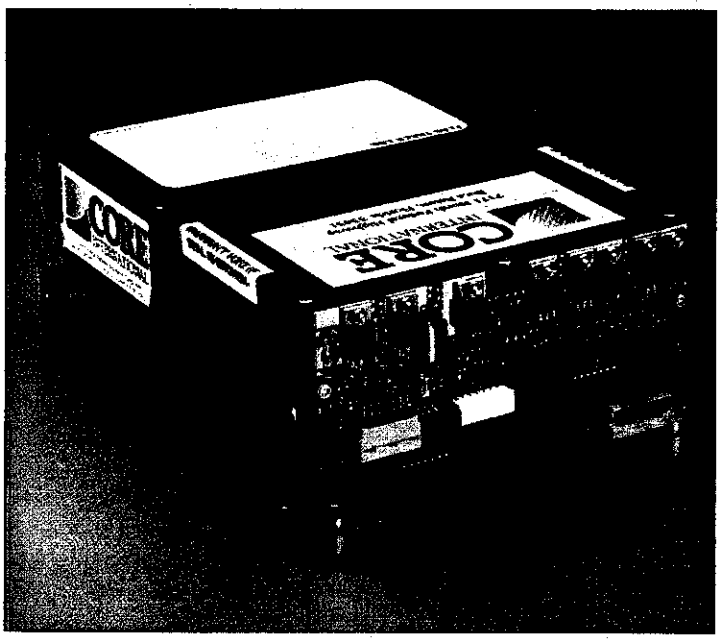
ONE, TWO, BREAKTHROUGH: THE CORE HC25

High-quality construction gives the Core drive 250 megabytes of storage, while its brand-new interface breaks the speed barrier for access times. Will other manufacturers follow suit?

Of late, personal computer technology has been progressing at the slow, diligent pace of a sculptor honing and polishing his work to gleaming perfection. At long last, creative inspiration has struck. Breakthroughs are taking place in hard disk technology, and the latest series of high-capacity, high-performance hard disks from Core International are revealing the shape of things to come.

The Core HC-Series (for high capacity) hard disks are big and fast, probably the biggest and fastest drives that can fit inside an AT system unit. What's more, the HC-Series drives blaze into all-new territory and break down yesterday's barriers with a vengeance.

These drives far exceed the 60-megabyte official IBM limit of the AT chassis, pushing that maximum up nearly ten times, to a half gigabyte (500 megabytes) of internal storage. Instead of shaving a few more milliseconds off their average access times, the HC-Series drives slice data transfer time in half by adopting a totally new disk-interface standard. And to put all that speed and capacity to good use, Core adds some novel software that doesn't just let the HC-Series inch beyond the 32-megabyte DOS disk size limit but smashes it thoroughly, allowing up to 1 gigabyte of disk storage to be accessed as a single drive.



Unlike some earlier Core drives whose ancestry could be traced back almost directly to Control Data Corp., the HC-Series drives are essentially manufactured by

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Core (although the drives do include subcontracted parts). At present, the series consists of two models, the HC15 with 150 megabytes of formatted capacity and the 250-megabyte HC25, of which a preproduction model was received for evaluation.

BIG BYTES On the surface, the HC25 looks like just about any other full-height hard disk you would want to slide into a drive slot in your AT, though it's a bit more rugged than most. It operates just like any other drive—at least until you decide to read a directory. If you're sharp-eyed, you might notice the characters snap on the screen a bit faster than with other drives. The only hint of the amazing abilities of the HC25 is the number of "bytes free" that finally pops on the screen—250 million.

The real differences are hidden inside the cast-aluminum chassis. There you'll find (if you take the head-chamber cover off and void the warranty) that the HC25 has a tall stack of seven 5¼-inch platters, the actual hard disks that data is recorded on. Each platter is covered with a sputtered pure-metal thin-film recording medium. (Sputtering is a form of vacuum plating that creates extremely uniform and very hard recording surfaces that can store information at high densities.)

Fourteen read/write heads scurry back and forth across the surfaces of the platters: 12 heads for data, 1 for reading head-positioning information from a dedicated servo surface, and 1 spare. The heads are moved by a high-performance voice-coil actuator that has a rated average access time of 26 milliseconds. An automatic park-and-lock mechanism withdraws the read/write heads from the active data area when the drive is shut down to protect against head crashes and media degradation even when the power is off.

Because the HC25 uses a new interface standard (see sidebar), it is not compatible with the factory-equipped, combined floppy/hard disk controller IBM provides with the PC AT. The HC25 requires its own, Core-de-signed controller card, model HC, which fits into an empty PC AT 16-bit expansion slot.

A single HC card can operate two Core internal drives. The Core HC card does not replace the original IBM controller, however, because it does not operate floppy disk drives. So for most applications, you need both the IBM and Core controllers. The HC controller has on-board ROM code that permits it to boot its host computer from a HC25 hard disk.

Under normal use, the HC25 is quiet, quieter than the fan in the AT power supply. Only the rigorous access-time testing program caused a discernible noise—a gentle, subdued rattle. The only telltale signature of the voice-coil actuator of the HC25 is a strange metallic singing/humming it makes for about 1 second at turn-on time.

In addition to the normal installation of the AT internal hard disk—sliding the drive on its mounting rails into a slot and then connecting the cables—and the HC controller card, the HC25 requires special (though simple) software installation. Because the HC25 uses its own controller, the IBM AT SETUP program (part of diagnostics) is told that no hard disk is being installed. Instead, the drive is set up and partitioned using a Core-provided program, ATFDISK, which generally corresponds to the DOS FDISK program. Finally, the HC25 is formatted with Core-provided ATFORMAT and afterward can be used like any other hard disk—except you may never worry about a disk full of errors again.

One of the limitations of DOS is its so-called 32-megabyte hard disk volume limit. According to the DOS standard, the largest single disk drive that the operating system is willing to deal with is 32 megabytes. To operate under unadorned DOS, larger disks must be partitioned or subdivided into a number of virtual disks, each with its own drive letter and no larger than 32 megabytes. Files must necessarily be smaller than 32 megabytes as well, because other than through the BACKUP program, no provision is made in DOS for dividing up a single file among several drives or partitions.

This limit is imposed by the hard disk structure dictated by DOS. DOS stores information on disk in allocation units called clusters, which in the normal scheme of things are made from four physical disk sectors, each holding 512 bytes. Individual files are assigned clusters through a mapping system based on a file allocation table (FAT) stored on the disk. DOS specifies that a certain limited amount of disk space be devoted to the FAT, enough to hold numbers that map 32 megabytes of clusters.

EXCEEDING THE LIMIT The remedies to this malaise, the lack of FAT, are all hard to swallow. All involve some modification to DOS, which means altering the standard that has been instrumental in making the PC popular.

The most forthright solution is to abandon DOS altogether for another operating system that supports larger disks. In today's PC environment, this strategy is probably the most foolish because it means giving up the very reason for buying a PC in the first place—its immense software base. Core allows for this possibility by offering full Xenix support for the HC25.

Another alternative is to modify DOS itself ever so slightly to allow it to handle bigger disks. DOS is easily amenable to such software surgery, though the complications that can arise are potentially malignant. Although DOS as delivered by IBM (or Microsoft) is reasonably bug-free and thoroughly tested, modified versions are not as blessed. Changing an individual byte in the code of an operating system can lead to unforeseen consequences, particularly when the modifications are done without the benefit of the source code, as third-party modifications must be. Fur-

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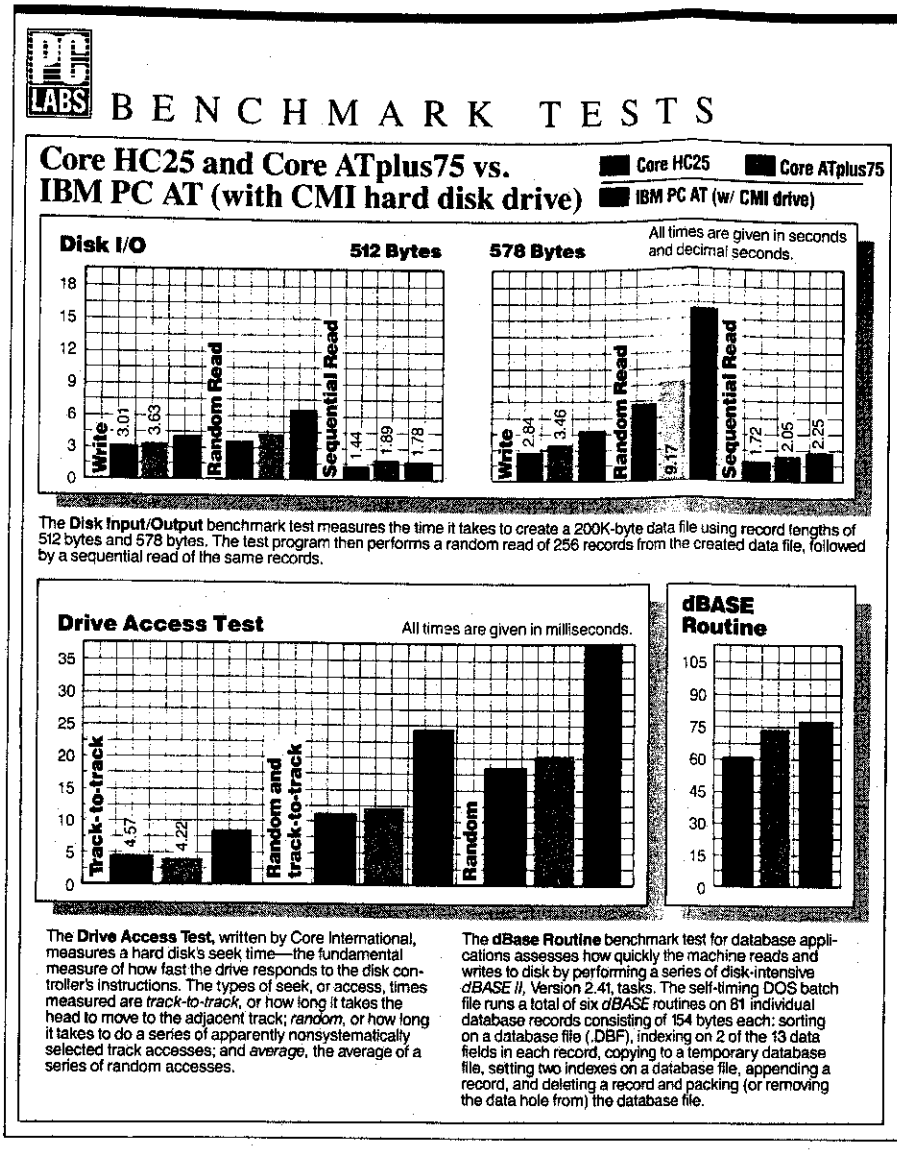
HC-Series Hard Disks
Core International
7171 N. Federal Hwy.
Boca Raton, FL 33431
(305) 997-6055
List Price: HC25 (drive only) $8,995; HC15 (drive only) $6,995; HC controller, $595 (available for purchase separately)
Requires: AT computer, DOS 3.0 or later, HC controller.
In Short: Very large (150 and 250-megabyte formatted) high-speed (18-millisecond average access time and 10-MHz transfer rate) AT internal hard disks that can be configured as one or more DOS volumes.



PC Labs compared the Core HC25 to two other levels of AT hard disk performance: a standard PC AT (with a CMI drive) representing the base level, and the Core ATplus72, a high-performance drive with a conventional interface. Not surprisingly, the HC25, a high-performance drive with a high-performance interface, is the clear winner in virtually every test. It lives up to its greatest potential when handling larger files: in that situation, the performance gap is even more dramatic.

ther, a modified DOS may or may not be compatible with machines other than those that it has been modified to run on. Disk swapping may lead to strange, hard-to-trace failures on other machines, possibly trashing disks in the process. It may also prove unexpectedly incompatible with software.

The third, and arguably the best, alternative is the one chosen by Core for use of the HC25 under DOS: modifying the disk parameters used by DOS without changing the DOS programs themselves. Because DOS remains unchanged, there are no worries about hidden bugs, and most programs run without a hitch. Only programs that access the disk drive directly rather than through DOS will likely have difficulties. Core even allows for such finicky programs by letting you keep part of the disk in complete accord with the DOS standard.

GANGING GIGAFILES What makes this possible is a system Core calls GIGAfile, which is part of the ATFDISK program. It works, much like other disk modifications of its ilk, by modifying the sector size on the disk from its DOS standard size of 512 bytes. In the case of the HC25, sector size is increased eightfold to 4,096 bytes, pushing up the maximum size of a DOS volume by eight as well. Disk clusters, still made of four sectors, thus grow to 16,384 bytes (from normal DOS 2,048 bytes).

This strategy suffers some weaknesses. In particular, it can waste disk space when files are small. No matter how little data is in a file, it will take up a minimum 16K bytes of disk space. Every directory (except for the root directory) will also take up a minimum of 16K.

The waste can be best illustrated by example. I copied a complete directory containing DOS commands from a DOS-formatted volume to a GIGAfile directory with a 16K-byte cluster size. The original files required about 320K of disk space; in the GIGAfile volume, it required more than 660K—for exactly the same files!

Fortunately, as file sizes become larger, the importance and the effect of this shortcoming (though not the shortcoming itself) are reduced. Moreover, when compared to earlier versions of DOS, the penalty is nowhere near as severe. For instance, DOS versions before 3.0 used an 8K sector size on hard disks, resulting in nearly as much waste.

Other manufacturers have used similar sector-enlarging schemes. GIGAfile improves on previous efforts by making its modifications only within partitions instead of across the whole disk. It is also clever enough to enlarge sector size sufficiently for DOS to handle a disk in one chunk. For instance, to allocate the full 250 megabytes of the HC25, 16K sectors are necessary. A 120K partition on the disk would be formatted with 8K sectors, and so on, minimizing the waste per file. GIGAfile extends the same strategy to make up to 1,000 megabytes—a full gigabyte (hence the name)—accessible by DOS as a single volume.

Core does not offer a drive that large, so GIGAfile allows multiple physical drives to be linked together as a single virtual

drive, exactly the opposite concept from partitioning. A single file may stretch across nearly as many drives as can be connected to a single PC—GIGAfile can gang together up to ten partitions, all functioning together as a single unit with one drive letter.

Of course, weaknesses exist in such a system. The loss of any one drive disables them all. Backing up may well be an adventure in that conventional backup systems make no provision for such monstrous files. (At the time of this writing, Core is adapting its own tape backup system to handle gigabyte-sized files. You might also use the DOS BACKUP function, but backing up 250 megabytes to floppy disk seems somewhat ill-advised.) Furthermore, finding any specific file when all files are lumped together in subdirectories on one huge drive usually is slower than putting them on smaller drives because of the time DOS must spend wending its way through directories.

Thus GIGAfile is not the ultimate solution but another tool. The strategy it represents is perhaps the best way of handling files in excess of 32 megabytes with current DOS versions. It also allows putting genuinely huge numbers of files onto a single disk when access might be limited to a single volume—for instance, in a network.

Perhaps the most amazing aspect of GIGAfile is that it almost does not exist. There is no GIGAfile program and no unwieldy documentation to dig into. The GIGAfile system is brought to life when setting up the disk drive for the first time as part of the ATFDISK program. It's just another option to choose from when setting up a partition.

The ATFDISK program gives you three options for each partition: standard DOS partitions (a good choice for compatibility with finicky programs that depend on 512-byte sectors), ATplus partitions (big, over 32-megabyte but nonlinked partitions), and GIGAfile partitions (one or more disks or partitions linked into a single volume). After the drive is formatted, you need never deal with GIGAfile again.

The performance of any hard disk is handicapped by two primary speed limits: average access time (how fast the read/write heads can shuttle between individual

THE NEW INTERFACES: THE ESDI AND THE SCSI

A new industry standard speeds up drive operation, making the Core HC25 the fastest drive around.

Although the HC25 seems destined to set new standards in the disk drive industry, it's actually the first PC product that follows a new industry standard, the Enhanced Small Device Interface (ESDI), instead of the ST506/412 interface that nearly all PC hard disks have hitherto used. In so doing, it operates faster than any other drive you can currently connect to an AT.

In addition to its higher data-transfer rate, the ESDI interface allows several features that make designing and manufacturing hard disks easier. ESDI stores disk-configuration information on the disk itself and allows self-contained defect maps.

The new ESDI interface also moves a key part of the disk subsystem, the data separator, onto the drive. That permits the drive to communicate with NRZ (not return to zero) data rather than raw MFM (modified frequency modulation) data, which is a much better method of sending data across wires and ensures better data integrity over long transmission distances. Furthermore, it allows future use of Run Length Limited data coding, which can increase hard disk capacity 50 percent without a change in the disk drive itself.

In ESDI systems, the same controller can handle multiple disk, tape, or even floppy drives. Besides just operating all the peripherals, the same controller can also manage file transfers between them. In addition, the controller can be tuned to move data in different block sizes.

As with the classic ST506/412, the ESDI interface is classified as a device-level interface in that it does not directly connect into the host computer but instead requires a separate host interface. The Core HC controller combines the host adapter and the ESDI controller card onto a single card.

Device-level interfaces are often the favorite choice of system integrators because they permit configuring systems for optimum performance while still allowing the integrators to connect their products up to a variety of host buses.

The other new disk interface, the Small Computer Systems Interface (SCSI), is classified as a high-level, or system-level, interface. A system-level interface is often described as "intelligent" because it incorporates all the abilities that the controller once assumed into the interface itself.

The definition of the SCSI interface specifies two speeds, a 1.5-megabyte-per-second (12-MHz) asynchronous data transfer rate and 4-megabyte-per-second (32-MHz) synchronous rate. Currently, only slower, asynchronous designs have been implemented.

That high level of integration makes SCSI drives easier for system integrators—and even end users—to work with, but it also imposes penalties, primarily in that it forces the duplication of circuitry when several peripherals are connected to the same SCSI interface.

The two new interfaces are not mutually exclusive. In fact, because they function at different levels of the PC connection, they can be used in tandem.

According to Core International, when SCSI is used in conjunction with an ESDI interface (as some disk makers are attempting), a speed limit on the order of the old ST506/412 interface arises. The rate at which data can be transferred is limited by the data manipulations that the interface combination must carry out.

Core thus took the additional step to create its own ESDI system interface. The ESDI controller itself plugs into the AT drive slot and the drive unit, eliminating further circuitry and speed limits.

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disk sectors) and transfer rate (how rapidly the data in a sector can be read from the disk and fed to the host system). The former limit has been steadily nudged upward by refinements in the physical mechanism that shuttles the read/write head across the disk surface.

In the dark ages of personal computing, when the original PC-XT was introduced, the head-shifting mechanism was essentially the same as that which cranks the heads of floppy disk drives back and forth—stepping motors, special direct-current motors that, instead of turning smoothly, cog to discrete angular displacements of their shafts. Because the motor shaft is coupled to the read/write head by a thin, flexible band of metal, its discrete angular positions are translated into discrete linear positions across the disk surface, corresponding to individual disk tracks or cylinders.

The major alternative to such band-stepper head actuators is the servo voice-coil design, as used in the HC25 as well as other high-performance drives including previous Core models. In essence, this mechanism works like an electromagnet pulling against a spring. The stronger the force of the electromagnet, the more the spring is stretched. The read/write head rides on an arm attached to the moving mechanism.

POSITIONING THE HEAD The exact position of the head in a voice-coil system depends on the relative voltages and currents. Because of the high degree of precision required, the head might not be reliably positioned. The head mechanism requires an additional device to monitor the location of the head and then feed correct information into a servomechanism, which then constantly adjusts the head position by minute amounts to keep it precisely over the track desired. In most hard disk systems, there are actually several hard disks, called platters, each with its own read/write head, and the heads are ganged together to a single actuator. The necessary servo information for positioning the stack of heads is written on a side of one of the platters, which is dedicated to that purpose. Thus the servo voice-coil system has a singular disadvantage, one storage surface wasted on overhead.

Several advantages make up for such a defect, however. No mechanical cogging motion limits how finely the tracks can be spaced, so the mechanism is more precise, and greater amounts of data can be squeezed onto each remaining disk surface. Moreover, voice-coil–type positioners are faster.

Larger-capacity disks almost automatically have a speed advantage over their smaller kin because they have more platters and more heads, and one of the heads is always more likely to be close to the desired sector. In addition, larger disks often have greater storage density—tracks of data are closer together—so heads do not need to move as far to shuttle between tracks. Little wonder, then, that the HC25 is a genuine speed demon when it comes to average access time, dashing between random tracks in 18.39 milliseconds, one of the fastest drives tested by PC Labs.

■ Larger-capacity disks almost automatically have a speed advantage over their smaller kin.

BEYOND 5 MHz The other speed limit, data transfer rate, is more difficult to circumvent, primarily because the limit is political rather than mechanical. The data transfer rate is the realm of standardization. The principal standard in personal computing has been ST506/412. Originally developed nearly 10 years ago when 5¼-inch hard disk drives with 5 megabytes of capacity were the leading edge in technology, it caught on because it gave drive makers a uniform standard to design to and left them free to concentrate on developing other aspects of their products, such as larger capacities and faster access times.

Part of the ST506/412 definition is a data transfer rate of 5 MHz, or 625K bytes per second. At first that speed limit was not onerous—for instance, it was much faster than the XT could handle the information read from a disk. Moreover, when drive capacities were limited to 5 or 10 megabytes, there just wasn't that much data to move around. Alas, today the AT can handle data faster than the ST506 interface can deliver it, and disks with capacities of hundreds of megabytes can make the wait unbearable.

NEW BREED The HC25 is the first of a new breed of hard disk drives using a new interface called the Enhanced Small Device Interface (ESDI). Both ESDI and another new interface, the Small Computer Systems Interface (SCSI, pronounced as "scuzzy"), break through the 5-MHz barrier. SCSI made a debut of sorts by being adopted as the expansion interface for the revised Apple Macintosh. ESDI premieres as a PC product in this series of Core International drives.

The ESDI specification allows the data transfer rate to be set by the peripheral that it is connected to rather than being limited by the controller. Speeds of 20 MHz or higher are possible. However, the HC25—along with all other ESDI drives now being turned out by other manufacturers—operates at 10 MHz, twice as fast as PC drives heretofore.

The higher data-transfer rate makes a real difference. In the moderately disk-intensive PC Magazine Labs Compiler Routine benchmark test, the HC25 proved itself almost 30 percent faster than the standard IBM 20-megabyte AT hard disk. It also proved itself somewhat faster on the Disk Input/Output benchmark test. Neither benchmark test reflects the real speed potential of the HC25 because it comes into its own only with long, sequential data reads and writes, while both benchmark tests use short files and involve substantial amounts of microprocessor overhead.

While the HC25 can be imagined as the ultimate in personal computer hard disks (at least for now), it's probably more than any single user will ever need. Both its speed and capacity make it an excellent choice for anchoring a network or multiuser system. More than that, it's a harbinger of an entire new generation of hard disk drives.

Winn L. Rosch is a contributing editor of PC Magazine.