers to use identical controllers for different computer systems, they've become the most popular method of interfacing a computer and Winchester hard disk. A number of companies have entered the hard disk "sweepstakes" in the past couple of years and, consequently, there are several "standard" host/controller interfaces. Two of the most popular are the SASI (Shugart Associates System Interface) and Seagate Technology's ST506/406.

The heart of a hard disk system is the controller. It connects between the host adapter and the drive. To-

day's intelligent controllers, such as the Western Digital WD1000 and the Shugart SA1400, make the disk completely transparent to the host computer and perform formatting, head positioning, data I/O, error checking and correction, and other necessary "housekeeping" tasks. The controller coupled with DMA (direct memory access), which allows data to be swapped from RAM to disk and back without any intervention from the host processor, vastly increases system throughput.

A "Typical" intelligent controller includes a microprocessor, line drivers and receivers, input/output buffers, and control software in ROM. Today's sophisticated intelligent controllers are versatile, too. For example, Shugart's SA1400 is based on an advanced bit-slice microprocessor and can control up to five devices, including any combination of hard disk drives (5¼", 8", or 14"), floppy disk drives (5¼" or 8"), and streaming tape drives.

Such versatility doesn't come cheap. In fact, the cost of the actual drives has become a small part of the cost of the plug-in hard disk controller. Controllers are sophisticated, and the many components needed to build one keep their price from falling as fast as other peripherals. (For example, Shugart's SA1400 contains some 150 ICs.) A typical controller costs the manufacturer $500 to $1000. But this may change very soon. Earlier this year, National Semiconduc-

tor announced a 4-chip hard disk controller. This breakthrough should result in less expensive controllers and, thus, Winchester systems in the future.

**What Should You Buy?** The largest manufacturers of Winchester drives sell most of their output on an OEM (original equipment manufacturer) basis, with the OEM adapting the controller to a particular system. Numerous companies offer complete systems that are ready to plug in and run. Although it may cost a bit more than "rolling your own," buying a Winchester with a controller specifically set up for your particular personal computer system is generally the best way to go.

**Summary.** Even though they've just recently become economical for personal computer users, Winchester hard disks are fast becoming popular peripherals. Besides their storage capability, speed, and convenience, one of their greatest drawing cards is cost. When looked at on a cost-per-byte basis, a Winchester can be as much as five times less expensive than multiple floppy disk drives. And prices are falling rapidly, too. As this was written, Xebec (Sunnyvale, CA) was offering a complete ready-to-plug-in-and-run 5-megabyte system for just $1299. There is little doubt that we can expect to see more and more hard disk drives used with sophisticated microcomputer systems.  ◇