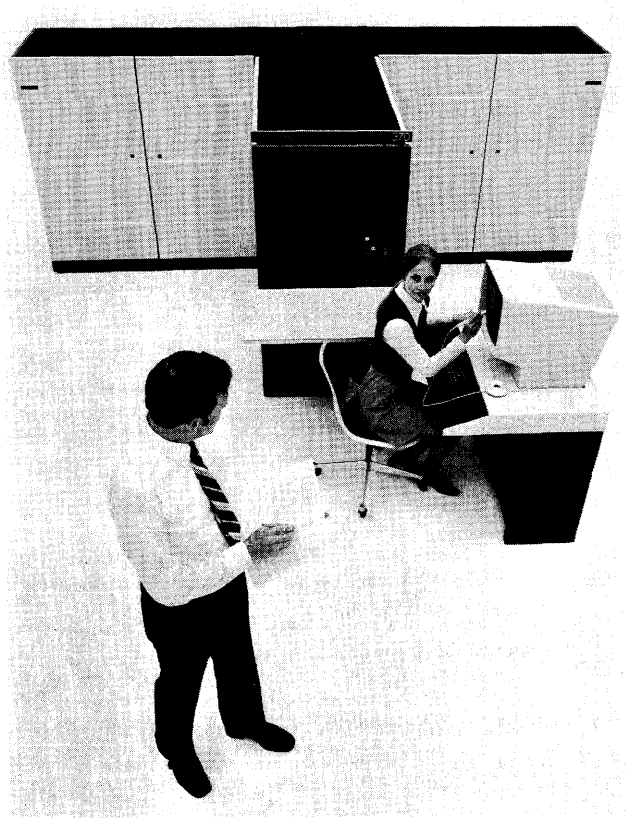
IBM System/370



The System/370 Model 158 Processing Unit, introduced in August 1972, provides up to 2 million characters of MOS main storage and up to 16 million characters of virtual storage. A feature of the Model 158 is its CRT display console with light-pen input.

Newly expanded to seven processor models and enhanced through the addition of virtual storage facilities, the System/370 is everybody's standard of comparison for medium-to-large-scale computers. The System/370 product line spans a broad range of applications and workloads, at system rentals ranging from about $9,800 to $270,000 per month.

MANAGEMENT SUMMARY

The System/370 is the successor to the System/360 as IBM's current line of medium-to-large-scale computer systems. It now consists of seven basic central processor models designed to handle a broad range of business and scientific applications in both batch and on-line environments. The processors are supported by more than 40 peripheral devices and a uniquely broad array of software facilities. In addition, dozens of independent hardware and software suppliers offer a bewildering variety of equipment and programs that can be used to augment or replace IBM's own products.

The System/370 got off to a surprisingly low-key start in June 1970, when IBM introduced the large-scale Models 155 and 165. Though they offered significant price/performance improvements without reprogramming to users of the large-scale System/360 computers, Models 166 and 165 encompassed no technological breakthroughs. They retained the System/360 architecture, used conventional core memories, and achieved their impressive performance largely through the use of fast ▷

CHARACTERISTICS

MANUFACTURER: International Business Machines Corporation, 1133 Westchester Avenue, White Plains, New York 10604.

MODELS: System/370 Models 135, 145, 155, 158, 165, 168, and 195.

DATA FORMATS

BASIC UNIT: 8-bit byte. Each byte can represent 1 alphanumeric character, 2 BCD digits, or 8 binary bits. Two consecutive bytes form a "halfword" of 16 bits, while 4 consecutive bytes form a 32-bit "word."

FIXED-POINT OPERANDS: Can range from 1 to 16 bytes (1 to 31 digits plus sign) in decimal mode; 1 halfword (16 bits) or 1 word (32 bits) in binary mode.

FLOATING-POINT OPERANDS: 1 word, consisting of 24-bit fraction and 7-bit hexadecimal exponent, in "short" format; 2 words, consisting of 56-bit fraction and 7-bit hexadecimal exponent, in "long" format; or 4 words in "extended precision" format.

INSTRUCTIONS: 2, 4, or 6 bytes in length, specifying 0, 1, or 2 memory addresses, respectively.

INTERNAL CODE: EBCDIC (Extended Binary-Coded Decimal Interchange Code).

MAIN STORAGE

STORAGE TYPE: See table.

CAPACITY: See table and price list. Note: In a Model 145, the Reloadable Control Storage can be expanded from its standard 32,768 bytes to a maximum of 65,536 bytes, in 2048-byte increments, at the expense of main storage capacity (e.g., if the full 65,536 bytes of RCS is required, the main storage capacity will be reduced by 32,768 bytes).

CYCLE TIME: See table. Note: For Models 155 through 195, the effective main storage speeds are considerably higher than the figures would seem to indicate because of the semiconductor buffer storage (see table), which greatly reduces the number of main storage references required in most applications.

CHECKING: All data paths between the central processor and main storage are parity-checked by byte. When data is stored, an error-correcting code is substituted for the parity bits. (An 8-bit modified Hamming code is appended to each 8-byte "doubleword" of data.) When the data is retrieved, single-bit errors are detected and corrected automatically, ▶

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buffer storage units similar to the ones that had previously been used in the System/360 Models 85 and 195.

In September 1970, the nature of the "real System/370" became much clearer when IBM unveiled a truly advanced computer—the medium-scale Model 145. In addition to being the first commercial computer from a major manufacturer to use an all-semiconductor main memory, Model 145 extended the concept of microprogrammed control to a new high in flexibility (which, incidentally, has since been surpassed by the "variable micrologic" of the Burroughs B 1700 Systems).

During 1971, IBM extended the System/370 line both upward and downward by introducing the smaller Model 135 and the ultra-large-scale Model 195. Model 135 is essentially a scaled-down Model 145, enhanced through the availability of integrated control units for a 1403 Printer and up to eight communications lines, while Model 195 is a slightly upgraded version of the earlier System/360 Model 195. Meanwhile, customer deliveries of the first three System/370 models began; most of the early users have experienced minimal problems in converting from their System/360's and express a fairly high degree of satisfaction with the System/370 equipment.

By April 1972, IBM had installed more than 2000 System/370's. Yet there was no joy in Armonk. Domestic sales were running well below quotas. Many System/360 users were still resisting IBM's efforts to upgrade them to the System/370; instead, they were squeezing more throughput out of their System/360's by taking advantage of plug-compatible tape and disk drives, add-on main memory, proprietary software, reduced prices on used equipment, etc. Other users, to IBM's horror, had taken advantage of the System/370's improved price/performance to *reduce* their monthly equipment bills while upgrading their throughput. Clearly, it was time to give computer buyers a new—and hopefully irresistible—reason to follow IBM's prescribed upward migration route. At the same time, IBM hoped to make life more difficult for the independent disk drive and main memory suppliers that have been diverting a steadily increasing share of equipment revenues away from IBM's own coffers.

On August 2, 1972—after numerous delays and despite the threat of an injunction sought by Telex Corporation—IBM announced its "direction of the future" for the System/370 line. That direction can be summed up in two words: *virtual storage.*

The August 1972 announcements, under the catch-all title "System/370 Advanced Function," had four principal facets:

- Two new large-scale processors—Models 158 and 168—which have virtual storage capabilities, use low-cost MOS main memories, and offer more processing power in smaller cabinets than the earlier Models 155 and 165.

and most multiple-bit errors are detected and signalled so that appropriate program action can be taken. (Note: The bit correction facility is not implemented in Model 195.)

STORAGE PROTECTION: The Store and Fetch Protection features, which guard against inadvertent overwriting and/or unauthorized reading of data in specified 2048-byte blocks of storage, are standard in all models.

CENTRAL PROCESSORS

INDEX REGISTERS: Sixteen 32-bit general registers, used for indexing, base addressing, and as accumulators, plus four 64-bit floating-point registers.

INDIRECT ADDRESSING: None.

INSTRUCTION REPERTOIRE: The basic System/370 instruction set consists of all of the instructions that comprise the System/360 "commerical instruction set" (i.e., the standard System/360 set plus the decimal arithmetic instructions), together with 13 new "enhancement" instructions.

The basic System/370 instruction set includes complete arithmetic facilities for processing variable-length decimal and fixed-point binary operands, as well as instructions which handle loading, storing, comparing, branching, shifting, editing, radix conversion, code translation, logical operations, packing, and unpacking. In addition, a group of "privileged instructions," usable only by the operating system, handle input/output and various hardware control functions. Floating-point arithmetic instructions are optional in Models 135 and 145 and standard in the larger models (see table).

The 13 new (non-System/360) instructions in all System/370 processors are:

Compare Logical Characters Under Mask (CLM)
Compare Logical Long (CLCL)
Halt Device*
Insert Characters under Mask (ICM)
Load Control (LCTL)*
Move Long (MVCL)
Set Clock (SCK)*
Shift and Round Decimal (SRP)
Store Channel ID (STIDC)*
Store Characters under Mask (STCM)
Store Clock (TCK)
Store CPU ID (STIDP)*
Store Control (STCTL)*

*Privileged instruction.

These new instructions facilitate programming and reduce execution times for record blocking and unblocking, long move and compare operations, decimal arithmetic, and various hardware control functions.

In addition, all models with virtual storage capabilities have five new instructions for Dynamic Address Translation:

Load Real Address
Reset Reference Bit
Purge Translation Look-Aside Buffer
Store Then AND System Mask
Store Then OR System Mask

INSTRUCTION TIMES: See table for average add times. Average execution times, in microseconds, for some additional representative instructions on Models 135 and 145 in Basic Control mode are as follows:

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CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS

	Model 135	Model 145	Model 155	Model 158	Model 165	Model 168	Model 195
SYSTEM CHARACTERISTICS							
Date of introduction	March 1971	Sept. 1970	June 1970	Aug. 1972	June 1970	Aug. 1972	July 1971
Date of first delivery	May 1972	July 1971	Feb. 1971	April 1973	April 1971	Aug. 1973	2nd qtr. 1973
Virtual storage capability	Standard	Standard	No*	Standard	No*	Standard	No
Principal operating systems	DOS/VS, OS/VS1	DOS/VS, OS/VS1, OS/VS2	DOS, OS/MFT, OS/MVT	DOS/VS, OS/VS1, OS/VS2	OS/MFT, OS/MVT	OS/VS1, OS/VS2	OS/MVT
System rental range	$9,800 to $22,600	$14,700 to $45,000	$32,000 to $80,000	$49,500 to $85,000	$70,000 to $150,000	$93,000 to $170,000	$190,000 to $270,000
MAIN STORAGE							
Storage type	Semicond. (bipolar)	Semicond. (bipolar)	Core	Semicond. (MOS)	Core	Semicond. (MOS)	Core
Read cycle time, nanoseconds	770	540	2070	1035	2000	480	756
Write cycle time, nanoseconds	935	608	2070	690	2000	480	756
Bytes fetched per cycle	2 or 4	4 or 8	16	8 or 16	8	8	8
Storage interleaving (maximum)	None	None	None	None	4-way	4-way	16-way
Minimum capacity, bytes	98,304	114,688	262,144	524,288	524,288	1,048,576	1,048,576
Maximum capacity, bytes	245,760	524,288	2,097,152	2,097,152	3,145,728	4,194,304	4,194,304
Increment size, bytes	49,152	49,152 or 131,072	131,072 to 524,288	524,288	524,288 or 1,048,576	1,048,576	1,048,576
BUFFER STORAGE							
Cycle time, nanoseconds	—	—	115	115	80	80	54
Bytes fetched per cycle	—	—	2	2	4	4	8
Minimum capacity, bytes	None	None	8,192	8,192	8,192	8,192	32,768
Maximum capacity, bytes	None	None	8,192	8,192	16,384	16,384	32,768
PROCESSING UNIT							
Machine cycle time, nanoseconds	275-1485	203-315	115	115	80	80	54
Add time, microseconds (32-bit binary fields)	4.21	2.14	0.99	**	0.16	***	0.054
Add time, microseconds (5-digit decimal fields)	40.92	11.90	4.93	**	1.42	***	Not spec'd.
Processing unit features:							
Clock Comparator & CPU Timer	Optional	Optional	No*	Standard	No*	Standard	No
Direct Control	Optional	Optional	Optional	Optional	Standard	Standard	Standard
Dynamic Address Translation	Standard	Standard	No*	Standard	No*	Standard	No
Floating Point	Optional	Optional	Standard	Standard	Standard	Standard	Standard
Extended Precision Floating Point	Optional	Optional	Optional	Optional	Standard	Standard	Standard
High-Speed Multiply	No	No	No	No	Optional	Optional	Standard
Integrated 2319 Disk Control	Optional	Optional	No	No	No	No	No
Integrated 3330 Disk Control	Optional	Optional	No	Optional	No	Optional	No
Integrated 1403 Printer Control	Optional	No	No	No	No	No	No
Integrated Communications Control	Optional	No	No	No	No	No	No
Compatibility features:							
IBM 1401/1440/1460 Compatibility	Optional	Optional	Optional	Optional	No	No	No
IBM 1410/7010 Compatibility	No	Optional	Optional	Optional	No	No	No
IBM 7070/7074 Compatibility	No	No	Optional	Optional	Optional	Optional	No
IBM 7080, Compatibility	No	No	No	No	Optional	Optional	No
IBM 709/7090/7094 Compatibility	No	No	No	No	Optional	Optional	No
IBM 360/20 Compatibility	Optional	No	No	No	No	No	No
OS/DOS Compatibility	Standard	Standard	Optional	Optional	No	No	No
CHANNELS							
No. of Selector Channels	0 to 2	1 to 4	None	None	0 to 6	0 to 6	0 to 6
No. of Block Multiplexer Channels	0 to 2	1 to 4	2 to 5	2 to 5	0 to 11	0 to 11	0 to 13
No. of Byte Multiplexer Channels	1	1	1 or 2	1 or 2	0 to 2	0 to 2	0 to 2
Maximum total I/O data rate, bytes/second	2,400,000	5,300,000	5,400,000	Not spec'd.	8,000,000	16,000,000	Not spec'd.

*Virtual storage capability can be added to a purchased Model 155 or 165 through field installation of the Dynamic Address Translation facility, which converts it into a Model 155-II or 165-II, respectively.

**The Model 158's instruction execution rate is typically 20% to 40% faster than that of Model 155.

***The Model 168's instruction execution rate is typically 10% to 30% faster than that of Model 165.

- Dynamic Address Translation (DAT) hardware, required for the implementation of virtual storage and available as a standard, no-charge feature for Models 135, 145, 158, and 168, and as a high-cost, field-installable option for purchased Model 155 and 165 systems only.

- Four new operating systems–DOS/VS, OS/VS1, OS/VS2, and VM/370–which support the new virtual storage capabilities and are functional extensions of the earlier DOS, OS/MFT, OS/MVT, and CP-67 systems, respectively.

- Integrated disk controls that reduce the cost of using the high-performance 3330 disk drives in Model 135, 145, 158, and 168 systems, plus a redesign of the control logic to permit up to sixteen 3330 drives in a subsystem.

IBM's "direction of the future" is bound to have momentous effects upon IBM computer users, IBM's competitors, and the future of the EDP field as a whole. The details and ramifications of the System/370 hardware and software, as it stands today, are discussed in depth in the balance of this report.

VIRTUAL STORAGE

Computer users who attended IBM's August 1972 product announcement or read the associated ads and brochures could easily have concluded that virtual storage is a bold new technique pioneered by IBM. In fact, the concept is more than a decade old and has previously been employed, for better or worse, in dozens of computer systems from numerous manufacturers.

Credit for originating the virtual storage technique, in 1959, is generally given to the developers of the Atlas computer system at Manchester University, England. Since then, the technique has been used in widely publicized computers such as the Burroughs B 6700, the GE (now Honeywell) 645, the RCA (now UNIVAC) 70/46, and IBM's own System/360 Model 67. To date, virtual storage has been used mainly in large, expensive computers designed primarily for conversational time-sharing; but RCA anticipated IBM's move nearly two years ago by stressing the advantages of virtual storage for medium-scale computers in typical business data processing environments. Although RCA's marketing efforts were spectacularly unsuccessful, IBM's full-barreled support of the concept makes it clear that virtual storage will be the new way of life for most users of medium and large-scale computers.

Virtual storage can be defined as a storage allocation scheme in which the addresses used by a program to identify information are distinguished from the addresses used by the storage system to identify physical storage locations; all program-generated (virtual) addresses are

	Model 135	Model 145
Add (32-bit binary):	4.21	2.14
Multiply (32-bit binary):	25.52	20.1
Divide (32-bit binary):	41.92	34.8
Load (32-bit binary):	3.08	1.69
Store (32-bit binary):	3.30	1.50
Add (5-digit packed decimal):	40.92	11.9
Compare (5-digit packed decimal):	37.57	10.6
Add (short floating-point):	13.73*	5.85*
Multiply (short floating-point):	32.24*	16.8*
Divide (short floating-point):	49.39*	28.7*
Add (long floating-point):	17.73*	7.52*
Multiply (long floating-point):	51.32*	45.7*
Divide (long floating-point):	79.21*	89.6*

*With optional Floating-Point Instructions.

RELOADABLE CONTROL STORAGE: All System/370 central processor operations are controlled by microprogramming. In the Model 135, 145, and 158 Processing Units, the microprograms reside in a semiconductor memory unit called Reloadable Control Storage (RCS) and are loaded into RCS by means of a small read-only disk unit called the Console File. This unit reads special single-disk cartridges at the rate of 33,000 bits per second. Each cartridge can hold approximately 75,000 bytes. IBM supplies prewritten disk cartridges containing all the control microprograms required for a specific installation.

The Model 135 RCS has a minimum cycle time of 275 nanoseconds, and the time required to execute each microinstruction ranges from 275 to 1430 nanoseconds, depending upon the operation. The basic RCS capacity of 24,576 bytes can be expanded to either 36,864 or 49,152 bytes. Expansion is required when certain optional features or combinations are selected.

Model 135 RCS requirements, in bytes, are as follows:

Basic System Microcode	15,482
Autocall	440
Block Multiplexer Channel	1,568
Clock Computer and CPU Timer	1,400
Direct Control	50
Extended Precision Floating Point	676
Floating Point	1,200
64 Byte Multiplexer Subchannels	1,024
128 Byte Multiplexer Subchannels	2,048
256 Byte Multiplexer Subchannels	4,096
1401/1440/1460 Compatibility	3,492
Integrated Communications Adapter	2,100
2319 Integrated File Adapter	4,652
3330 Integrated File Adapter	10,192
Integrated Printer Adapter	1,300
First or First and Second Selector Channel	1,584
System/360 Model 20 Compatibility	876
3210 Model 1 Adapter	1,494
3215 Adapter	1,930
Synchronous Data Adapter, Type II	3,700
Adapter Base, Type I	1,200
Terminal Adapter, Type I Model II	500
Telegraph Adapter, Type II	200
Terminal Adapter, Type III	2,100

The Model 145 RCS is an extension of the semiconductor main storage. The basic 32K bytes of RCS can be extended to a maximum of 65K bytes at the expense of a corresponding reduction in main storage capacity. This can

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automatically translated to the corresponding physical storage (real) addresses.

As implemented in the System/370, virtual storage permits programmers and operators to work with their computer as if it had up to 16 million bytes of main storage—even though the real main storage capacity may be only a small fraction of that size. The secret, of course, is that only those portions of a program that are actually required at any given time need to be present in main storage. The rest of each program is kept on a disk file, ready to be loaded into main storage when needed.

The Dynamic Address Translation (DAT) facility is the "mapping" mechanism that automatically translates the virtual storage addresses contained in program instructions into real main storage addresses as each instruction is executed. The translation is accomplished by a hardware-implemented table-lookup procedure that accesses tables in main storage which are created and maintained by the operating system.

Virtual storage in the System/370 is divided into fixed-length, consecutively addressed sections called *pages,* which are either 2K or 4K bytes in length, depending upon the operating system. For ease of addressing, the pages are assigned to larger groups of 65K or 1048K bytes, called *segments.* The IBM operating systems generally allocate virtual storage to problem programs in contiguous pages. Real storage is similarly divided into fixed-length sections called *page frames,* which are the same size as the virtual storage pages. The page frames in real storage, unlike the pages in virtual storage, need not be contiguous. The direct-access storage device that holds the virtual storage pages is called *external page storage,* and the ongoing transfer of pages between real storage and external page storage is called *demand paging,* or "swapping." Demand paging can take place because all instructions and data items are referenced by their virtual storage addresses—regardless of whether or not, at a given time, they are present in real storage.

When an instruction or a data item is referenced by a program, the Dynamic Address Translation facility automatically breaks the virtual storage address into segment number, page number within segment, and position of the instruction or data item with regard to the beginning of the page.

Segment tables and page tables maintained by the operating system indicate whether the needed page is already in real storage. If so, execution of the program continues. If the page is not present in real storage, then paging takes place under supervision of the operating system. To speed program execution, the DAT facility includes a *translation lookaside buffer,* which holds the addresses of previously referenced pages located in real storage. If the real storage location of a referenced page is

be done at any time, in 2048-byte increments, by simply changing the value in an address boundary register. In fact, most Model 145 installations are finding it necessary to extend the RCS capacity well beyond the basic 32K bytes.

Model 145 RCS requirements, in bytes, are as follows:

Basic System Microcode	26,000
16 Byte Multiplexer Subchannels	256
32 Byte Multiplexer Subchannels	512
64 Byte Multiplexer Subchannels	1,024
128 Byte Multiplexer Subchannels	2,048
256 Byte Multiplexer Subchannels	4,096
Selector Channel Block Multiplexer Feature	2,500
16 UCW's for Block Multiplexer Channel (512 max.)	128
2319 Integrated File Adapter	9,760
3210 Model 1 Adapter	3,200
3215 Adapter	3,800
1401/1440/1460 Compatibility	5,200
1401/1440/1460 & 1410/7010 Compatibility	6,000
Floating Point	2,240
Direct Control	80
Clock Comparator and CPU Timer	1,800

DYNAMIC ADDRESS TRANSLATION: This facility, which is now standard in Models 135, 145, 155-II, 158, 165-II, and 168, is the mechanism that translates the virtual storage addresses contained in instructions into real main storage addresses as each instruction is executed. All six models can address a virtual storage space of 16,777,216 bytes. A two-level address translation process divides the virtual storage space into segments of either 65,536 or 1,048,576 bytes, which are in turn divided into pages of either 2,048 or 4,096 bytes, depending upon the operating system.

Translation between the virtual and real addresses is accomplished by a hardware-implemented table-lookup procedure that accesses tables in main storage which are created and maintained by the operating system. The translation process is speeded up by a group of high-speed registers called the Translation Look-aside Buffer (TLB), which holds recently referenced virtual storage addresses and their real storage equivalents. The TLB in Models 155-II, 158, 165-II, and 168 holds up to 128 entries, while the counterpart registers in Models 135 and 145, which are called the Associative Array, hold 8 entries. The translation of addresses contained in the TLB or Associative Array can be accomplished much more rapidly than when references to the page and segment tables in main storage are required.

OPERATIONAL MODES: Models 135, 145, 155-II, 158, 165-II, and 168 can operate in either the Basic Control (BC) or Extended Control (EC) mode. The BC mode maintains general upward compatibility with the System/360 architecture and programming. In the new EC mode, the Program Status Word (PSW) and the layout of the permanently assigned lower main storage area are altered to support Dynamic Address Translation and other new system control functions; therefore, the new virtual-storage-oriented operating systems must be used.

OPTIONAL FEATURES: The table indicates which of the following features are standard or optional in each of the processor models.

The Clock Comparator and CPU Timer feature provides expanded system timing facilities. The Clock Comparator provides a means for causing an interrupt when the standard Time-of Day Clock reaches a program-specified value. The CPU Timer is a binary counter that is decremented every microsecond and causes an interrupt

found in this manner, a search of the segment and page tables is not required.

The operating system automatically monitors page usage in main storage to identify inactive pages. These are paged out, when necessary, to meet new demands for main storage space. If a page has been changed during the run of a program, it is written over the former version that exists on external page storage. If a page has not been changed, however, no actual transfer of data needs to take place.

The principal benefits of virtual storage are three-fold: (1) reduced programming costs through elimination of the constraints imposed by limited main memory capacity; (2) increased flexibility for processing existing applications and developing new ones; and (3) potentially improved throughput and/or faster response times through more efficient storage allocation. Attractive benefits they are—but, like most good things, they have their price. For most System/370 users, the transition to virtual storage will almost certainly be accompanied by a significant increase in hardware costs. From IBM's point of view, that will be a happy development indeed—and it may well be the principal reason why virtual storage has been adopted as IBM's "direction of the future."

These increased hardware costs are likely to result from any or all of the following factors:

- Additional computational capability may be needed to compensate for the added overhead that is inherent in virtual-mode operation. (IBM currently—and perhaps optimistically—estimates the DAT overhead to be about 5 to 8 percent for typical program mixes.)
- Additional real main storage may be needed to accommodate the virtual-mode operating systems, whose storage residence requirements are considerably larger than those of their real-mode counterparts.
- Additional and/or faster direct-access storage devices, and in most cases a dedicated I/O channel, may well be needed to achieve an adequate level of demand paging performance. (In a simple, batch-mode DOS/VS or OS/VS1 environment, IBM estimates that the paging rate will typically be about 3 to 5 pages per second, which could reasonably be handled by a low-cost 2319 disk drive. But in a complex OS/VS2 or VM/370 environment, the required paging rate can easily exceed 100 pages per second. This rate would considerably exceed the capabilities of a 3330 Disk Storage facility, and would therefore require the use of the grossly overpriced 2305 Fixed-Head Storage Facility.)
- Additional peripheral devices may be required to support a larger number of concurrently active

when its value reaches zero. Additional instructions are provided to set and store both the Clock Comparator and the CPU timer.

The Floating-Point Arithmetic feature, a no-cost option, provides instructions to perform floating-point arithmetic operations on both short (1-word) and long (2-word) operands.

The Extended Precision Floating-Point feature provides 7 instructions for performing floating-point arithmetic on 4-word (16-byte) operands that provide a precision of up to 28 hexadecimal or 34 decimal digits. The Floating-Point Arithmetic feature is a prerequisite.

The Direct Control Feature provides six external interrupt lines which are independent of the normal data channels, plus two instructions which provide for single-byte data transfers between an external device and main storage.

High-Speed Multiply reduces the time required for long-precision floating-point and fixed-point multiply instructions. For Model 165, the times are reduced from 1.87 to 0.61 microseconds and from 0.78 to 0.42 microseconds, respectively.

The Channel-to-Channel Adapter permits direct communication between two System/370 processors via their standard I/O channels. The adapter occupies one control unit position on each of the two channels it interconnects.

Other processor options are described in the following sections on Compatibility Features, Input/Output Control, and Communications Control.

COMPATIBILITY FEATURES: The System/370 processors can be equipped with extra-cost compatibility features and associated emulator routines that enable them to execute programs written for earlier IBM computers, as listed in the table. These "integrated emulators" enable emulated programs to be processed along with native-mode System/370 programs in a multiprogramming mix under operating system control. In general, their use requires a System/370 with I/O devices equivalent to those of the system to be emulated (plus the devices required by the operating system), and with more core storage capacity and processing power. Only the more common peripheral devices can be emulated.

The OS/DOS Compatibility Feature facilitates DOS-to-OS conversions by making it possible to run DOS programs under control of the Operating System/360 (MFT or MVT). The DOS Emulator runs as a problem program under OS control. It can be multiprogrammed with other OS jobs, and it in turn can use the multiprogramming options of DOS. The DOS Emulator Program, the DOS Supervisor, and up to three DOS processing-program partitions are all executed in a single MFT partition or MVT region of at least 38K bytes; the DOS Emulator Program alone requires 22K to 26K bytes of main storage. IBM states that the internal speed of executing DOS job streams in OS/DOS Compatibility mode on a Model 145 varies from approximately 1.0 to 4.3 times faster than execution of the same job streams under DOS control on a 360/40.

The 1401/1440/1460 Compatibility Feature is a field-installable option which, in combination with special software, enables a System/370 to execute IBM 1401, 1440, or 1460 instructions. Internal speed of a Model 145 in the emulation mode is approximately 4.9 times that of the 1401—and about 10% faster than 1401 emulation under CS40 on an IBM 360/40. The associated emulator routines

programs. (Under virtual storage, users can expect a slowdown in the execution times for individual jobs, even if the overall throughput of the system increases. Thus, it follows that more programs will need to be sharing the system's resources at any given time.)

- Finally, additional hardware resources of all types may well be needed to support the expanded applications that virtual storage makes possible. Unlike the other four factors cited above, increased costs for this reason will be a happy development from the user's viewpoint—provided the new applications are economically justifiable.

Thus, virtual storage may or may not be a good thing for specific computer installations, depending upon the nature of their current and future workloads. But for IBM itself, there can be little doubt that virtual storage will prove to be a very good thing indeed.

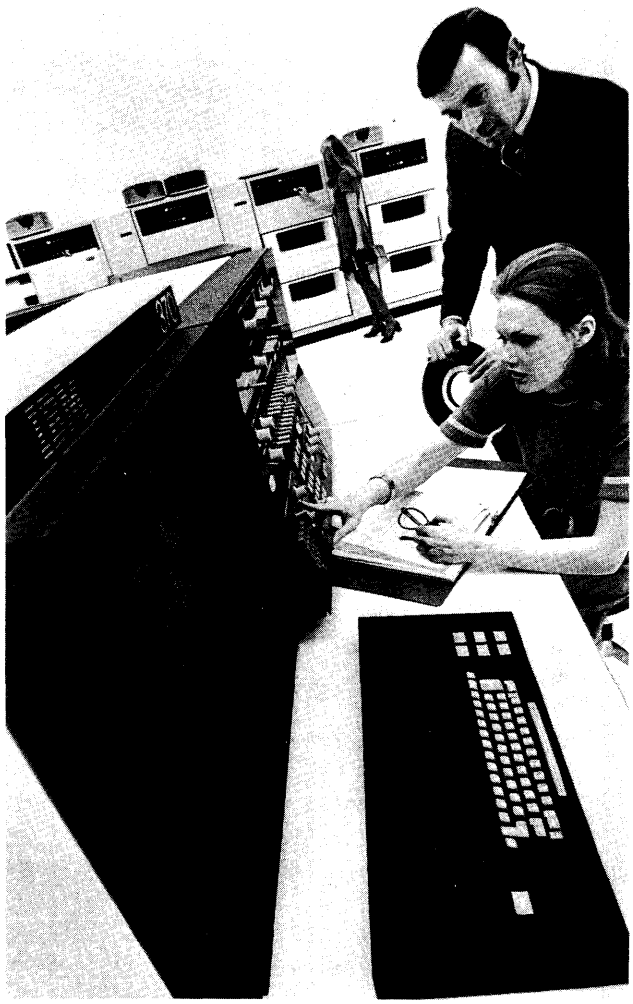
PROCESSOR MODELS

There are now seven basic central processor models in the System/370 line. Their characteristics are summarized and compared in the table on page 70C-491-04c.

Model 135, the smallest processor in the current System/370 family, was introduced in March 1971 and enhanced through the addition of virtual storage capabilities in August 1972. Its distinctive features include 98K to 245K bytes of semiconductor main storage, 24K to 49K bytes of Reloadable Control Storage, integrated control logic for 2319 or 3330 Disk Storage, an integrated control unit for a 1403 Printer, and an Integrated Communications Adapter that provides low-cost control facilities for up to eight data communications lines. The hardware facilities required to support virtual storage will be field-installed on previously delivered Model 135 Processors at no charge.

Model 135 is designed to serve as an effective upgrade machine for current users of the System/360 Models 25 and 30. For these users, Model 135 provides greatly increased internal speed, memory capacity, and input/output capabilities with little or no need for reprogramming. Model 135 delivers internal processing speeds ranging from 2 to 4.5 times that of the Model 30 for commercial applications and from 3.5 to 7 times that of the Model 30 for scientific applications. As compared with the Model 25, Model 135 offers from 3.5 to 6.5 times the internal speed for commercial applications and from 5.5 to 16 times the internal speed for scientific applications.

Monthly rentals for typical Model 135 configurations range from about $9,800 to $22,600, with purchase prices ranging from about $467,000 to $1,068,000. Thus, Model 135 is priced between System/360 Models 30 and 40, while its performance substantially exceeds that of the Model 40.



The System Console of the new Model 168 system features a CRT display and keyboard. In the background is a 3330 Disk Storage facility, which stores 100 million bytes per spindle.

require a minimum of 17K bytes of main storage under DOS and 20K bytes under OS.

The 1401/1440/1460, 1410/7010 Compatibility Feature is a field-installable option that provides the capability to emulate IBM 1410 and 7010 programs in addition to all the facilities of the 1401/1440/1460 Compatibility Feature described above. Internal speed of a Model 145 in the emulation mode is about twice that of the 1410 and two-thirds that of the 7010. The associated emulator routines require a minimum of 28K bytes of main storage under DOS and 22.5K bytes under OS.

The 7070/7074 Compatibility Feature is an option that provides the capability to execute programs written for an IBM 7070 or 7074 system. Internal speed of a Model 165 in the emulation mode is approximately three times that of the 7074, and operation is under OS control.

The 7080 Compatibility Feature provides the capability to execute, under OS control, programs written for an IBM 7080 system. Internal speed of a Model 165 in the emulation mode is approximately twice that of the 7080.

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Model 145, which provides roughly twice the internal processing power of the Model 135, was announced in September 1970 and enhanced through the addition of virtual storage in August 1972. At the time of its introduction, Model 145 was one of the most technologically exciting computers ever to reach the market. It was the first commercial computer from a major manufacturer to use an all-semiconductor main memory. What's more, Model 145's Reloadable Control Storage extended the concept of microprogrammed control to a new high in flexibility, while its integrated disk control logic permitted large-capacity disk pack storage at an unprecedentedly low price.

Model 145 is designed to serve as an effective upgrade machine for current users of the System/360 Models 30 and 40. It offers internal processing speeds 3 to 5 times as fast as the Model 40 and 5 to 11 times as fast as the Model 30, plus main storage capacities of up to 524,288 bytes—twice the maximum capacity of the Model 40 and eight times that of the Model 30. Model 145 also provides greatly increased I/O capabilities: a standard Byte Multiplexer Channel, up to four Selector or Block Multiplexer Channels, and a maximum system I/O data rate of 5.3 million bytes per second.

Monthly rentals for typical Model 145 configurations range from about $14,700 to $45,000, with purchase prices ranging from about $690,000 to $2,150,000. Thus, the Model 145 is priced between System/360 Models 40 and 50, while its performance substantially exceeds that of the Model 50. The hardware facilities required for virtual storage will be field-installed on previously delivered Model 145 Processors at no charge.

Model 155, along with Model 165, was part of the original System/370 announcement in June 1970. Designed as a growth system for System/360 Model 40 and 50 users, Model 155 operates at 3.5 to 4 times the internal speed of the Model 50. It offers from 262,144 to 2,097,152 bytes of conventional magnetic core storage—four times the maximum storage capacity available to Model 50 users. Though Model 155's core cycle time is a surprisingly slow 2.07 microseconds, 16 bytes of information are fetched or stored during each cycle. The 8,192-byte buffer storage, like the central processor, has a 115-nanosecond cycle time. Instruction fetching is overlapped with instruction execution.

Two Block Multiplexer Channels and one Byte Multiplexer Channel are standard in Model 155, and up to three more Block Multiplexer Channels and a second Byte Multiplexer Channel can be added. Model 155 can handle a total I/O data rate of up to 5.4 million bytes per second. Typical system rentals range from about $32,000 to $80,000 per month.

Users of rented Model 155 systems will not be able to make use of the new virtual storage software unless they

The 709/7090/7094 Compatibility Feature provides the capability to execute, under OS control, programs written for an IBM 709, 7090, 7094, or 7094 II system. Internal speed of a Model 165 in the emulation mode is approximately 1.5 times that of the 7094 II.

The System/360 Model 20 Compatibility Feature enables a Model 135 to execute, under DOS control, programs written for a System/360 Model 20 card, tape, or disk system. Prerequisites for the emulating Model 135 system are: (1) the I/O devices required by DOS; (2) the I/O devices required to emulate the Model 20 I/O units; (3) sufficient main storage to hold the DOS Supervisor (at least 12K bytes), the emulator routines (8K to 17K), and the emulated Model 20 storage (4K to 32K); and (4) sufficient Reloadable Control Storage to hold the Model 20 Compatibility Feature.

CONSOLE INPUT/OUTPUT: Users of Model 135, 145, and 155 systems have a choice of two Console Printer-Keyboards. The 3215 uses a matrix printing unit that operates at 85 characters per second. The 3210 prints at 15 characters per second. In Model 145 and 155 systems, an additional 3210 Console Printer-Keyboard can be installed in a remote area (such as the installations's tape library or scheduling room). The 3210 and 3215 are functionally compatible and program-compatible with the earlier 1052 Printer-Keyboard.

Model 158 uses a new operator display console, which is supplied along with the Processing Unit as standard equipment. It contains a CRT display, keyboard, light pen, two Console Files, and microcode control storage. A stand-alone 3213 Printer, rated at 85 characters per second, can be added as an optional hard-copy output unit.

Every Model 165 and 168 system requires a 3066 System Console, which provides a CRT display with 4K buffer, an alphanumeric keyboard, a microfiche maintenance display to facilitate servicing, and a device for reading microprograms from a magnetic disk cartridge into writable control storage.

Every Model 195 system requires a 3060 System Console, which provides a CRT display with 8K buffer, an alphanumeric keyboard, a light pen, and numerous switches and lights.

In addition to these standard console I/O units, other devices such as displays, card readers, punches, and printers can be used to provide additional console functions.

INPUT/OUTPUT CONTROL

I/O CHANNELS: The System/370 employs three distinct types of I/O channels:

Byte Multiplexer Channels have a single data path that can be shared by a number of simultaneously operating low-to-medium-speed I/O devices (in "multiplex mode") or monopolized by a single faster device (in "burst mode"). In either case, one byte of data at a time is transferred between main storage and an I/O device. These channels are functionally compatible with the System/360 Multiplexer Channels.

Selector Channels permit high-speed data transfer operations by one peripheral device at a time. The channel remains busy throughout the time a channel program is in operation, even when no data is being transferred.

Block Multiplexer Channels provide a single data path that can be shared by a number of high-speed peripheral

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elect to move up to a Model 158. For purchased Model 155 systems, IBM will field-install the Dynamic Address Translation facility for a cool $200,000, beginning in April 1973. The DAT facility includes the Extended Control mode, the Clock Comparator and CPU Timer, Program Event Recording, and additional instructions to control the new facilities. A Model 155 modified in this manner will be designated a Model 155-II.

Model 158, introduced in August 1972, effectively supersedes the Model 155 as the medium-large-scale member of the new lineup of System/370 processors with virtual storage capabilities. Model 158 also features semiconductor main memory, Reloadable Control Storage, Integrated Storage Controls for up to thirty-two 3330 Disk Storage drives, and a new CRT display console. The 8K buffer storage and 115-nanosecond processor cycle time used in Model 155 are retained in the newer model. The net result is that Model 158 executes instructions at a rate 20 to 40 percent faster than a similarly programmed Model 155.

Monthly rentals for typical Model 158 configurations range from about $49,500 to $85,000, with purchase prices ranging from about $2,300,000 to $3,700,000. As compared with Model 155, IBM has boosted the CPU price and slashed the cost of main storage for the Model 158. Thus, a Model 158 system with 1 million or fewer bytes of main storage costs more than the corresponding Model 155 system, while a Model 158 with 1.5 million or more bytes costs less than its Model 155 counterpart. Customer shipments are scheduled to begin in April 1973. Model 158 will be manufactured at Poughkeepsie, New York, where it was developed, and at IBM's plants in Montpellier, France and Fujisawa, Japan.

Model 165, introduced in June 1970, was the most powerful System/370 processor until Model 195 joined the family a year later. Designed as an upgrade machine for users of System/360 Models 65 and 75, Model 165 operates at from 2 to 5 times the internal speed of the Model 65 and offers from 524,288 to 3,145,728 bytes of conventional magnetic core storage. Four-way interleaving of 8-byte accesses to core storage, coupled with 8,192 or 16,384 bytes of 80-nanosecond buffer storage, add up to high performance despite a slow 2-microsecond core cycle time. The processor has an 80-nanosecond cycle time, and the fetching and decoding of several instructions is automatically overlapped with the execution of one instruction at a time.

A Model 165 system can include three different types of I/O channels. Up to 6 Selector Channels, 11 Block Multiplexer Channels, and 2 Byte Multiplexer Channels can be installed (though the total number of channels may not exceed 12). Total I/O data rates in excess of 8 million bytes per second can be accommodated. Typical Model 165 system rentals range from about $70,000 to $150,000 per month.

devices which transfer data alternately in burst-mode fashion. While the channel is interleaving blocks of data to and from various devices, it can also control non-data-transfer functions on other devices. These channels can also operate in Selector Channel mode, in which case they are functionally compatible with the System/360 Selector Channels.

The I/O channels are an integral part of the processing unit in Models 135 through 158, whereas Models 165 through 195 use the separately packaged 2860 Selector Channels, 2870 Byte Multiplexer Channels, and/or 2880 Block Multiplexer Channels.

The Model 135 Processing Unit includes one Byte Multiplexer Channel as standard equipment, and one or two Selector Channels are optional. The Selector Channels can be equipped to operate as Block Multiplexer Channels. The optional Integrated File Adapter, for either 2319 or 3330 Disk Storage, is functionally equivalent to a Selector Channel and disk control unit.

The Model 135 Byte Multiplexer Channel has 16 standard subchannels, and no-charge options extend the number of subchannels to 64, 128, or 256. A maximum of 8 of the subchannels can be shared (i.e., assigned to an I/O control unit that can have several devices attached). Maximum data transfer rate is approximately 41,000 bytes/second in the multiplex mode and 149,000 bytes/second in the burst mode. Because of the likelihood of overruns, use of the Model 135 Byte Multiplexer Channel for unbuffered burst-mode devices is not recommended if there is any possibility of the burst-mode device operating concurrently with the integrated File Adapter, the Integrated Communications Adapter, or a Selector Channel.

The Model 135 Selector Channels normally transfer two bytes of data at a time to or from main storage. Maximum data transfer rates are 1,300,000 bytes/second for the first Selector Channel and 1,200,000 bytes/second for the second. The combined data rate for both Selector Channels, however, may not exceed 2,400,000 bytes/second. The Block Multiplexer Channel feature, a no-charge option for Model 135, permits either or both of the Selector Channels to operate as Block Multiplexer Channels. Each Block Multiplexer Channel as 17 subchannels.

The Model 145 Processing Unit includes one Byte Multiplexer Channel and one Selector Channel as standard equipment. Up to three additional Selector Channels can be added, and any or all of the Selector Channels can be equipped to operate as Block Multiplexer Channels. (If the Integrated File Adapter is installed, only one additional Selector Channel can be used.) The Model 145 Byte Multiplexer Channel has 16 standard subchannels. No-charge options permit the number of subchannels to be expanded to 32, 64, 128, or 256.

The Model 145 Selector Channels transfer data to and from main storage on a one-byte-at-a-time basis unless the optional Word Buffer feature is installed; the buffer provides four-byte data transfers on all Selector Channels and permits higher data rates. The maximum Selector Channel data rate is 1.85 million bytes/second with the Word Buffer and 820,000 bytes/second without it. The Block Multiplexer Channel Feature, a no-charge option, permits any or all of the installed Selector Channels to operate as Block Multiplexer Channels.

The Model 155 or 155-II Processing Unit includes one Byte Multiplexer Channel and two Block Multiplexer Channels as

Users of purchased Model 165 systems will be able to join the swing to virtual storage through field installation of the Dynamic Address Translation facility—at a cost of $400,000. Shipment of the Model 165 DAT facility will begin in December 1973, and a system that includes it will be designated a Model 165-II. The DAT facility, however, is not available for rented Model 165 systems.

Model 168, announced in August 1972, features virtual storage capabilities, 1,048,576 to 4,194,304 bytes of fast semiconductor main memory, a Dual-Channel I/O bus that handles total I/O data rates of up to 16 million bytes per second, and Integrated Storage Controls for up to thirty-two 3330 Disk Storage drives. Model 168 retains the 8K or 16K bytes of high-speed buffer storage and the 80-nanosecond processor cycle time of the earlier Model 165. The net result is that Model 168 executes instructions at a rate 10 to 30 percent faster than a similarly programmed Model 165.

Monthly rentals for typical Model 168 configurations range from about $93,000 to $170,000, with purchase prices ranging from about $4,200,000 to $7,300,000. As compared with Model 165, IBM has raised the CPU price and reduced the cost of main storage for the Model 168. Thus, a 2-million-byte Model 168 costs more than its Model 165 counterpart, while a 3-million-byte Model 168 costs less. Developed at Poughkeepsie, Model 168 will be manufactured in Kingston, New York and Havant, England. Customer deliveries are scheduled to begin in August 1973.

Model 195 took its place at the top of the System/370 family in July 1971. The 370/195 "supercomputer" differs from the previously announced 360/195 only in the inclusion of some new features, such as a 250-nanosecond time-of-day clock, additional instructions for processing variable-length fields, and additional control registers. Model 195 delivers roughly 2 to 3 times the internal processing power of the Model 165, depending upon the application. Because of the emphasis upon ultra-high performance in Model 195, there are minor operational differences and incompatibilities with the smaller System/370 processors.

Model 195 includes 1,048,576 to 4,194,304 bytes of core storage with a 756-nanosecond cycle time and 8-way or 16-way interleaving. Other throughput-boosting features include a 32K buffer storage unit with a 54-nanosecond cycle time, an instruction stack, operand stacks, and extensive overlapping of operations in the instruction unit and six execution units. Emphasis is placed upon floating-point arithmetic speeds; a floating-point addition takes only 108 nanoseconds. Model 195 system rentals range from about $190,000 to $270,000 per month.

SEMICONDUCTOR MAIN STORAGE

When the System/370 Model 145 was unveiled in September 1970, its most newsworthy feature was its standard equipment. Up to three more Block Multiplexer Channels and a second Byte Multiplexer Channel (which takes the place of one of the Block Multiplexer Channels) are optional. (Selector Channels are not used with the Model 155). Each Byte Multiplexer Channel provides from 128 to 256 subchannels (depending upon the system's main storage capacity), and 8 of these subchannels can be shared by 2 or more connected I/O devices. Each Block Multiplexer Channel provides 16 shared subchannels and from 96 to 480 nonshared subchannels (depending upon main storage capacity). Each Model 155 Block Multiplexer Channel can accommodate data rates of over 1.5 million bytes per second.

The Model 158 Processing Unit includes one Byte Multiplexer Channel and two Block Multiplexer Channels as standard equipment. Up to three more Block Multiplexer Channels and a second Byte Multiplexer Channel (which takes the place of one of the Block Multiplexer Channels) are optional. (Selector Channels are not used with the Model 158). Each Byte Multiplexer Channel provides 256 nonshared subchannels or 8 shared and 120 nonshared subchannels. Each Block Multiplexer Channel provides 16 shared and 480 nonshared subchannels, and can accommodate data rates of over 1.5 million bytes per second.

A Model 165, 165-II, or 168 system can include a maximum of six 2860 Selector Channels, two 2870 Byte Multiplexer Channels, and/or eleven 2880 Block Multiplexer Channels. The total number of I/O channels is limited to 7 in the basic system and 12 if the Extended Channels feature is installed.

A Model 195 system can include a maximum of six 2860 Selector Channels, two 2870 Byte Multiplexer Channels, and/or thirteen 2880 Block Multiplexer Channels. The total number of I/O channels is limited to 7 in the basic Model 195 system and 14 if the Extended Channels feature is installed.

Each 2860 Selector Channel handles one I/O operation at a time, at a data rate of up to 1.3 million bytes per second.

Each 2870 Byte Multiplexer Channel provides 192 subchannels. Optionally, selector subchannels can be added—up to 4 on the first 2870 in a system, and up to 2 on the second. Each selector subchannel can handle one I/O operation of up to 180,000 bytes per second at a time, concurrently with multiplexed I/O operations on the basic channel. The aggregate data rate for the basic multiplexer channel may not exceed 110,000 bytes per second, and the maximum total data rate for all operations on a 2870 Byte Multiplexer Channel is 670,000 bytes per second.

Each 2880 Block Multiplexer Channel provides up to 56 nonshared subchannels and one shared subchannel. Data is transferred in burst mode, to or from one device at a time, at up to 1.5 million bytes per second. The optional Two-Byte Interface permits a data rate of up to 3.0 million bytes per second.

CONFIGURATION RULES: In general, each System/370 channel can accommodate up to 8 peripheral control units and address as many as 256 devices. Most System/370 peripheral devices can be connected to any of the three types of channels. High-speed tape, disk, and drum units require either a Block Multiplexer or Selector Channel, and card readers, printers, and other low-speed devices are normally connected to a Byte Multiplexer Channel.

SIMULTANEOUS OPERATIONS: Concurrently with computing, a System/370 can control a maximum of one

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"monolithic main memory," which makes use of bipolar LSI (large-scale integration) technology in place of conventional magnetic cores. A Model 145 system can have from 114K to 524K bytes of main storage plus 32K bytes of Reloadable Control Storage (RCS), all consisting of LSI chips. Cycle times are 540 nanoseconds per 4-byte or 8-byte fetch and 607.5 nanoseconds per 4-byte store.

Model 135 uses the same bipolar memory technology as the Model 145. A Model 135 system can have from 98,304 to 245,760 bytes of main storage in 49,152-byte increments. Cycle times are 770 nanoseconds per 2-byte read and 935 nanoseconds per 2-byte write operation.

A Model 135 or 145 storage array chip is about one-eighth of an inch square and contains 1434 microscopic circuit elements forming 174 interconnected circuits. Each chip holds 128 storage bits and the associated decoding, addressing, and sensing circuitry. Two storage array chips are mounted on a half-inch-square substrate, and two of the substrates are packaged into a 512-bit storage array module. Twenty-four of the modules are then mounted on a storage array card, which is about 3.50 by 4.75 inches in size and holds 12,288 storage bits. Finally, the cards are placed in Basic Storage Modules. Each module is about 13.25 inches long, 5.5 inches deep, and 9 inches wide and contains 48K bytes of storage plus its associated circuitry.

In designing the Model 135 and 145 memories, IBM chose bipolar LSI technology over the newer and even more promising MOS (metal-oxide semiconductor) technology because of uncertainty as to whether the necessary degree of quality control could be maintained in the mass production of MOS circuits. Apparently these doubts have now been resolved, because the new Model 158 and 168 systems will use metal-oxide semiconductor field-effect transistor (MOSFET) main memories. Like the bipolar memories, MOSFET memories are fabricated on tiny silicon chips which are assembled into compact storage modules. But the MOSFET circuits are even smaller. In the Model 158 and 168 memories, each one-eighth-inch-square chip holds 1024 bits of storage and the associated circuitry, compared with 128 bits per chip in the bipolar Model 135 and 145 memories.

The chief advantage of the bipolar LSI technology over MOS is higher potential operating speed—but this is currently achieved at the expense of higher manufacturing cost, higher power consumption, and higher heat dissipation. (In fact, the current bipolar memories tend to require even more power and more air conditioning than equivalent core memories.) MOS memories can deliver moderately high speeds along with extremely compact size, low power consumption, and minimal heat dissipation. For most applications, the MOS technique shapes up as the more cost-effective of the two, but manufacturing and quality control problems have caused its commercial acceptance to lag behind that of the bipolar technology.

high-speed I/O data transfer operation per Block Multiplexer Channel, one high-speed I/O operation per Selector Channel, one high-speed I/O operation on the Integrated File Adapter or Integrated Storage Control (if installed), and one low-speed I/O operation on each subchannel of a Byte Multiplexer Channel. Alternatively, a Byte Multiplexer Channel can operate in burst mode and handle a single higher-speed I/O operation. Maximum total I/O data rates for all channels are shown in the table.

MASS STORAGE

2305 FIXED-HEAD STORAGE: Provides fast access to comparatively small quantities of information. Each drive unit contains 6 non-removable disks with 12 recording surfaces. A fixed read/write head serves each track. One or two 2305 drive units can be connected to a 2835 Storage Control. A Two-Channel Switch can optionally be added to the 2835.

The 2305 Model 1, usable only with Models 165 and above, stores up to 5.4 million bytes of data. Each of the 384 addressable tracks can hold up to 14,136 bytes. Average access time is 2.5 milliseconds, and data transfer rate is 3.0 million bytes per second.

The 2305 Model 2, usable with Models 145 and above, stores up to 11.2 million bytes of data. Each of the 768 addressable tracks can hold up to 14,660 bytes. Average access time is 5.0 milliseconds, and data transfer rate is 1.5 million bytes per second.

Two standard features help the 2305 take advantage of the capabilities of the System/370 Block Multiplexer Channels. Rotational Position Sensing lets the drive unit disconnect from the channel during most of the rotational delay period, leaving the channel free for other operations. Multiple Requesting permits queuing of multiple requests for access to data stored on a 2305 drive; after each request is logged, the channel disconnects until the desired record position is reached and the channel is free.

2319 DISK STORAGE: Provides fairly rapid access to moderately large quantities of data stored in interchangeable 2316 Disk Packs. Can either be directly connected to a Model 135 or 145 system or used in a 2314-B Direct Access Storage Facility (DASF). Five models of the 2319 are currently available:

Model A1—three disk drives (87 million bytes) and associated control for attachment to a Model 135 or 145 via the Integrated File Adapter (IFA).

Model A2—three additional disk drives (87 million bytes) for attachment to the 2319 Model A1 in a Model 145 system.

Model A3—three additional disk drives (87 million bytes) for attachment to the 2319 Model A1 in a Model 135 system.

Model B-1—three disk drives (87 million bytes) and associated control for attachment to a 2314 Model B1 Storage Control in a 2314-B DASF.

Model B2—three additional disk drives (87 million bytes) for attachment to the 2319 Model B1 in a 2314-B DASF.

Each "2314-style" drive stores up to 29.17 million bytes of data on-line. The 11-disk 2316 Disk Pack has 200 data tracks on each of the 20 data recording surfaces. Each track

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IBM's selection of MOS for the Model 158 and 168 main memories is almost certain to change all that and ensure the widespread use of MOS memories in future computers.

IBM claims three important advantages for its semiconductor main storage:

- Higher storage speeds can be obtained because of (1) the shorter physical distances between the memory components, and (2) the nondestructive readout capability of the monolithic storage, which eliminates the need for a regeneration cycle after each read operation.
- Storage serviceability is improved because each storage array card is a complete functional component that can be replaced within a few minutes.
- Floor-space requirements for large-capacity main memories are greatly reduced. (A Model 168 Processing Unit, for example, requires 40 percent less floor space than a similarly configured Model 165.)

On the negative side, the volatility and newness of the semiconductor main storage may cause some concern among prospective users.

Semiconductor storage requires power to maintain either a zero or one state. Thus, the stored data is lost whenever the power is turned off (whereas core storage maintains its magnetized state when the power is removed). This storage volatility is not likely to create serious problems for System/370 users—but it should spur them to review their operating and checkpoint/restart procedures to make sure that processing can be resumed after unexpected power failures without undue loss of time.

The newness of the semiconductor storage technology naturally makes it less of a "sure thing" than core memory, which has been refined to a high level of reliability through more than 15 years of widespread use. On the other hand, early users of the Model 145 are experiencing no significant memory problems—and it is clear that IBM did not announce the long-awaited advances to bipolar and then MOS memories until it was quite certain that they could pass the critical tests of economy and high reliability in mass production.

RELOADABLE CONTROL STORAGE

The microprograms that control all the internal operations of the Model 135, 145, and 158 Processing Units reside in a semiconductor memory unit called Reloadable Control Storage (RCS). The microprograms are loaded into RCS by means of a small read-only disk unit called the Console File, which reads special "floppy" single-disk cartridges at the rate of 33,300 bits per second. Each cartridge can hold approximately 75,000 bytes, and IBM supplies can hold up to 7,294 bytes of data in variable-length records. Each drive has a comb-type access mechanism that can read or write up to 145,880 bytes (20 tracks) in each of its 200 positions. Average head movement time is 60 milliseconds, average rotational delay is 12.5 milliseconds, and data transfer rate is 312,000 bytes per second.

The IFA on a Model 135 or 145 permits attachment of up to eight 2319 drives. The first three are contained in the 2319 Model A1. Up to five additional drives can be connected, using various combinations of the three-drive 2319 Model A2 or A3, the single-drive 2312 Disk Storage Module, the two-drive 2318, and the four-drive 2313. Total on-line storage capacity with the maximum complement of eight drives is 233 million bytes.

A 2314 DASF consists of a 2314 Model B1 Storage Control and three, six, or nine (eight active plus one spare) 2319 disk drives. Thus, it provides 87, 175, or 233 million bytes of on-line data storage at a substantially lower price than the earlier 2314-A and 2314-1 Direct Access Storage Facilities, with which it is functionally compatible. The 2314-B DASF can be used with all models of the System/370.

3330 DISK STORAGE: Provides fairly rapid access to extremely large quantities of data stored in interchangeable 3336 Disk Packs. Each 3330 or 3333 Disk Storage module contains two independent disk drives, each mounted in a powered drawer for operating convenience.

Each 3336 Disk Pack contains 12 disks. Nineteen disk surfaces are used for data recording, and a 20th surface holds prerecorded data that controls seeking, position sensing, and clocking. Each disk pack holds up to 100,018,000 bytes of data, so a 16-drive 3330 subsystem can store over 1.6 billion bytes on-line. Each data track has a capacity of 13,030 bytes, and each of the 404 data cylinders holds up to 247,570 bytes (19 tracks). Head movement time ranges from 10 to 55 milliseconds and averages 30 for random accesses. Average rotational delay is 8.4 milliseconds, and data transfer rate is 806,000 bytes per second. Rotational Position Sensing and Multiple Requesting, as described under the 2305 above, are standard features. A Command Retry facility enables the 3330 subsystem to recover from many errors without the use of time-consuming error recovery programs. Error correction coding circuitry in the control unit permits detection and correction of bursts of errors up to 11 bits in length on a single track.

A 3330 subsystem can include from 2 to 16 disk drives, in 2-drive increments. A "channel-attached" 3330 subsystem consists of a 3830 Model 2 Storage Control and one or two 3333 Disk Storage and Control modules, containing two drives each. Up to three 3330 Disk Storage modules, containing two drives each, can in turn be attached to each 3333. The 3333 provides logic and power for the attached 3330 modules. (Alternatively, a 3830 Model 1 Storage Control, now offered only on an "as available" basis, can be used to control from one to four 3330 Disk Storage Modules, or two to eight drives; in this case, no 3333's are used.) One or two Two-Channel Switches can be added to the 3830 Storage Control to permit program-controlled switching between two or four channels on the same CPU or different CPU's. There is only one data path, however, for all drives connected to a 3830.

An "integrated" 3330 subsystem consists of one or two 3333 Disk Storage and Control modules, containing two

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prewritten cartridges containing all the control microprograms required for a specific installation.

RCS is an unusually effective microprogramming technique that has several significant advantages:

- Different versions of the system microcode, supporting different features and options, can be readily interchanged. The use of RCS made it relatively easy for IBM to add virtual storage capabilities to Models 135 and 145. What's more, at some appropriate future date, the System/370 processors could conceivably assume a radically different instruction repertoire and functional characteristics. Many of the functions now performed by software could be "built into the hardware" through the development of suitable control microprograms (the much-discussed "firmware" concept).

- Many of the capabilities which formerly required specialized hardware (floating-point arithmetic, emulators, block multiplexing, disk control logic, etc.) can now be implemented through microprogramming, at no extra cost to the user except for the RCS required to hold the microcode.

- Serviceability is enhanced because the basic system microcode can quickly be replaced by suitable diagnostic microprograms whenever maintenance is required.

Unfortunately, the cost of providing the RCS required to hold the microcode is by no means negligible. For example, every Model 135 system that includes the 3330 Integrated File Adapter will need at least one, and quite possibly two, 12K extensions of the basic 24K-byte RCS—and each 12K increment rents for $225 per month. In the Model 145, which houses its RCS in an extension of the semiconductor main memory, any increase beyond the basic 32K bytes of RCS is accompanied by an equivalent reduction in the system's main memory capacity.

HARDWARE FEATURES

The System/370 processing units share many significant characteristics with the earlier System/360 processors (Models 25 and above). Reflecting their "all-purpose" design philosophy, they have a large, complex instruction repertoire. They can perform fixed-point arithmetic in either fixed-length binary or variable-length decimal modes, and floating-point arithmetic on operands of three different sizes. In addition, they can perform radix conversions, code translations, and conversions between the packed (2 digits per byte) and unpacked (1 digit per byte) data formats. They have a comprehensive interrupt system that enables them to respond to a variety of special conditions, both internal and external. They have sixteen 32-bit general registers that can serve as accumu-

drives each. Up to three 3330 Disk Storage Modules, containing two drives each, can in turn be attached to each of the 3333 modules. The subsystem can be connected to a Model 135 via the 3330 Integrated File Adapter, to a Model 145 via the 3345 Storage and Control Frame (Model 3, 4, or 5), or to a Model 158 or 168 via the Integrated Storage Control (ISC). The ISC in a Model 158 or 168 Processing Unit includes two data paths (logical control units) and can control two 3330 subsystems containing a total of up to 32 drives.

OTHER MASS STORAGE DEVICES: In addition to the equipment described above, the following older IBM mass storage devices can also be included in a System/370 configuration:

2301 Drum Storage (with Models 165-195)
2303 Drum Storage
2311 Disk Storage Drive
2314 Direct Access Storage Facility, Series A
2321 Data Cell Drive

For details and prices of these units, please refer to the IBM System/360 report (70C-491-03).

INPUT/OUTPUT UNITS

2401 MAGNETIC TAPE UNIT, MODELS 1–6: These units have the following basic characteristics:

Model 1: 800 bpi; 30,000 bytes/sec at 37.5 in/sec.
Model 2: 800 bpi; 60,000 bytes/sec at 75.0 in/sec.
Model 3: 800 bpi; 90,000 bytes/sec at 112.5 in/sec.
Model 4: 1600 bpi; 60,000 bytes/sec at 37.5 in/sec.
Model 5: 1600 bpi; 120,000 bytes/sec at 75.0 in/sec.
Model 6: 1600 bpi; 180,000 bytes/sec at 112.5 in/sec.

All models use standard 1/2-inch, 9-track tape, have 0.6-inch inter-record gaps, and can read backward as well as forward. Models 1, 2, and 3 can alternatively be equipped with a 7-track head, making them compatible with the second-generation IBM 729 tape units. Models 4, 5, and 6 can be equipped with a Dual Density feature that enables them to operate at 800 bpi as well as 1600 bpi.

All models perform read-after-write checking of the data they record. Models 1, 2, and 3 perform vertical, longitudinal, and diagonal parity checks. Models 4, 5 and 6 perform vertical parity checking only, but can automatically correct single-track read errors without rereading.

Up to eight 2401 units can be connected to a 2803 (single-channel) or 2804 (dual-channel) Tape Control of the appropriate model. These tape drives are usable with all System/370 processor models.

The 2816 Switching Unit permits individual tape drives to be switched between two or more control units. One 2816 can accommodate a maximum of eight 2401 or 2420 Magnetic Tape Units and four 2803 Tape Controls.

2401 MAGNETIC TAPE UNIT, MODEL 8: This model is designed specifically for 7-track tape users; 9-track capability is not available. Standard 1/2-inch tape is read and written at 200, 556, or 800 bpi, with associated data transfer rates of 15,000, 41,700, or 60,000 characters/second. Up to eight 2401 Model 8 drives can be connected to a 2803 Model 3 (single-channel) or 2804 Model 3 (dual-channel) Tape Control. The Data Conversion Feature is standard on these tape controls, but the 2816 Switching Unit cannot be used.

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lators, index registers, or base address registers, as well as four 64-bit floating-point registers. And finally, when operating in the System/360-style Basic Control mode, they use a base-plus-displacement addressing scheme that permits direct addressing of up to 16 million bytes of core storage.

The System/370 adds 13 new instructions to the System/360's already large instruction set. The new instructions help reduce execution time and program storage requirements by enhancing decimal arithmetic performance, eliminating the need for multiple "move" instructions, and facilitating the blocking and unblocking of records. System/370 processors with virtual storage also include five additional instructions that facilitate control of the Dynamic Address Translation facility.

The Byte-Oriented Operand Feature, standard in the System/370, allows users to ignore, in part, the System/360 restriction that non-decimal operands must be stored in core locations whose addresses are integral multiples of the operand length. It is important to note, however, that significant performance degradation is likely to occur if programmers are allowed to take advantage of this feature and ignore the usual boundary constraints on operand placement.

Two standard hardware features help to make the System/370 a more "time-conscious" system. An improved interval timer with a resolution of 3.3 milliseconds facilitates the timing of short-duration tasks, while a time-of-day clock with a 1-microsecond resolution provides a consistent measure of elapsed time for job accounting, communications, and real-time functions. The new Clock Comparator and CPU Timer feature further expands the system timing capabilities.

The buffer (or cache) storage unit, which is a significant architectural feature of Models 155 through 195, consists of 8,192 to 32,768 bytes of fast-access semiconductor storage, depending upon the model. For all processor fetch operations, the buffer storage control determines whether the referenced data is available in buffer storage. If so, buffer storage is accessed; if not, main storage is accessed and the addressed data is both transmitted to the processor and loaded into buffer storage. Buffer loading is performed in units of 32-byte "blocks" in Models 165 and 168, and in 16-byte "halfblocks" in Models 155 and 158. A continuously updated index array provides rapid references to the main storage addresses of all data contained in buffer storage. Thus, in most applications there is a fairly high probability that the operands and instructions required by the processor will already be present in buffer storage and rapidly accessible. Moreover, all buffer storage operations are automatic and completely "transparent" to the System/370 programmer; he can simply ignore the existence of the buffer storage when writing his programs.

2415 MAGNETIC TAPE UNIT AND CONTROL: Consists of 2, 4, or 6 tape drives and an integral controller. Usable with System/370 Models 135 through 158. All 6 models of the 2415 use standard 1/2-inch, 9-track tape, have 0.6-inch inter-record gaps, and can read backward as well as forward. Optional features permit reading and writing of 7-track tape by all models, and of 800-bpi tape by the 1600-bpi models. The following models are available:

Model 1: 2 drives; 800 bpi; 15,000 bytes/sec.
Model 2: 4 drives; 800 bpi; 15,000 by es/sec.
Model 3: 6 drives; 800 bpi; 15,000 bytes/sec.
Model 4: 2 drives; 1600 bpi; 30,000 bytes/sec.
Model 5: 4 drives; 1600 bpi; 30,000 bytes/sec.
Model 6: 6 drives; 1600 bpi; 30,000 bytes/sec.

2420 MAGNETIC TAPE UNIT: A high-performance tape drive with automatic threading and a single-capstan vacuum drive. Uses standard 1/2-inch, 9-track tape, recorded at 1600 bpi. Model 5 transfers 160,000 bytes/sec and Model 7 transfers 320,000 bytes/sec. Up to 8 drives can be connected to a 2803 Model 2 Tape Control. The 2420 drives are usable with all System/370 processor models.

3410/3411 MAGNETIC TAPE SUBSYSTEM: These compact, low-cost tape units, designed primarily to bring magnetic tape capabilities to the small-scale IBM System/3 Model 10, are also available for use with System/370 Models 135 through 158. The 3410 is a tape unit only, while the 3411 contains both a tape unit and the subsystem control unit. The compact, waist-high cabinets are cable-connected to one another at the front corners, making it possible to place them side by side or at any angle up to 90 degrees to one another. The 3410 and 3411 are available in three models, whose principal characteristics are as follows:

	Model 1	Model 2	Model 3
Tape speed, inches/sec	12.5	25	50
Recording density, bpi	1600	1600/800*	1600/800*
Date rate, bytes/sec:			
At 1600 bpi (phase-encoded)	20,000	40,000	80,000
At 800 bpi (NRZI)	Not avail.	20,000	40,000*
Inter-block gap, inches	0.6	0.6	0.6
Rewind time, minutes/2400' reel	3	3	2

*Requires Dual Density feature.

All three models use half-inch tape recorded in the standard IBM 9-track formats. On a System/370, a 3411 Model 1 Magnetic Tape Unit and Control can accommodate up to three additional 3410 Model 1 Magnetic Tape Units for a maximum subsystem capacity of four tape drives. A 3411 Model 2 can control up to five additional 3410 Model 2 units, and a 3411 Model 3 can control up to five additional 3411 Model 3 units. Models cannot be intermixed within a subsystem. Every 3410 and 3411 tape unit must be equipped with either the Single Density (1600 bpi) or Dual Density (1600 or 800 bpi) feature; the Dual Density capability is not available for the Model 1 units. A System/360/370 Attachment is required on the 3411 Control Unit.

Features of the 3410/3411 subsystem include single-capstan drive, linear rewind, simplified tape threading, and a push-pull quick-release latch. As in the high-performance IBM 3803/3420 subsystem, the tape units are connected to

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Models 135 and 145 do not utilize the buffer memory concept. Cost/performance considerations apparently dictated the use of a single level of high-speed semiconductor main storage instead of the more complex two-level memories employed in the larger System/370 processors.

Curiously absent from the System/370 product line is any capability for effective multiprocessing. It is not currently possible for two or more System/370 processors to share a common bank of main storage-even though this capability is available for the System/360 Model 65 and has long been a feature of competitive lines from Burroughs, Control Data, Honeywell, and UNIVAC.

For their logic circuits (as distinguished from their memory circuits), the System/370 processors employ IBM's Monolithic Systems Technology (MST). Each MST logic chip is slightly over one-sixteenth of an inch square and contains more than 100 components forming up to 8 interconnected circuits. Thus, the circuit density is considerably lower than in the storage array chips, though the concepts employed are quite similar.

Along with performance and compatibility, IBM is strongly stressing increased reliability in the System/370. Admitting that the System/360 initially failed to operate at the reliability level its customers had come to expect, IBM has paid a great deal of attention to reliability and ease of maintenance in designing the System/370. An automatic retry capability for central processor operations and error-correcting circuits for main storage often make it possible to continue processing despite hardware faults. New hardware and software facilities, together with centrally located maintenance data banks, facilitate equipment servicing. Program Event Recording, a new standard feature in Models 135, 145, 158, and 168, is a dynamic debugging facility that aids in system maintenance by monitoring selected program events and triggering interrupts when they occur.

PERIPHERAL EQUIPMENT

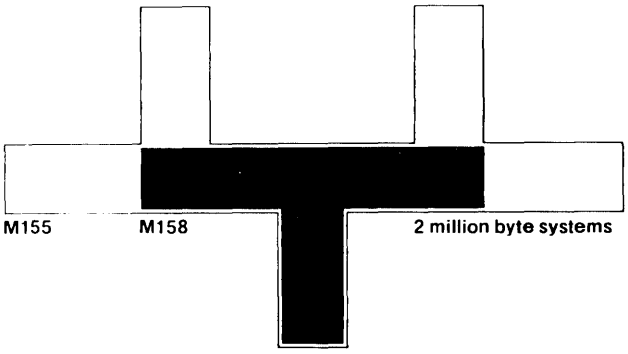
System/370 computers can utilize most of the 50-odd System/360 peripheral devices. The System/360 peripherals that are *not* supported for use in a System/370 configuration (mainly because of obsolescence or very limited user interest) are as follows:

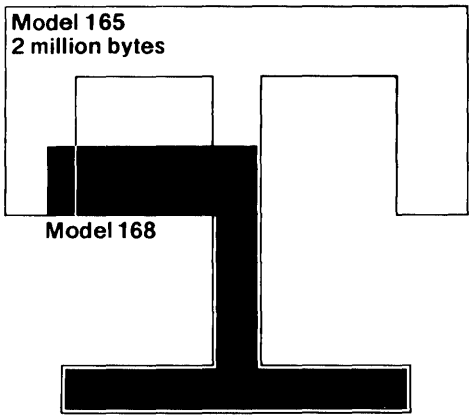
1231 Optical Mark Page Reader
1285 Optical Reader
1404 Printer
1412 Magnetic Character Reader
1418 Optical Character Reader
1428 Alphanumeric Optical Reader
1445 Printer
1827 Data Control Unit

the control unit in radial rather than series fashion to facilitate maintenance. Only digital signals are transmitted across the interface to reduce the sensitivity to noise. Deliveries of 3410/3411 subsystems to System/370 users are scheduled to begin in December 1972.

3420 MAGNETIC TAPE UNIT: An economical, high-performance tape drive introduced in November 1970. Incorporates the features of the earlier 2420 drives together with several worthwhile improvements. Air bearings and a single-capstan drive are used to reduce tape wear, and the tape's oxide surface touches only the read/write head and tape cleaner. Wraparound cartridge loading and automatic tape threading are standard features, and a new automatic reel latch makes it unnecessary for the operator to lock the tape reel in place. Additional tachometers control the reel motors' speeds for smoother winding. Read access times are considerably faster than those of the corresponding 2420 drives. A new "radial interface" connects each tape drive directly to the control unit, making it possible to switch individual drives off-line without cable changing. Principal characteristics of the three models are as follows:

Model 3: 75 inches/sec; 120,000 bytes/sec at 1600 bpi.
Model 5: 125 inches/sec; 200,000 bytes/sec at 1600 bpi.
Model 7: 200 inches/sec; 320,000 bytes/sec at 1600 bpi.





IBM's new MOS main memories result in greatly reduced floor-space requirements. The top illustration shows a 2-million-byte Model 158 CPU (shaded black) superimposed against a Model 155 with the same amount of core storage. Below, a 2-million-byte Model 168 CPU is similarly compared with a Model 165 of equivalent capacity.

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2302 Disk Storage
2361 Large-Capacity Core Storage
7340 Hypertape Drive
7772 Audio Response Unit.

In addition to the wide array of System/360 peripheral equipment, IBM has recently developed a number of noteworthy mass storage and input/output units primarily for use with the System/370. In general, these newer devices represent significant improvements in performance and/or economy. Examples are the high-performance 3330 Disk Storage facility, the economical 2319 Disk Storage facility, the 2000-1pm 3211 Printer, the low-priced 3411 Magnetic Tape Subsystem, the highly cost-effective 3420 Magnetic Tape Units, the 96-column 2596 Card Read Punch, the 3881 Optical Mark Reader, and the 3505 Card Reader and 3525 Card Punch, which share a microprogrammed control unit. Detailed descriptions of all these units can be found in the "Characteristics" section of this report.

Most significant of all the System/370 peripheral devices is the 3330 Disk Storage facility, a logical extension of the design concepts employed in the earlier 2314 Direct Access Storage Facility. The 3330 is making it economically feasible to implement a host of new applications that require rapid access to large on-line data banks. As compared with an 8-drive 2314-A facility, an 8-drive 3330 facility provides 3.4 times the storage capacity (800 million bytes versus 233 million), half the average head-positioning time (30 milliseconds versus 60), two-thirds the average rotational delay (8.4 milliseconds versus 12.5), and 2.6 times the data transfer rate (806,000 bytes per second versus 312,000)—all at a far lower cost per byte stored. In August 1972, IBM increased the maximum number of drives in a 3330 subsystem from 8 to 16 and announced integrated control features that reduce the cost of using 3330 drives with four of the System/370 processing units. Up to 16 drives (or 1.6 billion bytes) can be connected directly to a Model 135 or 145, while a Model 158 or 168 can handle up to 32 drives in two independent subsystems.

Most System/370 installations will use the 3330 as their virtual storage residence device, but users who need really high performance in a paging environment will probably find it necessary to install a 2305 Fixed-Head Storage Facility. The 2305 provides much faster access to comparatively small quantities of data. Unfortunately, its price is high—$6,400 per month for an 11.2-million-byte unit and its controller. The absence of a fast, economical fixed-head disk or drum is the most obvious weakness in IBM's current lineup of peripheral equipment.

COMMUNICATIONS

Until March 1972, communications control functions in the System/370, as in the System/360, were handled by the 2701 Data Adapter or the 2702 or 2703 Transmission

Operation in the basic 9-track mode, at 1600 bpi only, requires use of the Single-Density Feature on both the tape drives and the control unit. The Dual-Density Feature permits 9-track operation at either 1600 bpi (phase-encoded) or 800 bpi (NRZI). The 7-Track Feature permits 7-track operation in NRZI mode at either 556 or 800 bpi. One of these three optional features is required on every tape drive and every control unit.

The 3420 tape drives can be used with all of the System/370 processor models. Up to eight 3420 drives can be connected to a 3803 Tape Control. The control unit uses monolithic circuits and features "microdiagnostic programs" which facilitate maintenance. Optional Tape Switching Features permit two, three, or four control units to jointly access up to 16 tape drives. The Two-Channel Switch Feature permits a control unit to be accessed via either of two I/O channels.

2495 TAPE CARTRIDGE READER: Reads 16-millimeter sprocketed magnetic tape cartridges recorded by an IBM 50 Magnetic Data Inscriber or Magnetic Tape Selectric Typewriter (MTST). Recording density is 20 bpi, and rated speed is 900 bytes/sec. Feed hopper holds up to 12 cartridges, and successive cartridges are loaded and read automatically at the rate of about 1 cartridge per minute. Usable with Models 135 through 168.

1442 CARD READ PUNCH, MODEL N1: Reads 80-column cards at 400 cpm and punches them at 160 columns per second. Usable with Models 135 through 195; includes an integrated control unit.

1442 CARD PUNCH MODEL N2: Punches 80-column cards in column-by-column fashion at 160 columns per second (or 91 cpm when all 80 columns are punched). Usable with Models 135 through 168; includes an integrated control unit.

2501 CARD READER: Reads 80-column cards serially by column at either 600 cpm (Model B1) or 1000 cpm (Model B2). Usable with Models 135 through 195; includes an integrated control unit.

2520 CARD READ PUNCH, MODEL B1: Can read cards in column-by-column fashion, punch cards in row-by-row fashion, or read and punch simultaneously, at the rate of 500 cpm. Usable with Models 135 through 195; includes an integrated control unit.

2520 CARD PUNCH, MODELS B2 AND B3: Punches 80-column cards in row-by-row fashion at either 500 cpm (Model B2) or 300 cpm (Model B3). Usable with Models 135 through 195; includes an integrated control unit.

2540 CARD READ PUNCH: Consists of two functionally separate units, a 1000-cpm reader and a 300-cpm punch, in a single cabinet. Usable with Models 135 through 195. The 2821 Control Unit provides fully buffered card reading and punching; some models of the 2821 can also control one or two 1403 Printers.

2596 CARD READ PUNCH: Equips a System/370 computer to read, punch, and interpret IBM's new 96-column "minicards". Thus, the 2596 makes it possible to interchange 96-column card data between an IBM System/3 and the larger IBM computers. The 2596 has essentially the same mechanical specifications as the 5424 Model A2 Multi-Function Card Unit for the System/3 Model 10. It consists of two 2000-card input hoppers, a read station, a punch station, an optional print station, and four 600-card stackers. On the 2596 (unlike the 5424 MFCU), one input

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Controls, which place the communications processing burden squarely upon the associated central processor. Then IBM unveiled the 3705 Communications Controller, a minicomputer-based "front-end" processor that contains from 16K to 240K bytes of core storage and can control up to 352 communications lines.

When connected to a System/370 computer, the 3705 can use either the Network Control Program (NCP) or the 2701/2/3 Emulation Program. When the NCP is used, the 3705 relieves the central processor of many routine tasks such as line control, character and block checking, character buffering, polling, and error recovery. But when the 3705 is connected to a System/360 computer, it can function only in the 2701/2/3 Emulation mode. Thus, the 3705 will not enable System/360 users to obtain the increased central processor throughput that represents the biggest single benefit of front-end communications processing. This arbitrary limitation represents another far-from-subtle IBM move to pressure System/360 users into upgrading to a System/370.

Model 135 users can control small communications networks without the need for a separate communications controller by installing the Integrated Communications Adapter—another example of the flexibility and economy that can result from microprogrammed control. The ICA uses a combination of hardware logic and microcode to control up to eight lines operating at speeds of up to 4800 bits per second.

Virtually the entire complement of IBM communications terminals, as described in Reports 70D-491-02 through 70D-491-13, can be connected to a System/370—as can literally hundreds of terminals from independent suppliers.

SOFTWARE

Users of the virtual-storage System/370 processors (Models 135, 145, 155-II, 158, 165-II, and 168) can choose from as many as seven operating systems. Three of them—DOS, OS/MFT, and OS/MVT—are carried over from the System/360 and require the System/370 processor to operate in the Basic Control mode, which means that the virtual storage capabilities cannot be utilized. Three of the four "new" operating system—DOS/VS, OS/VS1, and OS/VS2—are functional extensions of DOS, OS/MFT, and OS/MVT, respectively; all three operate in the Extended Control mode and support up to 16 million bytes of virtual storage. Associated with each of these systems is a broad range of compilers, utility routines, and application programs. The seventh operating system, VM/370, manages the real resources of a System/370, including CPU time, to create and control multiple concurrent virtual machines.

DOS/VS is an upward extension of DOS that supports virtual storage, permits up to five jobs to be processed

hopper and two stackers are used for reading and the other input hopper and two stackers are used for punching. The 2596 cannot read and punch the same card during a single pass. Rated speeds are 500 cpm for reading and 120 cpm for punching. The optional Card Print feature permits interpretive printing of the data being punched. The printing is in a fixed format of three 32-character lines across the top of each card. Printing is performed simultaneously with punching at 120 cpm. The 2596 contains a built-in control unit and can be used with Models 135 through 195.

3505 CARD READER: Reads standard 80-column cards at either 800 cpm (Model B1) or 1200 cpm (Model B2). Contains its own fully buffered, microprogrammed control unit, and can be connected directly to any System/370 I/O channel. The 3505 reads cards photoelectrically, in column-by-column fashion, in either EBCDIC or card image mode. Vacuum-assisted friction feeding is used in place of the conventional "picker knife" feeding. If a card fails to feed, three retries are made automatically before a misfeed indication is given. The 3505 has a 3000-card file feed hopper and two 1750-card stackers. Whenever one stacker becomes full, cards are automatically directed to the other stacker while the operator empties the first one. A third, program-selectable 1750-card stacker is optional.

The optional Read Column Eliminate feature for the 3505 suppresses the reading (and checking) of data from specified card columns. The Optical Mark Read feature permits the reading of up to 40 columns of information marked on the cards with ordinary pencils; both marked fields and punched fields can be read during a single pass.

3525 CARD PUNCH: Punches standard 80-column cards at 100 cpm (Model P1), 200 cpm (Model P2), or 300 cpm (Model P3). Punches a row at a time, in either EBCDIC or card image mode. Utilizes the buffered control unit and power supply in the 3505 Card Reader, to which the 3525 is connected via a 3525 Adapter on the 3505. The 3505/3525 subsystem can be connected to any System/370 I/O channel.

The 3525 has a 1200-card feed hopper, two program-selectable 1200-card stackers, and a 200-card reject stacker. When a punching error is detected, the error card is directed to the reject stacker and the contents of the punch buffer are automatically repunched into the next card. If the retry is successful, the correct card is also routed to the error stacker to aid in diagnosing the malfunction. Finally, a third card is punched with the same data and stacked normally.

An optional Card Print unit for the 3525 uses engraved type slugs to print data on the cards in either an EBCDIC or ASCII 64-character set. The Two-Line Card Print feature prints one or two lines of up to 64 characters on each card during a single pass at the rated punching speed. Alternatively, the Multi-Line Card Print feature permits up to 25 lines, each 64 characters in length, to be printed on each card during a single pass. Card speeds are considerably reduced when more than 2 lines are printed; when all 25 lines are printed, the speed drops to 24 cpm for Model P1 and 29 cpm for Models P2 and P3.

The optional Card Read feature for the 3525 provides a parallel photoelectric reading station ahead of the punching station. The feature includes the Read Column Eliminate capability, which permits suppression of the reading (and checking) of data from specified card columns. Reading, punching, and printing operations can be performed on each card during a single pass.

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simultaneously (compared with the previous three), includes a new relocating loader, and features the POWER spooling facility as a built-in function. Although DOS/VS can support up to 16 million bytes of virtual storage, most installations will get better overall results by choosing to work within a considerably smaller virtual storage size. And, although DOS/VS provides automatic management of main storage allocation, it requires the user to divide the virtual storage space into a maximum of five fixed partitions and predetermine the programs to be executed in each partition. Thus, DOS/VS simply shifts the fixed-partition requirement of DOS from real storage into virtual storage—and falls far short of delivering all the promised benefits of virtual-storage operation. DOS/VS is scheduled for availability in June 1973.

OS/VS1 is an extension of OS/MFT that supports virtual storage and includes a few other improvements. In the words of one senior IBMer: "VS1's only real advantage is that it lets you run very large jobs you couldn't run before." VS1, like MFT, supports up to 15 fixed partitions—except that under VS1 the fixed partitions are in virtual storage rather than real storage. The partition sizes can be altered dynamically by the operator. As in the case of DOS/VS, most VS1 installations will find it wise to work with a virtual storage size that is considerably smaller than the 16-million-byte maximum. VS1 is currently in use in numerous IBM Datacenters and customer field-test locations—but the average time between unscheduled IPL's (i.e., system failures) at this writing is only 18 hours, so it is clear that considerable work remains to be done. IBM claims that VS1 is delivering throughput performance equal to or better than that of OS/MFT in most cases.

OS/VS2 is a significantly improved version of OS/MVT. In addition to supporting a full 16 million bytes of virtual storage, VS2 can handle up to 63 protected batch user regions or 42 TSO user regions, compared with a maximum of 15 regions for MVT. VS2, unlike the smaller IBM operating systems, should enable users to take full advantage of the flexibility that virtual storage promises—but the associated cost, in terms of system resources required for the operating system itself, is high.

Virtual Machine Facility/370 (VM/370) is a sort of "super operating system" that divides a System/370's real resources among two or more virtual machines. Each virtual machine, in turn, can run under any of the System/370 operating systems and is protected from failures in other virtual machines. VM/370, which is based upon CP-67/CMS for the 360/67, also includes a Conversational Monitor System that provides a general-purpose time-sharing capability. VM/370 should be useful in the development of new systems, conversion from one operating system to another, and provision of economical backup facilities. Its use in a pure production environment, however, will usually be ruled out by the the added

1017 PAPER TAPE READER: Reads 5- to 8-track punched tape at up to 120 char/sec. Model 1 reads strips of tape, while Model 2 includes supply and take-up reels. Usable with Models 135 through 158. Requires 2826 Paper Tape Control, which controls up to two 1017 Readers and two 1017 Punches.

1018 PAPER TAPE PUNCH: Punches 5- to 8-track tape at up to 120 char/sec. Usable with Models 135 through 158. Requires 2826 Paper Tape Control.

2671 PAPER TAPE READER: Reads 5- to 8-track punched tape in strip form at up to 1000 char/sec. Optional facilities permit center-roll or reel feeding and reel take-up at 500 char/sec. or more. Usable with Models 135 through 158. Requires 2822 Paper Tape Reader Control.

1403 PRINTER: Provides high-quality printed output by means of a horizontal chain or train mechanism. Standard character set contains 48 characters, expandable to up to 240 with the optional Universal Character Set feature (not available for Model 7). Standard skipping speed is 33 inches per second; a dual-speed carriage in Models 2 and N1 permits speed of 75 inches per second on skips of more than 8 lines. Model N1 has a motor-operated acoustical cover to reduce the noise level.

Models 2, 7, and N1 of the 1403 Printer can be connected to any System/370 processor via the 2821 Control Unit, or directly to a Model 135 via the optional Integrated Printer Adapter. Characteristics of the three models are as follows:

Model 2: 600 lpm; 132 print positions.
Model 7: 600 lpm; 120 print positions.
Model N1: 1100 lpm; 132 print positions.

1443 PRINTER, MODEL N1: Uses a horizontally oscillating typebar. Rated speed is 240 lpm with standard 52-character set. Standard model has 120 print positions, with 24 more positions available as an option. Selective Character Set Feature permits the use of other interchangeable typebars; speeds range from 200 lpm for 63-character set to 600 lpm for 13-character set. Usable with Models 135 through 195; includes an integrated control unit.

3211 PRINTER: Provides high-speed printed output by means of an endless "train" of 432 type characters that move horizontally in front of the printer hammers. The standard character set, consisting of 48 graphic characters in 9 identical arrays, yields a single-spaced printing speed of 2000 lines per minute. Speeds of up to 2500 lpm can be obtained with smaller character sets, and a 120-character Text Printing Set yields an expected printing speed of 906 lpm. The Universal Character Set feature is standard, permitting the use of character arrangements which are optimized for specific applications. Up to 254 different graphic characters can be used on a print train, and the train cartridges can be interchanged by an operator.

The 3211 Printer has a standard 132-character line that can be expanded to 150 print positions. Horizontal spacing is 10 characters/inch, and vertical spacing is 6 or 8 lines/inch. A 180-position forms control buffer, loadable from main storage, defines vertical format control operations, eliminating the need for a carriage control tape. Skipping speed is at least 30 inches per second, with acceleration to a maximum speed of 90 inches per second after 7 lines have passed. Forms ranging from 3.5 to 18.75 inches in width and from 3 to 24 inches in length can be handled. A powered forms stacker automatically compensates for the

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overhead and resulting performance degradation (typically in the range of 25 to 40 percent) that is unavoidably imposed by this additional level of software.

VSAM (Virtual Storage Access Method) is a new data access method that is available for DOS/VS, VS1, and VS2 as a replacement for ISAM. VSAM promises generally better performance than ISAM, improved security, and complete interchangeability of data sets among the three operating systems. IBM will supply utility routines to aid users in converting their files and programs from ISAM to VSAM.

With the announcement of the new virtual-storage operating systems, IBM has made it clear that there will be few, if any, future improvements to DOS, OS/MFT, or OS/MVT, and that free support for these systems will probably be withdrawn within the next two years. Thus, the IBM pressure upon System/360 users to upgrade to the System/370 continues to increase—and users of System/370 computers are now being similarly pressured to climb aboard the virtual storage bandwagon.

COMPATIBILITY

Designed as an evolutionary outgrowth of the System/360, the System/370 offers a high degree of program and data compatibility with the earlier IBM computer line. The new hardware features of the System/370 represent extensions, rather than modifications, of the System/360. As a result, System/360 users can run their application programs on a System/370 in the Basic Control mode with little or no modification and, in most cases, without recompilation. Conversely, it is not possible to directly execute System/370 programs on a System/360 if they make use of the System/370's new instructions or other new hardware features—but this type of downward compatibility is of far less importance to most users.

To run System/360 programs in Extended Control mode, under the new virtual-storage operating systems, all that will normally be required is a pass through the appropriate Linkage Editor. Most System/360 programs can be run in the virtual addressing (paged) mode, with the Linkage Editor performing the necessary division into appropriately sized pages. Programs that are highly time-dependent, and certain other programs that employ nonroutine coding techniques, cannot be paged and must be run in the "virtual-real" or non-swapped mode.

Integrated emulation is an optional System/370 capability that permits direct execution of most programs written for IBM's second-generation 1400 and 7000 Series computers. The table on page 70C-491-04c shows which compatibility features are available for each of the System/370 processor models. These compatibility options run under control of the regular operating system, enabling emulator jobs to be processed as part of a multiprogramming mix. Thus, IBM has granted another reprieve to the thousands of users who have not yet

height of the paper stack, and a self-positioning platen adjusts itself to the thickness of the forms being used. The 3211 can be connected to any System/370 processor via the 3811 Printer Control Unit.

1255 MAGNETIC CHARACTER READER: Reads and sorts MICR-encoded documents from 5.75 to 8.875 inches in length, 2.5 to 4.25 inches in width, and 0.003 to 0.007 inch in thickness. Three models are available. Model 1 reads up to 500 six-inch documents per minute, while Models 2 and 3 read up to 750 six-inch documents per minute. Models 1 and 2 have six horizontal stackers arranged in a single vertical bay and require one and one-half sort passes for each digit position. Model 3 has twelve horizontal stackers in two vertical bays. All three models can also be used for off-line sorting. The optional Self-Checking Number, 51-Column Card Sorting, and Dash Symbol Transmission features are available for all three models. Model 3 can also be equipped with the High-Order Zero and Blank Selection feature, which reduces off-line sorting times. One 1255 can be connected to a Model 135, 145, 155, or 158 via a System/360/370 Adapter.

1259 MAGNETIC CHARACTER READER, MODEL 2: Reads and sorts MICR-encoded documents at up to 600 per minute. Has 11 pockets. Usable only with Models 135 and 145. Also usable for off-line sorting.

1419 MAGNETIC CHARACTER READER: Reads and sorts MICR-encoded documents at up to 1600 per minute. Has 13 pockets. Usable with Models 135 through 168. Also usable for off-line sorting.

1287 OPTICAL READER: Optically reads printed characters into a System/360 at speeds ranging from less than 100 to about 665 documents per minute, depending on document size, number of characters per document, etc. Can also be equipped to read pencil-marked data and/or the handprinted digits 0 thru 9 and letters C, S, T, X, and Z; shapes and sizes of hanprinted characters must conform with specified rules. Usable with Models 135 through 168. Five models of the 1287 are available:

Model 1: Reads multiple lines of numeric data from individual paper or card documents up to 5.91 by 9 inches in size.

Model 2: Can read data from continuous journal tapes as well as individual paper or card documents.

Model 3: Same as Model 1, with added capability of reading the alphanumeric USASCSOCR Size A font.

Model 4: Same as Model 2, with added capability of reading the alphanumeric USASCSOCR Size A font.

Model 5: Reads multiple lines of handprinted numeric digits and six letters from individual paper or card documents.

1288 OPTICAL PAGE READER: Reads alphanumeric data printed in the USASCSOCR Size A font from page-size documents up to 9 by 14 inches. Can also be equipped to read pencil-marked data and/or the hand-printed digits 0 thru 9 and letters C, S, T, X, and Z. Speed varies with document size, number of characters and fields to be read, etc. (e.g., 14 documents per minute for 8.5-by-11-inch documents with 65 characters on each of 50 lines). Usable with Models 135 through 168.

3881 OPTICAL MARK READER: Reads machine-printed and/or hand-marked data from documents ranging from 3

gotten around to converting their second-generation programs—and simultaneously ensured that a high percentage of these users will stay "locked in" to IBM for several more years.

To date, the swing from the System/360 to System/370 has been marked by a noteworthy *lack* of conversion problems. The reason is simply that neither IBM nor its users can afford another conversion nightmare of the type that accompanied the advent of the System/360 in the mid-sixties, and IBM has obviously taken great pains to avoid a recurrence. The similarity of the System/370 architecture to that of the System/360, coupled with the use of essentially the same peripheral equipment and software, ensures comparatively smooth, straightforward conversions this time.

SUPPORT

As a result of IBM's "unbundled" pricing policy, announced in June 1969, System/370 users must pay separately for most of the educational courses, technical support, and software that were formerly included in IBM's equipment prices.

Most of the existing System/360 software facilities were delivered prior to IBM's unbundling announcement and are therefore available to System/370 users at no additional cost. But most System/370 users will find it advantageous—and in many cases essential—to use the improved assemblers, compilers, sort routines, and other software products that have been introduced during the past three years—and these new products are separately priced. Thus, it has become quite apparent that IBM computer users will henceforth be subjected to subtle pressures toward continual upgrading—to IBM's economic advantage—of their software as well as their hardware.

Because of the widely varying pricing and support policies now offered by IBM and its competitors, users who want to get the most value for their EDP dollars must shop more carefully and determinedly than ever. Hardware costs are now only the first part of the story; the quantities and costs of the required software, education, and professional assistance—and the numerous alternative sources of supply for them—must also be carefully evaluated. □

by 3 inches to 9 by 12 inches in size. Model 1 reads data directly into a System/370 Model 135 or 145 at a speed of 4000 to 6000 documents per hour, depending upon the document size. Model 2 operates off-line, transferring the data to a 3410 Model 1 Magnetic Tape Unit at a speed of 3700 to 5700 documents per hour. Up to 2480 marking positions are available on each 9-by-12-inch document. Up to six different document formats, loaded from format control sheets, can be stored and read during the same run. An optional BCD Read feature facilitates the processing of turnaround documents, and a Serial Numbering feature prints consecutive numbers on the documents being processed.

2250 DISPLAY UNIT: Displays data in both alphanumeric and graphic (line drawing) form in a 12-by-12-inch area on the face of a CRT. Displays up to 52 lines of 74 characters each, and provides format flexibility to position characters, points, and vector end-points anywhere on a 1024-by-1024-position grid. Optional light pen allows program detection of specific displayed points or characters indiciated by the operator. Optional keyboard permits entry of alphanumeric data. Model 1 has a built-in control unit and 4K or 8K bytes of buffer storage. Model 3 requires a 2840 Display control, which has a 32K buffer and can control up to four display units. Both models are designed for direct connection to System/370 Models 135 through 195.

TERMINALS: Numerous IBM display terminals, batch terminals, and typewriter terminals can be connected to a System/370 in remote and/or local configurations. For details, please refer to Reports 70D-491-02 through 70D-491-13 in the Peripherals section.

COMMUNICATIONS CONTROL

2701 DATA ADAPTER UNIT: Enables System/370 Models 135 through 195 to communicate, via appropriate transmission facilities, with a broad range of terminal equipment or with other computers. Accommodates up to four half-duplex start/stop lines with speeds of up to 600 bps; or up to four half-duplex synchronous lines (only two of which can operate simultaneously) with speeds of up to 230,400 bps; or up to four parallel data acquisition devices with word widths of 16 to 48 bits. The 2701 is highly modular; various adapters and special features equip it to transmit via switched or leased telephone lines, the TWX network, Western Union Type A, B, C, D, E, or F Channels, common-carrier broadband services, and privately-owned communication facilities.

2702 TRANSMISSION CONTROL: Permits connection of multiple low-speed terminals to a System/370, Models 135 through 195. Handles a maximum of 31 half-duplex lines with speeds of up to 200 bps, or up to 15 half-duplex lines with speeds of up to 600 bps, all of which can operate simultaneously. Transmission is serial by bit, in start/stop mode. Various adapters and special features equip the 2702 to transmit via switched or leased telephone lines, the TWX network, Western Union Type A, B, C, D, or E Channels, and suitable private communication facilities.

2703 TRANSMISSION CONTROL: Permits connection of multiple low-speed and medium-speed terminals to a System/370, Models 135 through 195. Operates in half-duplex fashion, in either start/stop or synchronous mode. In start/stop mode, a 2703 handles up to 176 lines with speeds of up to 180 bps or up to 72 lines with speeds of up to 600 bps. In synchronous mode, a 2703 handles up to 48 lines with speeds of up to 2400 bps, in either EBCDIC or USASCII code; if 6-bit Transcode is used, the maximum number of lines is 32. Various adapters and special features equip the 2703 to transmit via switched or leased telephone lines, the TWX network, Western Union Type A, B, C, D, E, or F Channels, and suitable private communication facilities.

2711 LINE ADAPTER UNIT: Accommodates up to 32 IBM Line Adapters, which permit an associated 2702 or 2703 Transmission Control or Model 135 Processing Unit to communicate with various IBM Terminals over leased telephone lines or privately-owned facilities. Common-carrier data sets are not required when IBM Line Adapters are used.

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3705 COMMUNICATIONS CONTROLLER: On March 1, 1972, IBM unveiled its long-awaited programmable communications processor for the System/360 and System/370 computers. Designed as IBM's evolutionary replacement for the hard-wired 2701, 2702, and 2703 transmission controls, the 3705 Communications Controller is a minicomputer-based front-end processor that can have from 16K to 240K bytes of core storage and control up to 352 communications lines. The 3705 is available in 20 models with varying storage sizes and line capacities, as listed in the price list. Customer shipments began in July 1972.

When connected to a System/370 computer, the 3705 can use either the Network Control Program (NCP) or the 2701/2/3 Emulation Program. When the NCP is used, the 3705 functions as a true "front-end" communications processor and relieves the central processor of many routine tasks such as line control, character and block checking, character buffering, polling, and error recovery.

The 3705 consists of a Basic Module and up to three Expansion Modules. The Basic Module houses the Central Control Unit and Control Panel. Also contained in these modules are the core storage, Channel Adapters, Communications Scanners, Line Interface Bases, and Line Sets required to accommodate up to 352 communication lines. Configuration rules for the 3705, which are quite complex, are summarized in the price list. The maximum number of lines that can be connected is a function of the 3705 model, the line line speeds and types, and the mode of operation. In the 2701/2/3 Emulation mode, a maximum of 255 lines can be controlled. Line speeds can range from 45.5 to 50,000 bits per second. Data is transferred between the 3705 and the host computer via a single subchannel interface–a significant difference from the 2701/2/3 controls, which require separate multiplexer subchannel for each communications line.

MODEL 135 INTEGRATED COMMUNICATIONS ADAPTER: This optional feature permits up to eight communications lines to be connected directly to a Model 135 Processing Unit, without the need for the usual separate communications controller. When the ICA is installed, each line appears to the Model 135 to be a subchannel of the Byte Multiplexer Channel. The ICA is controlled by a combination of microcode and hardware logic. The amount of control storage required for the ICA microcode varies with the number of lines, the types of terminal adapters, and the features employed.

The ICA supports private, leased, or switched half-duplex communications lines. Data rates of up to 4800 bits/second can be handled when self-clocking modems are used. When the ICA does the clocking, it can provide a data rate of 1200 bits/second or any rate between 0 and 600 bits/second.

The ICA provides up to eight line adapters in any combination of the following three types:

IBM Terminal Adapter Type I, Model II–supports communication, at either 134.5 or 600 bits/second, with an IBM 1050, 2740, 2741, or System/7.

IBM Terminal Adapter Type III–supports communication, at either 1200 or 2400 bits/second, with 2260 or 2265 Display Stations and their associated control units.

Synchronous Data Adapter Type II–supports communication, in BSC mode at up to 4800 bits/second, with an IBM 2770, 2780, 2790, 3735, or any of the following IBM computers equipped for BSC transmission: System/3, System/360, 1130, or 1800. Each BSC line can operate in any of three codes: EBCDIC, ASCII, or Six-Bit Transcode. The Autoanswer feature is available for the ICA, but the Autocall feature is not.

7770 AUDIO RESPONSE UNIT: Provides audio responses, in recorded human-voice form, to digital inquiries from pushbutton telephones or other inquiry-type terminals. Usable with Models 135 through 195. Handles a maximum of 48 lines, any or all of which can be active simultaneously. Has a 32-word basic vocabulary, expandable in 16-word increments to a maximum of 128 words. Receives inquiry messages and forwards them to the processing unit, which processes each message and composes an appropriate reply. The 7770 then converts the reply into a sequence of English words which are read from its magnetic drum and transmitted to the inquirer.

SOFTWARE

GENERAL: Software support for the System/370 Models 135 through 195 is basically the same as that provided for the System/360, plus an Extended Control (EC) or virtual mode of operation for Models 135, 145, 155-II, 158, 165-II, and 168 that utilizes the Dynamic Address Translation (DAT) hardware feature.

In Basic Control (BC) or real mode, either the Disk Operating System (DOS) or the Operating System (OS) can be used. Two versions of OS support are provided: Multiprogramming with a Fixed Number of Tasks (MFT) and Multiprogramming with a Variable Number of Tasks (MVT). The virtual-mode counterparts of these systems are Disk Operating System/Virtual Storage (DOS/VS), the Virtual Storage 1 option of the Operating System (OS/VS1 or VS1), and the Virtual Storage 2 option of the Operating System (OS/VS2 or VS2), respectively.

In addition to the above three virtual-storage extensions of existing operating systems, a higher-level control system called Virtual Machine Facility/370 (VM/370) is also

Operating System Availability

	135	145	155	155-II	158	165	165-II	168	195
DOS	Yes	Yes	Yes	4/73	4/73*	–	–	–	–
DOS/VS	6/73	6/73	–	12/73	12/73	–	–	–	–
OS/MFT	Yes	Yes	Yes	4/73	4/73	Yes	12/73	8/73	–
OS/MVT	–	Yes	Yes	4/73	4/73	Yes	12/73	8/73	Yes
OS/VS1	8/72	8/72	–	4/73	4/73	–	12/73	12/73	–
OS/VS2	–	12/72	–	4/73	4/73	–	12/73	8/73	–
VM/370	11/72	11/72	–	4/73	4/73	–	12/73	8/73	–

*Hard Stop mode only.

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available. VM/370 provides support for the Conversational Monitor System (CMS)—a general purpose time-sharing facility—as well as for all of the other real and/or virtual operating systems. The table shows which operating systems are available on which computer systems, including the scheduled availability date if the release is planned for the future.

Prior to the August 1972 announcement of virtual storage, the System/370 was compatible with the System/360 and operated under control of basically the same software. Thus, the great variety of System/360 DOS and OS compilers, assemblers, utilities, application packages, etc., was also available, for the most part, for use with the System/370. With the announcement of virtual storage, the full complement of existing System/370 Program Products is also available for the virtual machines, although a number of these programs must be run in a "virtual=real" or non-paged mode. (Any program that modifies active channel programs, contains I/O appendage routines, uses EXCP coding, or is highly time-dependent may not be pageable.) A full list of these Program Products is found in the Pricing section, with indicators showing whether each program can be paged (V) or can be executed only when fully resident in main memory (R, for virtual=real).

DISK OPERATING SYSTEM: DOS is a disk-oriented operating system for installations with at least 16K bytes of core storage and one 2311 Disk Storage Drive or 2314 or 2319 Direct Access Storage Facility. It was the most widely used of the System/360's eight operating systems and is currently being used on a high proportion of the installed System/370 computers. Multiprogramming, data communications, MICR processing, or COBOL compilation under DOS requires a minimum of 24K bytes. The Storage Protection feature is also required for multiprogramming.

DOS can control concurrent processing of one "background" program and one or two "foreground" programs, each in a fixed "partition" or program area within core storage. Partition sizes can be varied by the operator, in 2K increments. Programs in the background partition are executed sequentially, in automatic stacked-job fashion. Programs in one or both of the foreground partitions can be loaded and executed in similar stacked-job fashion if sufficient storage and I/O facilities are available; if not, each foreground program must be explicitly initiated by the operator. Foreground programs always have priority over the background program.

The principal DOS control program is the Supervisor, which handles I/O scheduling, interrupts, operator communications, multiprogramming control, etc. It occupies from 6K to over 12K bytes of core storage, depending upon the facilities required in a specific installation. A Job Control routine handles job-to-job transitions and I/O device assignments. A Librarian routine creates and maintains a core image library, a relocatable library, a source statement library, and optional private libraries, all on disk files. A Linkage Editor routine combines program sections from the relocatable libraries and/or a system input unit and prepares them for execution.

Several Input/Output Control Systems are available with DOS, providing macros to handle the following types of I/O: consecutive processing of tape or disk files, indexed sequential access method (for either random or sequential processing of sequentially organized disk files), direct access method (for randomly organized disk files), MICR or OCR input, and telecommunications. DOS provides two distinct types of communications support: the Basic Telecommunications Access Method (BTAM), which performs basic line and message control functions, and the Queued Telecommunications Access Method (QTAM), which extends the techniques of IBM's logical Input/Output Control Systems into the communications environment. BTAM requires a minimum of 24K bytes of core storage, while QTAM requires at least 65K bytes.

As an optional supplement to DOS, POWER II (Priority Output Writers, Execution Processors, and Input Readers) is a Type III DOS enhancement that adds input reader and output writer capabilities similar to those of the full Operating System. In addition to direct spooling capability, POWER II also has optional Remote Job Entry facilities to support up to five batch terminals. By overlapping I/O data transcriptions with disk-oriented processing, POWER II can increase the throughput of some DOS installations by up to 40 percent. Operating in a dedicated foreground partition, POWER II transcribes all input data from card readers and other low-speed input devices to disk storage and transcribes all output data from disk storage to printers and other output devices. Thus, the user's application programs can operate on a disk-to-disk basis for maximum processing efficiency. POWER II can support one or two independent batch job streams and up to 26 I/O devices.

DOS provides language translators for Assembler, RPG, COBOL, FORTRAN, and PL/I. Service routines include both disk and tape sort/merge programs, Autotest, and a wide variety of utility programs.

DOS is classified as a Type I-support program for operation on the System/370 in Basic Control mode only.

DISK OPERATING SYSTEM/VIRTUAL STORAGE: DOS/VS (Release 28 of DOS) is the fifth major version of DOS, and has been designed: (1) to extend to DOS a number of features that were previously reserved exclusively for OS, and (2) to implement support of virtual storage. Among the OS-type features added, DOS/VS allows the user to have: five problem program partitions (F1-F4 and BG) instead of three as in DOS (F1, F2, and BG); single or multi-phase user programs that are self-relocating through the use of a relocating loader; POWER (for spooling) with RJE capability as a built-in function at Sysgen time; procedure library support that allows JCL sets to be cataloged with extended support for procedures with Job Control, service program, and utility program statements; and a Dynamic Partition Priority adjustment capability to specify partition dispatching priority at Sysgen time and alter it at IPL or during system operation. Virtual storage support for the System/370 under DOS/VS recognizes up to 16 million bytes of virtual storage in pages of 2K bytes each.

The minimum system supported by DOS/VS is a Model 135 with 96K bytes. The actual minimum resident memory requirement for DOS/VS is 26K bytes for Models 135 and 145 and 28K bytes for Models 155-II and 158. Systems residence for DOS/VS must be on a 2319 or 3330-type direct-access storage device, or on a 2305 Model 2 Fixed-Head Storage Facility (not available for Model 135). Support for the 2311 Disk as a systems residence device is not provided, and DOS/VS does not support Rotational Position Sensing for 3330 Disks. DOS/VS will become available for Models 135 and 145 in June 1973, and for Models 155-II and 158 in December 1973.

Also available with DOS/VS is a new Assembler Language Translator and a new Virtual Storage Access Method. The Assembler is a superset of DOS Assemblers D and F that

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implements all of the System/370 instructions. Among the additions to the Assembler are the following: COPY statements are permitted anywhere in the program; the PRINT statement is effective in macro expansions; and a NOALIGN option allows utilization of the System/370 Byte-Oriented Operand feature by 360-type Assembly programs without recording.

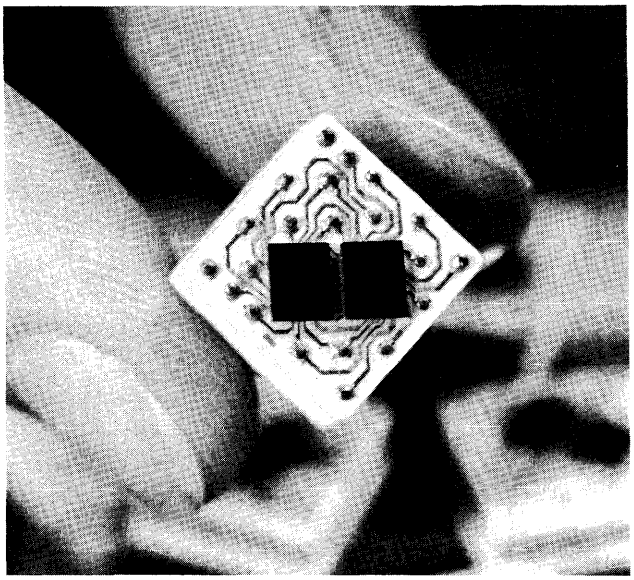
The Virtual Sequential Access Method (VSAM) is a major, optional data management extension that is available for both DOS/VS and OS/VS as an extension and replacement for ISAM. Data sets created by DOS/VS, OS/VS1, or OS/VS2 can be freely interchanged among the three operating systems. Among the features of VSAM are: (1) five types of indexing, including non-dense, key compression, replication, high-level main storage, and low-level with data; (2) distributed free space at the time the data set is created to eliminate ISAM-like overflow and automatically reclaim deleted record space; (3) master catalog with device independence; (4) password data set security protection; and (5) a variety of utility services, including an ISAM/SAM data set conversion facility and an ISAM Interface Program that maps ISAM requests into corresponding VSAM requests. VSAM has Class A support as an SCP component of DOS/VS, and will become available in June 1973.

OPERATING SYSTEM/360: OS is a comprehensive and general-purpose operating system for the System/360 and 370 computers. It is designed for installations with disk and/or drum storage facilities and sizeable main memory capacities. The system is highly modular and offers a broad range of control program options, language translators, data management techniques, and service programs. In large, multiprogrammed systems, the OS resident control programs alone may require as much as 200K bytes of core storage.

Two basic versions of OS are available for the System/370: Multiprogramming with a Fixed Number of Tasks (MFT), and Multiprogramming with a Variable Number of Tasks (MVT). They differ primarily in the amount and flexibility of the multiprogramming operations they can control. In both versions, the control programs perform the supervisory functions of job scheduling, resource allocation, I/O scheduling, interrupt control, error handling, and storage and retrieval of data.

Multiprogramming with a Fixed Number of Tasks (MFT) was delivered in December 1966, and a greatly improved "Version II" became available in July 1968. MFT provides the ability to control multiprogramming in up to 15 fixed partitions as small as 8K bytes in size. Partition sizes can be varied by the operator. Automatic job-to-job transistions can be effected in any or all of the partitions. MFT requires at least 131K bytes of core storage.

Multiprogramming with a Variable Number of Tasks (MVT), delivered in October 1967, controls multiprogrammed operation of up to 15 simultaneous tasks. The amount of storage allocated to each task and the number of tasks being processed at any time are dynamically variable. Core storage is allocated in 2048-byte blocks, and the blocks assigned to a given program may be non-contiguous. Task dispatching is performed on the basis of priorities, which may be altered by the tasks themselves during execution. A "roll-out/roll-in" facility enables one task to obtain more core storage by displacing one or more lower-priority tasks. MVT requires at least 262K bytes of core storage.



Silicon chips, each about one-eighth-inch square, contain 1024 microscopically small MOS data storage circuits for use in Models 158 and 168. Two of the chips are shown here mounted on a ceramic base, which is assembled into a tiny 4-chip storage module containing 4096 circuits.

Also available for OS/MVT is a Time-Sharing Option (TSO). This extension, announced in November 1969, permits interactive time-sharing operations to be run concurrently with teleprocessing and batch processing on a 524K-byte or larger system. Up to 14 regions can be devoted to time-sharing. Programmers at remote terminals can develop, execute, store, and modify programs written in any OS-supported language. COBOL, FORTRAN, and Assembler "prompters" permit the associated compilers to be used in a conversational mode, and dynamic debugging facilities aid in program testing. TSO also offers three compilers designed specifically for use by nonprogrammers: Code and Go FORTRAN, ITF-BASIC, and ITF-PL/I. TSO uses the OS/360 Telecommunications Access Method (TCAM) to handle all remote-terminal I/O operations. TSO-supported terminals include the IBM 2741, 1050, 2260, and 2265, and the Teletype Models 33 and 35. Most of the TSO functions are provided by separately priced IBM Program Products, as listed under "Software Prices."

I/O control under OS is accomplished by an extensive array of "data management" facilities. OS, like earlier IBM input/output control systems, supports two fundamental types of data access techniques: basic and queued. The queued access technique deals with individual logical records, provides automatic blocking and buffering facilities, and applies only to sequentially organized files. The basic access technique deals with blocks of I/O data rather than logical records, provides direct programmer control of blocking, buffering, and I/O device functions, and is usable with direct (random) and sequential file organizations.

IBM defines the combination of a specific data access technique and a specific type of file organization as a "data access method." Ten data and telecommunications access methods are available under OS: Basic Sequential Access Method (BSAM), Queued Sequential Access Method (QSAM), Basic Indexed Sequential Access Method (BISAM), Queued Indexed Sequential Access Method

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(QISAM), Basic Direct Access Method (BDAM), Basic Partitioned Access Method (BPAM), Telecommunications Access Method (TCAM), Basic Telecommunications Access Method (BTAM), Queued Telecommunications Access Method (QTAM), and Graphic Access Method (GAM). With Version 2 of the Information Management System (IMS-2), a separately priced Program Product, four hierarchical structures based on the standard OS access methods are also supported: Hierarchical Sequential Access Method (HSAM), Hierarchical Indexed Sequential Access Method (HISAM), Hierarchical Direct Access Method (HDAM), and Hierarchical Indexed Direct Access Method (HIDAM).

OS provides language translators for all of the System/360 or 370 programming languages: Assembler, RPG, COBOL, FORTRAN, PL/I, and ALGOL. Users of the Assembler, COBOL, or FORTRAN language, in fact, are offered a choice of two or more translators. OS service routines include a sort/merge program for either tape or disk, a TESTRAN package that facilitates program debugging, a Graphic Job Processor that permits jobs to be initiated and controlled from a 2250 Display Unit, a Remote Job Entry system that permits jobs to be submitted to a System/370 from a remote communications terminal, a Conversational Remote Job Entry (CRJE) system that supports concurrent on-line development of applications programmers from multiple remote terminals as if each programmer were in a hands-on environment, Linkage Editors that combine separately compiled object modules into programs in a format suitable for loading and execution, and a comprehensive package of utility routines.

Of particular interest are two additional OS support programs that are provided by IBM at no additional charge, but which are considered "prior use" software rather than System Control Programming (SCP): ASP Version 3 and HASP II.

The Asymmetric Multiprocessing System (formerly Attached Support Processor) is an application program that works in conjunction with OS to control a multiprocessing system with up to 32 processors–one of which is the host processor for ASP residence. Under ASP, the "support processor" (Model 50 or larger) handles all support functions (such as card reading, punching, and printing) and automates many of the operator functions while the host processor plus up to 31 additional "remote main processors" process the computational workload. The practical limit on the number of systems in an ASP network is about 4 or 5, however. ASP also supports remote job submission from binary synchronous communications (BSC) terminals via Remote Job Processing (RJP); and provides peripheral support for large job shop systems. In RJP functions, ASP is ordinarily used in conjunction with HASP to provide individual remote terminal programming support. The processors are interconnected by means of the Channel-to-Channel Adapter. ASP requires a minimum partition or region size under OS/MVT of about 150K bytes for the Single Processor version, plus about 20K bytes for RJP and about 20K bytes for each additional main processor. ASP is classified as a Type II program.

The Houston Automatic Spooling Priority System (HASP II) is a high-volume spooling package that can handle an essentially unlimited number of peripheral devices, including high-speed remote batch terminals, using 2311 and/or 2319-type direct-access devices for intermediate storage. This Type III prior-use program was developed by IBM's Houston office in conjunction with NASA. Minimum main memory resident requirement for HASP II is about 36K bytes under either OS/MFT or OS/MVT.

Future enhancements to OS will apply only to the virtual storage versions, OS/VS1 and OS/VS2. Thus, Release 21 of OS will be the last major functional release for OS/MFT and OS/MVT. Though these versions will be "functionally stabilized", subsequent maintenance releases to Release 21 will add support for a limited number of new I/O devices. Release 20 of OS will be current through June 1973, while no end of currency for Release 21 of OS has yet been announced. Free support for Release 21, however, is not likely to extend beyond 1974.

OPERATING SYSTEM/VIRTUAL STORAGE: OS/VS is the true System/370 Version of OS/360. It consists of two versions–OS/VS1 (or VS/1) and OS/VS2 (or VS/2)–that directly extend the capabilities of and are highly compatible with OS/MFT and OS/MVT, respectively.

In addition to the basic facilities offered by OS/MFT, VS1 supports a system total of up to 16 million bytes of virtual storage that is divided into 64K-byte segments and 2K-byte pages. Other new facilities of VS1 include: a Job Entry Subsystem (JES) that provides many of the most important functions of HASP, including Remote Entry Services (RES) and high-volume I/O spooling and scheduling, and supersedes HASP under VS1; additional control block protection; a Centralized Queue Manager facility with Scheduler Work Area Data Sets (SWADS) to improve utilization of the job queue and allow more jobs to be put into queue; and the Dynamic Support System (DSS), an interactive debugger used to identify and correct VS1 programming failures.

VS1 requires a minimum main or real storage size of 160K bytes, although most users will find a partition size of 240K bytes or larger to be more effective for their VS1 system. VS1 can be run on a Model 135 with 128K bytes of real memory if only one active partition is allowed for most environments, and neither OLTEP nor the external trace option of GTF is supported. A minimum of three direct access devices must be provided for VS1 system residence: at least two must be 2319- or 3330-type drives, and the third can be a 2305-2. VS1 was released and demonstrated on August 2, 1972, concurrently with the announcement of virtual storage for the System/370.

VS2 is a significantly improved version of OS/MVT. The enhancements of VS2 include support of a system total of 16 million bytes of virtual storage that is divided into 64K-byte segments and 4K-byte pages; virtual storage support of TSO in foreground regions, including native-mode support for the 3705 Communications Controller under TSO; up to 63 protected batch user regions or 42 TSO user regions (instead of 15 under MVT); Dynamic Priority Scheduling, including I/O load balancing based upon respective I/O data rates; Dynamic Support System (DSS) as in VS1; and a variety of virtual storage support features, including enhancements to the Linkage Editor, Systems Management Facilities (SMF), Link Pack Area (LPA), etc.

Concurrent operations of TSO, batch, and HASP are permitted under OS/VS2. With its availability under VS2, HASP must be run in the "virtual=real" mode only, making all of HASP resident in real memory during execution (i.e., nonpaged). HASP under VS2 has been upgraded to Programming Service Classification A. ASP Version 3 support is available under VS2, but also in virtual=real mode only, meaning that all of ASP must be resident in the support processor's real memory during execution. The Job Entry Subsystem provided for VS1 is not available under VS2. Otherwise, VS2 is upward-compatible with OS/MFT, OS/MVT, and OS/VS1, except for the CRJE facility, which is not supported under VS2.

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The minimum real memory requirement for a basic batch version of VS2 is 384K bytes. A concurrent batch and TSO system requires at least 512K bytes of real storage, and concurrent operation of HASP, batch, and TSO requires about 768K bytes of real storage. Release 1 of OS/VS2 is scheduled for availability in December 1972.

VSAM support is provided for both versions of OS/VS and is similar to VSAM support under DOS/VS, except that user exits for security routines other than standard password protection are provided and user VSAM catalogs are supported in addition to the master VSAM catalog. For OS/VS data set sharing, VSAM provides protection for multiple intra-region updates only.

OS/360 facilities that are not supported by either version of OS/VS include: main storage hierarchies involving Large Core Storage (LCS), QTAM (superseded by TCAM), RJE (superseded by RES in VS1 and HASP-ASP/RJE in VS2), TESTRAN, Graphic Job Processor, Rollout/Rollin (obviated by virtual storage), Multiprocessing (MP65), and Direct SYSOUT Writer.

VIRTUAL MACHINE FACILITY/370: VM/370 is a high-level operating environment that provides complementary time-sharing and virtual-machine support to the virtual programming systems provided by DOS/VS and OS/VS. VM/370 runs on the Advanced Function System/370 processors and consists of two major components: the Control Program (CP) and the Conversational Monitor System (CMS).

The VM/370 Control Program divides the resources of a System/370 configuration into multiple virtual machines and allows the concurrent execution of multiple operating systems in any mix: DOS, DOS/VS, OS/MFT, MVT, VS1 and VS2, and VM/370. Each virtual machine can have up to 16 million bytes of virtual storage. The capability to run multiple virtual machines simultaneously should aid System/370 users in developing new systems, converting from one operating system to another, scheduling complex workloads, and providing economical backup facilities.

The Conversational Monitor System (CMS) is an upgraded version of Control Program 67/Cambridge Monitor System (CP-67/CMS), originally designed and implemented on a limited basis in 1968 for use on the time-sharing System/360 Model 67. CMS is virtual storage-based and provides a general-purpose time-sharing capability. CMS supports the BASIC, ANS COBOL, FORTRAN IV, and PL/1 languages.

The minimum system that can support VM/370 is a 240K-byte Model 135. The resident memory requirement for the VM/370 control program is about 80K bytes of real storage plus about 2K bytes of real storage per active virtual machine. Release 1 of VM/370 is scheduled to become available in November 1972.

ITF (INTERACTIVE TERMINAL FACILITY): This separately priced IBM Program Product, announced in November 1969, permits interactive problem-solving on up to 31 terminals in either a dedicated or multiprogramming environment. The terminal users can program in either ITF-BASIC or ITF-PL/1, a subset of PL/1. Each user has access to both a common program library and a private library in which his own programs and data files are stored. ITF will support 10 to 12 terminals on either a 49K DOS (or DOS/VS) system or a 65K OS/360 (or OS/VS) system. Additional core storage permits the use of up to 31 terminals, as well as concurrent batch processing. IBM 2741 and Teletype Model 33 and 35 terminals are supported.

COBOL: IBM offers COBOL compilers under DOS, DOS/VS, OS/360, and OS/VS. DOS COBOL and OS/360 COBOL E use essentially the same source language, which includes many of the facilities of ANS COBOL but also has numerous incompatibilities and restrictions with respect to the standard language. OS/360 COBOL F, which requires at least 80K bytes of core storage for compilation, offers all the language facilities of COBOL E plus useful extensions such as the Sort and Report Writer facilities.

In 1968 IBM announced no-charge ANS (formerly USASI) COBOL compilers for operation under both DOS and OS/360. These two compilers implement the full American National Standard COBOL language as well as certain IBM extensions; the extensions are primarily in the areas of source-language debugging and mass-storage file accessing. IBM offers Language Conversion Programs to aid users in resolving the numerous detail differences between ANS COBOL and the earlier IBM COBOL languages. In 1971, IBM withdrew support of the OS/360 COBOL F compiler in favor of ANS COBOL. The latest and most powerful versions of both the DOS and OS ANS COBOL compilers are classified as separately priced Program Products.

The ANS Subset COBOL Compiler is another IBM Program Product, for use in DOS installations with as little as 32K bytes of storage and one disk drive. (Full ANS COBOL under OS requires at least 65K bytes.) The Subset COBOL language includes the following modules of ANS COBOL: Nucleus (Level 2), Sequential Access (Level 2), Random Access (Level 2), Library (Level 1), Table Handling (Level 2), and Segmentation (Level 1). The ANS Report Writer and Sort modules are not implemented.

For OS/360 and OS/VS, Full ANS COBOL is available in either Version 3 or Version 4, either of which is most conveniently invoked through the TSO COBOL Prompter. Both versions support TSO, and Version 4 can also be used under CMS. Version 3 (also available under DOS and DOS/VS) provides: modification of the generated code for OPEN and MOVE statements to give substantial savings in object-program space; an alphabetized cross-reference listing; a Flow Trace option that gives a formatted trace of a selected number of procedures; a Statement Number option for detailed information about the COBOL statement being executed at the time of an abnormal termination; expanded CLIST and DMAP functions to give more detailed information about the Data Division and Procedure Division; and a RERUN facility that allows automatic checkpoints at end-of-volume. In addition, ON statement count-conditional operands can be identifiers; the GIVING phrase (which requests statistics about an existing error) can be specified; and support is provided for creation and retrieval of ASCII tape files. Also, Version 3 can save machine time by batch compilation, allowing more than one COBOL source program to be processed with a single invocation of the compiler.

Version 4 of Full ANS COBOL provides the facilities of Version 3 plus advanced symbolic debugging; optimized object code; the ability to write teleprocessing (TP) programs in COBOL (in conjunction with TCAM); a COBOL library management facility; dynamic subprogram linkage giving the user object-time control of main storage; syntax-checking compilation; and string manipulation, for more flexible data handling. A Version 4 Interactive COBOL Debug is also available for use with OS under TSO.

FORTRAN: IBM offers ANS FORTRAN compilers for operation under all levels of System/370 software support as separately priced Program Products. These compilers also provide support for numerous IBM extensions to the language.

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Code and Go FORTRAN and the FORTRAN IV (G1) compiler are compile-and-go and batch-mode compilers, respectively, that use the same language level as FORTRAN G and operate under the OS/360 Time-Sharing Option (TSO) as well as under OS/VS. A TSO FORTRAN Prompter is also available to set up and execute the FORTRAN IV (G1) compiler. The FORTRAN IV (H Extended) compiler operates under OS/360 or OS/VS and provides all the facilities of FORTRAN H plus extended-precision arithmetic, asynchronous I/O, and other extensions. An Interactive FORTRAN Debug is available that can be used in conjunction with the Code and Go FORTRAN and FORTRAN IV (G1) compilers in the TSO foreground or under the CMS option of VM/370.

Under DOS or DOS/VS, a DOS FORTRAN IV compiler (not a Program Product) permits the use of an enhanced ANS FORTRAN IV language that includes direct-access I/O statements and arrays of up to seven dimensions.

PL/1: IBM currently offers compilers for PL/1, its multipurpose programming language, under DOS, DOS/VS, OS/360, OS/VS, and ITF. PL/1 includes a broad range of language facilities suitable for both business and scientific programming, enabling it to handle applications beyond the scope of either COBOL or FORTRAN. Despite its power, PL/1 has not yet found widespread acceptance among users.

The OS/360 PL/1 F compiler requires at least 44K bytes of core storage and handles most—but by no means all—of the language facilities defined by PL/1's co-developers, IBM and the SHARE user group. It provides facilities for handling numerous data types and arithmetic modes, dynamic storage allocation, source-language debugging, data communications, sorting, program segmentation, etc. Moreover, it accommodates six different data access modes: BSAM, QSAM, BISAM, QISAM, BDAM, and QTAM.

The DOS and DOS/VS PL/1 compilers accommodate a "Basic PL/1" language whose facilities are a proper subset of, but considerably less extensive than, those of OS/360 PL/1. Both compilers can be used in 16K-byte systems.

Several other PL/1 compilers are offered as separately priced Program Products. PL/1 Optimizing Compilers offer improvements in compilation speed, object program efficiency, and language facilities through proper use of three optimization options. The OS PL/1 Checkout Compiler is an interpretive processor for the PL/1 F language that features high translation speeds and effective diagnostic and debugging capabilities; it can be used in batch mode under MFT, MVT, VS1, or VS2, or in conversational mode under TSO. ITF-PL/1 uses a subset of the PL/1 language and is designed specifically for time-sharing operation under ITF.

BASIC: The BASIC language, which is gaining widespread popularity for problem-solving applications because of its simplicity and ease of use, is supported for time-sharing use under either ITF or TSO. The BASIC compilers are separately priced Program Products. The language features extensive matrix handling facilities and a variety of built-in mathematical functions, but arrays are limited to two dimensions.

APL: Conceived in the early 1960's by Dr. Kenneth E. Iverson of IBM, the APL language is designed to permit clear, concise expression of computational algorithms. Its facilities for handling vectors and arrays are especially powerful. The APL/360 system is a separately priced Program Product, available for time-shared operation under DOS, DOS/VS, OS, or OS/VS. The system requires a minimum partition of 170K bytes and supports IBM 2740, 2741 and 1050 terminals.

ALGOL: As a reluctant concession to current ALGOL users, IBM offers a single ALGOL compiler, which operates under OS on a system with at least 65K bytes of core storage. The OS/360 ALGOL language is a proper subset of ALGOL 60 that encompasses the ECMA and IFIP subsets and provides the IFIP Input/Output Procedures and other useful additions. IBM has stated that it plans no further ALGOL compiler development work and is encouraging ALGOL users to switch to PL/I.

REPORT PROGRAM GENERATORS: IBM offers RPG II as a Program Product for use under DOS or DOS/VS. Both versions use data from five types of user-prepared specification sheets to generate object programs to perform common business data processing functions. If desired, the generated programs can be executed immediately. RPG II for the System/370 is generally compatible with RPG II for the small-scale IBM System/3, where it is the principal language. All of the facilities of the System/3 language are supported except the telecommunications and automatic program overlay functions. Thus, the availability of RPG II for the System/370 represents a significant step toward improved compatibility between the System/3 and the larger IBM computers.

Compilers for the original System/360 RPG language are also available for operation under DOS or OS/360. If desired, the generated programs can be executed immediately. In addition to their basic report-writing functions, RPG programs can handle various types of calculations, update files, perform table look-up operations, accept data from multiple input files, and accommodate user-coded routines to handle functions that cannot be programmed in the RPG language.

ASSEMBLERS: The Assembler language, often called BAL (Basic Assembly Language) or ALP (Assembly Language Programming), is the standard symbolic assembly language used to write machine-oriented programs for all models of the System/370. Assemblers are therefore furnished at all levels of System/370 software support. Facilities for handling macro-instructions and literals are provided at all levels. Though the Assembler language is essentially the same at all the various levels, there are certain differences in the handling of literals, constants, and macros that preclude complete freedom to transfer Assembler-coded programs between the various operating systems.

DOS and OS/360 users are offered a choice of two Assemblers. The two DOS Assemblers require 10K and 44K bytes of core storage. OS/360 Assemblers E and F require a minimum of 18K and 44K bytes, respectively. In both cases, the larger version provides considerably faster assembly.

The new DOS/VS Assembler is a superset of the earlier DOS Assemblers that implements all of the System/370 instructions and promises improved performance through the use of a pre-edited macro library.

OS Assembler H is a separately priced Program Product that requires at least 200K bytes. It is upward-compatible with the other System/370 assemblers and features improved

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assembly speed (as much as 50 percent faster than earlier versions) macro language extensions, improved diagnostics, batched assemblies within a single job step, and support of the new machine instructions in the System/370 processors. OS Assembler H runs under MFT, MVT, VS1, or VS2. A subset of Assembler H—the System Assembler—is the only language translator provided as a standard component of VS.

UTILITY ROUTINES: Sort/merge programs are offered at all levels of software support for the System/370. All are generalized programs which are controlled by user-supplied parameters, and all can accommodate either fixed or variable-length records. Improved sort/merge programs for both DOS and OS are offered as separately priced Program Products. The enhanced OS or OS/VS version of the Sort/Merge utility program, called OS-SM1, has features and capabilities similar to those of the DOS-SM1 Sort/Merge package, announced in April 1970, which can also function with the System/370. Existing user-prepared control cards and exit routines can be used with no change when using the new Sort/Merge programs.

The new OS or OS/VS Sort/Merge is approximately 10 percent faster than its earlier counterpart, and the DOS or DOS/VS improvement can be up to 42 percent, according to IBM. The OS Sort/Merge program fully supports the 3330 Disk Storage Facility. The new Sort/Merge programs also include support for ASCII-formatted files recorded on 9-track magnetic tape and offer expanded exit facilities to assist the user in writing his own-code additions to the sort/merge process.

Each software level also includes an appropriate complement of data transcription, diagnostic, and other utility routines.

RETAIN/370: This is a system maintenance software package introduced with the System/370. Its acronym stands for "Remote Technical Assistance and Information Network." Its purpose is to provide special assistance to the IBM Customer Engineers when they encounter unusual difficulties in solving complex hardware maintenance problems.

IBM is creating data banks of technical information on hardware problems in Technical Support Centers in New York, Chicago, and Los Angeles. Through RETAIN/370, Customer Engineers can dial up access to these data banks and request any available information in the specific problems at hand. A technician at the support center views any available information on a display screen and relays anything pertinent to the Customer Engineer. If the results are uninformative, the technician at the support center can initiate remote testing of the malfunctioning unit or system for his own analysis and evaluation. When a solution is finally reached, it is stored in the support center's data bank for use whenever a similar problem arises.

MSP/7 HOST PROGRAM PREPARATION FACILITY II: This facility permits the preparation of System/7 programs on a System/370 computer under DOS, DOS/VS, OS, or OS/VS. HPPF II provides an MSP/7 Macro Library, with System/7 assembler/macro control and I/O subroutines, and the System/7's Host Macro Assemblers (ASM/7), Host Linkage Editors (LINK/7), and Host Storage Load Formatting Program (FORMAT/7). The HPPF II programs are classified as System Control Programming and can run in a paged mode on the System/370 virtual systems.

APPLICATION PROGRAMS: An enormous number of "packaged" application programs—more than 2500—are now available for the System/370 at no charge from IBM as "Prior Use" Type I, II, III, or IV software. These programs were in general use on the System/360 prior to unbundling on December 31, 1969. While many of these programs are rather simple utilities, others are major systems representing dozens of man-years of effort that have subsequently been made available in improved and maintained versions for a fee as IBM Program Products. The Prior Use programs are provided with no free IBM support. Information concerning these programs is available in the *Catalog of Programs for IBM System/360 Models 25 and Above* (GC20-1619).

In the separately priced application programs category, three types of programs are available: Program Products, Field Developed Programs (FDP's), and Installed User Programs (IUP's). Limited support is provided for the FDP's and IUP's (which were first made available in August and October 1971, respectively); it consists only of pertinent error-correction information during the first six months after initial general availability of the programs. Nearly three dozen FDP's and less than one dozen IUP's are currently available.

A list of the currently available System/370 Program Products can be found in the price list at the end of this report, along with an indicator showing whether or not each program can run in virtual (paged) mode.

Three major Program Products with the broadest general interest are described below:

- Generalized Information System, Version 2: GIS/2 provides sets of generalized routines that handle the creation and maintenance of structured data bases, selective retrieval of information, and preparation of customized reports. The system operates under OS/360 or OS/VS and requires a minimum of 196K or 524K bytes for the MFT (VS1) or MVT (VS2) version, respectively.
- Information Management System, Version 2: IMS 2 is designed to ease the task of creating, maintaining and accessing large direct-access data files, including support for the 3330 Disk Storage Facility. A new data base indexing capability permits the inter-relating of multiple data bases. Access to logically related data files stored on direct-access devices can be in either direct or indexed direct fashion.

  IMS 2 is provided in two versions, one for batch processing data base (DB) environments and one for data communications (DB/DC) environments, in which the access to centrally stored data files takes place through remote terminals.

  IMS 2 must be run in virtual-real (non-paged) mode under VS. The user must provide suitable application programs written in COBOL, PL/1, or Assembler language. The minimum resident main memory requirement for the DB system is 76K bytes under MFT or 81K bytes under MVT, while the DB/DC system requires 175K bytes under MFT and 171K bytes under MVT.

- Customer Information Control System (CICS): CICS is a transaction-oriented, multi-application data base/data communications, (DB/DC) interface between any System/370 operating system and user-written application programs in an on-line environment. CICS provides standard facilities for message switching, terminal inquiry, data collection, order entry, and interactive processing. CICS for DOS (or DOS/VS) requires a minimum main memory of 30K or 44K bytes for the Entry or Standard versions, respectively. Under OS/360 (or OS/VS), CICS-2 requires 64K bytes of resident main memory.

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PRICING

EQUIPMENT: The following systems illustrate typical System/370 configurations. Obviously, they comprise only a small sampling of the extensive configuration possibilities within the System/370 line. All necessary control units and adapters are included in the indicated prices, and the quoted rental prices include equipment maintenance.

SMALL MODEL 135 DISK SYSTEM: Consists of 98K Model 135 Processing Unit with Integrated File Adapter, 2319 Disk Storage Facility (3 drives, 87 million bytes total), 3505 Model B1 Card Reader, 3525 Model P2 Card Punch, 1403 Model 2 Printer, and 3210 Model 1 Console Printer-Keyboard. Monthly rental and purchase prices are approximately $10,300 and $476,000, respectively.

MODEL 135 TAPE/DISK SYSTEM: Consists of 245K Model 135 Processing Unit with Integrated File Adapter, two Selector Channels, and 12K Control Storage Expansion, 2319 Disk Storage Facility with one additional 2312 Disk Drive (4 drives, 116 million bytes total), eight 3420 Model 3 Magnetic Tape Units (120KB) and dual tape controls, 3505 Model B2 Card Reader, 3525 Model P3 Card Punch, 1403 Model N1 Printer, and 3210 Model 1 Console Printer-Keyboard. Monthly rental and purchase prices are approximately $19,700 and $869,000, respectively.

MODEL 145 TAPE/DISK SYSTEM: Consists of 262K Model 145 Processor with Integrated File Adapter and Two Selector Channels, 2319 Disk Storage Facility with one additional 2312 Disk Drive (4 drives, 116 million bytes total), eight 3420 Model 3 Magnetic Tape Units (120K) and dual-channel tape controls, 2540 Card Read Punch, 1403 Model N1 Printer, and 3210 Model I Console Printer-keyboard. Monthly rental and purchase prices are approximately $24,300 and $1,089,000, respective.

EXPANDED MODEL 145 TAPE/DISK SYSTEM: Consists of 524K Model 145 Processor with four Selector Channels, Block Multiplexer Channel and Word Buffer Features, 3346 Main Storage Frame, 3046 Power Unit, eight-drive 3330 Disk Storage facility (800 million bytes), twelve 3420 Model 5 Magnetic Tape Units (200KB) and two tape controls, two 2540 Card Read Punches, two 3211 Printers, and 3215 Console Printer-Keyboard. Monthly rental and purchase prices are approximately $43,500 and $1,899,000, respectively.

MODEL 158 TAPE/DISK SYSTEM: Consists of 1048K Model 158 Processor with four Block Multiplexer Channels and two Byte Multiplexer Channels, eight-drive 3330 Disk Storage facility (800 million bytes), 2305 Model 2 Fixed-Head Storage Facility (11.2 million bytes), twelve 3420 Model 5 Magnetic Tape Units (200KB) and two tape controls, two 2540 Card Read Punches, and two 3211 Printers. Monthly rental and purchase prices are approximately $68,000 and $3,018,000, respectively.

MODEL 168 TAPE/DISK SYSTEM: Consists of 2097K Model 168 Processor with Buffer Expansion and High-Speed Multiply features, four Block Multiplexer Channels, two Byte Multiplexer Channels, two 8-drive 3330 Disk Storage facilities (1600 million bytes), 2305 Model 2 Fixed-Head Storage Facility (11.2 million bytes), twelve 3420 Model 7 Magnetic Tape Units (320KB) and two tape controls, two 2540 Card Read Punches, two 3211 Printers, and 3066 System Console. Monthly rental and purchase prices are approximately $120,900 and $5,517,000, respectively.

SOFTWARE: System/360 software which was being distributed by the IBM Program Library as of June 23, 1969, is available to System/370 users at no additional charge. All subsequent IBM programming announcements (except for certain modifications and improvements of existing IBM programs) are designated as either System Control Programming or Program Products.

System Control Programming provides functions which are fundamental to the operation and maintenance of a system (e.g., loading, scheduling, supervising, and data management) and is available without charge.

Program Products are related to the application of a system to user tasks (e.g., compilers, utility programs, and application programs). These are offered on an individual-charge basis, as listed under "Software Prices."

Also available on an individual-charge basis, but without centralized IBM programming support, are approximately 34 Field-Developed Programs and 7 Installed User Programs for the System/370.

SUPPORT: IBM Systems Engineering assistance is available to System/370 users at a basic rate of $28 or $35 per hour, depending upon the size and complexity of the system.

EDUCATION: IBM "Professional Courses" are now individually priced. System Features Instruction is offered to users of IBM data processing equipment at no charge. Customer Executive Seminars, Industry Seminars, and promotional sessions are still offered at no charge by IBM invitation.

CONTRACT TERMS: The standard IBM rental contract includes equipment maintenance and entitles the customer to up to 176 hours of billable time per month. Time used in excess of that amount is charged for, on all machines equipped with meters, at an extra-use rate. This rate, for most System/370 components, is 10% of the basic hourly rate (i.e., 10% of 1/176 of the monthly rental for each hour of extra use).

IBM'S Fixed-Term Lease Plan, introduced on June 1, 1971, offers price reductions of 8 or 16 percent from the short-term monthly rental rates to users willing to sign a 12-month or 24-month contract, respectively. The Fixed-Term Leases apply to nearly all of the System/370 magnetic tape, disk, drum, and printer units and to the associated control units and features, but not to the mainframes or other types of peripheral devices. Extra-use charges are eliminated under these leases, and up to two years of purchase option accruals are available. The user has the option to extend his lease for an indefinite number of additional 12-month or 24-month periods and for one shorter period under the same terms. Users who elect to cancel a Fixed-Term Lease will be assessed a penalty of 2.5 times the monthly rental on a 12-month contract or 5 times the monthly rental on a 24-month contract (or the remaining due, whichever is less).

IBM's Extended-Term Lease Plan, introduced with the 3705 Communications Controller on March 1, 1972, is a more flexible lease plan under which "selected machines" will be offered. The plan has a basic contract period of 24 months and offers monthly charges approximately 15% below the short-term rental prices. Significant provisions of the Extended-Term Plan include: elimination of additional-use charges, unlimited one-year extensions after the initial contract period, a single extension of less than one year, purchase option credits for 24 months, protection against price increases during the contract period, and upgrading of installed machines (through field-installable features and model changes) without termination charges. Charges for early termination decline from a maximum of five times the monthly charge (for the first six months of the lease) to the smaller of two times the monthly charge or the remaining amount due (during the last six months of the initial contract period or during any extension). ■

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*
PROCESSORS AND MAIN STORAGE				
3135	Processing Unit (for Model 135 system):			
	Model FE; 98,304 bytes	281,230	460	5,670
	Model GD; 147,456 bytes	325,255	490	6,570
	Model GF; 196,608 bytes	369,280	520	7,470
	Model DH; 245,760 bytes	413,305	550	8,370
3046	Power Unit (required for 3135)	15,550	33	324
3145	Processing Unit (for Model 145 system):			
	Model GE; 163,840 bytes	583,440	1,070	12,155
	Model GFD; 212,992 bytes	626,640	1,100	13,055
	Model H; 262,144 bytes	669,840	1,130	13,955
	Model HG; 393,316 bytes when used with a 3345 Model 1 or 4	670,845	1,135	13,975
	Model I; 524,288 bytes when used with a 3345 Model 2 or 5	671,850	1,135	13,995
3345	Storage and Control Frame (for Model 145):			
	Model 1; 131,072 bytes	138,240	90	2,880
	Model 2; 262,144 bytes	252,480	165	5,260
	Model 3; Integrated 3330 Disk Storage Control	60,000	85	1,250
	Model 4; 131,072 bytes plus Integrated 3330 Disk Storage Control	193,440	175	4,030
	Model 5; 262,144 bytes plus Integrated 3330 Disk Storage Control	307,680	250	6,410
8100	Two-Channel Switch for 3345 Model 3, 4, or 5	9,710	10	200
3046	Power Unit (required for 3345 Model 1, 2, 4, or 5)	15,550	33	324
3155	Processing Unit (for Model 155 system; requires 3360 Mod. 1, 2, or 3 Processor Storage)			
	Model H; 262,144 bytes	959,040	1,730	19,980
	Model HG; 393,216 bytes	960,240	1,730	20,005
	Model I; 524,288 bytes	961,440	1,730	20,030
	Model IH; 786,432 bytes	984,960	1,740	20,520
	Model J; 1,048,576 bytes	987,360	1,740	20,570
	Model JI; 1,572,964 bytes	1,070,400	1,790	22,300
	Model K; 2,097,152 bytes	1,096,320	1,800	22,840
3360	Processor Storage (for Model 155);			
	Mod. 1; 262,144 bytes	132,000	290	3,000
	Mod. 2; 393,216 bytes	198,000	435	4,500
	Mod. 3; 524,288 bytes	264,000	580	6,000
3158	Processing Unit (for Model 158 system; includes semiconductor main storage as indicated)			
	Model I; 524,288 bytes	1,615,200	1,940	33,300
	Model J; 1,048,576 bytes	1,730,100	2,000	35,900
	Model JI; 1,572,864 bytes	1,845,000	2,060	38,500
	Model K; 2,097,152 bytes	1,959,900	2,120	41,100
3165	Processing Unit (for Model 165 system; requires 3360 Mod. 4 or 5 Processor Storage)			
	Model I; 524,288 bytes	1,710,720	2,970	35,640
	Model J; 1,048,576 bytes	1,715,760	2,980	35,745
	Model JI; 1,572,864 bytes	1,736,640	3,010	36,180
	Model K; 2,097,152 bytes	1,752,000	3,060	36,500
	Model KJ; 3,145,728 bytes	1,803,840	3,160	37,580
3066-1	System Console (required in Model 165 system)	160,560	460	3,345
3067-1	Power and Coolant Distribution Unit (required in Model 165 system)	119,040	110	2,480
9447	208/230-volt Motor Generator Set (for Model 165)	15,000	–	Purchase only
9449	440-volt Motor Generator Set (for Model 165)	15,000	–	Purchase only
3360	Processor Storage (for Model 165);			
	Mod. 4; 262,144 bytes	132,000	290	3,000
	Mod. 5; 524,288 bytes	264,000	580	6,000
3168	Processing Unit (for Model 168 system; includes semiconductor main storage as indicated)			
	Model J; 1,048,576 bytes	2,611,900	4,230	53,800
	Model K; 2,097,152 bytes	2,841,700	4,350	59,000
	Model KJ; 3,145,728 bytes	3,081,300	4,630	64,400
	Model L; 4,194,304 bytes	3,311,100	4,750	69,600
3066-2	System Console (required in Model 168 system)	160,560	460	3,345
3067-2	Power and Coolant Distribution Unit (required in Model 168 system)	119,040	110	2,480
9447	208/230-volt Motor Generator Set (for Model 168)	15,000	–	Purchase only
9449	440-volt Motor Generator Set (for Model 168)	15,000	–	Purchase only
3195	Processing Unit (for Model 195 system; includes core storage as indicated)			
	Model J1; 1,048,576 bytes	4,366,000	13,135	100,800
	Model K1; 2,097,152 bytes	5,866,000	13,885	131,800
	Model KJ1; 3,145,728 bytes	6,900,000	14,700	152,800
	Model L1; 4,194,304 bytes	7,866,000	15,385	171,800
3060	System Console (required in Model 195 system)	308,000	450	7,200
3080	Power Units (three required in Model 195 system)	37,400	15	850
3085	Power Distribution Unit (required in Model 195 system)	30,800	10	700
3086	Coolant Distribution Unit (required in Model 195 system)	33,000	10	750

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*
PROCESSORS AND MAIN STORAGE (Continued)				
9442	208/230-volt Motor Generator Set (for Model 195)	14,500	–	Purchase only
9443	440-volt Motor Generator Set (for Model 195)	14,500	–	Purchase only
NOTE:	A purchased Model 155 Processing Unit can be converted into a Model 155-II by field installation of the Dynamic Address Translation facility at a one-time charge of $200,000 and a $630 increase in the monthly maintenance charge. A purchased Model 165 can be similarly converted into a Model 165-II at a one-time charge of $400,000 and a $1,000 increase in the monthly maintenance charge.			
PROCESSOR FEATURES AND CHANNELS				
For 3135 Processing Unit (Model 135):				
1290	Autocall	2,450	1	50
1421	Block Multiplexer Channel	No charge	No charge	No charge
1431	Block Multiplexer Shared Subchannel	No charge	No charge	No charge
1501	Channel Priority	No charge	No charge	No charge
2001	Clock Comparator & CPU Timer	No charge	No charge	No charge
3274	Direct Control	5,830	1	118
3840	Extended Precision Floating-Point	1,330	1	27
3900	Floating-Point	No charge	No charge	No charge
3905-3907	Additional Multiplexer Subchannels (64, 128, or 256)	No charge	No charge	No charge
4457	IBM 1401/1440/1460 Compatibility	No charge	No charge	No charge
4650	Integrated File Adapter (IFA) for 2319	25,340	12	510
4655	Integrated File Adapter (IFA) for 3330 Series	34,700	3	700
4640	Integrated Communications Adapter (ICA)	10,670	21	216
4722	Second Line on ICA	2,130	5	43
4723	Third Line on ICA	4,265	9	86
4724	Fourth Line on ICA	2,130	5	43
4725	Fifth Line on ICA	6,365	14	129
4726	Sixth Line on ICA	2,130	5	43
4727	Seventh Line on ICA	2,130	5	43
4728	Eighth Line on ICA	2,130	5	43
4662	Integrated Printer Adapter for 1403 Model 2	19,165	20	388
4667	Integrated Printer Adapter for 1403 Model 7	19,165	20	388
4668	Integrated Printer Adapter for 1403 Model N1	19,165	20	388
6981	Selector Channel No. 1	9,335	4	189
6982	Selector Channel No. 2	8,000	4	162
7520	System/360 Model 20 Compatibility	No charge	No charge	No charge
7861	Control Storage Expansion; 1st 12K increment	11,005	19	225
7862	Control Storage Expansion; 2nd 12K Increment	11,005	19	225
7844	Adapter for 3210-1 Console Printer-Keyboard	5,335	4	108
7845	Adapter for 3215 Console Printer-Keyboard	9,040	5	183
8637	Universal Character Set Adapter	1,825	7	37
3210-1	Console Printer-Keyboard; 15 char/sec	5,600	85	175
3215	Console Printer-Keyboard; 85 char/sec	8,000	55	200
For 3145 Processing Unit (Model 145):				
1421-1424	Block Multiplexer Channel Features	No charge	No charge	No charge
1850	Channel-to-Channel Adapter	13,730	12	286
2001	Clock Comparator & CPU Timer	4,800	3	100
3274	Direct Control	6,190	4	129
3910	Floating-Point Instructions	No charge	No charge	No charge
4457	1401/1440/1460 Compatibility	No charge	No charge	No charge
4458	1401/1440/1460, 1410/7010 Compatibility	No charge	No charge	No charge
4650	Integrated File Adapter (IFA) for 2319	28,320	42	590
4951-4954	Additional Multiplexer Subchannels (32, 64, 128, or 256)	No charge	No charge	No charge
6982	Selector Channel—2nd	11,660	15	243
6983	Selector Channel—3rd	11,660	15	243
6984	Selector Channel—4th	11,660	15	243
7844	Console Printer Adapter for 3210 Model 1	6,480	4	135
7845	Console Printer Adapter for 3210 Model 2	5,180	6	108
7855	Console Printer Adapter for 3215	9,070	6	189
8810	Word Buffer	10,365	6	216
3210	Console Printer-Keyboard; 15 char/sec:			
	Model 1; for local use	5,600	85	175
	Model 2; for remote use	5,760	90	180
3215	Console Printer-Keyboard; 85 char/sec	8,000	55	200
For 3155 Processing Unit (Model 155):				
1433	Third Block Multiplexer Channel	14,175	12	405
1434	Fourth Block Multiplexer Channel	13,230	10	378
1435	Fifth Block Multiplexer Channel	6,615	5	189
1850	Channel-to-Channel Adapter	13,230	8	378
3274	Direct Control	3,240	4	108
3700	Extended Precision Floating Point	9,070	16	189
3950	IBM 1401/1440/1460/1410/7010 Compatibility	17,280	16	432
4990	Second Byte Multiplexer Channel	14,175	12	405
5450	OS/DOS Compatibility	10,800	16	270
7117	7070/7074 Compatibility	46,655	60	970

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*
PROCESSOR FEATURES AND CHANNELS (continued)				
7844	Adapter for 3210 1 Printer Keyboard	7,775	8	162
7845	Adapter for 3210 2 Printer Keyboard	8,785	8	183
7855	Adapter for 3215 Printer Keyboard	10,365	8	216
3210	Console Printer-Keyboard; 15 char/sec:			
	Model 1; for local use	5,600	85	175
	Model 2; for remote use	5,760	90	180
3215	Console Printer-Keyboard; 85 char/sec	8,000	55	200
For 3158 Processing Unit (Model 158):				
1433	Third Block Multiplexer Channel	14,175	12	405
1434	Fourth Block Multiplexer Channel	13,230	10	378
1435	Fifth Block Multiplexer Channel	6,615	5	189
1850	Channel-to-Channel Adapter	13,230	8	378
3274	Direct Control	3,240	4	108
3700	Extended Precision Floating Point	No charge	No charge	No charge
3950	IBM 1401/1440/1460/1410/7010 Compatibility	No charge	No charge	No charge
4650	Integrated Storage Controls (for 3330 Series)	106,800	215	2,200
4990	Second Byte Multiplexer Channel	14,175	12	405
5450	OS/DOS Compatibility	No charge	No charge	No charge
7117	7070/7074 Compatibility	No charge	No charge	No charge
7840	3213 Console Printer Attachment	4,850	1	100
7905	Two-Channel Switch for Integrated Storage Control	19,420	20	400
3213	Console Printer; 85 char/sec	6,800	73	210
For 3165 Processing Unit (Model 165):				
1432	Buffer Expansion (to 16K bytes)	72,835	55	1,520
3850	Extended Channels	23,280	70	485
4520	High-Speed Multiply	127,910	110	2,665
7117	IBM 7070/7074 Compatibility	132,615	165	2,765
7118	IBM 7080 Compatibility	132,615	165	2,765
7119	IBM 709/7090/7094/7094 II Compatibility	132,615	165	2,765
For 3168 Processing Unit (Model 168):				
1435	Buffer Expansion (to 16K bytes)	72,835	55	1,520
3855	Extended Channels	23,280	70	485
4525	High-Speed Multiply	127,910	110	2,665
4650	Integrated Storage Controls (for 3330 Series)	106,800	215	2,200
7127	IBM 7070/7074 Compatibility	132,615	165	2,765
7128	IBM 7080 Compatibility	132,615	165	2,765
7129	IBM 709/7090/7094/7094 II Compatibility	132,615	165	2,765
7905	Two-Channel Switch for Integrated Storage Control	19,420	20	400
For 3195 Processing Unit (Model 195):				
3851	Extended Channels	14,100	2	300
2860	Selector Channel (for Models 165-195):			
	Mod. 1; one channel	97,855	55	2,100
	Mod. 2; two channels	139,435	90	2,995
	Mod. 3; three channels	181,120	120	3,895
1850	Channel-to-Channel Adapter (for 2860)	9,455	3.75	225
	Channel Indirect Data Addressing (required on 2860 for operation in Extended Control mode):			
1861	For 2860 Model 1	6,990	2	150
1862	For 2860 Model 2	13,970	3	300
1863	For 2860 Model 3	20,930	5	450
2870	Byte Multiplexer Channel (for Models 165-195)	103,500	97	2,195
6990	Selector Subchannel—First (for 2870)	17,400	15	400
6991	Selector Subchannel—Second (for 2870)	10,585	10	250
6992	Selector Subchannel—Third (for 2870)	10,585	10	250
6993	Selector Subchannel—Fourth (for 2870)	10,585	10	250
1861	Channel Indirect Data Addressing (required on 2870 for operation in Extended Control mode)	9,430	2	200
2880	Block Multiplexer Channel (for Models 165-195):			
	Mod. 1; one channel	152,280	340	3,240
	Mod. 2; two channels	218,080	450	4,640
	Channel Indirect Data Addressing (required on 2880 for operation in Extended Control mode):			
1861	For 2880 Model 1	7,050	1	150
1862	For 2880 Model 2	14,100	2	300
	Two-Byte Interface (required on 2880 for attachment of 2305 Model 1 Fixed-Head Storage):			
7850	For 2880 Model 1 or first channel of Model 2	17,765	6	378
7851	For second channel of 2880 Model 2	17,765	6	378

		Purchase Price	Monthly Maint.	Rental (short-term lease)*	Rental (12-month lease)*	Rental (24-month lease)*
MASS STORAGE						
2305	Fixed-Head Storage Facility:					
	Mod. 1; 5.4 million bytes	195,760	495.00	4,900	4,508	4,116
	Mod. 2; 11.2 million bytes	155,810	470.00	3,900	3,588	3,276

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*	Rental (12-month lease)*	Rental (24-month lease)*
MASS STORAGE (Continued)						
2835	Storage Control:					
	Mod. 1; for 2305 Mod. 1	119,850	445.00	3,000	2,760	2,520
	Mod. 2; for 2305 Mod. 2	99,880	380.00	2,500	2,300	2,100
2319	Disk Storage (each unit has 3 disk drives and stores a total of 87 million bytes):					
	Model A1; 3 drives and control, for connection to Model 135 or 145 IFA	38,250	210.00	1,000	920	840
	Model A2; 3 additional drives for Model 145	38,250	210.00	1,000	920	840
	Model A3; 3 additional drives for Model 135	38,475	220.00	1,050	966	882
	Model B1; 3 drives and control, for connection to 2314-B1 Storage Control	38,250	210.00	1,000	920	840
	Model B2; 3 additional drives for connection to 2314-B1 Storage Control	38,250	210.00	1,000	920	840
2314	Storage Control, Model B1	56,810	60.00	1,480	1,362	1,243
2312	Disk Storage; 1 drive, 29 million bytes	20,490	75.00	535	492	449
2313	Disk Storage; 4 drives, 116 million bytes	67,050	240.00	1,745	1,605	1,466
2318	Disk Storage; 2 drives, 58 million bytes	35,390	135.00	920	846	773
3330	Disk Storage; 2 drives, 200 million bytes	51,940	170.00	1,300	1,196	1,092**
3333	Disk Storage and Control; 2 drives, 200 million bytes (up to three 3330 modules can be attached)	65,000	200.00	1,627	–	1,385**
3830	Storage Control, Model 2 (controls up to two 3333's and six 3330's)	81,000	115.00	2,025	1,874	1,723**
8170	Two-Channel Switch (for 3830)	7,990	10.00	200	184	168
8171	Two-Channel Switch, Additional (for 3830)	7,990	10.00	200	184	168
NOTE:	The older IBM 2301, 2303, 2311, 2314-A, and 2321 mass storage devices can also be used in a System/370; for details and prices, please refer to the IBM System/360 report (70C-491-03).					
MAGNETIC TAPE INPUT/OUTPUT						
2803	Tape Control (single-channel; for 2401 or 2420):					
	Mod. 1; for 800 bpi drives	26,070	20.00	650	598	546
	Mod. 2; for 1600 bpi drives	32,070	25.00	800	736	672
	Mod. 3; for 7-track 2401 Model 8 drives	15,300	30.00	450	414	378
5320	Nine-Track Compatibility (for 2803 Mod. 2)	8,840	28.00	230	212	193
7135	Seven- and Nine-Track Compatibility (for 2803 Mod. 2)	14,390	47.00	375	345	315
7185	16-Drive Addressing (for 2803 Mod. 1 or 2)	990	0.75	25	23	21
7900	2420 Model 5/7 Attachment (for 2803 Mod. 2)	13,600	10.00	340	313	286
8100	Two-Channel Switch (for 2803 Mod. 1)	3,360	4.00	100	92	84
2804	Tape Control (two-channel; for 2401):					
	Mod. 1; for 800 bpi drives	37,350	35.00	930	856	781
	Mod. 2; for 1600 bpi drives	43,350	40.00	1,080	994	907
	Mod. 3; for 7-Track 2401 Model 8 drives	21,250	45.00	625	575	525
5321	Nine-Track Compatibility (for 2804 Mod. 2)	10,750	22.00	278	256	234
7136	Seven- and Nine-Track Compatibility (for 2804 Mod. 2)	17,270	43.00	450	414	378
2401	Magnetic Tape Unit:					
	Mod. 1; 30,000 bytes/sec; 800 bpi	12,880	62.00	335	308	281
	Mod. 2; 60,000 bytes/sec; 800 bpi	18,720	70.00	485	446	407
	Mod. 3; 90,000 bytes/sec; 800 bpi	30,310	86.00	785	722	659
	Mod. 4; 60,000 bytes/sec; 1600 bpi	14,800	74.00	385	354	323
	Mod. 5; 120,000 bytes/sec; 1600 bpi	20,640	82.00	535	492	449
	Mod. 6; 180,000 bytes/sec; 1600 bpi	32,230	98.00	835	768	701
	Mod. 8; 15,000/41,700/60,000 char/sec; 7-track	13,600	85.00	400	368	336
3471	Dual Density (for 2401 Mod. 4, 5, or 6)	990	1.75	25	23	21
5121	Mode Compatibility (for 2401 Mod. 1, 2, or 3)	380	No charge	10	9	8
7160	Simultaneous Read-While-Write (for any 2401)	380	No charge	10	9	8
2420	Magnetic Tape Unit:					
	Mod. 5; 160,000 bytes/sec; 1600 bpi	24,870	110.00	565	520	475
	Mod. 7; 320,000 bytes/sec; 1600 bpi	45,020	120.00	1,020	938	857
2816	Magnetic Tape Switching Unit	21,190	4.00	550	506	462
2415	Magnetic Tape Unit and Control:					
	Mod. 1; 2 tape drives; 800 bpi	29,390	100.00	750	690	630
	Mod. 2; 4 tape drives; 800 bpi	47,030	180.00	1,205	1,109	1,012
	Mod. 3; 6 tape drives; 800 bpi	64,660	260.00	1,655	1,523	1,390
	Mod. 4; 2 tape drives; 800/1600 bpi	35,590	115.00	905	833	760
	Mod. 5; 4 tape drives; 800/1600 bpi	57,180	205.00	1,455	1,339	1,222
	Mod. 6; 6 tape drives; 800/1600 bpi	78,770	295.00	2,005	1,845	1,684
3228	Data Conversion Feature (for 2415; either 7125, 7127, or 7135 is a prerequisite)	1,730	1.00	45	41	38
5320	Nine-Track Compatibility (for 2415 Mod. 4, 5, or 6)	5,190	10.00	135	124	113

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*	Rental (12-month lease)*	Rental (24-month lease)*
MAGNETIC TAPE INPUT/OUTPUT (continued)						
7125	Seven-Track Compatibility (for 2415 Mod. 1, 2, or 3)	1,920	1.25	50	46	42
7127	Seven-Track Compatibility (for 2415 Mod. 4, 5, or 6)	3,640	3.50	95	87	80
7135	Seven- and Nine-Track Compatibility (for Mod. 4, 5, or 6)	5,950	13.00	155	143	130
3410	Magnetic Tape Unit:					
	Model 1; 20 KB	7,700	45.00	185	170	155
	Model 2; 40/20 KB	10,300	50.00	245	225	206
	Model 3; 80/40 KB	12,800	55.00	305	281	256
3411	Magnetic Tape Unit and Control:					
	Model 1; 20KB	17,000	70.00	405	373	340
	Model 2; 40/20 KB	21,600	75.00	515	474	433
	Model 3; 80/40 KB	26,300	80.00	625	575	525
3211	Single Density Feature (for 3410 & 3411)	2,500	7.50	55	51	46
3221	Dual Density Feature (for 3410 & 3411, Models 2 & 3 only)	3,600	27.00	80	74	67
7360	System/360/370 Attachment (required on 3411)	6,300	15.00	150	138	126
3803	Tape Control (for 3420 Magnetic Tape Units)	25,820	95.00	675	621	567
9570	Single Density Feature (for 3803)	No charge	No charge	No charge	No charge	No charge
3551	Dual Density Feature (for 3803)	2,870	3.00	75	69	63
6408	7-Track Feature (for 3803)	2,870	3.00	75	69	63
8100	Two-Channel Switch (for 3803)	5,740	5.00	150	138	126
1792	2 x 16 Switching Feature	7,650	10.00	200	184	168
1793	3 x 16 Switching Feature	9,760	15.00	255	235	214
1794	4 x 16 Switching Feature	11,480	15.00	300	276	252
3420	Magnetic Tape Units:					
	Mod. 3; 120,000 bytes/sec at 1600 bpi	13,580	50.00	355	327	298
	Mod. 5; 200,000 bytes/sec at 1600 bpi	18,170	55.00	475	437	399
	Mod. 7; 320,000 bytes/sec at 1600 bpi	22,380	65.00	585	538	491
6631	Single Density Feature (for 3420)	3,260	15.00	85	78	71
3550	Dual Density Feature (3420)	4,210	25.00	110	101	92
6407	7-Track Feature (for 3420)	3,260	25.00	85	78	71
2495	Tape Cartridge Reader	18,670	155.00	340		
PUNCHED CARD I/O AND PRINTERS						
1442	Card Read Punch (with control), Mod. N1; 400/91 cpm	25,460	81.00	510		
1442	Card Punch (with control), Mod. N2; 91 cpm	18,185	71.00	365		
2501	Card Reader (with control):					
	Mod. B1; 600 cpm	14,590	51.50	260		
	Mod. B2; 1000 cpm	14,820	55.50	320		
2520	Card Read Punch (with control), Mod. B1; 500 cpm	39,520	151.00	915		
2520	Card Punch (with control):					
	Mod. B2; 500 cpm	35,000	142.00	810		
	Mod. B3; 300 cpm	34,715	114.00	625		
2540	Card Read Punch; 1000/300 cpm (requires 2821 Control Unit)	32,930	124.00	710		
3505	Card Reader:					
	Model B1; 800 cpm	28,250	85.00	565		
	Model B2; 1200 cpm	29,250	115.00	670		
5450	Optical Mark Read (for 3505)	7,950	35.00	185		
6122	Read Column Eliminate (for 3505)	No charge	No charge	No charge		
6555	Selective Stacker (for 3505)	2,250	7.00	50		
6777	Special Feature Adapter (for 3505)	250	0.50	5		
8103	3505 Punch Adapter (for 3505)	4,750	3.00	95		
8105	3525 Read/Punch Adapter (for 3505)	5,250	3.50	120		
8101	3525 Multi-Line Print Control (for 3505)	3,000	4.00	60		
8107	3525 Two-Line Print Control (for 3505)	3,000	4.00	60		
3525	Card Punch:					
	Model P1; 100 cpm	20,000	60.00	400		
	Model P2; 200 cpm	20,800	80.00	505		
	Model P3; 300 cpm	21,600	100.00	610		
1533	Card Read Feature (for 3525)	6,000	15.00	120		
5272	Multi-Line Card Print (for 3525)	14,220	83.00	350		
8338	Two-Line Card Print (for 3525)	13,920	68.00	290		
2596	Card Read Punch (for 96-column cards)	29,575	330.00	845		
1510	Card Print Feature (for 2596)	5,250	52.00	150		
2821	Control Unit:					
	Mod. 1; for one 2540 & one 1403	37,180	41.00	970	892	815
	Mod. 2; for one 1403	23,040	32.00	600	552	504
	Mod. 3; for two 1403's	46,070	64.00	1,200	1,104	1,008
	Mod. 5; for one 2540 & two 1403's	60,220	73.00	1,565	1,440	1,315
	Mod. 6; for one 2540 only	12,720	90.00	440	405	370
3615	1100 lpm Printer Adapter (for 2821; required for 1403 Mod. 3 or N1)	2,400	1.00	75	69	63

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*	Rental (12-month lease)*	Rental (24-month lease)*
PUNCHED CARD I/O AND PRINTERS (Continued)						
7945	Third Printer Control (for 2821 Mod. 3 or 5)	19,190	6.50	500	460	420
8100	Two-Channel Switch (for 2821)	8,390	8.00	200	184	168
8637	Universal Character Set Adapter (for 2821)	610	3.50	15	14	13
1403	Printer:					
	Mod. 2; 600 lpm; 132 print positions	28,030	177.00	750	690	630
	Mod. 7; 600 lpm; 120 print positions	29,960	153.00	630	580	529
	Mod. N1; 1100 lpm; 132 print positions	33,970	183.00	875	805	735
1416	Interchangeable Train Cartridge (required for 1403 Mod. N1)	2,910	Time & mat'ls.	97		
4740	Interchangeable Chain Cartridge Adapter (for 1403 Mod. 2 or 7)	2,580	No charge	73	67	61
8640	Universal Character Set Feature (for 1403 Mod. N1)	380	1.75	10	9	8
8641	Universal Character Set Feature (for 1403 Mod. 2)	380	1.75	10	9	8
1443	Printer (with control), Mod. N1; 240 lpm	36,500	87.50	850	782	714
3211	Printer; 2000 lpm, 132 print positions	69,360	365.00	1,700	1,564	1,428
3216	Interchangeable Train Cartridge (for 3211)	11,550	170.00	350		
5554	18 Additional Print Positions (for 3211)	2,240	8.00	55	51	46
3811	Control Unit (for 3211 Printer)	30,600	115.00	750	690	630
5553	18 Additional Print Positions (for 3811)	820	5.00	20	18	17
PAPER TAPE INPUT/OUTPUT						
2826	Paper Tape Control, Mod. 1; for up to two 1017's and/or 1018's	14,380	35.00	275		
5801	Punch Adapter; for first 1018 on 2826 Mod. 1	4,945	9.00	97		
5802	Punch Adapter; for second 1018 on 2826 Mod. 1	4,220	5.00	82		
6101	Reader Adapter; for first 1017 on 2826 Mod. 1	4,220	8.00	82		
6102	Reader Adapter; for second 1017 on 2826 Mod. 1	3,470	5.00	68		
1017	Paper Tape Reader (120 char/sec):					
	Mod. 1; reads strips only	2,330	14.00	49		
	Mod. 2; reads strips or reels	3,565	17.00	73		
1018	Paper Tape Punch (120 char/sec)	5,395	40.00	121		
2822	Paper Tape Reader Control (for one 2671)	9,410	8.25	210		
2671	Paper Tape Reader (100 char/sec)	6,305	21.00	140		
OPTICAL AND MAGNETIC READERS						
1287	Optical Reader:					
	Mod. 1; reads documents only	122,220	800.00	2,715		
	Mod. 2; reads documents and journal tape	139,680	900.00	3,105		
	Mod. 3; reads documents only	183,525	1,150.00	4,170		
	Mod. 4; reads documents and journal tape	205,155	1,200.00	4,560		
	Mod. 5; reads handprinted digits from documents only	136,000	1,160.00	3,400		
3945	Farrington 7B Font (for 1287)	1,090	1.00	25		
4470	1428 & USASCSOCR Font (for 1287)	1,090	1.00	25		
5300	NCR Optical Type Font (for 1287)	4,365	5.00	97		
5370	Numeric Handwriting (for 1287)	34,920	50.00	775		
5479	Optical Mark Reading (for 1287)	4,365	5.00	97		
1288	Optical Page Reader	223,390	1,225.00	4,755		
3850	Expanded Symbol Set (for 1288)	3,055	3.50	68		
5370	Numeric Handwriting (for 1288)	52,380	75.00	970		
5479	Optical Mark Reading (for 1288)	5,140	7.00	97		
6550	Serial Numbering (for 1288)	12,515	60.00	290		
3881	Optical Mark Reader:					
	Mod. 1; for on-line use with Model 135 or 145	56,000	140.00	1,351	–	1,150**
	Mod. 2; for off-line use with 3410 Mod. 1 Magnetic Tape Unit	51,000	110.00	1,234	–	1,050**
1471	BCD Read (for 3881)	2,350	1.50	56	–	48**
3450	Document Counters (for 3881)	930	2.00	22	–	19**
3550	Dual Density (for 3881 Mod. 2 only)	5,900	0.50	141	–	120**
3801	Expanded Storage (for 3881)	2,350	0.50	56	–	48**
6451	Serial Numbering (for 3881)	6,900	25.00	165	–	140**
1255	Magnetic Character Reader:					
	Mod. 1; 500 dpm, 6 stackers	38,645	210.00	805		
	Mod. 2; 750 dpm, 6 stackers	44,260	335.00	980		
	Mod. 3; 750 dpm, 12 stackers	60,240	440.00	1,300		
3215	Dash Symbol Transmission (for 1255)	35	No charge	50(1-time)		
4380	51-Column Card Sorting (for 1255)	720	No charge	15		
4520	High-Order Zero & Blank Selection (for 1255 Mod. 3 only)	1,440	5.00	30		
7060	Self-Checking Numbers (for 1255)	2,330	2.50	49		
6360	System/360/370 Adapter (required on 1255)	21,600	31.00	450		
1259	Magnetic Character Reader; 600 dpm	61,110	260.00	1,360		
1419	Magnetic Character Reader; 1600 dpm	107,185	224.00	2,205		

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IBM System/370

EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*	Rental (12-month lease)*	Rental (24-month lease)*
GRAPHIC DISPLAYS						
2250	Display Unit:					
	Mod. 1; connects directly to a channel	51,215	157.00	1,065		
	Mod. 3; requires 2840 Display Control	74,495	177.00	1,550		
1245	Alphameric Keyboard (for 2250 Mod. 1 or 2)	3,490	4.00	73		
4785	Light Pen (for 2250 Mod. 1 or 2)	4,655	11.00	97		
1001	Absolute Vectors (for 2250 Mod. 2)	13,580	10.00	340		
1002	Absolute Vectors and Control (for 2250 Mod. 1)	15,520	11.00	390		
1498	Buffer; 4,096 bytes (for 2250 Mod. 1)	16,295	7.00	340		
1499	Buffer; 8,192 bytes (for 2250 Mod. 1)	23,280	10.00	485		
1880	Character Generator (for 2250 Mod. 1)	17,460	15.00	365		
NOTE:	Numerous IBM terminals can be connected to a System/370 in local and/or remote configurations. For details and prices, please see Reports 70D-491-02 through 70D-491-13 in the Peripherals section.					
AUDIO RESPONSE						
7770	Audio Response Unit (up to 4 lines)	55,870	38.50	1,165		
4677	I/O Line Expander (for 7770; up to 4 more lines)	8,150	12.50	170		
4679	I/O Line Panel (for 7770; one 4679 required for each 8 lines beyond the first 8)	3,490	2.00	73		
4668	I/O Line Frame (for 7770; required for over 16 lines)	9,310	2.50	194		
8721	Six Additional Vocabulary Words (for 7770)	4,655	2.50	97		
COMMUNICATION CONTROLS						
2701	Data Adapter Unit	9,130	15.00	200		
2702	Transmission Control (for up to 15 lines)	38,395	57.00	850		
7955	31-Line Expansion (for up to 16 more lines on 2702)	4,425	5.00	100		
2703	Transmission Control	65,485	95.00	1,450		
2711	Line Adapter Unit	5,890	23.00	130		
NOTE:	Numerous adapters and optional features enable the above controls to accommodate a wide range of communications facilities and terminals; the associated configuration rules and pricing are extremely complex.					
3705 COMMUNICATIONS CONTROLLER						
Model A1	16K bytes, up to 64 lines	47,150	150.00	1,152	–	980**
Model A2	48K bytes, up to 64 lines	67,650	182.00	1,651	–	1,405**
Model B1	16K bytes, up to 160 lines	62,525	167.00	1,528	–	1,300**
Model B2	48K bytes, up to 160 lines	83,025	199.00	2,027	–	1,725**
Model B3	80K bytes, up to 160 lines	103,525	231.00	2,526	–	2,150**
Model B4	112K bytes, up to 160 lines	124,025	263.00	3,026	–	2,575**
Mocel C1	16K bytes, up to 256 lines	77,900	184.00	1,904	–	1,620**
Model C2	48K bytes, up to 256 lines	98,400	216.00	2,403	–	2,045**
Model C3	80K bytes, up to 256 lines	118,900	248.00	2,902	–	2,470**
Model C4	112K bytes, up to 256 lines	139,400	280.00	3,402	–	2,895**
Model C5	144K bytes, up to 256 lines	159,900	312.00	3,901	–	3,320**
Model C6	176K bytes, up to 256 lines	180,400	344.00	4,400	–	3,745**
Model D1	16K bytes, up to 352 lines	93,275	201.00	2,280	–	1,940**
Model D2	48K bytes, up to 352 lines	113,775	233.00	2,779	–	2,365**
Model D3	80K bytes, up to 352 lines	134,275	265.00	3,278	–	2,790**
Model D4	112K bytes, up to 352 lines	154,775	297.00	3,778	–	3,215**
Model D5	144K bytes, up to 352 lines	175,275	329.00	4,277	–	3,640**
Model D6	176K bytes, up to 352 lines	195,775	361.00	4,776	–	4,065**
Model D7	208K bytes, up to 352 lines	216,275	393.00	5,276	–	4,490**
Model D8	240K bytes, up to 352 lines	236,775	425.00	5,775	–	4,915**
OPTIONS FOR 3705:						
1301	Attachment Base, Type 1 (for attachment of #1541 and/or #1641)	740	0.50	18	–	15**
1302	Attachment Base, Type 2 (for attachment of #1642)	740	0.50	18	–	15**
1541	Channel Adapter, Type 1 (for communication with a System/360 or 370 byte multiplexer channel)	4,100	12.00	100	–	85**
1542	Channel Adapter, Type 2 (for communication with a System/370 byte multiplexer, block multiplexer, or selector channel at up to 375 kilobytes/second)	7,465	12.00	182	–	155**
1641	Communication Scanner, Type 1 (interface between line attachment features and central control unit; character assembly/disassembly is performed by the stored program)	2,175	8.00	53	–	45**

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EQUIPMENT PRICES

		Purchase Price	Monthly Maint.	Rental (short-term lease)*	Rental (12-month lease)*	Rental (24-month lease)*
COMMUNICATIONS CONTROLS (Continued)						
1642	Communication Scanner, Type 2 (interface between line attachment features and central control unit; performs character assembly/disassembly and character buffering for each line automatically)4650	7,215	12.00	176	–	150**
4650	Business Machine Clock (provides clocking, at 45.5 to 2400 bps, when not provided by modems)	490	1.00	12	–	10**
4701	Line Interface Base, Type 1 (for attachment of up to 8 line sets, Types 1A through 1G, in any combination)	1,680	4.00	41	–	35**
4711	Line Set, Type 1A (for 2 start/stop lines at up to 1200 bps via external modems)	740	2.00	18	–	15**
4713	Line Set, Type 1C (for 2 half-duplex IBM start/stop terminals at up to 1200 bps via IBM-provided cables)	740	2.00	18	–	15**
4714	Line Set, Type 1D (for 2 start/stop or synchronous lines at up to 7200 bps via external modems)	2,420	6.50	59	–	50**
4715	Line Set, Type 1E (for attachment of 2 external Automatic Calling Units)	1,190	2.50	29	–	25**
4716	Line Set, Type 1F (for 2 half-duplex IBM synchronous terminals at up to 2400 bps via IBM-provided cables)	2,420	6.50	59	–	50**
4717	Line Set, Type 1G (for 1 synchronous line at 19,200 or 50,000 bps via external modem)	3,115	7.50	76	–	65**
4702	Line Interface Base, Type 2 (for attachment of up to 8 Type 2A line sets)	1,680	3.50	41	–	35**
4721	Line Set, Type 2A (for 2 single-current telegraph lines)	1,190	5.00	29	–	25**
4703	Line Interface Base, Type 3 (for attachment of up to 6 Type 3A and/or 3B line sets)	2,910	3.00	71	–	60**
4731	Line Set, Type 3A (for 2 half-duplex, start/stop lines at up to 134.5 bps)	985	2.00	24	–	20**
4731	Line Set, Type 3B (for 2 four-wire, start/stop lines at up to 134.5 bps)	985	2.00	24	–	20**
4704	Line Interface Base, Type 4 (for attachment of up to 2 Type 4A, 4B, and/or 4C line sets)	1,930	4.00	47	–	40**
4741	Line Set, Type 4A (for 2 half-duplex, start/stop lines at up to 600 bps)	1,680	4.50	41	–	35**
4742	Line Set, Type 4B (for 2 half-duplex, leased start/stop lines at up to 600 bps)	1,680	6.00	41	–	35**
4743	Line Set, Type 4C (for 2 four-wire leased start/stop lines at up to 600 bps)	1,680	6.00	41	–	35**
8002	Two-Channel Switch (permits a #1541 or #1542 to be switched between 2 System/360 or 370 channels on same or different CPU's)	2,420	3.50	59	–	50**

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SOFTWARE PRICES

	Monthly Use Charge					
	DOS	DOS/VS	OS/MFT	OS/VS1	OS/MVT	OS/VS2
PROGRAM PRODUCTS–SYSTEMS						
APL/360	275R	–	400R	–	400R	–
Assembler H	–	225V	225R	225V	225R	225V
TSO Assembler Prompter	–	–	–	–	30R	30V
ITF BASIC*	120R	120R	120R	120R	120R	120R
TSO ITF BASIC*	–	–	–	–	120R	120V
Full ANS COBOL Version 3 Compiler and Library	75R	75V	40R	40V	40R	40V
Full ANS COBOL Library Version 3	20R	20V	–	–	–	–
Full ANS COBOL Version 4 Compiler and Library	–	–	175R	175V	175R	175V
Full ANS COBOL Library Version 4	–	–	60R	60V	60R	60V
TSO COBOL Prompter	–	–	–	–	30R	30V
COBOL Interactive Debug (TSO)	–	–	–	–	220R	220V
Subset ANS COBOL Compiler and Library	150R	150V	–	–	–	–

* Either ITF PL/1 or ITF BASIC as first language costs $120/month; as a second language, the charge is $60/month.
V: Program runs in virtual (paged) mode.
R: Program runs in virtual=real (nonpaged) mode.

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SOFTWARE PRICES

	Monthly Use Charge					
	DOS	DOS/VS	OS/MFT	OS/VS1	OS/MVT	OS/VS2
PROGRAM PRODUCTS—SYSTEMS (Continued)						
Customer Information and Control System (CICS)/Entry	200R	200V,R	–	–	–	–
Full Customer Information and Control System (CICS) Version 1		–	600R	–	600R	–
CICS Version 1 Language and Terminal Feature		–	85R	–	85R	–
Full Customer Information and Control System (CICS) Version 2/Standard	500R	500V,R	700R	700V,R	700R	700V,R
FASTER LC	100R	100V	–	–	–	–
FASTER MT	285R	285V	450R	450V	450R	450V
FORTRAN IV (G1) Compiler	–	–	65R	65V	65R	65V
FORTRAN IV (H Extended) Compiler	–	–	260R	260V	260R	260V
FORTRAN IV Library (Mod 1)	–	–	65R	65V	65R	65V
FORTRAN IV Library (Mod II)	–	–	90R	90V	90R	90V
FORTRAN IV Library (ASCII)	50R	50V	–	–	–	–
TSO FORTRAN Prompter	–	–	–	–	30R	30V
Code and Go FORTRAN Compiler	–	–	275R	275V	275R	275V
FORTRAN Interactive Debug	–	–	–	–	150R	150V
FORTRAN IV Library Option 1	30R	30V	–	–	–	–
Generalized Information System (GIS)/2	–	–	450-1500R	450-1500V	450-1500R	450-1500V
GIS DL/1 Query Support Feature	–	–	150R	150V	150R	150V
Information Management System (IMS) Version 1	–	–	600R	–	600R	–
Information Management System (IMS) Version 2	–	–	550R	550R	550R	550V,R
IMS Data Communications Feature	–	–	625R	625R	625R	625R
IMS Interactive Query Facility (IQF)	–	–	300R	300V	300R	300V
PL/1 Optimizing Compiler	185R	185V	185R	185V	185R	185V
PL/1 Optimizing Compiler and Libraries	250R	250V	250R	250V	250R	250V
PL/1 Checkout Compiler	–	–	340R	340V	340R	340V
PL/1 Resident Library	40R	40V	40R	40V	40R	40V
PL/1 Transient Library	25R	25V	25R	25V	25R	25V
ITF PL/1*	120R	120R	120R	120R	120R	120R
TSO ITF PL/1	–	–	–	–	120R	120V
RPG II	95R	95V	–	–	–	–
RPG II Auto Report Feature	30R	30V	–	–	–	–
Tape and Disk Sort/Merge	80R	80V	–	–	–	–
Sort/Merge SM1	40R	40V	60R	60V	60R	60V
ASCII Magnetic Tape/Data Set Utilities	100R	100V	100R	100V	100R	100V
TSO Data Utilities	–	–	–	–	145R	145V
1288 Basic Unformatted Read System (BURS)	50R	50V	50R	50V	50R	50V
VIDEO/370	210R	210R	210R	210R	210R	210R
PROGRAM PRODUCTS—APPLICATIONS						
Fashion Reporter System	165R	165V	–	–	–	–
Consumer Goods System—Allocation	150R	150V	150R	150V	150R	150V
Consumer Goods System—Forecasting	200R	200V	200R	200V	200R	200V
Order Allocation System	125R	–	–	–	–	–
Agribusiness Mgmt. Info. System	225R	–	–	–	–	–
Rigid Frame Selection Program	25R	–	25R	–	25R	–
Coursewriter III Version 2	–	–	150R	–	150R	–
Coursewriter III Version 3	200R	200V,R	275R	275V,R	275R	275V,R
Financial Terminal System	400R	–	–	–	–	–
Brokerage Acct. System Elements	800R	–	–	–	–	–
Active Certificate Info.	300R	–	–	–	–	–

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SOFTWARE PRICES

	Monthly Use Charge					
	DOS	DOS/VS	OS/MFT	OS/VS1	OS/MVT	OS/VS2
PROGRAM PRODUCTS—APPLICATIONS (continued)						
Law Enforcement Manpower Resource Allocation	350R	–	–	–	–	–
Budget Accounting Information System (BACIS)	260R	260V	–	–	–	–
Basic Courts System	625R	625V	–	–	–	–
Medical Information System V2	50R	–	–	–	–	–
Shared Laboratory Info. System	250R	–	–	–	–	–
SHAS Compatibility Teleprocessing	275R	–	–	–	–	–
Text Processor Edit 360	250R	250R	–	–	–	–
Text Processor Pagination/360	450R	450R	–	–	–	–
Capacity Planning Infinite Loading**	75R	75V	100R	100V	100R	100V
Capacity Planning Finite Loading**	225R	225V	275R	275V	275R	275V
Requirements Planning Interface**	25R	25V	–	–	–	–
Requirements Planning**	–	–	230R	230V	230R	230V
Inventory Control**	–	–	175R	175V	175R	175V
Data Base Organization & Maintenance Proc. (DBOMP)	100R	100V	–	–	–	–
Shop Floor Control**	100R	100V	155R	155V	155R	155V
Advanced Life Information System V2	500R	500V	–	–	–	–
Consolidated Functions Ordinary (CFO) II	300R	300V	300R	300V	300R	300V
Property and Liability Info. Systems V2	300R	300V	–	–	–	–
PALIS Additional File Facility 2314	250R	250V	–	–	–	–
PALIS Automobile Enhancements	225R	225V	–	–	–	–
PALIS Homeowner's Enhancements	225R	225V	–	–	–	–
Fare Quote/Ticketing (PARS)	–	–	–	–	8,500R	–
Tariff Publishing System	200R	200V	–	–	–	–
Traffic Profile Analysis System	300R	300V	–	–	–	–
Power System Planning (PSP)	–	–	300R	300V	300R	–
PSP Flow Output & Cap. Feature	–	–	90R	90V	90R	–
PSP Short Circuit Ro Feature	–	–	75R	75V	75R	–
Vehicle Scheduling - Extended	100R	100V	175R	175V	175R	175V
REAL/360	170R	–	–	–	–	–
General Purpose Simulation System V2	20R	–	150R	–	150R	–
DATA/360	50R	–	100R	–	100R	–
DATA/360 Version 2	125R	–	125R	–	125R	–
GPSS V	55R	–	55R	55V	55R	55V
Planning System Generator II	80R	80V	80R	80V	80R	80V
Catalist	1,200R	1,200V	–	–	–	–
Learn ATS	40R	–	40R	40R	40R	40R
DBOMP-CICS Interface	75R	75V,R	–	–	–	–
Electronic Circuit Analysis Program	–	–	170R	–	170R	–
Check Processing Control System	–	–	1,100R	1,100V,R	1,100R	1,100V,R
Telecommunications Control System	–	–	2,500R	–	2,500R	–
Securities Order Matching	–	–	2,100R	–	2,100R	–
STAT/BASIC - ITF	45R	45R	45R	45R	45R	45R
Display Management System	185R	–	185R	–	185R	–
Procedure Library Mathematics	100R	–	100R	100V	100R	100V
Mathematical Programming System Extended	–	–	130R	130V	130R	130V
MPS Upper Bound Feature	–	–	650R	650V	650R	650V
Project Management System, V3	–	–	300R	–	300R	–
Project Management System, V4	–	–	350R	350R	350R	350R
MiniPERT	150R	–	150R	–	150R	–
Computer System Simulator II	–	–	2,500R	2,500V	2,500R	2,500V
Continuous System Modeling	–	–	90R	–	90R	–
CSM Graphic Feature	–	–	340R	–	340R	–
Graphic Analysis of 3-Dimensional Data	–	–	300R	–	300R	–
Bill Processor Sys IMS/360 Bridge**	150R	–	150R	150R	150R	150R
EPIC - Socrates	175R	175V	175R	175V	175R	175V
EPIC - Fast	95R	95V	95R	95V	95R	95V
EPIC - Budget/Finance	110R	110V	110R	110V	110R	110V
EPIC Student	80R	80V	80R	80V	80R	80V
Interactive Training System (ITS)	225R	–	225R	225V,R	225R	225V,R
ITS Course Structuring Feature	25R	–	25R	25V,R	25R	25V,R
Math/BASIC ITF	45R	45R	45R	45R	45R	45R
Matrix Generator and Report Writer	400R	–	400R	–	400R	–
Subroutine Library Mathematics	100R	100V	100R	100V	100R	100V
STAIRS	500R	–	500R	500V,R	500R	500V,R
Vehicle Scheduling Program Extended	100R	100V	175R	175V	175R	175V

** Integral Part of Production Information and Control System (PICS).
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