## COMPAQ DESKPRO 386

# The New Standard

*Compaq has forged ahead of IBM with the first 80386-based machine, offering AT compatibility with twice the performance— and a bright future in multitasking.*

STEVEN ARMBRUST and TED FORGERON

Until now, Compaq Computer Corporation has been content with matching IBM's personal computer offerings, merely making minor improvements to what IBM already had created. With the introduction of the Deskpro 386, however, Compaq has leapfrogged over IBM into brand new territory. Powered by a 16-MHz Intel 80386 microprocessor and equipped with 32-bit memory and a speedy hard-disk drive, the Deskpro 386 not only offers compatibility with IBM's PC/AT at twice the performance, but also promises to run future multitasking operating environments that will take advantage of the 80386 processor.

The Deskpro 386 comes in three models, distinguished only by the hard disk. The model 40 is equipped with a 40MB hard disk, the model 70 with a 70MB hard disk, and the model 130 with a 130MB hard disk. The monitor, the amount of memory, and the keyboard are options that can be selected with each model. The accompanying sidebar lists the features available with the Deskpro 386. The unit reviewed in this article was the model 40 with 1MB of RAM, a 1.2MB diskette drive, a 360KB diskette drive, a 40MB tape backup unit, a serial and a parallel port, the Compaq Enhanced Color Graphics Board, and the Compaq Color Monitor.

At first glance, the Deskpro 386 looks just like the other members of the Deskpro family. It uses the same cabinet as the Deskpro 286 and therefore has many of the same advantages and disadvantages as that unit has (see "Out from the Shadow of IBM: Compaq Deskpro 286," Steven Armbrust and Ted Forgeron, August, 1986, p. 80). The size of the system unit is 19¾ inches by 16½ inches by 6¼ inches. Photo 1 compares its footprint with that of an AT.

Like the Deskpro 286, the Deskpro 386 includes the same unattractive keylock switch on the front of the system unit, with barely readable switch positions. It also has the on/off switch posi-
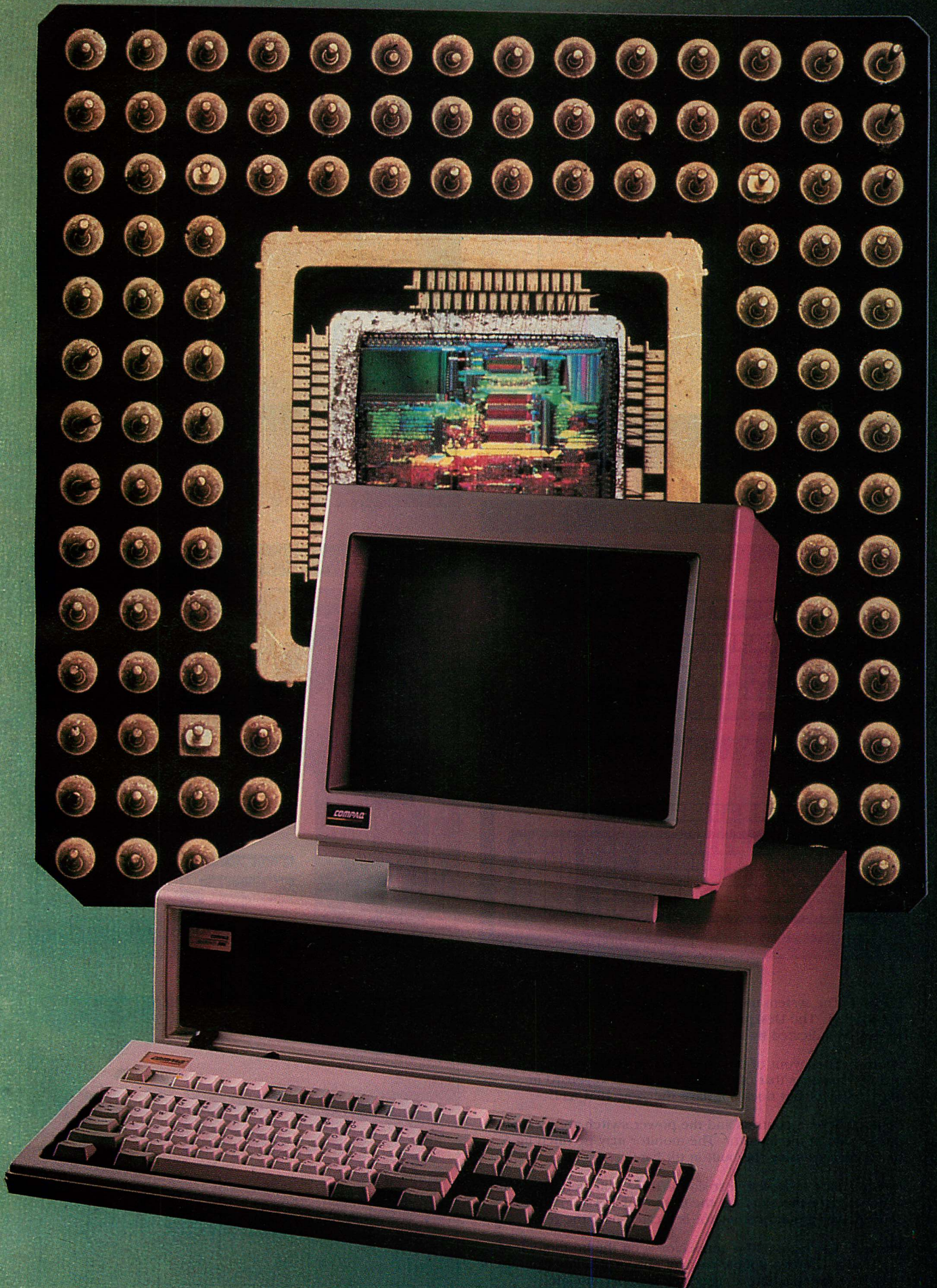
PHOTOGRAPH · MARC DAVID COHEN
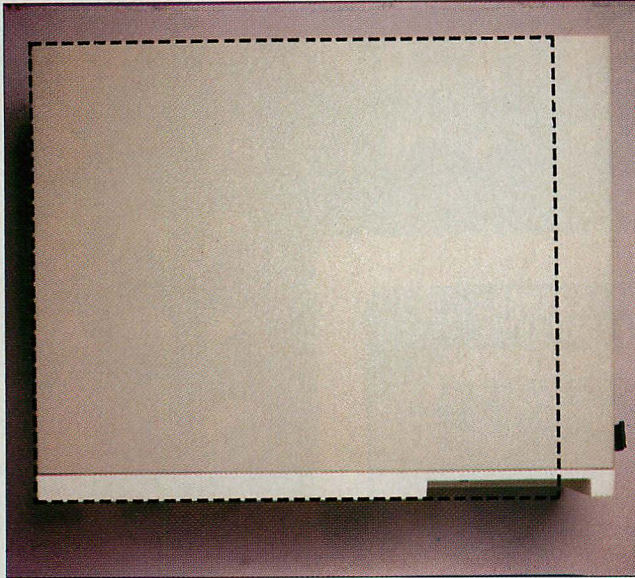
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**PHOTO 1:** *System Unit Footprint*



**PHOTO 3:** *Compaq Color Monitor*



**PHOTO 2:** *Keyboard Comparison*



**PHOTO 4:** *Inside the System Unit*



**PHOTO 5:** *System Memory Board*



*Photo 1*: The system unit of the Deskpro 386 is smaller than the IBM AT. The Deskpro measures 19¾ by 16½ by 6¼ inches, as indicated by the dotted lines.

*Photo 2*: The layout of the enhanced keyboard of the Deskpro 386 matches that of the IBM enhanced keyboard in most respects, but does not have the same IBM feel.

*Photo 3*: Screen controls and the power switch are located on the side of the monitor. The monitor may be tilted up 5 or 10 degrees using the built-in tilt bar.

*Photo 4*: Slot 1, the leftmost slot, is the 32-bit slot. The main connector for this slot is at the front of the system unit. A small power/ground connector is located near the rear.

*Photo 5*: The main 32-bit connector is on the bottom left of the board. The two double rows of pins protruding from the board are for attaching a piggyback memory module.
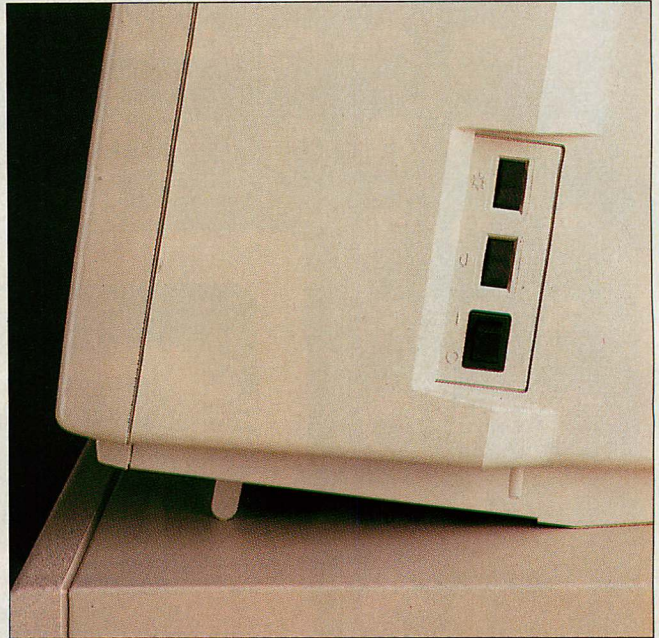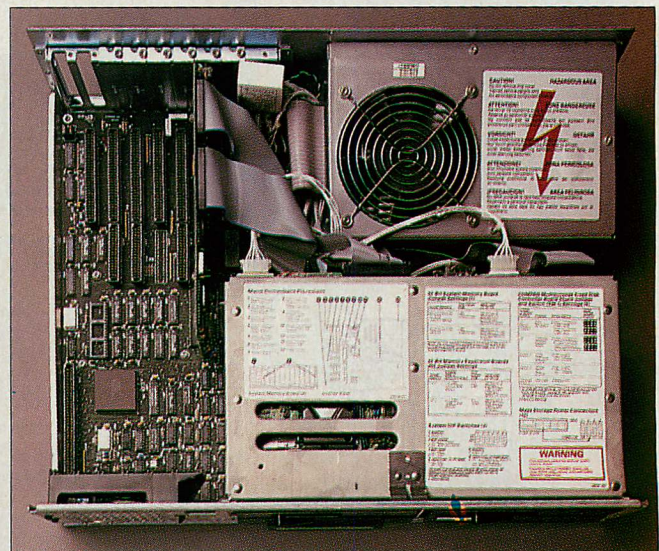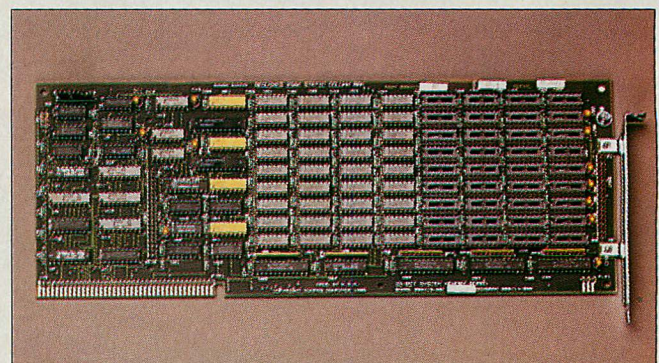
tioned on the rear panel of the unit where it is difficult to find. The two machines share the convenient feature of a two-color drive light that shines green when accessing a 1.2MB diskette and red when accessing a 360KB diskette.

Two keyboards are available for the Deskpro 386: one matching the layout of IBM's original AT keyboard and one matching IBM's enhanced keyboard. The only difference between the new Compaq keyboard and the earlier one is in the layout. The keys still have a light touch and provide little tactile feedback. The keyboard plugs into the front of the system unit, requiring its removal whenever the cover of the system unit is taken off. As with other Deskpro models, the keyboard cable seems to be excessively long, but this problem can be alleviated by tilting up the keyboard on its legs and placing the excess cable underneath. Photo 2 compares Compaq's enhanced keyboard with that of IBM.

With the Deskpro 386, Compaq offers its new Color Monitor and Enhanced Graphics Board, which is compatible with the IBM Enhanced Graphics Adapter (EGA). The Compaq Color Monitor is compatible with IBM's Enhanced Color Display. It produces accurate colors and text that is easy to read. However, when compared to the new generation of enhanced color monitors, such as the NEC Multisync, the characters produced by the Compaq monitor in high-resolution text mode are not as crisp and clear. The monitor controls are conveniently placed on the side of the display where they can be accessed easily (see photo 3).

The Compaq graphics board works with both the color display and Compaq's dual-mode monochrome display. When connected to the dual-mode monochrome display and switched into monochrome emulation mode, the Compaq graphics board can produce text with a resolution of 720-by-350 pixels. When connected to the Compaq Color Monitor (or another enhanced color display), it offers 16 colors from a palette of 64 and a resolution of 640-by-350 pixels. The graphics board also can be used with an ordinary color display to generate output equivalent to that produced by IBM's Color Graphics Adapter (CGA). However, it cannot be connected to an IBM monochrome monitor (or the equivalent) without damaging the display. The board can be installed in other Compaq computers, such as the Portable or Portable II, where it can drive either the built-in dual-mode display or a color display.

## 80386 ENHANCEMENT

The Deskpro 386 is loaded with extras that are not available on any other AT-compatible computer, but by far the most exciting and obvious of these is the 80386. This 32-bit microprocessor from Intel has 32-bit instruction and data paths, provides real and protected modes, and offers a virtual-8086 mode and memory paging that enable it to handle multiple real-mode applications (such as DOS applications) simultaneously. (For a complete description of the capabilities of the 80386, see "Upward to the 80386," Caldwell Crossswy and Mike Perez, February 1987, p. 50.)

The Deskpro 386 system starts running with the 80386 in real mode, and a reboot always returns the processor to this mode. When operating in real mode, all the restrictions associated with 8086/88 processors apply. Segments are limited to 64KB, and the memory address space is 1MB. The 80386's 32-bit instructions can be used, however, enabling programs to improve performance with 32-bit data transfers and 32-bit operands for instructions.

Protected mode in the Deskpro 386 is compatible with the protected mode in 80286 machines, but the 80386 increases the memory address space (from 16MB to 4GB) and the maximum segment size (from 64KB to 4GB). In addition, it also provides memory paging, I/O protection, a full 32-bit instruction set, and virtual-8086 mode.

Virtual-8086 mode is a special form of protected mode that enables real-mode applications to execute within protected mode. In virtual-8086 mode, memory addressing reverts to the base:offset form used in the 8088 and in real mode on the 80286 and 80386. This permits current application programs to run, but confines them to the 1MB address space of the 8088. Despite this limitation, the paging facilities (described below) of the 80386 permit the 1MB real-mode address space to be mapped anywhere in the 4GB address space that is available in protected mode, thus permitting several real-mode applications to run concurrently—without any modification.

The Deskpro 386 uses this virtual-8086 mode and memory paging combination to implement its own Compaq Expanded Memory Manager (CEMM). This program gives DOS applications access to the expanded memory outlined in the Lotus-Intel-Microsoft (LIM) specification without requiring special bank-switching memory boards.

In the Deskpro 386, the 80386 processor runs at 16 MHz, twice the speed at which the 80286 runs in the AT. In addition, the 80386 can access RAM 32 bits at a time (compared with the 16-bit memory access provided by the 80286). With this double dose of supercharging, DOS applications might be expected to run four times as fast as they do on an 8-MHz AT; however, because the cur-

## DESKPRO 386 VITAL STATISTICS

**Model 40:**       $6,499
1MB memory
Parallel printer interface
Serial interface
1.2MB diskette drive
Realtime clock
40MB hard disk

**Model 70:**       $7,299
All features of Model 40 except with a 70MB hard disk.

**Model 130:**       $8,799
All features of Model 40 except with a 130MB hard disk.

**Display adapters** (none is standard)
Dual-mode
Enhanced Color Graphics Board

**Monitors** (none is standard)
Dual-mode monochrome monitor
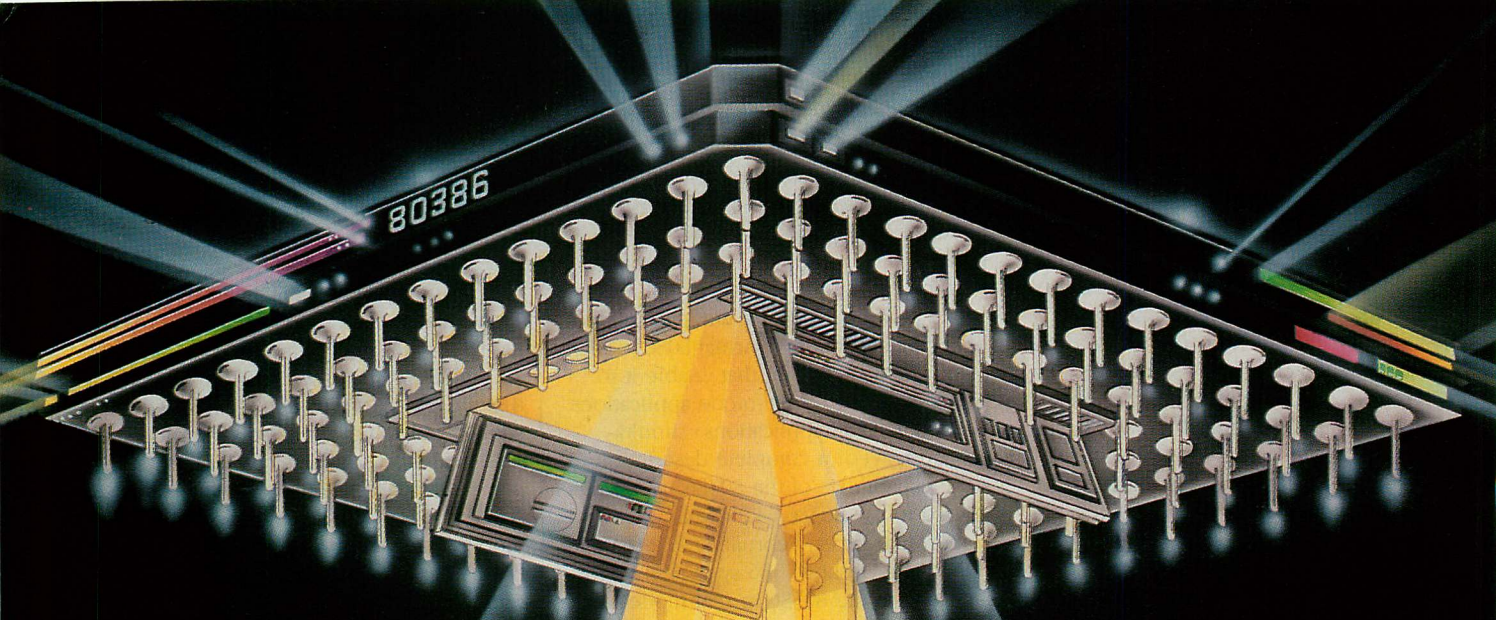Enhanced color monitor

**Memory capacity on system board**
None

**32-bit memory capacity of system**
10MB

**Expansion slots**
32-bit:  1
16-bit:  4
 8-bit:  3 (one half-size slot)

**Available slots**

| Model 40 | | Model 130 | |
|---|---|---|---|
| 32-bit: | 0 | 32-bit: | 0 |
| 16-bit: | 3 | 16-bit: | 2 |
| 8-bit: | 2 | 8-bit: | 2 |

**Other extras available**
40MB tape backup: $799
360KB diskette drive: $225
1MB memory option: $549
1MB/2MB expansion board: $849
4MB/8MB expansion board: $2,995

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rent versions of DOS and the applications that run under them are written for 16-bit processors, code and data are still accessed 16 bits, rather than 32, at a time. Despite this underutilization of the 80386, existing real-mode programs run approximately twice as fast on the Deskpro 386 as on an 8-MHz AT.

In the future, programs that take advantage of the 32-bit instruction set of the 80386 can expect to improve performance even more. For example, the 32-bit version of the MOV instruction, which is available even in real mode, can potentially double the data-transfer speed provided by the 80286.

To take advantage of the 32-bit data path of the 80386, the Deskpro 386 provides a 32-bit memory bus for access to RAM. This bus takes the form of a 32-bit slot on the system board. Compaq claims that this is not a general-purpose bus, but merely a mechanism to optimize the performance of the Deskpro 386 memory subsystem. It enforces this opinion by providing just a single 32-bit slot and by not supplying any RAM on the system board itself. A 32-bit memory board, supplied in the standard configuration with 1MB of soldered RAM, fits into this slot. With additional 256K-by-1 static-column DRAM chips, this board can be expanded to 2MB. One of two piggyback boards can be added to the 32-bit memory board: one provides 1MB, expandable to 2MB, with 256K-by-1 chips; the other provides 4MB, expandable to 8MB, with 1M-by-1 chips. Thus, the Deskpro 386 can contain as much as 10MB of RAM, all accessed via the single 32-bit slot.

The 32-bit slot consists of an 80-pin connector whose signals are generated directly by the 80386. This memory bus, which runs at 16 MHz, is simply an extension of the processor's local bus. This direct interface minimizes the signal delays between the processor and the memory subsystem.

The 32-bit memory boards are configured into a 36-bit wide arrangement, consisting of 32 bits of data and 4 bits of parity (one parity bit for each byte). On the system memory board, and on the 1MB/2MB piggyback board, the memory chips are 256K-by-1 static-column DRAMs, yielding a memory bank size of 256K 32-bit double words, or 1MB. On the 4MB/8MB piggyback board, the memory chips are 1M-by-1 DRAMs, yielding memory banks of 4MB.

With a 16-MHz processor, fast access to RAM is essential; otherwise, the speed advantages of the processor are negated. In the PC, the cycle time of the 8088 is 210 nanoseconds (ns), and a



**FIGURE 1:** *RAS/CAS Memory Access*
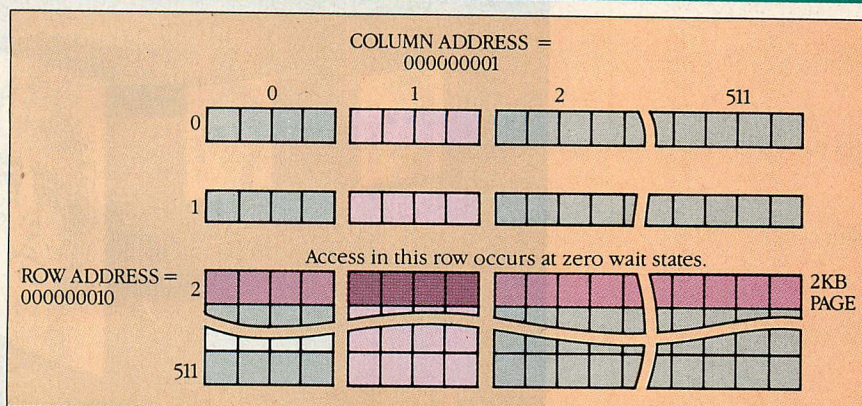
To access memory in each 1MB bank, the memory subsystem specifies nine-bit row and column addresses. Static-column RAM allows the memory to respond in zero wait states if the row address is the same as in the previous memory access.

bus cycle is 840 ns, enabling readily available 200-ns DRAM chips to be used. The 200 ns is the access time, or the time required for a charged DRAM to return information. Additional time is required to recharge the DRAM for the next memory access. The sum of the access time and the recharge time is the DRAM cycle time, which is the actual time needed to obtain information from the chip. In 200-ns DRAM chips, the cycle time is 345 ns.

The cycle time of a 16-MHz 80386 is 62.5 ns. Using 200-ns RAM chips and an ordinary memory-accessing scheme would reduce the overall performance to little better than that of a PC, because wait states would have to be inserted to make the processor spend some of its time waiting for memory.

The easiest way to improve memory access times is to remove all wait states and use faster DRAM chips. However, to make significant improvements, chips with memory access times in the 60-ns range are required, and those are prohibitively expensive. Computer manufacturers have resorted to other schemes to obtain better performance from the memory subsystems on high-performance computers while still using less expensive DRAM chips.
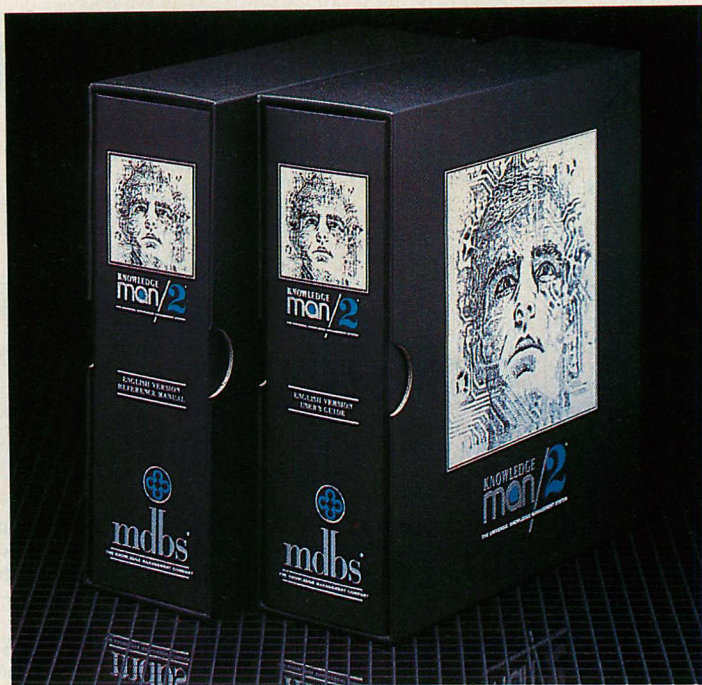
One method is to use a memory cache, a limited amount of high-speed static RAM that is used to store copies of the memory locations that are accessed most often. With a large enough memory cache and an appropriate algorithm for copying data to and from the cache, many caching systems are 90-percent effective (that is, more than 90 percent of the time, the data needed will already be in the high-speed cache). Caches are more expensive than some other methods, because they require

costly, high-speed SRAM chips in addition to the RAM in the user-address space. Extra board space is also required for the memory that makes up the cache and its support circuitry.

Another method for improving memory access times uses interleaved (or bank-switched) memory. This scheme assumes that most memory accesses are sequentially ordered. Therefore, the memory is divided into two or more banks, with the sequential addresses interleaved among the banks. For example, in a 32-bit computer with two memory banks, the first 32 bits would be in bank 0, the second 32 bits in bank 1, the third 32 bits back in bank 0, and so on. This interleaving speeds sequential accesses by enabling one memory bank to be fetching a subsequent double word while the processor accesses the previous double word from the other bank. However, the benefit of overlapped accesses is not without penalty. Additional logic is required to implement the interleaved memory, and initial accesses (and consecutive accesses to the same bank) are longer than they would be if the interleaving circuitry were not present.

Interleaving improves the performance of sequential accesses, but real mode on the 80386 (which almost all current applications use) requires a segmented program structure—that is, separate (often physically separated) segments are used to store a program's code and data. As a result, memory accesses often bounce around between the code and data segments with few extended periods of sequential accesses; thus, much of the advantage of an interleaved architecture is lost.

A third alternative, and the one used in the Deskpro 386, is memory

**FIGURE 2:** *Deskpro 386 Memory Map*
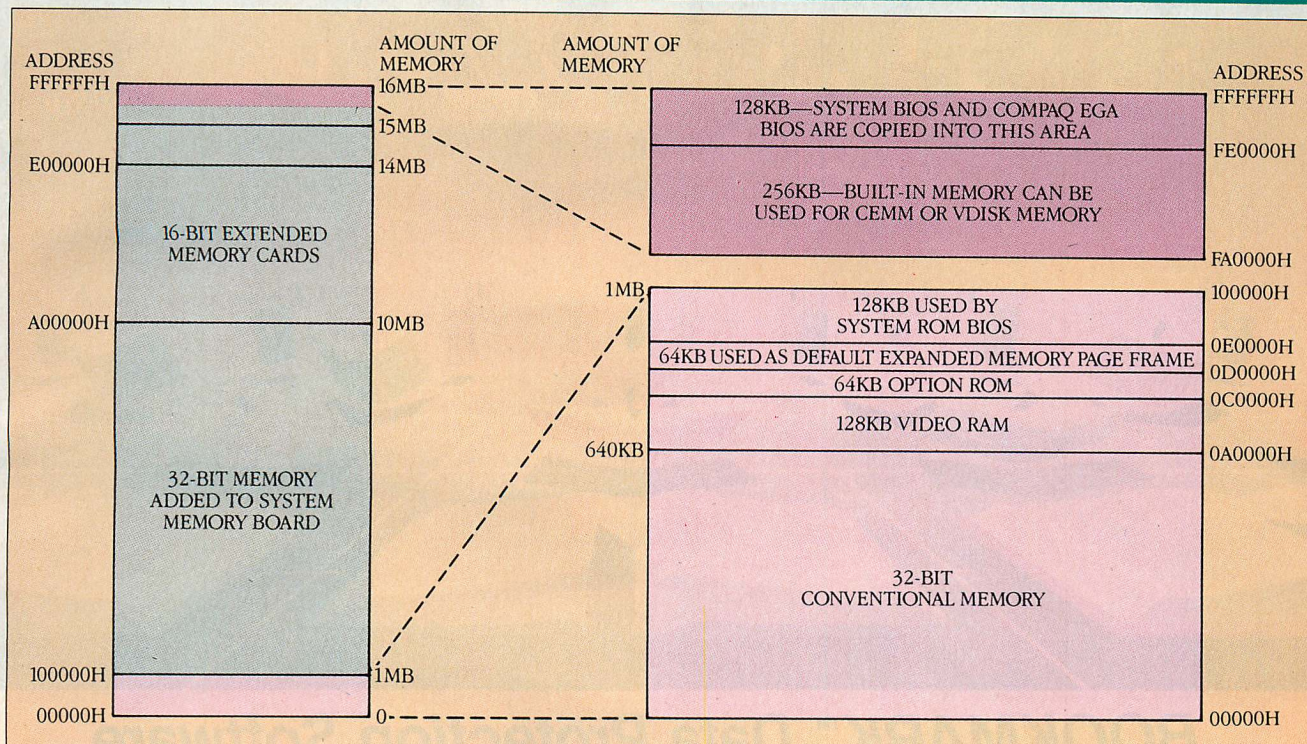


When the Deskpro 386 is set up for 640KB of conventional memory, the remaining memory in the first megabyte is located at addresses below 16MB. The BIOS is copied into the top 128KB. Other 32-bit memory is assigned addresses beginning at 1MB.

paging, in which the system RAM is divided into areas of equal size called pages. With the paging circuitry in operation, successive accesses to memory within a page are extremely fast, while successive accesses to different pages are slower. The segmented architecture of real mode negates some of the advantages of paging, just as it does with interleaving. Accessing memory outside a page boundary enacts the same type of performance penalty as consecutively accessing a single bank of an interleaved system.

The Deskpro 386 implements memory paging by using static-column RAM chips. For memory access, each 1MB bank of RAM is logically divided into rows and columns, and access to memory is obtained by presenting a row address and column address. These addresses are latched internally using the row address strobe (RAS) and column address strobe (CAS). The RAS and CAS combination identifies a specific 32-bit double word—the amount of memory that the 80386 can access in a single memory fetch. Each row and column address is a 9-bit quantity, implying 512 (or $2^9$) items in each row and column. With each item being 4 bytes (32 bits) long, each page (or specific row address) of memory consists of 512 ($2^9$ column addresses) by 4 bytes, or

2KB of memory. With 512 of these pages, the addressing scheme is able to handle 1MB of memory. Additional 1MB banks are accessed in the same manner, with their own row and column addresses (see figure 1).

With static-column DRAM chips, memory accesses within the same page can happen with zero wait states, because the RAS is maintained from the previous memory access. When a new memory access is required, the row address is compared with the value already maintained by the memory chips. If the new row address is the same as the previous one (that is, the memory is in the same 2KB page), only a new column address needs to be presented to the DRAM. This results in a zero-wait-state access. However, if the new row address is different (that is, the memory is in a different 2KB bank), the processor must wait for the memory to recharge and present a new row address followed by column address. This process results in two wait states.

There is one situation, however, in which access to memory occurs at two wait states, even if the access is within the same page. If an idle bus cycle occurs, the memory subsystem turns off paging mode, allowing the memory subsystem to get a head start on whatever memory access it predicts will hap-

pen next. If the next access is within the same page, however, it will occur at two rather than zero wait states, because the processor will have to restart paging mode and present both a row and a column address.

Idle bus cycles are common when writing to memory because the number of processor cycles required to execute some write instructions is more than the bus cycles needed to transfer the data. Thus, idle bus cycles are inserted, which turns off the paging.

Compaq turns off paging when an idle cycle occurs because tests showed that an idle cycle typically precedes an access outside the page. Therefore, even though some accesses within a page are slowed to two wait states, overall performance is increased by 1 to 2 percent by using the idle cycle to anticipate accesses outside a page.

The paging scheme used in the Deskpro 386 complements the way that the 80386 instruction prefetch works. The sequential nature of instructions and the 80386's desire to keep the prefetch queue full enable the memory subsystem to operate within a physical page much of the time.

Compaq claims that in average circumstances, approximately 60 percent of all memory accesses occur within a page. Therefore, the memory in the

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Deskpro 386 must average 0.8 wait states per 32-bit access. For tightly coded, highly sequential applications, such as graphics drivers, it is possible to approach zero wait states.

To put these figures into perspective, consider the difference in access times between 32-bit memory on the Deskpro 386 and 8-bit memory over the PC bus. A 32-bit access within the same page on the Deskpro 386 requires 2 processor cycles (at 62.5 ns per cycle) or 125 ns. A 32-bit access outside the current page requires 4 processor cycles or 250 ns. Assuming 60 percent of the accesses occur within the current page, the average 32-bit access time is 175 ns. A similar 32-bit access from 8-bit memory requires 48 processor cycles, or approximately 3 microseconds. No wonder the Deskpro 386 seems fast.

Tests conducted for this article revealed that it was possible to achieve zero wait states when reading and writing memory. However, normal programs will not achieve this level of performance unless their memory accesses are limited to the same 2KB page. One wait state is more realistic.

It remains to be seen whether the memory paging scheme used in the Deskpro 386 really performs better than interleaving or is more cost-effective than caching. Once the various kinds of systems become readily available, more conclusive real-world performance measurements can be taken.

## NO MEMORY WASTED

In its base configuration, the Deskpro 386 contains 1MB of 32-bit RAM soldered into a system memory card that fits into the 32-bit expansion slot. With jumpers on this memory card, the user can select 256KB, 512KB, or 640KB of conventional memory. The remainder of the 1MB is automatically mapped to just beneath the 16MB address. Figure 2 shows the memory map for the most common configuration (640KB).

Although the extra 384KB of RAM is not available via normal DOS operations, Compaq has not let that extra memory go to waste. The uppermost 128KB segment, located at address FE0000H, is used to improve the BIOS performance. Upon start-up, the Deskpro 386 copies the system BIOS and the Compaq Enhanced Graphics Board BIOS (if available) into that memory and remaps the memory via special hardware map registers so that it replaces the 128KB area normally reserved for the system ROM (from 0E0000H to 0FFFFFH). Once this mapping takes place, applications can access

**FIGURE 3:** *Memory-mapped Hardware Register*
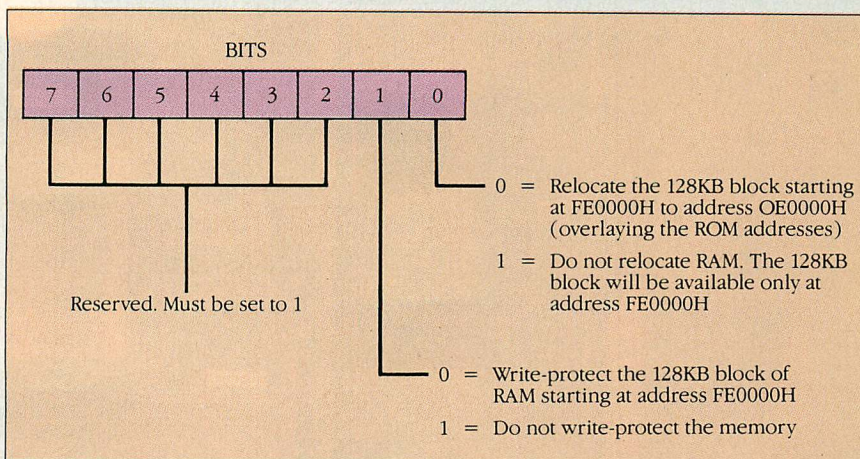


Writing to location 80C00000H sets the memory-mapped hardware register that is used to remap and write-protect the memory into which the ROM BIOS is copied.

**FIGURE 4:** *Memory-mapped Diagnostics Register*
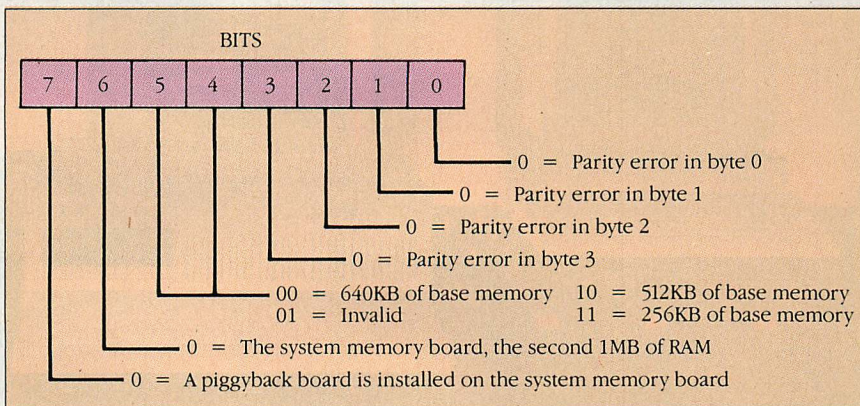


Reading location 80C00000H returns the status of the memory configuration jumpers and the parity bits for each of the four bytes of a 32-bit double word.

the remapped BIOS either at address FE0000H or 0E0000H; the actual system and graphics board ROM devices are no longer accessible. Even with the remapping, this procedure relocates the graphics board BIOS, which normally starts at 0C0000H, to 0E0000H to 0F0000H. Therefore, only the BIOS from a Compaq Enhanced Graphics Board is copied because there is no assurance that another BIOS will contain position-independent code that works properly when relocated.

By remapping the BIOS into 32-bit RAM, the Deskpro 386 dramatically improves the BIOS performance. Instead of residing on 250-ns ROM chips accessed via a 16-bit bus in the case of the system BIOS or via an 8-bit bus in the case of the enhanced graphics BIOS, the remapped BIOS is accessed out of 32-bit static-column RAM. This RAM is write protected by special hardware registers so that out-of-control

programs do not accidentally write to the BIOS and cause damage.

The Deskpro 386 contains a memory-mapped hardware register called the RAM relocation register that controls the mapping and write protection of this system RAM. It is a write-only register available at address 80C00000H. Bits 0 and 1 control the remapping of the ROM space and the write protection, as shown in figure 3.

Reading the same memory location (80C00000H) returns the contents of the diagnostics register. This register can pinpoint which byte within a 32-bit double word caused a parity error. It also identifies which memory is 32 bits so that diagnostics programs can use 32-bit reads and writes to speed up their RAM tests. Figure 4 shows the bit definitions of the diagnostics register.

Despite the speed improvements caused by the remapped ROM, this feature is not likely to improve overall

performance appreciably. The most performance-sensitive areas of the BIOS are the screen display routines, and most applications circumvent those routines by writing directly to the display adapter RAM via the 8-bit interface. Programs that use the BIOS for screen operations, such as DIR, TYPE, and other DOS commands, are much faster. Thus, the remapped BIOS can affect users' perceptions of overall performance, simply because many people judge a computer's speed by how fast a DIR listing scrolls up the screen.

On the other hand, if the BIOS were not copied into RAM, the performance of some tight loops that use the BIOS might actually be worse than on an 80286-based computer. This degradation could occur because the 80386 is optimized for 32-bit operations, while the BIOS is contained on ROM chips accessed via the 16-bit bus.

For example, the 80386 is constantly trying to fill its prefetch queue with the instructions it expects will execute next. This prefetch queue is 32 bits wide, so each prefetch is 32 bits, whether or not the bits come in one access from 32-bit memory, two accesses from 16-bit memory, or four accesses from 8-bit memory. A prefetch of system BIOS instructions from ROM requires two separate 16-bit accesses, both of which must be completed before the processor can contin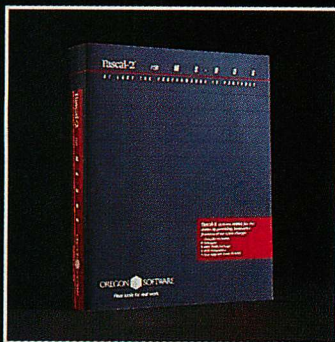ue with other operations. Because of the extra time required for two separate memory accesses, a processor that was idle at the start of the prefetch might be holding up other operations by the time it finishes. This effect will be especially noticeable in programs that have small (two instruction) loops, because the jump instruction at the end of the loop flushes the prefetch queue. Users also might notice this effect if they do not use the Compaq Enhanced Graphics Board, because the Deskpro 386 will not copy non-Compaq BIOS code into RAM. In this case, four separate 8-bit accesses are required for each 32-bit fetch because the graphics board uses an 8-bit interface.

The remaining 256KB of RAM not available via normal DOS operations is referred to by Compaq as *built-in memory*. Two programs are provided to enable ordinary DOS applications to take advantage of this memory: CEMM and VDISK, a RAM-disk program. Other programs will have difficulty using this built-in memory, because it resides at high memory addresses just below the remapped BIOS. Most programs that use extended memory require that such memory begin at the 1MB address and

that no gaps exist in the memory. This is not a problem, however, for the CEMM and VDISK programs. Even if other extended memory is added, CEMM and VDISK can use both the built-in memory and the other extended memory automatically.

CEMM was developed jointly with Microsoft to provide an expanded memory interface to extended memory. CEMM uses the virtual-8086 mode of the 80386 in combination with the 80386's paging capability to support the LIM expanded memory specification, without the need for special bank-switching memory boards such as Intel's Above Board. CEMM simulates the bank-switching hardware by mapping the Deskpro 386's 32-bit extended memory into the page frame specified in the LIM standard. This enables DOS applications that support the LIM specification to access additional memory up to the 8MB limit of the specification.

CEMM grants flexibility to the large amount of fast 32-bit memory that can be added to the Deskpro 386. For example, Intel's QUIKMEM2 RAM disk,

*Two programs are provided to enable ordinary DOS applications to take advantage of built-in memory: CEMM and VDISK.*

which normally requires an expanded memory board, ran without difficulty from extended memory when using CEMM. The added flexibility has its cost, however. System overhead for handling interrupts increases in virtual-8086 mode because of the time required for the 80386 to switch between protected and virtual-8086 modes. Thus, programs that run in virtual-8086 mode execute approximately 5 percent slower than programs that run in real mode.

In addition, other programs that run in protected mode cannot be used when CEMM is active. Attempts to run such programs (RAM disks and disk caches are two examples) cause CEMM to display the following message:

**Privileged Operation Error**
**Deactivate CEMM and Continue (C) or**
   **reBoot (B) (C/B)?**

When this message occurs, the user can either deactivate the expanded memory

and continue with the program or reboot the computer.

To avoid such messages when running software that uses protected mode, the user can switch expanded memory on or off from the keyboard, using the commands CEMM ON and CEMM OFF. CEMM AUTO is the default setting, making expanded memory (and its associated overhead) available when requested by an application program.

## 386 EXTRAS
As mentioned earlier, additional memory and piggyback cards can be added to the Deskpro 386 system memory card to supply as much as 10MB of high-speed, 32-bit RAM. Other 16-bit memory cards such as those used in the AT can be installed in addition to or in place of some of the 32-bit RAM. However, the performance difference between the 16-bit expansion bus and the 32-bit memory bus is so extreme that 16-bit memory should be added only as a last resort.

Another convenient feature of the Deskpro 386 is its processor speed control, which is designed to provide high performance while maintaining compatibility with programs that depend on program execution speed for critical timing functions. With the SPEED option of the MODE command (or BIOS interrupt 16H, AH=F0H), the processor speed can be set anywhere from slightly less than the 4.7 MHz used in the PC's 8088 to 16 MHz. Unlike the Deskpro 286, the Deskpro 386 does not support special keyboard sequences to switch in or out of any of these modes (the Deskpro 286 uses Ctrl-Alt-/ to change speeds). Only the MODE command or BIOS interrupt 16H can be used. Five options of the MODE command affect the processor speed:

**MODE SPEED=COMMON**
**MODE SPEED=FAST**
**MODE SPEED=HIGH**
**MODE SPEED=AUTO**
**MODE SPEED=num**

The COMMON setting causes the 80386 to simulate the speed of a 6-MHz 80286. FAST simulates an 8-MHz 80286. HIGH sets the speed to a full 16 MHz.

In AUTO mode, the default speed setting, the processor operates at full 16-MHz speed until a diskette access occurs; then it switches to 8-MHz (FAST) mode until the disk access is complete, when it switches back to 16 MHz. The BIOS recognizes when to switch speeds by keying on the diskette's motor-on switch. The AUTO mode is intended to help users install and run copy-pro-

tected programs, particularly those that require a key diskette. As Compaq realized, most copy-protection schemes are speed sensitive. With the processor slowed just during diskette accesses, the copy-protection mechanism can succeed without forcing the computer to run permanently at the slower speed. After installation (or key-diskette checking) is complete, the Deskpro 386 returns to 16-MHz operation.

The last form of the MODE SPEED command allows users to specify a numeric value from 1 to 50 for the processor speed. This form of the command corresponds to the way the speed is set using BIOS interrupt 16H and permits users to select from a large variety of speeds. Table 1 shows how these numbers correspond with the other MODE SPEED options.

The Deskpro 386 implements the speed controls by using the 80386 HOLD signal. The 80386 is in a HOLD state whenever a memory refresh occurs. Therefore, to slow down the processor, the refresh period is simply extended, reducing the amount of time that the 80386 is actually executing instructions. This method of slowing down the processor is better than adding memory wait states because it does not affect the bus bandwidth or the latency for direct memory access (or other bus master operations). However, extremely tight program loops that execute within the time of a refresh cycle and require a slowed processor might not work correctly.

The Deskpro 386 uses a signal from an 8254 interval timer to lengthen the refresh period. The 8254 timer is programmed using the values in the BIOS interrupt 16H; function request AH=F0H; the MODE SPEED=num command; or the values that correspond to the other MODE SPEED options.

Normally, the processor speed is set in its default state (AUTO). This permits 16-MHz speed during most system operations, but still allows copy-protected programs to be loaded from diskette. The other settings can be useful for running speed-sensitive programs such as games. One especially nice touch is that any selected speed survives a warm reboot of the computer. This means that even action games written especially for a 4.77-MHz 8088 can be run by first selecting a low speed, such as MODE SPEED=03 and then rebooting the computer with the game disk in drive A:.

Because the Deskpro 386 needs an 8254 signal for its speed control, it contains two 8254 timers, one more than

the AT. Both timers have three separate counters. In the first timer, which provides the same functions as the 8254 on the AT, counter 0 is connected to the 8259 interrupt controller and provides the system timer interrupt for time-of-day, diskette time-out, and other system functions; counter 1 generates the refresh request signal; and counter 2 generates the tone for the speaker.

The second 8254 timer provides functions not found in the AT. Counter 1 of the second timer is unused; counter 2 extends the refresh period as just

> **O**ne feature that the Deskpro 386 might be expected to contain, but does not, is a socket for an 80387 numeric coprocessor.

described; and counter 0 provides one of the most interesting features of the machine. It is a fail-safe timer that can generate interrupts on the nonmaskable interrupt line at regular intervals. The Compaq documentation states that operating systems can use this signal to prevent the system from locking up. It also claims that this function is intended for future operating system use. Therefore, this system "heartbeat" might be included in versions of DOS developed for the 80386 processor. A switch on the system board can turn the fail-safe timer on or off.

A Motorola MC146818 serves as the Deskpro 386's realtime clock and stores configuration information. This component, which also is used in the AT, contains 64 bytes of memory. The first 14 are used by the clock, and the last 50 are used to save the system configuration when the power is turned off. Three of the bits in configuration byte 45 (2DH) store additional information not maintained by the AT: bit 0 indi-

cates whether Compaq's dual-mode monitor is installed; bit 1 indicates whether the audible key-click feature is enabled; and bit 3 indicates whether a Compaq or non-Compaq graphics adapter is installed.

The Deskpro 386 has other features not found in the AT, most of which are also available in the Deskpro 286. These include the Ctrl-Alt-plus and Ctrl-Alt-minus sequences to increase or reduce the loudness of the key clicks and the optional tape backup unit.

The speed and capacity of the tape backup unit has been improved over the units previously available with the Deskpro computers. Tape backup now is twice as fast as earlier models; and the new unit can back up 40MB of information instead of 10MB, because it uses the 3M DC2000 3½-inch cartridges rather than the DC1000 cartridges. For compatibility with earlier Compaq computers, the new tape unit can read the DC1000 tapes produced by other Compaq tape units, but it cannot write to them. The new tape unit can be installed in the Deskpro 286.

Unfortunately, on several occasions the tape drive in the tested unit refused to back up data successfully. It locked up during the middle of a backup operation and could not be restarted except by turning the power off and on again. The backup operation was tried at several processor speeds, but the errors still occurred frequently. These problems did not reappear when another unit was tested, but the reliability of Compaq's higher-capacity tape drives should be questioned nonetheless.

One feature that the Deskpro 386 might be expected to contain, but does not, is a socket for an 80387 numeric coprocessor. This omission probably occurred because the design of the 80387 was incomplete when the Deskpro 386 was developed. The machine does have a socket for the 80287, which has a different number of pins and a different pin layout than the 80387. A further drawback is that the Deskpro 386 supports only 4- and 8-MHz 80287s, not the 10-MHz parts that are now

---

**TABLE 1:** *MODE SPEED Parameters*

| SYSTEM SPEED SIMULATED | MODE COMMANDS |
|---|---|
| 8088-based PC | MODE SPEED=3 |
| 6-MHz AT | MODE SPEED=COMMON or MODE SPEED=16 |
| 8-MHz AT | MODE SPEED=FAST or MODE SPEED=18 |
| 16-MHz 80386 | MODE SPEED=HIGH or MODE SPEED=50 |

The MODE SPEED command can be used to change operating speed. This table correlates the MODE SPEED parameters with the numeric values entered.

widely available. A switch on the system board indicates whether a 4- or 8-MHz 80287 is installed.

## LOOKING INSIDE THE 386

The box housing the system unit of the Deskpro 386 is virtually identical to that of the Deskpro 286, so the joys and sorrows of installation are also the same. On the negative side, Torx screws are used in most of the fastenings, and Torx screwdrivers are often difficult to find. Further, a metal brace is mounted on the left side of the system unit, immediately over slot one (the 32-bit slot). To take out the memory board, the brace has to be removed.

On the positive side, the cover of the system unit is held on by fewer screws on the rear panel so it is easier to remove than the cover of the Deskpro 286. Instead of selecting the correct three of eight screws, all of which look as if they need to come out, users now choose three of four screws.

Compaq has improved the installation process immensely by gluing a quick-reference card to the top of the peripheral bay enclosure. This card contains a drawing of the system board with callouts identifying all the expansion cards, the 80287 socket, the system board switches, the power supply and power connectors, and the system ROMs. In addition, it identifies the drive connectors, lists the settings for the system board switch, and lists the jumper selections for the memory board and disk controller board. With this convenient reference, the experienced user can perform almost all installation tasks without opening a manual.

The peripheral bay in the Deskpro 386 is capable of containing four half-height drives. This is a smaller area than the AT provides, but the extra space underneath the bay is filled with shock-mounting material to protect the drives from damage.

One well-designed feature is the easy-to-reach location of the 80386 and 80287 sockets on the left side of the system board. The B1 stepping of the 80386 is used in the Deskpro 386. Although this version of the 80386 has several programming anomalies, Compaq's technical reference contains 10 pages of valuable information that describes how to avoid problems with the stepping of the 80386. Most of the anomalies are of interest only to designers of protected-mode operating systems. Application programmers will rarely encounter any problems.

As shown in photo 4, the Deskpro 386 has eight expansion slots—three 8-bit slots (one of them half size), four 16-bit slots, and one 32-bit slot. The 8-bit and 16-bit slots operate at 8 MHz for compatibility with boards designed to operate in the AT. The 32-bit slot is slot 1, which is the leftmost slot in the photo. This slot consists of two connectors: an 80-pin connector positioned at the front of the system unit and a small one next to slot 2 that is actually a second set of power and ground signals for improved power distribution.

The system memory board, shown in photo 5, fits into the 32-bit slot. The board comes standard with 1MB of RAM, which is soldered in place. Sockets are available for an additional megabyte on the board, as are connectors for adding a single piggyback card. The memory board and piggyback card accept only static-column RAM chips. With

*The system memory board comes standard with 1MB of RAM, which is expandable to 2MB. More can be added using a piggyback card.*

the largest piggyback card installed, 10MB of RAM can be accessed from the system memory board.

The system board has only one switch block. It specifies the monitor type, default speed setting, whether the numeric coprocessor is present and, if so, the speed at which it runs, and whether the fail-safe timer is enabled.

Of the remaining seven slots, two are occupied with a 40MB hard disk—one 8-bit slot by the graphics controller and one 16-bit slot by the multipurpose hard-disk controller board. The multipurpose board controls the 40MB hard disk, the diskette drives, and the tape drive. On the units with 70MB or 130MB hard disks, another 16-bit slot is occupied, because the larger capacity drives require a separate controller.

In the model 40 unit, the multipurpose hard-disk controller is connected to two diskette drives (a 1.2MB drive and a 360KB drive), a 40MB hard disk, and a 40MB tape backup unit. The two diskette drives and the tape backup unit slots are attached to a single connector on the controller in a daisy-chain fashion. The controller supports a second 40MB drive, but the power supply, the same 192-watt model used in the Desk-

pro 286, is not powerful enough to handle two hard disks and a tape drive. Therefore, if a second hard disk is added, the tape backup unit must not be included. To pack all of that functionality into a single controller board, Compaq uses special 40MB disks. The drives contain much of the control circuitry on the drive circuit board rather than on the controller board.

The 70MB and 130MB drives do not connect to the multipurpose controller board. Both of these drives use the ESDI interface, so they require a separate controller card that supports a single drive. Both controllers use the same I/O addresses when communicating with the hard disks, so if a 70MB or 130MB drive is included, no 40MB drives are supported.

Although only the 40MB, 70MB, and 130MB drive options are available from Compaq, the ROM BIOS supports 47 types of hard disks. Table 2 lists the drive types and characteristics. All the Deskpro 386 drive types are supported by the AT, with the same type numbers.

A serial and a parallel port are also contained on the multipurpose hard-disk controller. The serial port uses a 9-pin, male, D-shell connector. The parallel port uses a 25-pin, female, D-shell connector. These connectors are the same as those used in the AT's parallel/serial card. The serial port can be switched between COM1 and COM2. The parallel port is set to LPT1, but it can be disabled if it conflicts with the ports on other expansion cards.

## STANDARD SOFTWARE

GW-BASIC version 3.0 and MS-DOS 3.10 are available at extra cost with the Deskpro 386. Included with this package is a DOS 3.2 support disk that contains a replacement set of disk utilities that works with IBM's PC-DOS 3.2 and is aware of the Deskpro 386's 40MB, 70MB, and 130MB hard disks.

Compaq's DOS 3.1 disk contains all the items that are contained in IBM's DOS 3.1, plus some extras. One of the added files is DISKINIT, a utility that simplifies setting up a hard disk. It performs the FDISK, ENHDISK, and FORMAT functions, creates CONFIG.SYS and AUTOEXEC.BAT files, and copies both DOS diskettes into a subdirectory called /DOS. These operations are similar to the ones that are performed by the SELECT command in DOS 3.2.

Other extra programs include SETCLOCK, which allows users to reset the date and time without running the set-up program; CMPQADAP, a utility for modifying the keyboard driver for

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international character sets; KEBDA, KEYBNO, KEYBSU, and KEYBSV, which are four additional keyboard drivers; GRAFTABL, which enables the color/graphics adapter when operating in graphics mode to display characters whose ASCII values are greater than 127; TAPE, a cartridge tape utility that formats a tape, backs up files to tape, restores files, lists a tape directory, and erases tapes; and SETUP, which stores configuration information in the memory of the realtime clock chip.

Software supplied with the Deskpro 386 includes ENHDISK.SYS, a driver that assigns a separate drive letter to each partition of a hard disk. This is necessary for using all the storage on the Deskpro 386's large hard disks, because DOS limits partitions to 32MB. Two CEMM programs (CEMM.EXE and CEMM.COM) are supplied, as well as INST386, which generates or modifies the CONFIG.SYS file in order to identify CEMM.EXE and VDISK.SYS as device drivers and indicate the amount of memory to be used for expanded memory and virtual disks.

Finally, Microsoft provides a diagnostic program called TEST that is the equivalent of IBM's standard diagnostics. Curiously, this program contains a test for the Microsoft InPort mouse. Compaq was rumored to be including an InPort connector on its Enhanced Graphics Board, but it is not contained on the released version. Compaq may have forgotten to remove the diagnostic test when it decided not to include the InPort connector.

Compaq continues to score high marks with its technical documentation. Included with every Deskpro 386 is a useful *Operations Guide*. Users also can purchase the excellent two-volume *Technical Reference Guide*.

The *Technical Reference Guide* is one of the finest works of its kind and an essential purchase for anyone who is curious about how the Deskpro 386 really works. It is clearly written and provides enough background material so that even novices can understand the complex topics it covers. The explanation of the 80386's B1 stepping is especially good. Unfortunately, much of the information that IBM places in its *Guide to Operations* manuals is available from Compaq only in this separately priced reference. The explanation of switch settings for the multipurpose disk controller board is one example.

Compaq produces a single set of DOS documentation for all Compaq computers, with special supplements for the Deskpro 386. While this may be

## TABLE 2: *Disk Drives Supported*

| DRIVE TYPE | NO. OF CYLINDERS | NO. OF HEADS | CAPACITY (MB) | LANDING ZONE CYLINDER | PRECOMPEN-SATION CYLINDER | SECTORS/TRACK |
|---|---|---|---|---|---|---|
| 1 | 306 | 4 | 10.65 | 305 | 128 | 17 |
| 2 | 615 | 4 | 21.41 | 638 | 128 | 17 |
| 3 | 615 | 6 | 32.12 | 615 | 128 | 17 |
| 4 | 1,024 | 8 | 71.30 | 1,023 | 512 | 17 |
| 5 | 940 | 6 | 49.09 | 939 | 512 | 17 |
| 6 | 697 | 5 | 30.33 | 696 | 128 | 17 |
| 7 | 462 | 8 | 32.17 | 511 | 256 | 17 |
| 8 | 925 | 5 | 40.26 | 924 | 128 | 17 |
| 9 | 900 | 15 | 117.50 | 899 | −1[a] | 17 |
| 10 | 980 | 5 | 42.65 | 980 | −1 | 17 |
| 11 | 823 | 10 | 71.63 | 822 | −1 | 17 |
| 12 | 925 | 9 | 72.46 | 924 | 128 | 17 |
| 13 | 612 | 8 | 42.61 | 611 | 256 | 17 |
| 14 | 754 | 11 | 72.19 | 753 | −1 | 17 |
| 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| 16 | 612 | 4 | 21.31 | 612 | 0 | 17 |
| 17 | 980 | 5 | 42.65 | 980 | 128 | 17 |
| 18 | 966 | 6 | 50.45 | 966 | 128 | 17 |
| 19 | 1,023 | 8 | 71.23 | 1,023 | −1 | 17 |
| 20 | 733 | 5 | 31.90 | 732 | 256 | 17 |
| 21 | 733 | 7 | 44.66 | 732 | 256 | 17 |
| 22 | 768 | 6 | 40.11 | 768 | −1 | 17 |
| 23 | 771 | 6 | 20.16 | 771 | −1 | 17 |
| 24 | 966 | 14 | 117.71 | 966 | −1 | 17 |
| 25 | 966 | 16 | 134.53 | 966 | −1 | 17 |
| 26 | 1,023 | 14 | 124.66 | 1,023 | −1 | 17 |
| 27 | 966 | 10 | 84.08 | 966 | −1 | 17 |
| 28 | 771 | 3 | 20.11 | 771 | −1 | 17 |
| 29 | 578 | 4 | 20.09 | 578 | −1 | 17 |
| 30 | 615 | 4 | 31.49 | 615 | 128 | 25 |
| 31 | 615 | 8 | 62.98 | 615 | 128 | 25 |
| 32 | 966 | 3 | 50.45 | 966 | −1 | 34 |
| 33 | 966 | 5 | 84.08 | 966 | −1 | 34 |
| 34 | 966 | 7 | 117.71 | 966 | −1 | 34 |
| 35 | 966 | 8 | 134.53 | 966 | −1 | 34 |
| 36 | 966 | 9 | 151.35 | 966 | −1 | 34 |
| 37 | 966 | 5 | 84.08 | 966 | −1 | 34 |
| 38 | 1,023 | 9 | 155.56 | 1,023 | −1 | 33 |
| 39 | 1,023 | 11 | 190.13 | 1,023 | −1 | 33 |
| 40 | 1,023 | 13 | 224.70 | 1,023 | −1 | 33 |
| 41 | 1,023 | 15 | 259.27 | 1,023 | −1 | 33 |
| 42 | 1,023 | 16 | 284.93 | 1,023 | −1 | 34 |
| 43 | 756 | 4 | 40.26 | 756 | −1 | 26 |
| 44 | 756 | 2 | 20.13 | 756 | −1 | 26 |
| 45 | 756 | 4 | 40.89 | 768 | −1 | 26 |
| 46 | 768 | 2 | 20.45 | 768 | −1 | 26 |
| 47 | 966 | 5 | 61.82 | 966 | 128 | 25 |

[a]*The −1 values mean that no write precompensation is used for the drive.*

The Deskpro 386 BIOS supports 47 drive types. These include all the drive types (with the same type numbers) supported by the IBM AT, plus many more. This allows a high degree of flexibility in the selection of disk drives.

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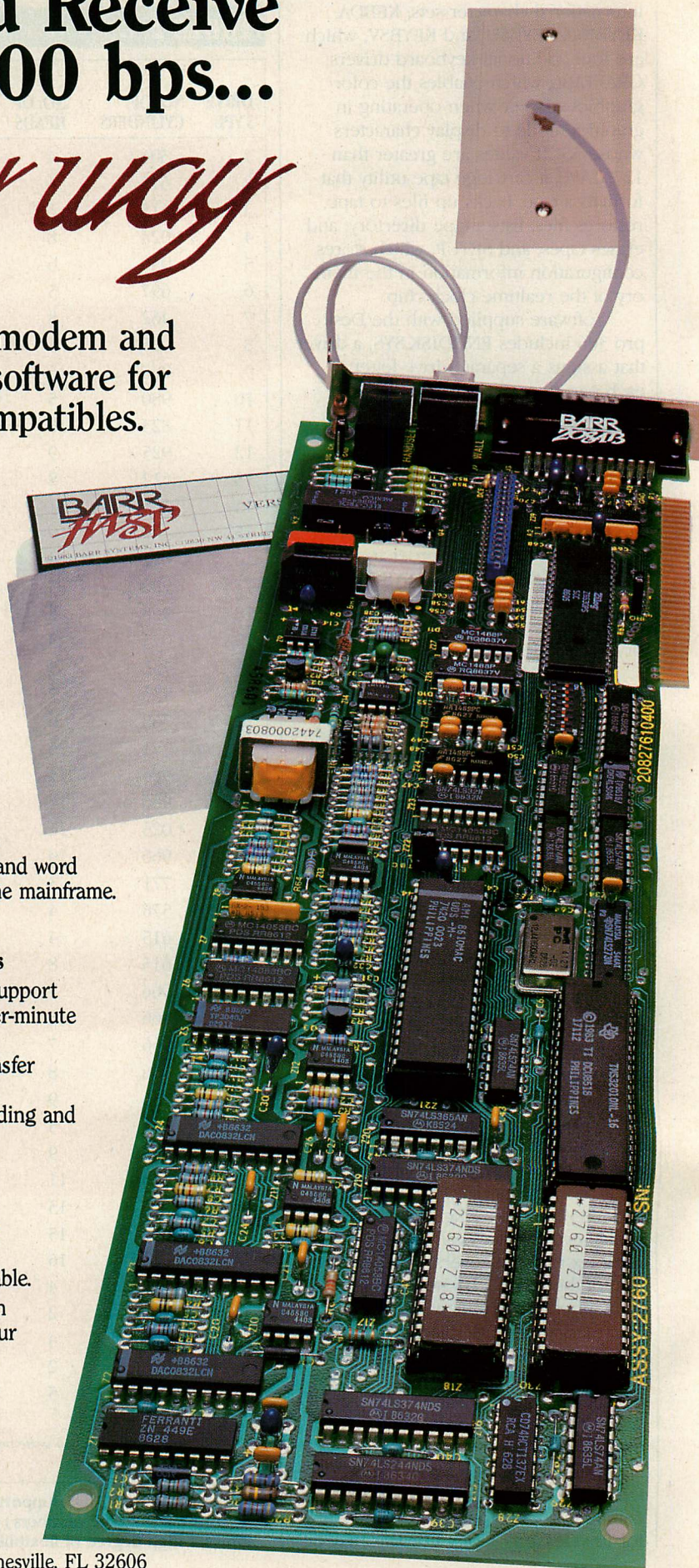
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convenient for Compaq, it creates a great deal of confusion for the user. The DOS 3.1 documentation and diskettes form a generic package that is available with all Compaq computers. Two other diskettes, the User Prog and Supplemental User Prog diskettes, contain additional utilities as well as updated versions of certain programs and versions designed especially for the Deskpro 386. For example, the User Prog diskette contains a new version of the TAPE program that must be used instead of the version on the DOS diskettes. The Supplemental User Prog diskette contains versions of VDISK and the MODE command designed for the 80386 processor. Nowhere does the DOS manual mention the existence of these updated programs. Nor does the DOS manual describe the CEMM program. The Deskpro 386 *Operations Guide* mentions the new VDISK, CEMM, and MODE versions, but not the new TAPE command. With multiple copies of programs and utilities, the user can easily install the wrong versions. The manuals do nothing to explain the situation or ease the problem.

Instead of the usual 90-day warranty, Compaq provides a one-year warranty for the Deskpro 386, including the Enhanced Graphics Board and Compaq Color Monitor. If users experience problems during that time, they can return the machine to their dealer for repairs or replacement.

**TEST RUN**
The Deskpro 386 was subjected to the same tests used throughout this series on AT compatibles, although they were modified to run on 80386-based computers. First, commonly used software and hardware products were installed to check for compatibility. Then the *PC Tech Journal* AT Evaluation Suite of compatibility and performance tests was run and the results were compared with those of the 8-MHz IBM AT. (For details on how these tests were modified, see "Updating the Evaluation Suite," Ted Forgeron, Paul Pierce, and Steven Armbrust, this issue, p. 70).

All of the hardware products tested with the Deskpro 386 worked without problem, including an 80287 numeric coprocessor, an Intel Above Board with 4MB of memory, Microsoft serial and bus mice, a Hayes Smartmodem 1200, and the Compaq Enhanced Graphics Board. One item worth special mention is that expanded memory on the Above Board (or on any expanded memory board) cannot be used when Compaq's CEMM driver is installed. The reason

for this is simply because only one expanded memory driver can be active at any one time in one computer.

Software installed in the Deskpro 386 included Microsoft Windows 1.01 and Microsoft Word 3.1 to test graphics capabilities and the mouse; Borland's SuperKey 1.11A, SideKick 1.56A, and Turbo Lightning 1.101A to test memory-resident programs; Living Videotext's Ready! 1.00C and Intel's QUIKMEM2 RAM disk to test expanded memory; both the IBM and Compaq versions of VDISK to check the computer's ability to switch in and out of protected mode; Fastback from Fifth Generation Systems to test direct memory access; and the IBM Advanced Diagnostics programs to perform a general check-up.

*T*he Technical Reference Guide is an essential purchase for anyone who is curious about how the Deskpro 386 really works.

Almost all the programs worked without error. Only SuperKey failed completely by locking the enhanced keyboard, but a new version (1.15) released specifically to solve this problem worked as advertised on the Deskpro 386. Fastback performed without errors, but the restore program required the processor speed to be set to 8 MHz. The only other program that showed a discrepancy was the IBM Advanced Diagnostics program, which recognized only 640KB of the Deskpro 386's first 1MB of RAM. The remaining 360KB is mapped to addresses that are just below 16MB, where the Diagnostics program could not find it.

The expanded memory programs (Ready! and QUIKMEM2) were tested by running them out of CEMM memory; both ran without problems.

The IBM VDISK program also worked as intended. This is significant because it implies that even though the 80386 can easily switch between protected and real modes, the Deskpro 386 also supports the more complicated method required for the 80286 (which involves resetting the processor). The Deskpro 386's VDISK program is written especially for the 80386 processor and does not need to reset the processor to go back to real mode.

One other program tested on the Deskpro 386 did not run correctly. Gold Hill Computers' Golden Common LISP (GCLISP) large memory version 2.0, a program that switches in and out of protected mode to execute code out of extended memory, caused the computer to perform a warm reboot. Gold Hill attributes the problem to the aggressive, nonstandard way that GCLISP uses 80286 protected mode. Gold Hill plans to market a Deskpro 386-compatible version of GCLISP in 1987.

The *PC Tech Journal* compatibility and performance tests consist of five programs: ATBIOS checks the BIOS and BIOS data areas; ATKEY checks for keyboard compatibility; ATFLOAT measures floating-point operations with the numeric coprocessor installed; ATDISK measures hard-disk performance; ATPERF measures processor and numeric coprocessor clock rates, as well as memory access times. Table 3 lists the results of these tests, and figure 5 presents bar-graph comparisons between the 8-MHz AT and Deskpro 386 for RAM instruction fetch, RAM read and write times, ROM read times, and EMM read and write times.

ATBIOS showed that the Deskpro 386 uses the BIOS data area in the same way as the AT. It listed a Compaq copyright and a date of 8/19/86.

ATKEY verified the keyboard compatibility. The original AT keyboard also worked with the Deskpro 386.

ATFLOAT showed that the Deskpro 386 can process floating-point operations 1.7 times as fast as an 8-MHz AT. Given that the processor runs at 16 MHz and the numeric coprocessor at 8 MHz (compared to 8 and 5.33 on the AT), this value seems appropriate.

ATDISK proved that the 40MB drive in the Deskpro 386 is a high-performance model consistent with the requirements of an 80386-based computer. It showed considerably better access times than the IBM drive, and it is formatted and works effectively with an interleave of 2, causing a higher effective transfer rate than the IBM drive (which uses an interleave of 3).

The most interesting results were obtained from ATPERF, which demonstrated that the Deskpro 386 is an extremely fast computer, with instruction fetches, as well as memory reads and writes, almost three times as fast as an 8-MHz AT. (Because the system normally runs at 8 MHz when the diskette drive is accessed, ATPERF must be run from the hard disk or SPEED must be set to HIGH using the MODE command to achieve these results.)

The RAM read and write times and the corresponding wait states show the values expected from a high-performance, 32-bit processor. ATPERF shows that reading from and writing to RAM within a 2KB page indeed occurs at zero wait states.

The modified version of ATPERF uses PUSHA instructions to measure RAM writes. These are fast instructions that do not result in idle bus cycles. Each PUSHA instruction involves eight PUSH instructions (pushing all of the registers), and therefore it writes to eight consecutive memory locations that are almost always within the same 2KB page. Memory is accessed outside the page when the processor fetches a new instruction. However, each PUSHA is a byte instruction, so each instruction fetch during this test fetches four separate PUSHA instructions (the 80386 accesses four bytes at a time). As a result, each instruction fetch results in 32 memory accesses (eight pushes from each of four PUSHA instructions). With this mechanism, the effect of accessing memory outside of a page during instruction fetch is barely noticeable and is not enough to affect the number of wait states measured.

The ROM read times are also worth discussing. ATPERF checks the ROM read time by using MOVS instructions to copy the system BIOS to RAM. However, in the Deskpro 386 the system BIOS reads are actually performed from RAM instead of ROM. Therefore, the ROM read times are, in fact, equal to the RAM read times as indicated in table 3, with the actual performance dependent upon the extent to which successive memory accesses occur within the same 2KB page.

The ROM read test is a general-purpose test that is not customized for the Deskpro 386. It subtracts the average RAM write time that was discussed previously from the average time required to copy ROM to RAM in order to determine the average ROM read time. In the case of the Deskpro 386, the average RAM write time is measured at zero wait states, whereas the RAM writes in the ROM copy operation occur at two wait states (because the MOVS source and destination addresses are not in the same 2KB page.) Therefore, subtracting the zero-wait-state average write time yields an inaccurate value for average ROM read time.

The value that is displayed (0.39 microseconds) is quite useful, however, for determining the average time needed for RAM read/write accesses that are not contained within the same 2KB

| **TABLE 3:** *Compatibility and Performance Tests* | | |
|---|---|---|
| | **8-MHz AT, 30MB DISK**[a] | **DESKPRO 386, 40MB DISK** |
| **ATBIOS** | | |
| ROM BIOS date | 11/15/85 | 08/19/86 |
| **ATPERF** | | |
| Average RAM instruction fetch (µs) | | |
| BYTE | .250 | .19 (130)[b] |
| WORD | .403 | .14 (280) |
| DWORD | N/A | .23 |
| Average RAM read time (µs)[c] | | |
| BYTE | .401 | .13/.26 (298/154) |
| WORD | .401 | .13/.26 (298/154) |
| DWORD | N/A | .14/.26 |
| Average RAM write time (µs)[c] | | |
| BYTE | .401 | .13/.26 (307/154) |
| WORD | .401 | .13/.26 (307/154) |
| DWORD | N/A | .13/.26 |
| Average ROM read time (µs) | | |
| BYTE | .401 | Same as RAM read |
| WORD | .401 | Same as RAM read |
| DWORD | N/A | Same as RAM read |
| Average CGA video write time (µs) | | |
| BYTE | 1.208 | 1.21 (100) |
| WORD | 2.415 | 2.42 (100) |
| DWORD | N/A | 4.83 |
| Average EMM read time (µs) | | |
| BYTE | .402 | .13 (301)[d] |
| WORD | .402 | .13 (301)[d] |
| DWORD | N/A | .14 |
| Average EMM write time (µs) | | |
| BYTE | .402 | .13 (306) |
| WORD | .402 | .13 (306) |
| DWORD | N/A | .13 |
| CPU clock rate (MHz) | 8.0 | 16.0 (200) |
| Numeric coprocessor clock rate (MHz) | 5.3 | 8.0 (150) |
| Refresh overhead (%) | 7.1 | 15 |
| RAM read/write wait states | 1/1 | 0/0 |
| ROM read wait states | 1 | 2 |
| Video write wait states (CGA) | 8 | 17 |
| EMM read/write wait states | 1/1 | 0/1[d] |
| **ATFLOAT** | | |
| Performance as percentage relative to AT | 100 | 107 |
| **ATDISK** | | |
| Sectors/track | 17 | 17 |
| Heads | 5 | 5 |
| Cylinders | 731 | 978 |
| Total space (million bytes) | 31.81 | 42.56 |
| Track-track seek time (ms) | 6.0 | 4.1 |
| Average seek time (ms) | 37.1 | 27.6 |
| Effective transfer rate (KB/sec) | 170.1 | 254.5 |
| DOS file I/O (sec) | 7.3 | 7.4 |
| Interleave | 3 | 2 |

[a]The figures for the IBM AT are the average results from several machines, whereas the results from the Compaq Deskpro 386 are taken only from the review sample model.
[b]Figures shown in parentheses represent the relative performance expressed as a percentage compared to PC Tech Journal's baseline machine, the 8-MHz, 30MB AT.
[c]For the Deskpro 386, first number is for memory access within the same 2KB page; the second is not within the same 2KB page.
[d]EMM measurements were taken using the Deskpro 386's CEMM driver and built-in memory.

**RAM read/write times are from 1.5 to 3 times faster that for the AT, depending on whether or not successive accesses are written to the same 2KB page.**

## RAM INSTRUCTION FETCH

.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0

BYTE   WORD   DWORD

## RAM READ TIME

.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0

BYTE   WORD   DWORD

## RAM WRITE TIME

.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0

BYTE   WORD   DWORD

## ROM READ TIME

.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0

BYTE   WORD   DWORD

## EMM READ TIME

.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0

BYTE   WORD   DWORD

## EMM WRITE TIME

.50
.45
.40
.35
.30
.25
.20
.15
.10
.05
0

BYTE   WORD   DWORD

*Time in Microseconds*

■ IBM 8-MHz AT

■ Deskpro 386, not within 2KB page

■ Deskpro 386, within 2KB page
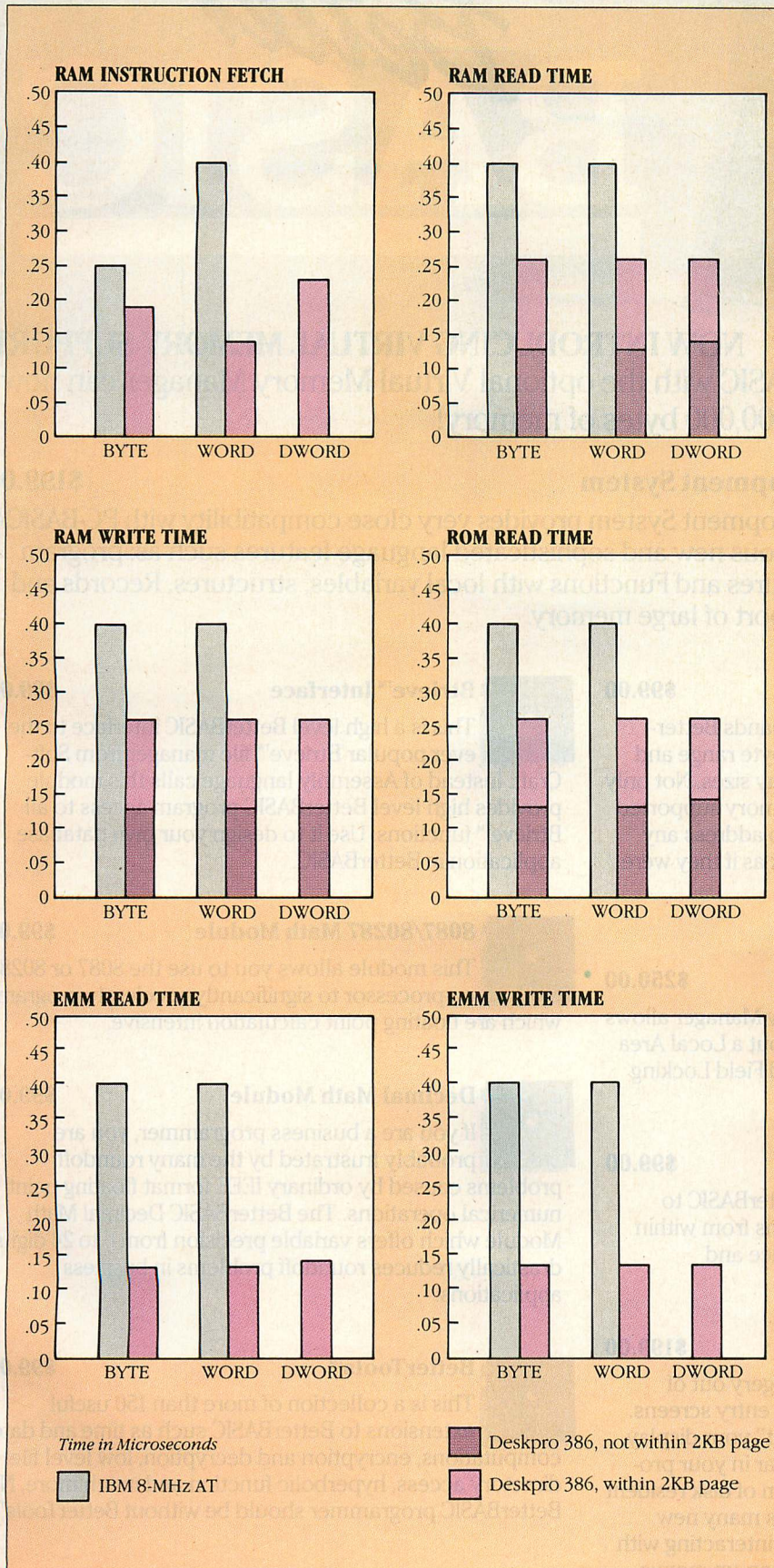
The Deskpro 386 can access a 32-bit double word faster than the AT can perform even one of the two 16-bit word accesses that it uses to perform the same task.

page. This value is determined by adding the previously subtracted average RAM write time to the average ROM read time displayed by ATPERF and then dividing that total by two (because the RAM reads and writes take the same amount of time). The resultant 0.26 microseconds per double word is the expected average time for a two-wait-state RAM read/write.

## FASTEST ON MARKET

For anyone who demands high performance and AT compatibility, the Compaq Deskpro 386 is definitely the computer of choice. At the time this review was written, it was easily the fastest AT compatible on the market, as well as one of the most compatible. The addition of Compaq's special touches, such as processor speed control, CEMM, and excellent documentation, make this computer even more desirable. Perhaps its best and brightest feature is its 80386, which offers a bridge between today's real-mode applications and tomorrow's more powerful multitasking and protected mode programs.

Only a few areas need improvement in the Deskpro 386. The absence of a socket for the 80387 numeric coprocessor will keep this machine's floating-point performance less than that provided by other new 80386-based machines that do support the 80387. Even other computers that contain 10-MHz 80287s will be able to edge the Deskpro 386's 4- and 8-MHz 80287 in floating-point performance. Other areas of concern are the tape backup drive, because one of the units examined did not work properly, and the Compaq Color Monitor, because it does not match the quality of some of the other enhanced color monitors that are currently on the market.

These are problems, however, that can be remedied, and they are far outweighed by the outstanding performance and quality of the Deskpro 386. Even IBM will have a hard time topping this machine.
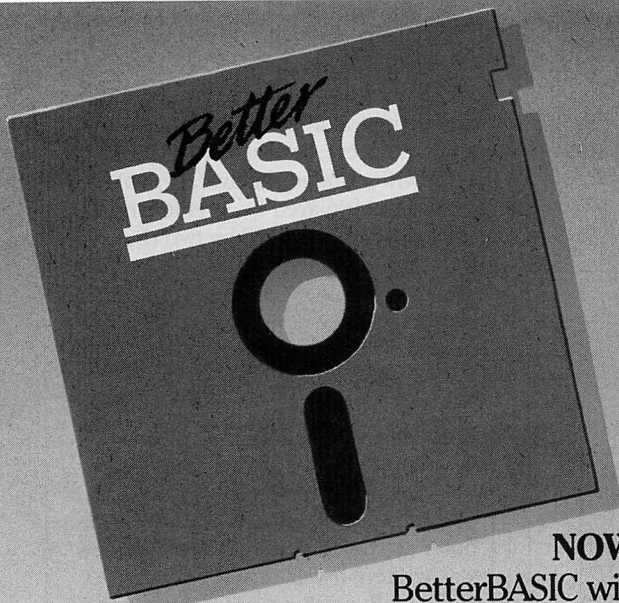
# Better BASIC

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