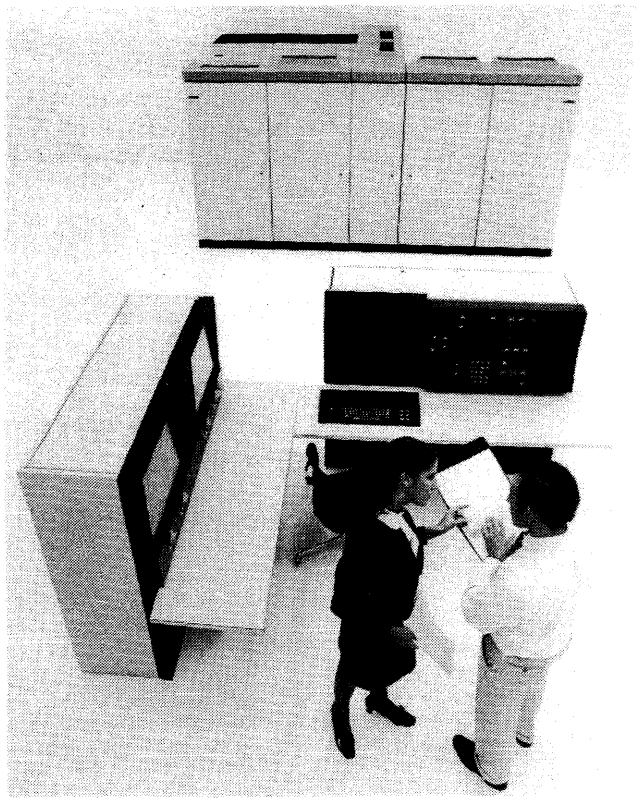
2/4/76

IBM System/370



The Model 168, largest of IBM's virtual-storage computers, offers up to 8 million bytes of real MOS main storage; a dual-processor 168 MP system can have up to 16 million bytes. The Model 168 console features a CRT display and keyboard.

With 13 processor models and system rentals ranging from about $6,000 to $400,000 per month, IBM's medium-to-large-scale computer product line spans a broad range of applications and workload volumes. This comprehensive report describes and analyzes all of the System/370 equipment and software, and summarizes the results of a survey of 385 System/370 users.

MANAGEMENT SUMMARY

The System/370 is IBM's current line of medium-to-large-scale computer systems. It now consists of 13 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.

Since its original announcement of the System/370 in 1970, IBM has added virtual storage and multiprocessing capabilities, increased its suitability for complex data base/data communications (DB/DC) applications, and narrowed the broad gap that previously existed between IBM's System/3 and System/370 computer families.

EVOLUTION OF THE SYSTEM/370

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 ▷

CHARACTERISTICS

MANUFACTURER: International Business Machines Corporation, 1133 Westchester Avenue, White Plains, New York 10604. Telephone (914) 696-1900.

MODELS: System/370 Model 115 through Model 195; see table on following pages.

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 on following pages.

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 ap- ➤

IBM System/370

CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS

	Model 115	Model 125	Model 135	Model 145	Model 155	Model 155-II	Model 158
SYSTEM CHARACTERISTICS							
Date of introduction	March 1973	Oct. 1972	March 1971	Sept. 1970	June 1970	Aug. 1972	Aug. 1972
Date of first delivery	1st Quarter 1974	April 1973	May 1972	July 1971	Feb. 1971	April 1973	April 1973
Virtual storage capability	Standard	Standard	Standard	Standard	No*	Standard	Standard
Number of central processors	1	1	1	1	1	1	1
Principal operating systems	DOS/VS	DOS/VS, DOS	DOS/VS, OS/VS1	DOS/VS, OS/VS1	DOS/VS, OS/MFT, OS/MVT	DOS/VS, OS/VS1, OS/VS2	DOS/VS, OS/VS1, OS/VS2
System rental range, $/month for typical systems	$6,240 to $8,640	$8,500 to $14,600	$10,400 to $25,000	$18,000 to $49,000	$35,000 to $86,000	Purchase only	$53,000 to $92,000
MAIN STORAGE							
Storage type	Semicond. (MOS)	Semicond. (MOS)	Semicond. (bipolar)	Semicond. (bipolar)	Core	Core	Semicond. (MOS)
Read cycle time, nanoseconds	480	480	770	540	2070	2070	1035
Write cycle time, nanoseconds	480	480	935	608	2070	2070	690
Bytes fetched per cycle	2	2	2 or 4	4 or 8	16	16	8 or 16
Storage interleaving (maximum)	None	None	None	None	None	None	None
Minimum capacity, bytes	65,536	98,304	98,304	164,840	262,144	262,144	524,288
Maximum capacity, bytes	196,608	262,144	524,288	2,097,152	2,097,152	2,097,152	4,194,304
Increment size, bytes	32,768	32,768 or 65,536	49,152 to 131,072	49,152 to 262,144	131,072 to 524,288	131,072 to 524,288	524,288 or 1,048,576
BUFFER STORAGE							
Cycle time, nanoseconds	--	--	--	--	115	115	115
Bytes fetched per cycle	--	--	--	--	2	2	2
Minimum capacity, bytes	None	None	None	None	8,192	8,192	8,192
Maximum capacity, bytes	None	None	None	None	8,192	8,192	8,192
PROCESSING UNIT							
Machine cycle time, nanoseconds	Not spec'd.	480-1440	275-1485	203-315	115	115	115
Add time, microseconds (32-bit binary fields)	14.5	9.8	4.21	2.14	0.99	0.99	**
Add time, microseconds (5-digit decimal fields)	107.6	46.1	40.92	11.90	4.93	4.93	**
Processing unit features:							
Clock Comparator & CPU Timer	Standard	Standard	Optional	Optional	No*	Standard	Standard
Direct Control	Optional	Optional	Optional	Optional	Optional	Optional	Optional
Dynamic Address Translation	Standard	Standard	Standard	Standard	No*	Standard	Standard
Floating Point	Optional	Optional	Optional	Optional	Standard	Standard	Standard
Extended Precision Floating Point	Optional	Optional	Optional	Optional	Optional	Optional	Optional
High-Speed Multiply	No	No	No	No	No	No	No
Integrated 2319 Disk Control	No	No	Optional	No***	No	No	No
Integrated 2330 Disk Control	No	Standard	Optional	Optional	No	No	Optional
Integrated 3340 Disk Control	Standard	Standard	Optional	Optional	No	No	Optional
Integrated 1403 Printer	No	Optional	Optional	No	No	No	No
Integrated 3203 Printer	Optional	Optional	No	No	No	No	No
Integrated 5203 Printer	Optional	No	No	No	No	No	No
Integrated Card I/O	Optional	Optional	No	No	No	No	No
Integrated Communications Control	Optional	Optional	Optional	No	No	No	No
Compatibility features:							
IBM 1401/1440/1460 Compatibility	Optional	Optional	Optional	Optional	Optional	Optional	Optional
IBM 1410/7010 Compatibility	No	No	No	Optional	Optional	Optional	Optional
IBM 7070/7074 Compatibility	No	No	No	No	Optional	Optional	Optional
IBM 7070 Compatibility	No	No	No	No	No	No	No
IBM 709/7090/7094 Compatibility	No	No	No	No	No	No	No
IBM 360/20 Compatibility	Optional	Optional	Optional	No	No	No	No
OS/DOS Compatibility	No	No	Standard	Standard	Optional	Optional	Optional
IBM 1052 & 2311 Compatibility	Optional	Optional	No	No	No	No	No
CHANNELS							
No. of Selector Channels	None	None	0 to 2	1 to 4	None	None	None
No. of Block Multiplexer Channels	None	None	0 to 2	1 to 4	2 to 5	2 to 5	2 to 5
No. of Byte Multiplexer Channels	0 or 1	0 or 1	1	1	1 or 2	1 or 2	1 or 2
Maximum total I/O data rate, bytes/second	Not spec'd.	Not spec'd.	2,400,000	5,300,000	5,400,000	5,400,000	Not spec'd.

*Virtual storage capability can be added to a purchased Model 155 through field installation of the Dynamic Address Translation facility, which converts it into a Model 155-11.

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

***Optionally available for Models GE through I of the 145 Processing Unit, which are no longer in production, but not for new Models H2 through J2.

IBM System/370

CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS

	Model 158 MP	Model 165	Model 165-II	Model 168	Model 168 MP	Model 195
SYSTEM CHARACTERISTICS						
Date of introduction	Feb. 1973	June 1970	Aug. 1972	Aug. 1972	Feb. 1973	July 1971
Date of first delivery	March 1974	April 1971	Dec. 1973	Aug. 1973	March 1974	2nd qtr. 1973
Virtual storage capability	Standard	No*	Standard	Standard	Standard	No
Number of central processors	2	1	1	1	2	1
Principal operating systems	OS/VS2 Release 2	OS/MFT, OS/MVT	OS/VS1, OS/VS2	OS/VS1, OS/VS2	OS/VS2 Release 2	OS/MVT
System rental range, $/month for typical systems	$116,000 to $216,000	$76,000 to $162,000	Purchase only	$100,000 to $184,000	$280,000 to $400,000	$200,000 to $290,000
MAIN STORAGE						
Storage type	Semicond. (MOS)	Core	Core	Semicond. (MOS)	Semicond. (MOS)	Core
Read cycle time, nanoseconds	1035	2000	2000	480	480	756
Write cycle time, nanoseconds	690	2000	2000	480	480	756
Bytes fetched per cycle	8 or 16	8	8	8	8	8
Storage interleaving (maximum)	None	4-way	4-way	4-way	4-way	16-way
Minimum capacity, bytes per system	1,048,576	524,288	524,288	1,048,576	2,097,152	1,048,576
Maximum capacity, bytes per system	8,388,608	3,145,728	3,145,728	8,388,608	16,777,216	4,194,304
Increment size, bytes	524,288 or 1,048,576	524,288 or 1,048,576	524,288 or 1,048,576	1,048,576	1,048,576	1,048,576
BUFFER STORAGE						
Cycle time, nanoseconds	115	80	80	80	80	54
Bytes fetched per cycle	2	4	4	4	4	8
Minimum capacity, bytes	8,192	8,192	8,192	8,192	8,192	32,768
Maximum capacity, bytes	8,192	16,384	16,384	16,384	16,384	32,768
PROCESSING UNIT						
Machine cycle time, nanoseconds	115	80	80	80	80	54
Add time, microseconds (32-bit binary fields)	**	0.16	0.16	***	***	0.054
Add time, microseconds (5-digit decimal fields)	**	1.42	1.42	***	***	Not spec'd.
Processing unit features:						
Clock Comparator & CPU Timer	Standard	No*	Standard	Standard	Standard	No
Direct Control	Optional	Standard	Standard	Standard	Standard	Standard
Dynamic Address Translation	Standard	No*	Standard	Standard	Standard	No
Floating Point	Standard	Standard	Standard	Standard	Standard	Standard
Extended Precision Floating Point	Optional	Standard	Standard	Standard	Standard	Standard
High-Speed Multiply	No	Optional	Optional	Optional	Optional	Standard
Integrated 2319 Disk Control	No	No	No	No	No	No
Integrated 3330 Disk Control	Optional	No	No	Optional	Optional	No
Integrated 3340 Disk Control	Optional	No	No	Optional	Optional	No
Integrated 1403 Printer Control	No	No	No	No	No	No
Integrated 3203 Printer	No	No	No	No	No	No
Integrated 5203 Printer	No	No	No	No	No	No
Integrated Card I/O	No	No	No	No	No	No
Integrated Communications Control	No	No	No	No	No	No
Compatibility features:						
IBM 1401/1440/1460 Compatibility	Optional	No	No	No	No	No
IBM 1410/7010 Compatibility	Optional	No	No	No	No	No
IBM 7070/7074 Compatibility	Optional	Optional	Optional	Optional	Optional	No
IBM 7080/Compatibility	No	Optional	Optional	Optional	Optional	No
IBM 709/7090/7094 Compatibility	No	Optional	Optional	Optional	Optional	No
IBM 360/20 Compatibility	No	No	No	No	No	No
OS/DOS Compatibility	Optional	No	No	No	No	No
IBM 1052 & 2311 Compatibility	No	No	No	No	No	No
CHANNELS						
No. of Selector Channels per system	None	0 to 6	0 to 6	0 to 6	0 to 12	0 to 6
No. of Block Multiplexer Channels	4 to 10	0 to 11	0 to 11	0 to 11	0 to 22	0 to 13
No of Byte Multiplexer Channels	2 to 4	0 to 2	0 to 2	0 to 2	0 to 4	0 to 2
Maximum total I/O data rate, bytes/second	7,500,000	8,000,000	8,000,000	16,000,000	28,000,000	Not spec'd.

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

**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.

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users of the large-scale System/360 computers, Models 155 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 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 early System/370 models began; most of the early users experienced minimal problems in converting from their System/360's and expressed a fairly high degree of satisfaction with the System/370 equipment, though many experienced smaller improvements in throughput than they had anticipated.

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 largely summed up in two words: *virtual storage.*

pended to each 8-byte "doubleword" of data.) When the data is retrieved, single-bit errors are detected and corrected automatically, 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 "commercial instruction set" (i.e., the standard System/360 set plus the decimal arithmetic instructions), together with from 13 to 27 new 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 115, 125, 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 Read Address
Reset Reference Bit
Purge Translation Look-Aside Buffer
Store Then AND System Mask
Store Then OR System Mask

Two additional, no-charge instructions are available to support VTAM on Models 115, 125, 135, 145, 155-II, 158, 165-II and 168:

Compare and Swap
Compare Double and Swap

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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.

- 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.

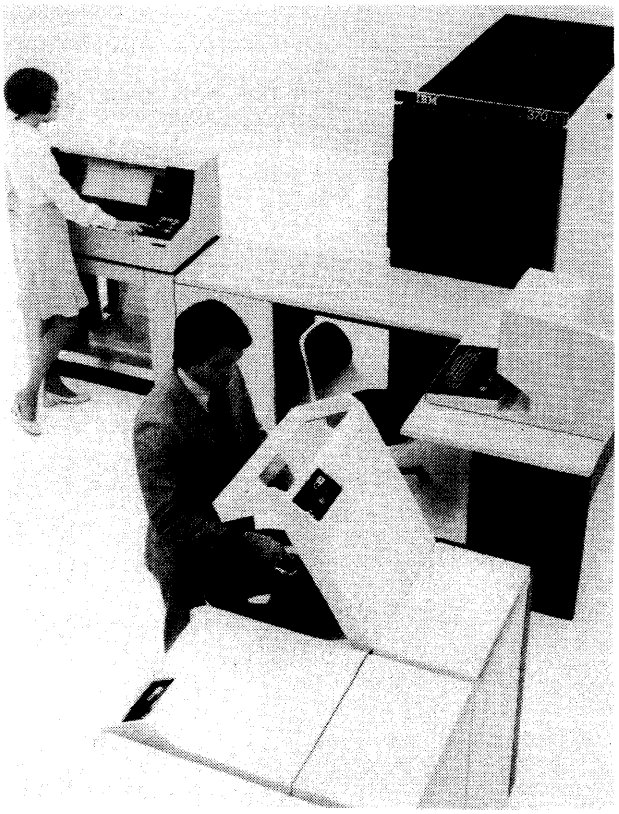
- Four new operating systems—DOS/VS, OS/VS1, OS/VS2, and VM/370—which support the new virtual storage capabilities and are functional extensions of the earlier DOS, OS/MFT, OS/MVT, and CP-67 systems, respectively.

- 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.

In October 1972, IBM extended the System/370 concepts downward to a somewhat lower price and performance level by introducing the Model 125. Completely upward-compatible with the larger System/370 processors, the Model 125 offers most of the same processing facilities, has the same virtual storage capabilities, and can use the same DOS/VS and/or DOS software. It continues the IBM trends to MOS main memory and toward integrated controllers for nearly all peripheral units, including up to 400 million bytes of high-performance 3330 Series Disk Storage and 22 data communications lines. Moreover, the Model 125 boasts two significant facilities that are not present in the larger Model 135 and 145 systems: a standard operator console with CRT display, and independent "satellite" processors that permit simultaneous instruction processing, input/output processing, and diagnostic/maintenance processing.

On February 1, 1973, IBM unleashed a flurry of announcements that significantly increased the attractiveness of the larger System/370 models, particularly with respect to their suitability for advanced data base/data communications processing. These announcements included:

- Dual-processor versions of the large-scale Model 158 and 168 systems, designated the 158 MP and 168 MP, respectively.



The Model 115, smallest and newest member of the System/370 family, employs distributed processing techniques and features integrated control units for attachment of disk drives, magnetic tape units, card unit, line printer, and communications terminals. Two 3340 Disk Drives are shown in the foreground, and the 3203 Printer is at left.

Three more no-charge instructions are available to support OS/VS2 Release 2 on Models 145 (IH2 and J2), 155-II, 158, 165-II, and 168:

Insert PSW Key
Set PSW Key from Address
Clear I/O Function

Finally, four new instructions are used by OS/VS2 Release 2 to support the Model 158 and 168 Multiprocessing systems:

Signal Processor
Set Prefix
Store Prefix
Store CPU Address

INSTRUCTION TIMES: See table for average add times. Average execution times, in microseconds, for some additional representative instructions on Models 115, 125, 135, and 145 in Basic Control mode are as follows:

	Model 115	Model 125	Model 135	Model 145
Add (32-bit binary):	14.5	9.8	4.21	2.14
Multiply (32-bit binary):	226.1	143.4	25.52	20.1
Divide (32-bit binary):	246.4	243.7	41.92	34.8
Load (32-bit binary):	11.3	7.7	3.08	1.69
Store (32-bit binary):	11.8	8.2	3.30	1.50
Add (5-digit packed decimal):	107.6	46.1	40.92	11.9

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- Doubling of the previous maximum main storage capacities of the Model 158 and 168 processors, to 4 million and 8 million bytes, respectively.

- Five new versions of the Model 145 Processing Unit that offer from 262,144 to 1,048,576 bytes of main storage – twice the previous maximum capacity – at a substantially lower cost per byte than the earlier models.

- OS/VS2 Release 2, an enhanced operating system that supports both "tightly coupled" multiprocessing, in the dual-processor 158 MP and 168 MP systems, and "loosely coupled" multiprocessing, in which multiple System/370 computers operate under the overall control of one of the computers in the complex.

- The 3704 Communications Controller, a smaller version of the programmable 3705 that can handle networks with up to 32 communications lines.

- New features for the 3330 Disk Storage subsystem that provide increased configuration flexibility and permit the use of up to 32 drives in a subsystem.

- New virtual-storage versions of CICS and IMS, IBM's principal Program Products for data base/data communications functions.

During the spring and summer of 1973, IBM put an end to speculation about the future of the lower end of its general-purpose product line by announcing two new small systems, the System/370 Model 115 and the System/3 Model 15. IBM also advanced the state of the art in both direct-access storage devices and magnetic tape units. Specifically, IBM's announcements from March through July of 1973 included:

- The System/370 Model 115 Processing Unit, a virtual storage computer that represents another step toward filling the gap between the System/3 and System/370 computer families.

- The 3340 Direct Access Storage Facility, a new disk subsystem that provides high-performance, medium-capacity storage and uses sealed Data Modules that contain read/write heads and access arms as well as disks.

- New models of the 3803/3420 Magnetic Tape Subsystem that read and record information at 6250 bytes per inch—nearly four times IBM's previous maximum density of 1600 bpi.

- The 3203 Printer, an improved version of the 1403 Model N1 Printer that provides output speeds of 600 or 1200 lines per minute for Model 115 or 125 systems only.

- A new Term Lease Plan that permits unlimited usage of the virtual storage central processors at no

	Model 115	Model 125	Model 135	Model 145
Compare (5-digit packed decimal):	92.3	44.6	37.57	10.6
Add (short floating-point):	51.6*	52.7*	13.73*	5.85*
Multiply (short floating-point:	161.3*	190.7*	32.24*	16.8*
Divide (short floating-point):	231.5*	230.4*	49.39*	28.7*
Add (long floating-point):	64.8*	66.6*	17.73*	7.52*
Multiply (long floating-point):	457.0*	565.8*	51.32*	45.7*
Divide (long floating-point):	713.8*	639.2*	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 115 and 125, the microprograms for the Machine Instruction Processor (MIP) or Instruction Processing Unit (IPU), Service Processor (SVP), and Input/Output Processors (IOP's) reside in discrete MOSFET Reloadable Control Storage (RCS) areas, which are separate from main storage. The microprograms are loaded into RCS by means of a small read/write disk drive, the Console File, which contains a removable magnetic "diskette." IBM supplies prewritten diskettes containing all the control microprograms and Field Engineering diagnostics required for a specific installation.

The basic Machine Instruction Processor (MIP) microprogram for the Model 115 resides in 20K 22-bit words of RCS. One or two additional 4,096-word increments may be added to support optional features. The following table shows the quantities of RCS required to support various combinations of optional features on the Model 115:

	20K Words of RCS			24K Words of RCS						28K Words of RCS	
System/360 Model 20 Compatibility	•			•	•	•	•				•
1401/1440/1460 Compatibility					•	•	•	•	•		•
Floating Point		•		•		•		•			
Floating Point (including Extended Precision)			•		•				•		•

The basic IPU microprogram for the Model 125 resides in 12,288 22-bit words of RCS, and one or two additional 4,096-word increments may be added to support optional IPU features. The following table shows the quantities of RCS required to support various combinations of optional features on the Model 125:

	12K Words of RCS				16K Words of RCS				20K Words of RCS		
1401/1440/1460 Compatibility	•				•				•		•
System/360 Model 20 Compatibility		•		•				•		•	
Floating Point (including Extended Precision)			•	•	•		•			•	•
2311 Model 1 Compatibility						•	•	•	•	•	•

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 single-disk cartridges called "diskettes" or "floppy disks" 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 control storage for a Model 165 or Model 168 consists of 2K 108-bit control words written in read-only storage (ROS) and 512 words of RCS. The IBM 7070/7074, 7080,

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additional monthly charge in return for a 48-month lease commitment.

- Increased main memory capacities for Model 115 (from 98,304 to 163,840 bytes), for Model 125 (from 131,072 to 262,144 bytes), and for Model 135 (from 245,760 to 524,288 bytes).

- Optional 1052 Compatibility that allows a Model 115 to be used as a remote workstation under HASP, ASP, JES2, JES3, or JES/RES.

- Stacking of IBM Program Products for DOS/VS on 2316 or 3336 Disk Packs or 3348 Data Modules when certain conditions are met.

- An integrated 7074 emulator for Models 155-II and 158, enabling those systems to execute 7074 programs in a multiprogramming mode under OS, OS/VS1, or OS/VS2.

- Reclassification and/or withdrawal of certain IBM programs.

- DMS-II programming support for the 3270 CRT displays under VS versions of CICS (see Report 70E-491-02); this replaces the original Display Management System for CICS, which supported 2260 CRT's and was significantly lower priced.

- Slippage of the Network Control Program (NCP) for the 3704 and 3705 Communications Controllers by an additional six months, thus forcing continued use of these advanced units in the 270X mode.

- The 3890 Document Processor, a high-speed MICR unit that can operate at twice the throughput rate of the IBM 1419 and is attachable to System/370 Models 135 through 168.

- The System/3 Model 15, a new System/3 model featuring up to 131,072 bytes of MOSFET main storage, a CRT display console, increased disk storage capacity, multiprogramming, and a spooling capability. The new system offers an attractive growth path for System/3 Model 10 users without necessitating software conversions, thus reducing IBM's chances of losing Model 10 users who would otherwise be faced with a complex conversion to the System/370 or switching to an alternate vendor's system. Moreover, IBM can enjoy the happy prospect of eventually upgrading thousands of $2,500-per-month systems to the typically $7,500-per-month Model 15. This important system is fully described in Report 70C-491-21.

The year 1974 saw several significant announcements for IBM in the area of mass storage devices, plus the relevation of the Advanced Function for Communications, IBM's direction for future development in its telecommunications product line. Not surprisingly, IBM also responded to an inflationary economy by announcing

or 7090/7094 compatibility feature adds 1024 additional control words to the RCS. The RCS is loaded from a console file or under microprogrammed control.

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 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 115, 125, 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 eight models can address a virtual storage space of 16,777,216 bytes. A two-level address translation

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in September 1974 a price hike of 6 to 8 percent applicable to nearly all of the System/370 processors and peripherals. The price increase, effective January 1, 1975, applies to both purchase and lease prices of most equipment and also extends to IBM maintenance service, systems engineering, data processing education, and separately priced Program Products.

IBM's "direction of the future," as reflected in these important announcements, 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 earlier 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 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.

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 in Models 135 through 168 is speeded up by a group of high-speed registers which hold recently referenced virtual storage addresses and their real storage equivalents. The Translation Look-aside Buffer (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 115, 125, 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 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 virtual-storage-oriented operating systems must be used.

OPTIONAL FEATURES: The table on pages 70C-491-04b and -04c 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 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. (The External Signals feature provides similar facilities for the Model 115 and Model 125.)

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.

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(Realistically, most System/370 users are achieving maximum throughput by working with virtual storage spaces only 1.5 to 4 times as large as their installed main memory capacities.)

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 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.

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 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.

An integrated emulator for IBM 7074 programs, which requires the 7070/7074 Compatibility feature on a Model 155-II or 158 CPU, became available in June 1973. It operates under OS or OS/VS to provide concurrent emulation with multiprogramming, tape formatting programs for conversions between 7074 and OS spanned variable-length record formats, and placement of 7074 and other jobs in a single job-stream.

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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The demand paging process itself places significant demands upon a system's central processor and input/output resources. Indeed, under certain conditions (such as when numerous large programs are being executed concurrently), the paging rate may become so high that little or no productive processing can be accomplished; this situation is called *thrashing.* To guard against thrashing, IBM's virtual storage operating systems continuously monitor the paging rate. Whenever it becomes excessively high, one or more jobs with comparatively low priorities will be deactivated. IBM points out that a high incidence of job deactivation is likely to indicate the need for increased system resources, such as increased real storage capacity or faster paging devices.

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.

- 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 until recently would therefore require the use of the grossly overpriced 2305 Fixed-Head Storage Facility.) The April 1974 announcement of the Fixed Head Feature for the Model 3340 Disk Storage Facility is evidence that IBM recognized the need for efficient paging facilities for large virtual memory configurations at a more reasonable cost to the user.

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 125 or 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.

The 1052 and 2311 Model 1 Compatibility Features are no-charge options that make it possible to use DOS, Version 3 or 4, on the Model 125. The 1052 Compatibility Feature (required for both Versions 3 and 4) permits emulation of the 1052 Printer-Keyboard by the 5213 Console Printer and the Model 125's standard console keyboard. The 2311 Model 1 Compatibility Feature (required for DOS Version 3 only) permits emulation of 2311 Model 1 disk files on 3333/3330 disk files connected to the Model 125. A single 3336 Disk Pack can hold the contents of up to eleven 1316 Packs.

The 1052 Compatibility Feature also is available at no charge for the Model 115. It permits the 5213 Console Printer and the Model 115 standard console keyboard to emulate a System/360 Model 1052 Printer-Keyboard. The 1052 Compatibility Feature, combined with the prerequisite 5213 Model 1 Console Printer, allows the Model 115 to operate as a remote job entry work system communicating with a host processor operating under HASP, ASP, and their virtual-storage remote job entry successors, Job Entry Subsystem 2 or 3 (JES 2 or JES 3) and Job Entry Subsystem/Remote Entry Services (JES/RES).

CONSOLE INPUT/OUTPUT: A keyboard/display operator console is an integral part of the Model 115 and Model 125 Processing Units. The console contains a typewriter-style keyboard, a CRT display, a complement of switches and lights, the Service Processor, and the Console File that loads the system's microprograms. The CRT can display sixteen 56-character lines of data. Data can be entered via the keyboard, displayed on the CRT for verification, and then directed into main storage or the CPU registers. Storage or register contents are displayed in hexadecimal notation. The keyboard and CRT can also be used as an inquiry terminal. A 5213 Printer, Model 1, can be connected to the Model 115 or 125 console via the Integrated 5213 Printer Attachment. The 5213 produces printed copies of input and output messages displayed on the CRT at a speed of 85 characters per second. Print line length is a maximum of 125 characters, spaced 10 to the inch, and vertical spacing is 6 lines per inch.

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 installation'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-

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The 3348 Data Module, used in IBM's 3340 "Winchester" Direct Access Storage Facility, stores up to 35 million or 70 million bytes of data and combines the disks, access arms, and read/write heads into a single sealed cartridge.

- Additional peripheral devices may be required to support a larger number of concurrently active 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 is proving to be a very good thing indeed.

PROCESSOR MODELS

There are now 13 central processor models in the System/370 line. Their characteristics are summarized and compared in the table on pages 70C-491-04b and -04c.

Model 115, the smallest System/370 processor, also is the most recently announced member of the family. Announced on March 13, 1973, only five months behind the Model 125, it narrows the gap that has long existed between IBM's System/3 and System/370 families.

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 (MODEL 115)

In place of conventional I/O channels, Model 115 uses internal Input/Output Processors (IOP's) to control its I/O operations. Each IOP is implemented through microprograms in Reloadable Control Storage and can access main storage independently. The number of IOP's depends upon the configuration of each Model 115 installation.

A 3340 Direct Access Storage Facility with two to four disk drives can be connected directly to a Model 115 Processing Unit. Optional integrated attachment features permit direct connection of any of the following I/O devices; no separate control units or I/O channels are required:

2560 Multi-Function Card Machine (80-column)
5425 Multi-Function Card Unit (96-column)
3203 Printer, Model 1 (600 lpm) or Model 2 (1200 lpm)
5203 Printer, Model 3 (300 lpm)
5213 Console Printer (85 char/sec)
3410/3411 Magnetic Tape Subsystem, Model 1 (20KB), Model 2 (40KB), or Model 3 (80KB)

Only one card unit and one line printer can be connected to a Model 115 by the integrated attachment method.

The optional Byte Multiplexer Channel permits a wide variety of low-speed I/O devices to be connected to a Model 115. This channel is implemented by a microprogrammed IOP and is functionally similar to the Byte Multiplexer Channels in other System/360 and 370 models. It has 8 control unit positions and 32 subchannels. Eight of the subchannels can be shared (i.e., assigned to an I/O control unit that has up to 16 devices attached). The Byte Multiplexer Channel is designed to operate primarily in the byte-interleaved mode, which allows multiple low-speed devices on separate subchannels to operate concurrently. It can also operate in burst mode, which allows only one I/O operation at a time, but burst-mode operation of unbuffered devices is not recommended. The maximum I/O data rate for the Byte Multiplexer Channel is 19,000 bytes/second in byte-interleaved mode and 29,000 bytes/second in burst mode. The Byte Multiplexer Channel and the Integrated Card I/O Attachment (for the 2560 MFCM or 5425 MFCU) are mutually exclusive unless RPQ Features 7B0141 and 7B0132 are installed.

No Block Multiplexer Channels nor Selector Channels are available for the Model 115.

INPUT/OUTPUT CONTROL (MODEL 125)

In place of conventional I/O channels, Model 125, like the smaller Model 115, uses internal Input/Output Processors

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Model 115 is upward-compatible with the larger System/370 processors, offers most of the same processing facilities, has the same virtual storage capabilities, and can use the same DOS/VS software facilities. Like the Model 125, which it strongly resembles in architecture and performance, the Model 115 incorporates two features that are not present in the larger Model 135 and 145 systems: a standard operator console with CRT display, and independent "satellite" processors that permit simultaneous instruction processing, input/output processing, and diagnostic/maintenance processing. In addition, the Model 115 continues the IBM trends to MOSFET main memory and toward integrated controllers for most peripheral units, including up to 280 million bytes of high-performance 3340 Disk Storage and 12 data communications lines.

The Model 115, like the Model 125, employs distributed processing techniques. The CPU includes a Machine Instruction Processor (MIP), a Service Processor (SVP), and Input/Output Processors (IOP's), all of which can operate independently and simultaneously. The MIP interprets the program instructions and executes the internal operations of the system. The SVP controls the console operations and handles a variety of diagnostic and error-recovery functions. The IOP's control the system's I/O operations in place of conventional input/output channels; the number of IOP's varies with the configuration of each installation.

The microprograms that control all the internal operations of the Model 115 Processing Unit reside in Reloadable Control Storage (RCS), a MOSFET memory that is separate from main storage. The microprograms are loaded into RCS via the Console File, a small read/write disk drive that holds a removable magnetic "diskette."

There are some significant limitations on the peripheral equipment that can be used in a Model 115 system. The only available high-performance peripheral subsystem is the new 3340 Direct Access Storage Facility. From two to four 3340 drives, each capable of storing either 35 or 70 million bytes of data in a removable 3348 Data Module, can be connected directly to a Model 115 Processing Unit. Optional integrated I/O attachments permit direct connection of the following I/O devices:

- Either a 2560 Multi-Function Card Machine (for 80-column cards) or a 5425 Multi-Function Card Unit (for 96-column cards).
- One of three line printers: the 300-lpm 5203 Model 1, the 600-lpm 3203 Model 1, or the 1200-lpm 3203 Model 2.
- A 5213 Console Printer (85 char/sec).
- Up to 4 synchronous (BSC) and 8 asynchronous (start-stop) communications lines.
- A 3410/3411 Magnetic Tape Subsystem, Model 1 (20KB), Model 2 (40KB), or Model 3 (80KB), con-

(IOP's) to control its I/O operations. Each IOP is implemented through microprograms in a discrete Reloadable Control Storage area and can access main storage independently. Thus, attached I/O devices can operate concurrently with devices attached to other IOP's and with internal computing. The number of IOP's depends upon the configuration and features of each Model 125 installation.

From two to four 3330 Series Disk Storage drives or two to eight 3340 Disk Drives can be connected directly to a Model 125 Processing Unit. Optional integrated attachment features permit direct connection of any of the following devices; no separate control units or I/O channels are required:

3410/3411 Magnetic Tape Subsystem
3504 Card Reader
3525 Card Punch
2560 Multi-Function Card Machine
5425 Multi-Function Card Unit (96-col.)
1403 Printer, Model 2, 7, or N1
3203 Printer, Model 1 or 2
Up to 16 asynchronous and 6 BSC communications lines

The optional Multiplexer Channel permits a wide variety of low-speed I/O devices to be connected to a Model 125. This channel is implemented by a microprogrammed IOP and is functionally similar to the Multiplexer Channels in other System/360 and 370 models. It has 8 control unit positions and 32 subchannels. Eight of the subchannels can be shared (i.e., assigned to an I/O control unit that has up to 16 devices attached). The Multiplexer Channel is designed to operate primarily in the byte-interleaved mode, which allows multiple low-speed devices on separate subchannels to operate concurrently. It can also operate in burst mode, which allows only one I/O operation at a time, but burst-mode operation of unbuffered devices is not recommended. The maximum I/O data rate for the Multiplexer Channel is 25,000 bytes/second in byte-interleaved mode and 29,000 bytes/second in burst mode.

No Block Multiplexer Channels nor Selector Channels are available for the Model 125.

INPUT/OUTPUT CONTROL (MODELS 135-195)

I/O CHANNELS: The System/370 employs three distinct types of I/O channels in Models 135 and above:

- 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 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.

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sisting of a control unit and up to four (Model 1) or six (Model 2 or 3) tape drives.

In addition, an optional Byte Multiplexer Channel permits the connection of a variety of other low-speed I/O devices, including paper tape readers and punches, optical the Byte Multiplexer Channel is only 19,000 bytes/second in byte mode or 29,000 bytes/second in burst mode, and no Block Multiplexer Channels nor Selector Channels are currently available for the Model 115.

IBM is marketing the Model 115 as a growth system for current users of the IBM System/3, 1130, and System/360 Models 20, 22, and 25. Conversion to the Model 115 should be relatively simple for System/360 Model 22 and 25 users, reasonably straightforward for 360/20 users (thanks to the availability of an integrated 360/20 emulator for the Model 115), and far from easy for users of the architecturally dissimilar System/3 and 1130 computers.

Instruction execution rates of the Model 115 in typical applications will be approximately 1 to 1.5 times faster than those of the 360/22 and 1.5 to 3 times faster than those of the 360/25. Moreover, a 65K Model 115 system with 140 million bytes of 3340 Disk Storage can be rented for about the same price as a 32K 360/25 system with only 15 million bytes of 2311 Disk Storage.

Typical Model 115 systems rent for $6,240 to $8,640 per month, with purchase prices ranging from about $265,000 to $352,000. Customer deliveries began in the first quarter of 1974.

As originally announced, the Model 115 offered only two main storage capacities: 65K or 98K bytes. The viability of a 65K or even a 98K real main storage capacity in a DOS/VS system was suspect from the very time of its announcement. It was widely speculated that it would be only a matter of time before IBM would announce increased main storage capacities for the Model 115 (and, indeed, for Models 125 and 135 also). Thus, the July 1973 announcement of 131K and 163K main storage capacities and the subsequent December 1974 expansion to 196K bytes of main storage for the Model 115 came as no surprise.

Users of the System/360 Model 30 will naturally view the Model 115 with great interest. For them, the new model offers somewhat higher internal performance together with significant reductions in equipment costs. This type of conversion is bound to be looked upon with disfavor by IBM unless the alternative is loss of the account to another manufacturer. An additional deterrent for Model 30 users is the lack of DOS support on the Model 115; unlike the larger Model 125, 135, and 145 systems, the Model 115 cannot operate under the older DOS system. Software support for the Model 115 will center on DOS/VS, since the limited main storage capacity precludes the use of IBM's more powerful OS/VS1, OS/VS2 or VM/370 operating systems and their associated facilities.

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, 3330, or 3340 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 has 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 original Models GE through I of the Model 145 Processing Unit can be equipped with an Integrated File Adapter (IFA) to control up to eight 2319 Disk Storage drives or with a 3345 Storage and Control Frame, Model 3, 4, or 5, to control up to 32 IBM 3330 or 3340 series disk drives. The new Models H2 through J2 of the Model 145 Processing Unit can be equipped with an Integrated Storage Control for up to 32 IBM 3330 or 3340 series disk storage drives; neither the IFA nor the 3345 Storage and Control Frame can be used with these models, and 2319 Disk Drives, if used, must be connected via a 2314 Storage Control.

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Although IBM is billing the Model 115 as a growth system for large System/3 and 1130 installations, no emulation features have been announced to help smooth the conversion process for users of these systems. IBM does offer upward-compatible RPG II and FORTRAN compilers for the Model 115, but System/3 and 1130 users will encounter numerous differences in system control, data management, and operational characteristics which could hamper conversions to the System/370.

Model 125 was added to the System/370 product line in October 1972. Its distinctive features include MOS main storage, distributed-processor architecture, an integrated CRT display console, and integrated controllers for a printer, card reader, punch, 80-column MFCM or 96-column MFCU, magnetic tape subsystem, up to 22 communications lines, and up to 400 million bytes of 3330-style disk storage. The Model 125 is fully program-compatible with the larger System/370 processors and offers most of the same facilities, including up to 16 million bytes of virtual storage. When it was originally announced, the Model 125 offered 98K or 131K bytes of main storage. IBM's July 1973 announcement of expanded memory capacities for the smaller System/370 processors added three new memory sizes for the Model 125: 163K bytes, 196K bytes, and 262K bytes.

The Model 125 provides approximately two-thirds of the internal processing power of the Model 135 at a substantially lower cost. Monthly rental prices for typical Model 125 systems range from about $8,500 to $14,600, with purchase prices ranging from about $385,000 to $615,000. Customer shipments began in April 1973, and the supporting DOS/VS software became available in June 1973.

IBM is placing primary marketing emphasis on the Model 125 as the growth system for System/360 Model 22 or 25 users who need to handle increased workloads or add applications. In typical commercial applications, the Model 125 in Basic Control mode delivers approximately 1.3 to 3.0 times the internal speed of a Model 22 and approximately 2.0 to 4.5 times the internal speed of a Model 25. Moreover, a 98K Model 125 system with 200 million bytes of 3330 Series Disk Storage (2 drives) can be rented or purchased for about the same price as a 49K Model 25 system with 29 million bytes of 2311 Disk Storage (4 drives).

The Model 125 enjoys the distinction of being the first IBM system below the "super-computer" class to employ distributed processing techniques. The Model 125 CPU includes an Instruction Processing Unit (IPU), a Service Processor (SVP), and Input/Output Processors (IOP's), all of which can operate independently and simultaneously. The IPU interprets the program instructions and executes the internal operations of the system. The SVP, located in the operator's console, controls the console operations and handles a variety of diagnostic and error-recovery functions. The IOP's control the system's I/O operations in place of conventional input/output channels; the

The Model 155 or 155-II 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 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.

The optional Integrated Storage Control, available for either the Model 158 or 168 Processing Unit, provides two separate data paths, each capable of accommodating up to 32 IBM 3330 or 3340 series disk drives.

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 de-

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number of IOP's varies with the configuration and features of each Model 125 installation.

Model 135 was introduced in March 1971 and enhanced through the addition of virtual storage capabilities in August 1972. Its distinctive features include 98K to 524K 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.

Four new central processor models were added to the Model 135 line when IBM announced expansions to the main memory capacities of the smaller members of the System/370 series in July 1973. Maximum main memory for Model 135 was thereby increased from 245K to 524K bytes.

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 $10,400 to $25,000, 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.

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, doubled main storage capacity in February 1973, and doubled main storage capacity again in June 1974. 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 was designed to serve as an effective upgrade machine for 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

vices are normally connected to a Byte Multiplexer Channel.

MULTIPROCESSING CONFIGURATIONS: A Model 158 MP (Multiprocessing) system consists of two 3158 MP Processing Units, a 3058 Multisystem Unit, and appropriate peripheral subsystems. Each of the two Processing Units in a system must have the same main storage capacity, which can range from 0.5 million to 4 million bytes per Processing Unit. Moreover, each Processing Unit can have up to 6 I/O channels (5 Block Multiplexers and 1 Byte Multiplexer or 4 Block Multiplexers and 2 Byte Multiplexers). The 3058 Multisystem Unit interconnects the two Processing Units and houses a configuration control panel which the operator can use to reconfigure the system.

A Model 168 MP (Multiprocessing) system consists of two 3168 MP Processing Units, a 3068 Multisystem Communication Unit, and appropriate peripheral subsystems. Each of the two Processing Units can have from 1 to 8 million bytes of main storage. The two Processing Units can have different storage capacities in a 168 MP system, but IBM recommends that the two systems be configured as symmetrically as possible for higher availability. Each Processing Unit can have up to 12 I/O channels, including a maximum of six 2860 Selector Channels, two 2870 Byte Multiplexer Channels, or eleven 2880 Block Multiplexer Channels. The 3068 Multisystem Communication Unit interconnects the two Processing Units and houses a configuration control panel which the operator can use to reconfigure the system. Multiprocessing features must be added to the 3066 Systems Console and the 3067 Power and Coolant Distribution Unit.

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

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main storage capacities of up to 2,097,152 bytes—16 times the maximum capacity of the Model 40 and 32 times that of the Model 30. Model 145 also provides greatly increased I/O capabilities: a standard Byte Multiplexer Channel 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 $18,000 to $49,000, with purchase prices ranging from about $800,000 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 $35,000 to $86,000 per month.

Users of rented Model 155 systems will not be able to make use of the new virtual storage software unless they elect to move up to a Model 158. For purchased Model 155 sytems, IBM will field-install the Dynamic Address Translation facility for a cool $200,000. 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 is designated a *Model 155-II.*

Model 158, introduced in August 1972, effectively superseded 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 sixty-four 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. In February 1973, IBM doubled the maximum main storage capacity of the Model 158 by

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). Note that the IFA, a featured capability of the original Models GE through I of the 145 Processing Unit, is not available for the new Models H2 through J2.

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 B1—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 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 System/370 Models 135 through 195.

3330 DISK STORAGE, MODELS 1 AND 2: Provides fairly rapid access to large quantities of data stored in interchangeable 3336 Disk Packs. Each 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.

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announcing two new central processor models with 3 and 4 megabytes.

Monthly rentals for typical Model 158 configurations range from about $53,000 to $92,000, with purchase prices ranging from about $2,300,000 to $4,000,000. As compared with Model 155, IBM 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 began in April 1973.

Model 158 MP is IBM's designation for the dual-processor Model 158 configuration introduced in February 1973. A Model 158 MP system consists of two 3158 MP Processing Units, a 3058 Multisystem Unit, and appropriate peripheral subsystems. The two processors in a system must have the same main storage capacity, which can range from 0.5 to 4 megabytes each, and each processor can have up to 6 I/O channels. Monthly rentals for typical Model 158 MP configurations range from about $116,000 to $216,000, and customer shipments began in March 1974.

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 $76,000 to $162,000 per month.

Users of purchased Model 165 systems can 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 166 DAT facility began in December 1973, and a system that includes it is 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 8,388,608 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

Rotational Position Sensing and Multiple Requesting are standard features. 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 disk drive; after each request is logged, the channel disconnects until the desired record position is reached and the channel is free. 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 error up to 11 bits in length on a single track.

Two, three, or four 3330 series drives, each providing 100 million bytes of on-line storage, can be connected directly to a Model 125 Processing Unit; no I/O channel or attachment feature is required. The first two drives are contained in the 3333 Disk Storage and Control module. The subsystem can be expanded by adding either a 3330 Model 1 Disk Storage module, which contains two drives, or a 3330 Model 2, which contains one drive. Each drive is mounted in a powered drawer for operating convenience.

In the larger System/370 models, a 3330 subsystem can include from 2 to 32 disk drives, in 1-drive or 2-drive increments. A "channel-attached" 3330 subsystem consists of a 3830 Model 2 Storage Control and from one to four 3333 Disk Storage and Control modules, containing two drives each; the 32-Drive Expansion feature, announced in February 1973, is required when more than two 3333's are used in a subsystem. Up to three 3330 Disk Storage modules, containing one or 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.)

An "integrated" 3330 subsystem contains from one to four 3333 Disk Storage and Control modules, containing two drives each; the 32-Drive Expansion feature, announced in February 1973, is required when more than two 3333's are used in a subsystem. Up to three 3330 Disk Storage modules, containing one or 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 H2, HG2, I2, IH2, or J2 via the Integrated Storage Control; to a Model 145 GE, GFD, H, HG, or I 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 64 drives. A 3330 subsystem connected to the Model 135 IFA is limited to a maximum of two 3333 modules and 16 drives total.

The 3333 String Switch Feature, announced in February 1973, permits program-controlled switching of a 3333 Disk Storage and Control module and its attached 3330 Disk Storage Modules between two control units or attachments. The switching can be either dynamic, with the two control units or attachments contending for the 3333 and its attached drives, or static, with the 3333 dedicated to a single control unit or attachment via an enable/disable switch. A Remote Switch Attachment permits installation of the 3333 String Switch on the configuration control panel of a Model 158 MP or 168 MP system.

3330 DISK STORAGE, MODEL 11: The 3333 Model 11 Disk Storage and Control and the 3330 Model 11 Disk

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per second, and Integrated Storage Controls for up to sixty-four 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 $100,000 to $184,000, with purchase prices ranging from about $4,500,000 to $8,400,000. As compared with Model 165, IBM 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. Customer deliveries began in August 1973.

Model 168 MP is IBM's designation for the dual-processor Model 168 configuration introduced in February 1973. A Model 168 MP system consists of two 3168 MP Processing Units, a 3068 Multisystem Communications Unit, and appropriate peripheral subsystems. Each of the two processors can have from 1 to 8 million bytes of main storage and up to 12 I/O channels. The two processors can have different storage capacities, but IBM recommends that the two systems be configured as symmetrically as possible to increase their availability. Monthly rentals for typical Model 168 MP systems range from about $280,000 to $400,000, and customer shipments began in March 1974.

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 $200,000 to $290,000 per month.

MULTIPROCESSING

Until February 1973, the most noteworthy omission from the impressive System/370 product line was multiprocessing. It was not possible for two or more System/370 processors to share a common bank of main

Storage, announced in July 1973, offer twice the capacity of the original 3330 Disk Storage units at about a 40 percent increase in price. The doubled disk pack capacity is achieved through the use of twice as many tracks on each disk pack surface. A full 8-drive string configuration of 200-million-byte-per-pack units provides up to 1.6 billion bytes of on-line storage for System/370 Models 135 through 168 OS/VS systems.

The "double-density" Model 11 units use the same track lengths and record formats as the Model 1 and 2 units and can be connected to any of the following: a stand-alone 3830 Model 2 Disk Control (on Models 135 through 168), an Integrated File Adapter (on Model 135), a 3345 Model 3, 4, or 5 Storage and Control Frame (on Model 145), or an Integrated Storage Control (on Model 145-2, 158, or 168).

A full 8-drive Model 11 subsystem string consists of four dual-spindle units (one 3333-11 and three 3330-11's). Model 11 and Model 1 units can be mixed in a subsystem, but Model 1 drives can only operate with Model 1 packs and Model 11 drives are restricted to using Model 11 packs. No special feature is required for intermixing the two types of drives in a subsystem. To prevent operator errors, Model 11 drives have black address plugs (those on Model 1 drives are white) and the Model 11 packs carry matching black stripes. A pack improperly placed on the wrong type of spindle will neither uncover nor be accepted. The size, weight, and other physical characteristics of the disk packs and drive units are unchanged.

All of the standard 3330 Model 1 features are retained and supported: Rotational Position Sensing, Multiple Requesting, Command Retry, Record Overflow, and String Switching. One new feature is available with Model 11: the Write Format Release frees the channel and control attachment while the drive erases to the end of the track from the end of a formatted write record, thus permitting concurrent direct-access storage device functions to take place while the Model 11 completes a format write command chain.

Support for the "double-density" drives and their features is provided under OS/VS1, OS/VS2, and VM/370.

Model 1 units can be converted to the corresponding Model 11 units, whether they are already in the field or on order. Conversion of a purchased 3330 or 3333 Model 1 to a 3330 or 3333 Model 11 will cost $26,500. Model 1 disk packs can be converted to 3336 Model 11 Disk Packs at a cost of $650; these must be returned to IBM for the conversion, which takes about 3 weeks. Lease plans can be converted as required without penalty.

3340 DIRECT ACCESS STORAGE FACILITY: Provides fairly rapid random access to large quantities of data stored in interchangeable 3348 Data Modules. Usable with System/370 Models 115 through 168, under DOS/VS or OS/VS.

The 3340 drives are available in three models with the following configuration rules. Model A2 contains two drives and a control; it can be connected to a System/370 Model 115 or 125 via direct attachment, to a System/370 Model 135 via the Integrated File Adapter, to a System/370 Model 145 or 158 via the Integrated Storage Control, or to a System/370 Model 135, 145, 155-II, or 158 via a 3830 Model 2 Storage Control. The 3340 Models B1 and B2 contain one and two drives, respectively; they can be connected to a 3340 Model A2 to form a string of up to eight drives. The maximum numbers of 3340 drives that can be connected via the integrated attachments are 4 drives on a Model 115, 8 on a Model 125, 16 on a Model 135, 32 on a Model 145, and 64 (in 2 subsystems) on a Model 158 or 168. Up to 32 drives (4 strings of 8) can be connected to a 3830 Model 2 Storage Control. The use of

storage—even though this capability was available for the earlier System/360 Model 65 and has long been an important feature of competitive lines from Burroughs, Control Data, Honeywell, and UNIVAC.

IBM has now attacked and obliterated this product-line deficiency with its customary thoroughness. Two fundamentally different types of System/370 multiprocessing are now supported.

A "tightly coupled" multiprocessing system features two Model 158 or Model 168 Processing Units which share their combined main storage and operate under a single OS/VS2 Release 2 control program; these are the previously described Model 158 MP and 168 MP systems.

A "loosely coupled" multiprocessing complex can consist of up to four uniprocessor or dual-processor "local systems", each accessing only its own main storage and running under its own OS/VS2 or OS/MVT control program, with the overall management and scheduling controlled by a single "global system" utilizing OS/VS2 Release 2 and the new JES3 job entry subsystem.

Both types of multiprocessing offer important benefits in terms of increased system reliability and more flexible utilization of system resources. But users who adopt System/370-style multiprocessing will pay a high price in terms of both equipment costs and software overheads. Even the smallest System/370 multiprocessing configurations are powerful, costly computer systems, and users with hardware budgets below $100,000 per month can pretty well forget about them. Practical configurations of the Model 158 MP begin at about $116,000 per month, which is far higher than other well-proven multiprocessor systems such as the Burroughs B 6700, CDC Cyber 70 Series, Honeywell Series 600, and UNIVAC 1106 and 1110.

SEMICONDUCTOR MAIN STORAGE

When the System/370 Model 145 was unveiled in September 1970, its most newsworthy feature was its "monolithic main memory," which makes use of bipolar LSI (large-scale integration) technology in place of conventional magnetic cores. 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. Cycle time is 770 nanoseconds per 2-byte write operation.

In the original Model 135 and 145 Processing Units, each 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-

more than 16 drives in a subsystem requires the addition of a Control Storage Extension and 32-Drive Attachment feature on the 3830 Storage Control or CPU Integrated Storage Control. It is possible to intermix 3330 and 3340 drives on the same attachment or control under OS/VS, but not under DOS/VS.

Each 3340 drive accommodates one 3348 Data Module, either Model 35 or Model 70, at a time. The Data Module is a self-contained unit that includes not only the magnetic disks, but also the associated access arms and read/write heads. Since the same heads always serve the same tracks, head alignment problems should be reduced and data reliability enhanced. Each Data Module is a sealed unit 8 inches high, 16 inches wide, 18 inches long, and 16 pounds (Model 35) or 18 pounds (Model 70) in weight. Loading of the Data Module is an automatic process; the operator simply places the Data Module on a drive, closes the drive cover, and turns on a switch. Processing can begin in less than 20 seconds.

The 3348 Model 35 Data Module has 348 cylinders and a total storage capacity of 34.9 million bytes. Model 70 has 696 cylinders and a total storage capacity of 69.8 million bytes. Both models have 12 tracks per cylinder and can store up to 8368 bytes in each track. Both models exhibit the same performance: average head movement time is 25 milliseconds, average rotational delay is 10.1 milliseconds, and data transfer rate is 885,000 bytes/second.

In addition to the sealed 3348 Data Modules, the 3340 subsystem includes other features that should contribute to improved reliability. An error correction code permits automatic correction of an error up to 3 bits long and detection of an error up to 11 bits long in each record. A closed-loop air filtration system reduces airborne contaminants that might cause read/write errors. A read-only switch on every 3340 drive is activated by inserting a latch in the Data Module; when the latch is not inserted, the data is protected against erasure or overwriting.

The command set for the 3340 subsystem is essentially the same as the 2314/3330 command set with minor modifications. Customer shipments of the 3340 began in November 1973 for System/370 Model 125 systems and in March 1974 for other System/370 models.

A System/370 Model 125 with 3340 Disk Storage can be equipped with a no-charge compatibility feature that enables it to execute DOS programs written for either IBM 2311 Model 1 or 2314 disk files. The data from four 2311 Model 1 disk packs or one 2314 disk pack can be contained in a single 3348 Model 35 Data Module, and a 3348 Model 70 Data Module holds twice as much data. Emulation of the 2311 Model 1 and the 2314 are mutually exclusive, and emulation can be performed only under DOS (Release 21 or later). Under DOS Release 21 through 27, the 1052 Compatibility Feature and the 5213 Model 1 Console Printer are prerequisites.

In April 1974, IBM announced a new 3348 Model 70F Data Module that provides 502,080 bytes of fixed-head disk storage and 69.3 million bytes of storage accessed by moveable heads. The Model 70F Data Module can be used on a 3340 Model A2 or Model B2 disk drive that is equipped with the 4301 Fixed Head Feature, and can be intermixed and interchanged on a 3340 Model A2 or B2 with other 3348 Data Modules. The first five logical cylinders on the Model 70F are accessed by a fixed read/write arm, while the remaining cylinders are serviced by moving read/write heads. The performance characteristics of the 3348 Model 70 and Model 70F Data Modules are compared below:

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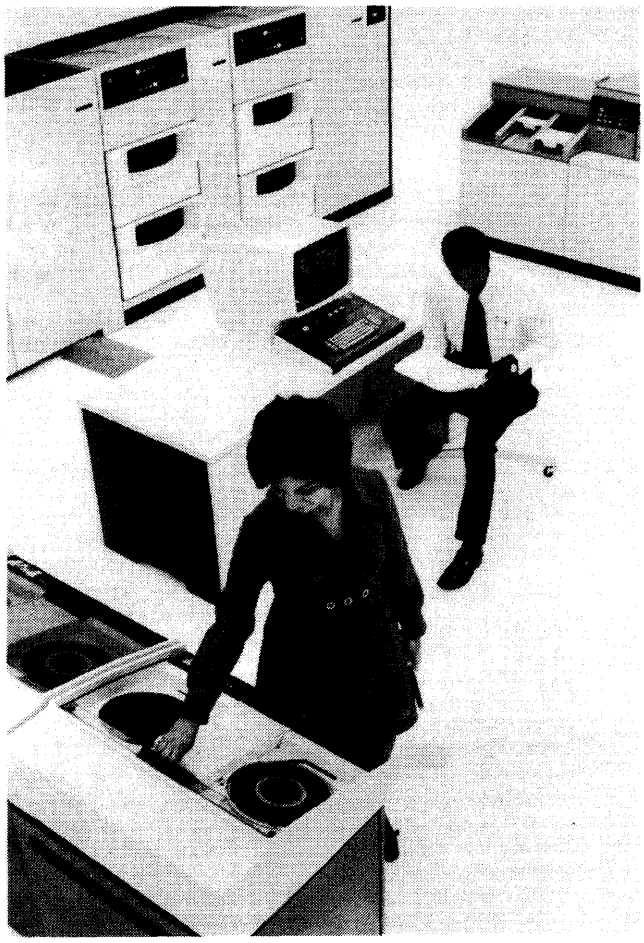

The Model 125, introduced in October 1972, was the first IBM system below the "super-computer" class to employ distributed processing techniques. Direct access storage devices available for the Model 125 include the 3330 Series Disk Storage drives (left rear) and the newer 3340 Direct Access Storage Facility.

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 the new Model 145 Processing Units introduced in February 1973 (Models HG2 through J2) and June 1974 (Models JI2 and K2), and the new Model 135 Processing Units introduced in July 1973 (Models H through I), IBM is using new and considerably denser bipolar memory circuits that store 1024 bits in each chip. The more compact circuits substantially reduce the CPU floor-space requirements, enabling up to 1048K bytes of storage to be housed in a Model 145 mainframe that previously held only 262K bytes.

The separate 3345 Storage and Control Frame, required with the earlier 393K and 524K Model 145 mainframes, is not used with the new models. Power and air conditioning requirements of the new chips are also substantially lower. The older 128-bit chips, however, will continue to be used for the first 262K bytes of storage in each processor. For

	3348 Model 70	3348 Model 70F	
	Cylinders 0-695	Cylinders 1-5	Cyl. 0 & 6-695
Average seek time (ms)	25	0	25
Average rotational delay (ms)	10.1	10.1	10.1
Data rate (KB/sec)	885	885	885
Bytes per track	8,368	8,368	8,368
Data cylinders	696	5	691
Tracks per cylinder	12	12	12
Capacity (bytes)	69,889,536	502,080	69,387,456

Model 35 and 70 Data Modules cannot be field-upgraded to the Model 70F. Each Model 3340 Model A2 or B2 that operates with the Model 70F Data Module must be equipped with the 4301 Fixed Head Feature. A 9190 Fixed Head Attachment is also required on each system attachment to which a 3340 Direct Access Storage Facility with the Fixed Head Feature is attached, including the 3135 IFA, the 3145 ISC, the 3158 ISC, the 3168 ISC, the 3340 Storage and Control Frame Model 3, 4, or 5, and the 3830 Storage Control Model 2. On the 3135 IFA, the 9190 Fixed Head Attachment requires 300 bytes of control storage; a 2150 Control Store Extension must be added to the 3145 ISC, the 3158 ISC, the 3168 ISC, the 3345 Models 3, 4, and 5, and the 3830 Model 2, which includes both the 9190 Fixed Head Attachment and the 9841 String Switch Attachment. Model 3830-2 Storage Control Units with the 8171 Two Channel Switch cannot be equipped with the 9190 Fixed Head Attachment. Software support for the 3348 Model 70F Data Module is provided under DOS/VS, OS/VS1, and OS/VS2. Customer deliveries began in the third quarter of 1974.

3850 MASS STORAGE SYSTEM: Announced in October 1974, the 3850 Mass Storage System combines both magnetic tape and disk storage technologies to provide on-line access to very large collections of data. The 3850 uses a cylindrical data cartridge, approximately 2 inches in diameter and 4 inches long, containing a 771-inch length of 3-inch-wide magnetic tape as the primary storage medium. Each cartridge can contain up to 50 million bytes of data, which is recorded in a format identical with that of the IBM 3336 Model 1 Disk Pack. One data cartridge, thus, can contain the equivalent of up to 202 cylinders, with 19 tracks per cylinder and 13,030 characters per track; and two data cartridges, according to IBM terminology, equal one "mass storage volume" (i.e., one 3336 Model 1 Disk Pack). Purchase price for a 3850 magnetic tape cartridge is $20, compared to $775 for one 3336 Model 1 Disk Pack.

The data cartridges are stored in honeycomb-like cells in the 3851 Mass Storage Facility. Also included in the 3851 are from two to eight Data Recording Devices that transcribe the data between the magnetic tape cartridges and a group of dedicated 3333/3330 Disk Storage Drives. The data transfer rate from the magnetic tape cartridge to the Data Recording Device is 874,000 bytes per second, and the transfer rate between the 3830 Model 3 Disk Control and the central processor is 806,000 bytes per second.

Each 3851 Mass Storage Facility contains one or two Mass Storage Controls, which provide interfaces between the System/370 central processor and the disk storage system controller to initiate and control the data transfer operations between the 3851 and the disk pack drives. The minimum time required for the accessor to place a cartridge in the Data Recording Device entry position, or to restore the cartridge, is approximately three seconds, and the maximum can range from four to eight seconds depending on the size of the Mass Storage Facility. After the cartridge is placed in the entry position of the Data Recording

capacities in excess of 262K bytes, IBM offered the new, denser Model 145 memory at an incremental purchase price of 46 cents per byte, compared with 96 cents per byte for the original Model 145 memory and 22 cents per byte for the MOS memory used in Models 158 and 168.

The expanded memories on the Model 135 above the 192K size (except for the 240K Model 135 DH) also employ the new bipolar technology. Model 135 will continue to use the 128-bit bipolar chips for the first 192K bytes, and upgrades in memory size will first require a buildup to the 245,760-byte Model 135DH size using the older technology. The denser new storage for Model 135 struck another blow against the burgeoning "add-on" memory market; prices on a monthly rental per byte basis for the new bipolar memory average nearly 48 percent lower than for the older-technology storage.

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, probably because of uncertainty as to whether the necessary degree of quality control could be maintained in the mass production of MOS circuits. It is clear that these doubts have now been resolved, because the newer Model 115, 125, 158, and 168 systems all 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 can be made even smaller. In the Model 158 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 memories. The smaller sizes of the Model 168 CPU use the same 1024-bit chips as the Model 158; but the 5, 6, 7, and 8 megabyte models, introduced in February 1973, store 2048 bits in each chip.

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. 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 caused its commercial acceptance to lag behind that of the bipolar technology.

IBM's selection of MOS for the Model 115, 125, 158, and 168 main memories has obviously helped 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

Device, the approximate positioning time to locate the first physical position and begin data transfer to the 3830 Model 3 Disk Control is five seconds.

The 3851 Mass Storage Facility comes in two versions, Models A and B, with four models of each version. The A series units have one Mass Storage Control, while the B series units each contain two Mass Storage Controls. All models have two accessor mechanisms; in Models A1 and B1 the second accessor serves as an alternative to an inoperative first accessor, while in Models A2 and B2 both accessors can operate simultaneously. The functional characteristics and storage capacities of all the models of the 3851 Mass Storage Facility are as follows:

	A1, B1	A2, B2	A3, B3	A4, B4
Cartridge capacity (no. of cartridges)	706	2044	3382	4720
Byte capacity (billions of bytes)	35.3	102.2	169.1	236.0
Data recording devices	2	4	6	8
Data recording controls	1	2	3	4
Accessors	2	2	2	2

A maximum of two 3851 Mass Storage Facilities from the A series of models or one 3851 Mass Storage Facility from the B series of models can be included in a 3850 Mass Storage System. The 3851 Mass Storage Facility attaches to a System/370 Byte Multiplexer or Block Multiplexer Channel and can be shared by up to four System/370 central processors, or by a maximum of two System/370 multiprocessor systems.

IBM Model 3333/3330 Disk Storage Units serve as intermediary storage between the central processor and the Mass Storage Facility. A new microprogrammed 3830 Model 3 Storage Control for System/370 Models 145, 155-II, 158, 165-II, and 168 is required to provide the capability to interact with the Mass Storage Controller. A maximum of sixteen 3330 Model 1 or 2 or eight 3330 Model 11 Disk Pack Drives on either controller can be dedicated as "staging drives" to serve as intermediaries between the central processor and data sets stored in the Mass Storage Facility. Addresses on these drives are associated with a set of virtual drive addresses by logic within the 3830 Model 3 or Integrated Storage Control. The disk controller, working in conjunction with the Mass Storage Controller, converts virtual addresses to actual addresses on the staging drives for use by the Mass Storage Controller. The Mass Storage Facility locates the data set and maps the data into available space on the staging drives in "pages" of eight cylinders for access by the central processor. The 3830 Model 3 and the Integrated Storage Control are connected to a Selector Channel with the Block Multiplexer Channel feature on a System/370 Model 145, or to a Block Multiplexer Channel on a System/370 Model 155-II, 158, 165-II, or 168.

The 3850 is supported under the OS/VS1 and OS/VS2 operating systems and uses a special Mass Storage System Communicator for control of mass storage volumes. Access methods include the BSAM, QSAM, BPAM, BDAM, VSAM, EXCP, and XDAP access methods for direct-access storage devices; use of ISAM will incur significant performance degradation. A new CONVERTV utility is available for conversion of 3336 Model 1 Disk Packs to 3850 volumes. Tape data sets and direct-access data sets, including those on 3336 Model 11 Disk Packs, can be converted to 3850 volumes by Job Control Language parameters directing file output to the 3850 Mass Storage System, or by an OS/VS data set copy utility program.

Models B1 and B2 of the 3851 Mass Storage Facility and the 3830 Model 3 Storage Control are scheduled for first

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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.)

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 apparently has not created 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 at first made 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, Datapro's user surveys have established that System/370 users 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 115, 125, 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 flexible single-disk cartridges called "diskettes" or "floppy disks" at the rate of 33,300 bits per second. Each diskette can hold approximately 75,000 bytes, and IBM supplies prewritten diskettes 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

customer delivery in July 1975. Models A1, A2, A3, A4, B3, and B4 are scheduled for customer delivery in November 1975.

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 System/370 Models 135 through 195.

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.

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 bytes/sec.
Model 3: 6 drives; 800 bpi; 15,000 bytes/sec.

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 $229 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 accumulators, 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 from 13 to 27 new instructions to the System/360's already large instruction set. Thirteen of 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. As many as nine more instructions are available for certain

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 System/370 Models 135 through 195.

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 115 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*
Data 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 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 began in December 1972.

3420 MAGNETIC TAPE UNIT, MODELS 3, 5, AND 7: 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. Wrap-around cartridge loading and automatic tape threading are standard features, and an automatic reel latch makes it unnecessary for the operator to lock the tape reel in place. Additional

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processor models to aid in implementing OS/VS2 Release 2, VTAM, and/or multiprocessing.

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.

Models 115, 125, 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.

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.

tachometers control the reel motors' speeds for smoother winding. Read access times are considerably faster than those of the corresponding 2420 drives. A "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.

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 System/370 Models 135 through 195. 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.

3420 MAGNETIC TAPE UNIT, MODELS 4, 6, AND 8: These high-performance models of the 3420 Magnetic Tape Units and 3803 Tape Control, announced in March 1973, provide data transfer rates of up to 1.25 million bytes per second for System/370 Models 135 through 195. The new models employ a proprietary recording method called Group Coded Recording (GCR), which permits data to be recorded on standard 1/2-inch tape at an effective density of 6250 bytes per inch. Information to be written on the tape is segmented into groups of characters to which a special coding character is added. When GCR-coded data is read from the tape, the uniquely coded information is restored to its original form.

The three 6250-bpi models of the 3420 Magnetic Tape Unit—Models 4, 6, and 8—provide maximum data transfer rates of 470,000, 780,000, and 1,250,000 bytes per second, respectively. All three models can be equipped to operate either at the 6250-bpi density only or at both 6250 and 1600 bpi. Unlike the earlier 3420 Models 3, 5, and 7, however, the 6250-bpi models cannot handle either 7-track tape or the 800-bpi 9-track format. The characteristics of the three 6250-bpi tape units are summarized in the following table.

	Model 4	Model 6	Model 8
Tape speed, inches/sec.	75	125	200
Data transfer rate, bytes/sec:			
At 6250 bpi	470,000	780,000	1,250,000
At 1600 bpi	120,000	200,000	320,000
Access time, milliseconds:			
Read, at 6250 bpi	2.3	1.6	1.1
Write, at 6250 bpi	2.1	1.5	0.95
Read, at 1600 bpi	4.0	2.6	1.7
Write, at 1600 bpi	3.0	2.0	1.3
Nominal inter-block gap, inches:			
At 6250 bpi	0.3	0.3	0.3
At 1600 bpi	0.6	0.6	0.6
Maximum rewind time, seconds/2400-ft reel	60	60	45

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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 115, 125, 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
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 unique 3340 Direct Access Storage Facility, the ultra-large-capacity 3850 Mass Storage System, the 2,000-lpm 3211 Printer, the low-priced 3411 Magnetic Tape Subsystem, the highly cost-effective 3420 Magnetic Tape Units (including the new models that record at 6250 bytes per inch), the 96-column 2596 Card Read Punch, the 3881 Optical Mark Reader, the 3886 Optical Character Reader, the 3890 MICR Document Processor, and the 3505 Card Reader and 3525 Card Punch, which share a microprogrammed control unit. Available only with the Model 115 and 125 systems is the 3203 Printer, an improved replacement for the 1403 N1 Printer. Detailed descriptions of all these units can be found in the "Characteristics" section of this report.

The 3803 Model 2 Tape Control provides the power and signal connections for the 3420 Magnetic Tape Units. Up to eight 3420 drives of any model can be signal-connected to a 3803 Model 2. A 3803 Tape Control (either Model 1 or Model 2) provides power for up to eight 3420 Model 3, 4, 5, 6, or 7 drives or for a maximum of six 3420 Model 8 drives. Seven-track and nine-track tape drives with various recording densities can be intermixed on a single 3803 Model 2, and a pool of up to 16 tape drives can be switched between 2, 3, or 4 control units.

At the new 6250-bpi recording density, IBM employs a more powerful encoding/checking technique that permits in-flight correction of errors occurring in any single track or in two tracks simultaneously. Moreover, errors in all nine tracks of a single data block can be corrected if they occur on no more than two tracks at a time. Long tape blocks are subdivided by "resynch bursts," which are inserted to allow error tracks to return to full operation when reading forward, thereby restoring the maximum error correction capability.

The 3420 Model 4, 6, and 8 Magnetic Tape Units employ a new tape cleaning mechanism and a high-precision tape motion control system. The cleaning mechanism is engaged during auto-threading, rewinding, and unloading operations to remove loose contaminants from the tape surface and protect the recording head. The improved tape motion control system permits a 50 percent reduction, from 0.6 inch to 0.3 inch, in the length of the gap between blocks of recorded data and also reduces the read/write access times. Other features of the previous 3420 models, such as automatic threading, cartridge loading, digital tachometers, and a radial interface, are retained in the new models.

The new 3803/3420 units can be used with System/370 Models 135 through 195. Software support is provided under DOS/VS, OS, OS/VS1, and OS/VS2. Customer shipments began in the fourth quarter of 1973, and field conversions of existing 3420 Magnetic Tape Units to the new models began in the first quarter of 1974. The new equipment is available under both IBM's Extended-Term and Fixed-Term Lease Plans.

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 115 through 168.

3540 DISKETTE INPUT/OUTPUT UNIT: Reads and writes IBM diskettes ("floppy disks") as an on-line I/O unit for use with a System/370 Model 115, 125, 135, 145, 155-II, or 158. The 3540 is designed primarily to read data recorded by an IBM 3740 Data Entry System (Report 70D-491-41) into a System/370 computer. Each IBM diskette is organized into 75 tracks, with 26 sectors per track and 128 bytes per sector. Only 73 of the tracks are used for data, so each diskette can store 1898 sectors or 242,944 bytes.

The 3540 consists of a control unit and either one diskette drive (Model B1) or two drives (Model B2). Each drive has a diskette hopper that can hold up to 20 diskettes. The diskettes are automatically fed from the hopper, mounted on the drive spindle for read/write operations, and then removed and stacked.

Double 128-byte buffers are associated with each drive. The diskettes revolve at 360 revolutions per minute. Effective

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3330 DISK STORAGE

In terms of its overall effect on the direct-access storage device offerings of all competitors–both mainframe manufacturers and plug-compatible peripheral suppliers–the 3330 Disk Storage facility probably still ranks as one of the most significant of all the System/370 peripheral devices. A logical extension of the design concepts employed in the earlier 2314 Direct Access Storage Facility, the 3330 made 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 Model 1 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. In February 1973, IBM again doubled the maximum subsystem size to 32 drives.

In July 1973, IBM announced the oft-predicted double-density versions of its 3330 Disk Storage. The new models are the 3333 Model 11 Disk Storage and Control, the 3330 Model 11 Disk Storage, and the 3336 Model 11 Disk Pack. The new 200-million-byte-per-pack units can be connected to System/370 Model 135 through 168 OS/VS systems. In a full 8-drive string configuration, 1.6 billion bytes of Model 11 storage rents for only about 40% more than 800 million bytes of Model 1 storage. The Model 11 units are completely analogous to the respective Model 1 units in the 3330 series except for the doubled disk pack capacity, gained through the placement and use of additional tracks on the disk pack surfaces. The size, weight, and other physical characteristics of the disk packs and drive units remain unchanged. Model 11 and Model 1 units can be mixed in a subsystem, but Model 1 drives can only operate with Model 1 packs, and Model 11 drives are likewise restricted to using Model 11 packs.

3340 DIRECT ACCESS STORAGE FACILITY

Concurrently with the Model 115 announcement in March 1973, IBM unveiled its long-awaited "Winchester" disk drive, officially named the 3340 Direct Access Storage Facility. Initially usable only with DOS/VS systems, the 3340 is now supported under OS/VS as well. It features a totally new approach to interchangeable-cartridge disk storage: the disks, access arms, and read/write heads are all sealed into a removable cartridge called the 3348 Data Module. Because the same heads always serve the same performance, which includes program open time and diskette changing time, depends on the number of sectors read or written per revolution of the diskette and the number of tracks written per diskette. IBM quotes performance rates of 2255 to 3635 records per minute for reading diskettes when more than half the sectors per track and more than half the tracks per diskette are read. Writing operations for equivalent conditions proceed at 1250 to 2210 records per minute.

1442 CARD READ PUNCH, MODEL N1: Reads 80-column cards at 400 cpm and punches them at 160 columns per second. Usable with Models 115 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 115 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 115 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 115 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 115 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 115 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 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 115 through 195.

3504 CARD READER: Reads standard 80-column cards at either 800 cpm (Model A1) or 1200 cpm (Model A2). Connects directly to a Model 125 Processing Unit via the Integrated 3504 Card Reader Attachment. Functionally identical with the 3505 Card Reader used with System/370 Models 135 through 195, below.

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 con-

data tracks within the same air-tight environment, the 3348 can provide reliable data storage at a recording density of more than 1.5 million bits per square inch—twice the density of the 3330 drives and nearly eight times that of the 2314.

The principal characteristics of the 3340 drives can be compared with those of the high-performance 3330 and the older 2314 drives as follows:

	3340	3330	2314
Maximum on-line data per spindle (millions of bytes)	35 or 70	100	29
Average head movement time (milliseconds)	25	30	60
Average rotational delay (milliseconds)	10.1	8.3	12.5
Maximum data rate (bytes per second)	885,000	806,000	312,000

The 3340 subsystem is priced at a somewhat lower cost per byte stored, and a much lower cost per spindle, than the 3330 subsystem. Thus, it is likely that most new DOS/VS installations will choose the 3340 in preference to the 3330.

The complexity—and resultant high cost—of the Data Modules represent the one serious flaw in the 3340 subsystem. At IBM's purchase prices of $1,600 for the 35-million-byte 3848 Model 35, $2,200 for the 70-million-byte 3848 Model 70, and $4,400 for the new 3848 Model 70F described below, these units are the most expensive interchangeable storage media to reach the EDP marketplace in many years. Thus, the high cost of the Data Modules may tend to cancel out the significant price/performance advantages of the 3340 drives themselves. At the very least, it will be economically impractical for an installation to use Data Modules in the same manner as magnetic tape reels—as so many installations are now using disk packs. Instead, the utilization, storage, and retention of all Data Modules will need to be carefully planned and controlled in order to minimize the total number required.

NEW MASS STORAGE CONCEPTS

In 1974 IBM announced two innovative concepts in mass storage, one designed to increase the efficiency of large virtual storage configurations and the second aimed at providing massive amounts of on-line data storage for installations with very large tape libraries.

The first, a fixed-head feature for the Model 3340 Direct Access Storage Facility, was announced in March 1974 and effectively replaces the high-priced Model 2305 Fixed Head Storage Facility as a paging medium for System/370

trol 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. In a Model 125 system, the 3525 can be connected directly to the Model 125 Processing Unit via the Integrated 3525 Card Punch Attachment; only one 3525 can be attached in this manner, and it cannot coexist with a directly connected 2560 MFCM or 5425 MFCU.

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.

2560 MULTI-FUNCTION CARD MACHINE (MFCM), MODEL A1: Combines the functions of an 80-column card reader, punch, collator, and interpreter in one unit. Reads at 500 cpm, punches at 160 columns per second, and (with the optional Card Print feature) prints on the cards at 140 print positions per second. Has two 1200-card feed hoppers and five 1300-card radial stackers. Cards can be fed from either hopper and directed to any stacker. One 2560 can be directly connected to a Model 115 or 125 via the Integrated 2560 Attachment; it cannot co-exist with a directly connected 3525 Card Punch or 5425 MFCU.

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configurations running under the virtual storage operating systems. The new fixed-head option permits 3340 Direct Access Storage Facilities to be field-upgraded with the addition of a Fixed Head Feature in order to accommodate a new 3348 Model 70F Data Module that includes both a fixed read/write arm and moveable read/write heads to provide a hierarchy of on-line main storage. Five of the data module's 696 cylinders, or 500K bytes, are accessed by the fixed read-write arm with only a 10-millisecond average rotational delay, while the remaining cylinders, representing 69.3 million bytes of storage, are served by moving heads with an average seek time of 25 milliseconds, as in the earlier 3348 Model 70 Data Module. The new fixed-head units are supported by the DOS/VS, OS/VS1, and OS/VS2 operating systems, and are available for the System/370 Models 135 through 168.

At the other end of the spectrum, IBM's long-discussed "Project Oak," unveiled as the 3850 Mass Storage System in October 1974, is designed to provide for massive amounts of data storage at much lower costs per byte than previously available equipment. Although the storage medium is a spool of magnetic tape housed in a plastic cylinder four inches in length and two inches in diameter, the operation of the 3850 Mass Storage System is effectively one of a virtual disk facility, with data from the storage device "staged" on Model 3330 or 3333 Disk Storage Drives for access by the central processor. Eight versions of the 3850 Mass Storage System are offered and are distinguished by their storage capacities and the number of control units they contain. The A-series models contain one Mass Storage Control, while the B-series models contain two. The entry-level system has a capacity of slightly more than 35 billion bytes, while a full-blown 3850 Mass Storage System (including two Model 3851 Mass Storage Facilities) provides up to 472 billion bytes of on-line storage—roughly the equivalent of 2,360 200-million-byte disk packs. A 3850 Mass Storage Facility can be shared by from one to four System/370 Models 145, 155-II, 158, 165-II, and 168 computer systems, or by two multiprocessor systems.

Each 3850 Mass Storage System requires a 3830 Model 3 Storage Control to control the flow of data between the Mass Storage Facility, the 3330 disk drives, and the central processor. A maximum of 16 Model 3330 or 8 Model 3330-11 Disk Drives attached to the 3830 Controller can be designated as "staging" drives to receive data stored in the 3851 facility. An expanded 64-unit virtual addressing capability permits the Mass Storage Controller to assign multiple addresses to the staging drives, and each direct-access volume on a staging drive can contain data from up to 51 mass storage "volumes." Hence the applicability of the term "virtual storage" to this new mass storage device. Cartridges stored in the Mass Storage Facility are retrieved by an accessor mechanism in a maximum of four to eight seconds, and then placed in a Data Recording Device which requires an estimated five seconds to locate the desired information. The nominal transfer rate of the Data Recording Device is 874K bytes per second.

The optional Card Print feature enables the 2560 to print 2, 4, or 6 lines on a card, operator-adjustable to any of 25 line positions. There are 64 alphanumeric print positions per line, spaced 10 to the inch. The 2560 Card Print Control feature is a prerequisite on the Model 115 or 125.

5425 MULTI-FUNCTION CARD UNIT (MFCU): Combines the functions of a 96-column card reader, punch, collator, and interpreter in a single unit. Has two 2000-card feed hoppers and four 600-card radial stackers. Cards fed from either or both hoppers can be read, punched, printed, and directed to any of the four stackers under program control. One 5425 can be directly connected to a Model 115 or 125 via the Integrated 5425 Attachment; it cannot coexist with a directly connected 3525 Card Punch or 2560 MFCM. Either the 1403 Printer/5425 MFCU Power Prerequisite or the 5425 MFCU Power Prerequisite is required on the Model 125, depending on whether or not a 1403 Printer is also installed.

The 5425—like the functionally similar 5424 MFCU used in the System/3—is available in two models. Cards are read serially at 250 cpm in Model A1 and 500 cpm in Model A2. Punching is performed serially at 60 cpm in Model A1 and 120 cpm in Model A2. Printing occurs at a speed of 60 cpm in Model A1 and 120 cpm in Model A2 when printing in any or all of the first three line positions on each card. If the fourth (lower) line position is used, the printing speed drops to 48 cpm for Model A1 and 96 cpm for Model A2. Each of the 4 lines can hold up to 32 printed characters.

In contrast to the 6-bit, 64-character code used in the System/3, the 5425 reads and punches an 8-row code representing a 256-character set. Eight-row punching in columns 33 through 96 can result in overpunching of print positions 65 through 128. Characters printed by the 5425 are a 64-character set that corresponds to a 6-bit subset of the 8-bit card code. A new 8-Bit Read/Punch Feature for the 5496 Data Recorder (Report 70D-491-22) will provide a limited capability for creating (through multi-punch keying) 96-column program or data cards using the 8-bit code structure. Customer shipments of the 5425 MFCU began in December 1973.

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 115 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 115 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 115 through 158. Requires 2822 Paper Tape Reader Control.

1403 PRINTER: Provides high-quality printed output by means of a horizontal chain or train mechanism. The standard character set contains 48 characters, and the Universal Character Set (a no-charge option for Model 2 or N1 only) permits up to 240 characters to be printed. Line spacing of 6 or 8 lines per inch is operator-controlled. Standard skipping speed is 33 inches per second; a dual-speed carriage in Models 2 and N1 permits a speed of 75 inches per second on skips of more than 8 lines.

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 125 via the integrated attach-

Software support for the 3850 is scheduled for the OS/VS1 and OS/VS2 operating systems under the standard access methods for direct-access data sets (except ISAM). First customer deliveries are scheduled for July 1975. With monthly rentals ranging from over $12,000 to $34,000, the 3850 obviously is aimed at installations with large tape libraries. In most cases, however, its selection should be preceded by careful consideration of alternatives, such as the use of 6250-bit-per-inch tape for sequential files, and competitive equipment that offers more flexibility in sharing the data base among many central processors.

6250-BPI MAGNETIC TAPE UNITS

On March 7, 1973, IBM advanced the state of the art in magnetic tape recording by introducing new, high-performance models of its 3420 Magnetic Tape Units and 3803 Tape Control. The new models employ a new recording technique called Group Coded Recording (GCR), which permits data to be recorded at an effective density of 6250 bytes per inch on standard 1/2-inch computer tape.

IBM's new 6250-bpi recording density roughly triples the amount of information that can be stored on a single reel of tape. At an average block length of 2000 bytes, for example, a standard 2400-foot reel holds about 31 million bytes at 1600 bpi and about 93 million bytes at 6250 bpi. Thus, the higher density can yield major reductions in tape handling time, tape costs, and tape library storage requirements. These savings, coupled with the much faster data transfer rates and access times of the new units, should help to ensure the continued widespread utilization of magnetic tape equipment despite the ever-increasing popularity of disk pack drives.

Once again a major IBM technological advance has forced the independent peripheral manufacturers to play catch-up. It is worth noting, though, that on the day after IBM's announcement, Storage Technology Corporation announced a new 3600/3800 series of plug-compatible tape drives and control units that match the capabilities of the new IBM units and undercut their prices. Somewhat later, Telex and Calcomp followed suit by announcing plug-compatible tape units. Similar units are also available on an OEM basis from Control Data.

3203 PRINTER

Along with the System/370 Model 115, IBM introduced the 3203 Printer. This improved version of the popular 1403 Model N1 Printer employs the same horizontal-train printing technique and adds a number of new features that make it smaller, quieter, more reliable, and easier to operate than the 1403. Available in two models with rated printing speeds of 600 and 1200 lines per minute, the 3203 is currently usable only with System/370 Models 115 and 125.

ment and power features listed below, or directly to a Model 135 via the optional Integrated Printer Adapter. Characteristics of the three models are as follows:

Model 2: 600 lpm (750 lpm maximum with UCS option), 132 print positions; Features 4505, 4662, and 4667 are required on a Model 125 for direct connection.

Model 7: 600 lpm, 120 print positions; Features 4505 and 4667 are required on a Model 125 for direct connection.

Model N1: 1100 lpm (1400 lpm maximum with UCS option), 132 print positions; Features 4505, 4662, 4667, and 4668 are required on a Model 125 for direct connection.

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 125 through 195; includes an integrated control unit.

3203 PRINTER: Uses IBM's proven horizontal-train printing technology to produce high quality printed output from either a System/370 Model 115 or Model 125 system. The 3203 is an improved version of the widely used 1403 Model N1 Printer and uses the same 1416 Interchangeable Train Cartridge. The 3203 is available in two models; rated print speeds with the standard 48-character set are 600 lpm for Model 1 and 1200 lpm for Model 2. Certain preferred character set arrangements permit speeds of up to 770 lpm for Model 1 and 1550 lpm for Model 2. Character sets containing from 30 to 240 characters can be used. The Universal Character Set feature, with a 240-position buffer, is standard. Both models have 132 print positions. Horizontal spacing is 10 characters/inch, and vertical spacing is 6 or 8 lines/inch. Forms ranging from 3.5 to 20 inches in width and from 3 to 24 inches in length can be fed. Normal skipping speed is up to 24 inches/second, with high-speed skipping at up to 55 inches/second after 6 lines have passed.

Improvements over the 1403 Model N1 include: (1) an electronic forms control buffer that controls skipping and spacing, eliminating the need to change carriage control tapes; (2) a new tractor design to simplify forms loading; (3) higher print-hammer energy to produce copies of improved quality; (4) smaller size and reduced floor-space requirements; (5) quieter operation; and (6) a vacuum cleaning system that continually cleans the print train. Additional 3203 improvements, announced subsequent to the printer's introduction, were ability to print the OCR A Size 1 font (thus creating turn-around documents automatically) and a power-assisted stacker.

A single 3203 Printer, Model 1 or 2, can be connected to either a Model 115 or Model 125 Processing Unit via the appropriate Integrated 3203 Printer Attachment (#4650 on the 125, or #4650 and #4653 on the 115). Customer shipments began in March 1974. Software support for the 3203 is provided under DOS/VS.

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

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At 1200 lpm, the 3203 Model 2 Printer is 100 lpm faster than the 1403 Model N1, while the 3203 Model 1 matches the 600 lpm speed of the 1403 Models 2 and 7. Both models of the 3203 also offer numerous worthwhile improvements over their 1403 counterparts. Unfortunately, this progress comes at a high cost to the user: purchase and rental prices of the 3203 models range from 26 to 44 percent higher than those of the corresponding 1403 models.

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 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. In February 1973, IBM added the smaller, program-compatible 3704, which handles up to 32 lines.

When connected to a System/370 computer, the 3704 and 3705 can use either the Network Control Program (NCP) or the 2701/2/3 Emulation Program. When the NCP is used, the 3704 or 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 3704 or 3705 is connected to a System/360 computer, it can function only in the 2701/2/3 Emulation mode. Thus, the 3704 or 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 115, 125, or 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 12 lines in the Model 115, up to 22 lines in the Model 125, or up to 8 lines in the Model 135.

Virtually the entire complement of IBM communications terminals, as described in Reports 70D-491-02 through 70D-491-45, can be connected to a System/370—as can literally hundreds of terminals from independent suppliers.

In September 1974, IBM restored a higher degree of order to a somewhat muddled communications product line under the resounding title of Advanced Function for Communications through Systems Network Architecture. This facility promises to be the foundation for future

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 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 System/370 Models 135 through 195 via the 3811 Printer Control Unit.

5203 PRINTER, MODEL 3: Uses an interchangeable, horizontal-chain cartridge to produce high-quality printed output from a System/370 Model 115 or a System/3 Model 10. Rated speed is 300 lpm with the standard 48-character set. The standard 96-position print line can optionally be expanded to 120 or 132 positions. Horizontal spacing is 10 characters/inch, and vertical spacing is 6 or 8 lines/inch. Skipping speed is 16.7 inches/second at the usual spacing of 6 lines/inch. Vertical format is under program control; there is no carriage control tape. The standard 48-character chain cartridge can be replaced by other operator-changeable cartridges. The Universal Character Set feature, which is standard when the 5203 is used with a 370/115, permits the use of cartridges containing up to 120 different characters. A single 5203 Model 3 Printer can be connected to a Model 115 Processing Unit via the #4653 Integrated 3203/5203 Printer Attachment.

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 115, 125, 135, 145, 155, or 158 via a System/360/370 Adapter.

1419 MAGNETIC CHARACTER READER: Reads and sorts MICR-encoded documents at up to 1600 per minute. Has 13 pockets. Usable with Models 115 through 168. Also usable for off-line sorting.

1287 OPTICAL READER: Optically reads printed characters into a System/370 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 handprinted characters must conform with specified rules. Usable with Models 115 through 168, although only Model 5 is available with the Model 115 and Model 125 systems. Five models of the 1287 are available:

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developments in IBM's data communications product line. The new approach includes a single communications access method, the Virtual Telecommunications Access Method (VTAM); a single, standardized line discipline, Synchronous Data Link Control (SDLC); a Network Control Program, operating on the IBM 3704 or 3705 Front-End Communications Controller in conjunction with VTAM to control the network; and a family of compatible terminals. The new terminals include the 3767 Communication System, the 3770 Data Communication System, and new models of the widely used 3270 Information Display System equipped to handle SDLC transmission. Also included in the System Network Architecture (SNA) are the special-purpose IBM 3600 Banking System, the 3650 Retail System, the 3660 Supermarket System, and the 3790 Programmable Terminal, as well as the recently announced System/32, the newest and smallest of IBM's computer systems (Report 70C-491-25).

The new SDLC line protocol, as yet undelivered, has the following key characteristics: 1) it is bit-oriented and therefore independent of any specific transmission code; 2) it does not utilize control characters but utilizes positional significance to indicate prescribed functions; 3) it is well suited to handle full-duplex transmission, unbalanced information flow, and unequal frame lengths—capabilities that are advantageous in remote job entry and inquiry/response applications; and 4) it permits communications terminals with dissimilar characteristics to share a single communication line, reducing line costs in communications networks. In announcing SNA, IBM supplied the last major building block in the System/370 architecture and defined a communications strategy that will become profoundly important both to IBM users and the myriad independent terminal manufacturers who supply terminals for use with IBM computer systems.

SOFTWARE

Users of the virtual-storage System/370 processors (Models 115, 125, 135, 145, 155-II, 158, 158 MP, 165-II, 168, and 168 MP) can choose from as many as eight 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 five "new" operating systems – DOS/VS, OS/VS1, and OS/VS2 Release 1 – 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. Release 2 of OS/VS2, announced in February 1973, supports multiprocessing in either a tightly coupled dual-processor configuration of the Model 158 MP or 168 MP or in a loosely coupled, ASP-like network of up to four Models 145, 155-II, 158, 158 MP, 165-II, 168, and/or 168 MP processors; it can also support approximately 1 billion bytes of virtual storage. Associated with each of these systems is a broad range of compilers, utility routines, and application programs. The

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 OCR A font.

Model 4: Same as Model 2, with added capability of reading the alphanumeric OCR 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 OCR A font from page-size documents up to 9 by 14 inches. 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. 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 the 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 by 3 inches to 9 by 12 inches in size. Model 1 reads data directly into a System/370 Model 115, 125, 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. Model 3 operates off-line, transferring data to an IBM diskette drive at speeds of 5,700 3-by-3-inch documents or 3,800 8½-by-11-inch pages per hour. Each diskette has a storage capacity of up to 1,898 records, each 128 characters in length. Data recorded on diskettes by the 3881 Model 3 is compatible with the IBM 3741 Data Station, 3742 Dual Data Station, 3747 Data Converter, and 3540 Diskette Input/Output Unit.

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.

3886 OPTICAL CHARACTER READER: Reads machine-printed characters and handprinted numerals from documents ranging from 3 by 3 inches to 9 by 12 inches in size. Can read typewritten pages measuring 8.5 by 11 inches at the rate of approximately 330 pages per hour for on-line input to a System/370 (3886 Model 1) or 300 pages per hour for off-line recording on magnetic tape (3886 Model 2). The 3886 reads alphanumeric characters in the OCR A and B fonts, preprinted 3/16-inch Gothic numerals, and the handprinted numerals 0 through 9 and letter X. Machine-printed and handprinted data can be read from the same document. Two output stackers permit segregation of unreadable documents. The 3886 Model 1 connects to a Multiplexer or Selector Channel of System/370 Models 115 through 168. The 3886 Model 2 operates off-line, recording data on a 3410 Model 1 Magnetic Tape Unit for later processing.

The Video Collect Features permit data read by the 3886 to be displayed on a 3277 CRT terminal for operator correction and verification and for keyed entry of nonscannable data The 8701 Video Collect Feature permits direct

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eighth 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 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 theoretically support up to 16 million bytes of virtual storage, most installations will get better overall results by choosing to work within a far 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. Release 28, the first version of DOS/VS, was released to users in June 1973.

Release 29 of DOS/VS was distributed in December 1973. New peripheral device support provided under Release 29 includes the 3340 Direct Access Storage Facility, the 3203 and 5203 Printers, the 3540 Diskette Input/Output Unit, the 6250-bpi 3420 Magnetic Tape Units, the 5425 Multi-Function Card Unit, and the 3780 Communications Terminal for remote job entry. In addition, Release 29 incorporates several enhancements to DOS/VS. A Shared Virtual Area (SVA), located at the high end of virtual storage, will enable application programs in several partitions to share the services of a single program, including phases. A System Directory List in the SVA is intended to speed retrieval of the program phases in the SVA. A Generic Device Assignment feature allows files to be assigned by device class, such as READER, PRINTER, PUNCH, TAPE, or DISK, or by device type (e.g., any 3420 Model 7 Magnetic Tape Unit). If only a device type or group is stated, the system searches for a free device in that category and automatically assigns it. In addition, peripheral devices can be pooled. An additional feature of Release 29 is a reorganized Core Image Library, freeing more space for user-cataloged data and enhancing retrieval times.

Release 30 of DOS/VS, distributed in the fourth quarter of 1974, supplies support for Rotational Position Sensing for System/370 Models 115 through 158 and the Block Multiplexor Channel on the System/370 Model 115. In addition, Release 30 provides a simplified system generation procedure using cataloged procedures, new user job control exits to permit modification of job control parameters and the insertion of user-written routines to guarantee system security and integrity, procedures to simplify printer forms changes during program execution, and improved job accounting facilities. DOS/VS Release 30 also provides support for the new virtual storage version of POWER.

attachment of a 3277 Display Station to a 3886 Model 2; either rejected characters or entire fields can be displayed for operator verification and correction before being transferred to tape storage. The 8702 Video Collect Feature, available for the 3886 Model 2 only, permits collection of video image data on a 3410 Magnetic Tape Unit for later display on a 3277 Display Station. The 8703 Video Collect Feature, available for the 3886 Model 1 only, provides the capability to transmit video image data directly to a central processor under control of user-written routines.

Considerably slower than the IBM 1287 Optical Reader, the 3886 is also significantly less expensive. Announced in October 1972, the 3886 was first shipped in the third quarter of 1973.

3890 DOCUMENT PROCESSING UNIT: A high-speed MICR sorter/reader that can be used off-line (delivery in August 1974), on-line to an OS/VS Model 155-II, 158, 165-II, or 168 (delivery in October 1974), on-line to an OS/VS Model 145 (August 1974), or on-line to an OS/VS Model 135 (November 1974). The 3890 is the only on-line IBM MICR unit that can run with the attached System/370 operating in the virtual storage mode. This is because the unit has built-in timing and logic controls that permit it to work time-independently from the CPU or, in off-line use, to provide advanced sorting techniques to reduce the number of item passes performed.

The 3890 operates at 125,000 documents/hour for typical check mixes, and requires only one operator even at this speed. Six models, designated A1 through A6, provide 6, 12, 18, 24, 30, and 36 pockets with a capacity of 800 to 1000 documents each. The pockets can be unloaded while the unit is running. The file feed hopper holds about 4800 documents and has an automatic jogger to eliminate that operator step. Stacker selection is under internal control, time-independent from the on-line CPU. The control is loadable from an on-line computer or off-line from a disk capable of holding 23 different stacker selection programs. A second feed hopper can automatically merge divider slips under program control.

Item numbering and endorsing are optional features for the 3890. The unit also contains built-in logic for error correction of special symbols and high-order zero correction. Sequence checking, split field, high-order zero kill, and multiple column control are programmable. All features and additional pockets are field-installable. Attachment to the System/370 is via a byte multiplexer or block multiplexer channel.

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 indicated 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 115 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-491-45 in the Peripherals section of DATAPRO 70.

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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 was already in operation at IBM Datacenters and customer field-test locations when IBM announced it in August 1972. Though early installations were plagued by numerous unscheduled IPL's (i.e., system failures), VS1 now appears to be delivering throughput performance equal to or better than that of OS/MFT in most cases.

OS/VS2 Release 1 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.

Release 2 of OS/VS2 followed closely on the heels of Release 1 and represents a dramatic improvement in capabilities. Principally, Release 2 provides for up to a *billion* bytes of virtual storage (up to 16 million bytes for each of more than 60 users) and supports the two IBM versions of multiprocessing–albeit at what must surely be considered an exorbitant cost in memory overhead. For example, execution of OS/VS2 Release 1 with concurrent batch, reader and writer, and TSO operation requires a minimum of 512K bytes of main memory, while OS/VS2 Release 2 with concurrent batch, TSO, and JES2 or JES3 comes with a minimum main memory requirement of 1,024K bytes. The first of IBM's multiprocessing versions – "tightly coupled" – permits two Model 158 MP or 168 MP systems to share up to 8 million or 16 million bytes of common real memory, respectively. A "loosely coupled" network involving a central or "global" processor that controls up to four uniprocessors and/or tightly coupled dual processor systems is also available under Release 2. In a loosely coupled system, main memory is not actually shared among systems, but a commonly controlled network (based upon ASP Version III) operates to distribute all or part of the combined pool of system resources among the jobs in a single input stream. OS/VS2 Release 2 can also be used in conjunction with uniprocessor operation, but the cost of the associated memory overhead 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-

COMMUNICATIONS CONTROL

2701 DATA ADAPTER UNIT: Enables System/370 Models 115 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. (For further details on the 2701, please see Report 70D-491-30.)

2702 TRANSMISSION CONTROL: Permits connection of multiple low-speed terminals to a System/370, Models 115 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. (For further details on the 2702, please see Report 70D-491-30.)

2703 TRANSMISSION CONTROL: Permits connection of multiple low-speed and medium-speed terminals to a System/370, Models 115 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 ASCII 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. (For further details on the 2703, please see Report 70D-491-30.)

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.

3704 AND 3705 COMMUNICATIONS CONTROLLERS: In March 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. Customer shipments began in July 1972.

In February 1973, IBM announced a smaller version of the 3705 called the 3704. The 3704 is available in only four models with a main memory capacity of 16K to 64K bytes. It can accommodate a maximum of 32 lines, just one-half the capacity of the basic 3705 configuration. The 3704 uses the same software as the 3705, ensuring upward compatibility for economic expansion of a small network into a large one. Customer shipments began in May 1973.

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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 back-up facilities. Its use in a pure production environment, however, will usually be ruled out by the added overhead and resulting performance degradation (typically in the range of 25 or 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.

VTAM (Virtual Telecommunications Access Method) is a new data communications access method that was announced for DOS/VS, VS1, and VS2 Release 2 as a replacement for BTAM, TCAM, and QTAM. VTAM is the primary data communications access method for future development efforts in virtual storage environments, with the promise of full upward compatibility between data communication applications programs for all three VS operating systems. Remote data communications under VTAM requires a 3704 or 3705 Communications Controller operating in NCP mode. Both TSO and TCAM access are supported in a sort of "coexistence" under VTAM, with a Teleprocessing On-Line Test Executive Program (TOLTEP) incorporated into VTAM to help set up the data communications terminal network. Originally targeted for delivery in November 1973, VTAM was just becoming available to users at this writing.

In February 1973, IBM announced virtual storage versions of its two primary data base/data communications Program Products, IMS and CICS. (See Reports 70E-491-01 and -02 for full information). With these announcements, IBM strongly emphasized that the DL/1 data base component of IMS is the main data base system and that CICS is the primary data communications monitor for future System/370 developments. In fact, CICS/VS incorporates the salient features of FASTER, a family of three state and local government data communications systems, and effectively removes the FASTER systems from the current product line.

In December 1973, IBM announced a virtual storage version of its Generalized Information System (GIS, Report 70E-491-21). The new GIS/VS can operate under IMS/VS (delivered in February 1974) or TSO and provides a remote batch capability, allowing terminals operating under IMS to accept GIS input, including modifications to files created by DL/1.

When connected to a System/370 computer, a 370X can use either the Network Control Program (NCP) or the 2701/2/3 Emulation Program. When the NCP is used, a 370X 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.

Along with the announcement of the 3704, IBM introduced significant new software capabilities. The 370X Controllers are also supported under VTAM; major advantages of NCP operation through VTAM include the capabilities for dynamic allocation of terminals, lines, and 370X Controllers among multiple applications programs and for simultaneous operation in the Emulation and NCP modes within one 370X. In addition, IBM introduced additional software and hardware to permit configuration and usage of a 370X as a remote concentrator. Communication between a remote 370X and a local 370X connected to the host computer is over a leased line operating full-duplex at 4800 bits per second or half-duplex at up to 50,000 bits per second.

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 are quite complex. The maximum number of lines that can be connected is a function of the 3705 model, the 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. In the NCP mode, 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 a separate multiplexer subchannel for each communications line.

Configuration rules for the 3704 follow the same general pattern as for the 3705, but are much more straightforward.

Detailed reports on both the 3704 and 3705 are contained in the Peripherals section; see Reports 70D-491-31 and 70D-491-32.

MODEL 115 INTEGRATED COMMUNICATIONS ADAPTER (ICA): This optional feature for the Model 115 Processing Unit provides the basic control storage and common circuits for direct connection of up to 5 synchronous (BSC) communications lines or for up to 4 synchronous and 8 asynchronous lines, depending on the line speeds. The ICA combines the functions of a Byte Multiplexer Channel and a communications control unit. Lines connected via the ICA are addressed and controlled as if they were connected to the Model 115's Byte Multiplexer Channel via a 2703 Transmission Control.

The basic ICA can control either up to 8 asynchronous lines or up to 5 BSC lines. All combinations of BSC and asynchronous lines require the ICA Extension feature. Additional features are required to create appropriate line interfaces for the individual lines, and the associated configuration rules are quite complex. Standard facilities of the ICA for BSC lines include Autopoll, multipoint central station functions, multipoint tributary station functions, EBCDIC transparent mode, and either EBCDIC or ASCII code; the Autopoll and multipoint central station functions are provided for asynchronous lines as well.

Asynchronous line speeds can range from 45.5 to 600 bits/second (though the maximum number of 600-bps lines

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STABILIZATION OF DOS AND OS

With the announcement of the new virtual-storage operating systems, it became evident that there would be few, if any, future improvements to the real-memory versions of DOS, OS/MFT, or OS/MVT. Not surprisingly, DOS users were notified of the "functional stabilization" of DOS for the System/360 with the distribution of Release 26 in December 1971. System/370 DOS users were given a reprieve: Release 27, the last real-memory version of DOS, is available to System/370 users only, along with free IBM support. Release 28 was the first version of DOS to incorporate virtual-storage concepts. Support for the newer, more attractive System/370 peripheral devices is provided only under the virtual-storage versions of DOS.

All three versions of OS/360 were stabilized at the time of the announcement of their virtual storage successors in August 1972. PCP (the Primary Control Program) was stabilized at Release 19, and MFT (Multiprogramming With a Fixed Number of Tasks) and MVT (Multiprogramming With a Variable Number of Tasks) at Release 21. Support for most of the recent IBM peripheral devices has been limited to the virtual storage releases of OS. Thus, System/370 users are receiving ever-increasing pressure from IBM 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. Exceptions consist primarily of programs that are device-dependent upon a non-supported device type.

Release 2 of OS/VS2 has been designed about a dual-processor, HASP-like multiprocessing system; an alternate ASP-III-like network multiprocessing mode of system operation is also available. In both cases, signifi-

on the ICA cannot exceed 4). Synchronous line speeds can range from 600 to 50,000 bits/second; but only one high-speed line (above 7200 bps) can be connected, and it must not be operated concurrently with any other line on the ICA. An ICA-equipped Model 115 can communicate with virtually the full gamut of IBM computers and communications terminals.

MODEL 125 INTEGRATED COMMUNICATIONS ADAPTER: This optional feature for the Model 125 Processing Unit provides the basic control storage and common circuits for direct connection of up to 6 synchronous (BSC) and 16 asynchronous communications lines, depending on the line speeds. The ICA combines the functions of a Byte Multiplexer Channel and a communications control unit. Lines connected via the ICA are addressed and controlled as if they were connected to the Model 125's Multiplexer Channel via a 2703 Transmission Control.

The basic ICA can control either up to 16 asynchronous lines or up to 6 BSC lines. All combinations of BSC and asynchronous lines require the ICA Extension feature. Additional features are required to create appropriate line interfaces for the individual lines, and the associated configuration rules are quite complex. Standard facilities of the ICA for BSC lines include Autopoll, multipoint central station functions, multipoint tributary station functions, EBCDIC transparent mode, and either EBCDIC or ASCII code; the Autopoll and multipoint central station functions are provided for asynchronous lines as well.

Asynchronous line speeds can range from 45.5 to 600 bits/second (though the maximum number of 600-bps lines on the ICA cannot exceed 8). Synchronous line speeds can range from 600 to 50,000 bits/second; but only one high-speed line (above 7200 bps) can be connected and must not be operated concurrently with any other line on the ICA. An ICA-equipped Model 125 can communicate with virtually the full gamut of IBM computers and communications terminals.

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 Model 135 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 trans-

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cant upward compatibility with the respective 360/370 predecessors is maintained. This is true not only in terms of programming considerations, but also from an operational point of view. In fact, IBM recommends an upward migration path through either HASP or ASP-III as the most suitable way of growing into VS2 Release 2.

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-491-04b 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 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

mission: 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 115 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 115 through 195 can be basically the same as that provided for the System/360. Alternatively, Models 115, 125, 135, 145, 155-II, 158, 165-II, and 168 can operate in an Extended Control (EC) or virtual mode that utilizes Dynamic Address Translation (DAT) hardware features, and a multiprocessing capability is supported for the 158 MP and 168 MP systems operating in EC mode.

In Basic Control (BC) or real mode, either the Disk Operating System (DOS) or the Operating System (OS) can be used, as on the System/360. 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 newer, virtual-mode counterparts of these systems are the 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. VS2 Release 2 goes a step further and includes support for either tightly coupled or loosely coupled multiprocessing networks.

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

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/

Operating System Availability

	115	125	135	145	155	155-II	158	158 MP	165	165-II	168	168 MP	195
DOS	–	4/73	5/72	7/71	2/71	4/73	4/73*	3/74*	–	–	–	–	–
DOS/VS	1Q74	4/73	6/73	6/73	–	12/73	12/73	3/74	–	–	–	–	–
OS/MFT	–	–	5/72	7/71	2/71	4/73	4/73	3/74	4/71	12/73	8/73	3/74	–
OS/MVT	–	–	–	7/71	2/71	4/73	4/73	3/74	4/71	12/73	8/73	3/74	4/73
OS/VS1	–	–	8/72	8/72	–	4/73	4/73	3/74	–	12/73	12/73	3/74	–
OS/VS2, Rel. 1	–	–	–	12/72	–	4/73	4/73	3/74	–	12/73	8/73	3/74	–
OS/VS2, Rel. 2	–	–	–	8/74	–	8/74	8/74	**	–	8/74	8/74	**	–
VM/370	–	–	11/72	11/72	–	4/73	4/73	3/74	–	12/73	8/73	3/74	–

*Hard Stop mode only.
**Tightly coupled multiprocessing or uniprocessing mode—8/74; loosely coupled multiprocessing—availability date not specified.

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software products that have been introduced during the past four 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.

It is important to note the the recently acquired multiprocessing capabilities of the System/370 automatically raise the ante on computer selection studies in terms of both costs and potential rewards. The entire system design effort for medium-to-large data processing environments has been increased by the addition of a new level of complexity. The conscientious user must now determine not only which central processor or processors are best able to handle his workload, but—more fundamentally—whether one or more uniprocessors or a distributed-intelligence multiprocessing network is the best answer to his overall requirements. This is a determination of no mean magnitude, and great care must be taken to define the projected workload and determine with as much precision as possible the performance of the system upon that workload.

USER REACTION

The user ratings that follow represent a composite of the opinions expressed by 385 users of System/370 equipment who responded to Datapro's 1974 survey of users of general-purpose computer systems. Since many responses were received from companies with multiple computer installations, a total of 440 computers are represented in this survey, distributed as follows:

Model 125:	32 systems
Model 135:	102 systems
Model 145:	165 systems
Model 155:	41 systems
Model 158:	75 systems
Model 165:	9 systems
Model 168:	10 systems
Model unidentified:	6 systems

In addition, in preparing this report Datapro conducted follow-up telephone interviews with a random selection of DOS/VS, OS/VS1, and OS/VS2 installations among the survey respondents to explore their attitudes toward the System/370 in greater depth. Here's how these 385 System/370 users rated their systems in eleven important categories:

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). In some cases where a program can be run in either virtual (V) or virtual=real (R) mode, performance of the system in V mode can be seriously degraded; such programs are marked V,R.

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 process-

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	Excellent	Good	Fair	Poor	WA*
Ease of operation	154	203	16	0	3.4
Reliability of mainframe	227	137	17	3	3.5
Reliability of peripherals	95	242	45	0	3.1
Maintenance service:					
Responsiveness	137	213	29	0	3.3
Effectiveness	112	218	47	3	3.2
Technical support	69	190	91	10	2.9
Manufacturer's software:					
Operating systems	74	242	61	6	3.0
Compilers and assemblers	88	246	46	4	3.1
Application programs	23	139	27	4	2.9
Ease of conversion	82	182	69	9	3.0
Overall satisfaction	77	277	25	1	3.1

*Weighted Average on a scale of 4.0 for Excellent.

The distribution of operating systems by central processor model among the survey respondents was as follows:

Processor Model	Operating System	Number Represented
370/125	DOS	9
	DOS/VS	23
370/135	DOS	34
	DOS/VS	54
	OS/MFT	2
	OS/VS1	5
370/145	VM/370	5
	OS/VS1	35
	OS/VS2	8
	OS/VS, unspecified	2
	DOS & OS/VS1	6
	OS & OS/VS1	1
	OS/MFT	10
	OS/MVT	3
370/155	OS/MFT	12
	OS/MVT	19
	OS, unspecified	5
	VS, unspecified	2
370/158	OS/VS1	5
	OS/VS2	25
	VM/370	1
	OS/360 & OS/VS2	3
370/165	OS/360	9
370/168	OS/VS2	3
	OS/360	7

In contrast to the results of Datapro's telephone survey a year ago, when most of the System/370 computer users interviewed were still operating under one of the System/360 operating systems, the majority of respondents to Datapro's June 1974 survey in almost every System/370 VS processor model category had installed one of IBM's virtual storage operating systems. It was plain that, in most cases, the incentives supplied by IBM for converting to a VS operating system outweighed the advantages of continuing to operate under stable system software that is no longer being supported or enhanced. The principal reasons for migrating to virtual storage operating systems cited by users include requirements to implement new applications, such as telecommunications, in which a VS operating system could better manage ing, 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.

While DOS can be run directly in the BC (System/360) mode on System/370 Models 135 through 158, operation of DOS on the Model 125 requires not only BC mode, but also the 5213 Console Printer, the 1052 Compatibility Feature, and (for DOS Version 3) the 2311 Model 1 Compatibility Feature. DOS cannot be used on the System/370 Model 115.

DISK OPERATING SYSTEM/VIRTUAL STORAGE: DOS/VS (Release 28 and later 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 supervisor required for execution of DOS/VS is 26K bytes for the System/370 Models 115 and 125, 28K bytes for the System/370 Models 135 and 145, and 30K bytes for the System/370 Models 155-II and 158.

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

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programs requiring large allocations of main memory, and support for new and more cost-effective peripheral devices. Several users stated quite frankly that System/370 users who haven't installed one of the virtual storage operating systems effectively forfeit their option to purchase any new IBM hardware, a condition that few installations are willing to accept.

In addition, many desirable operating features are steadily being added with each new release of the IBM virtual storage operating systems. Among the new processing facilities provided by DOS/VS, users pointed out the additional partitions, better memory management, an improved sort/merge utility, better compilers, support for rotational position sensing, better job accounting facilities, the relocating loader, and VSAM as features that made the transition from DOS to DOS/VS worthwhile. Other reasons given for upgrading to OS/VS1 and OS/VS2 were requirements for more throughput, more initiators, more flexibility in memory management, and support for new IBM software and peripheral products. Thus, it appears that IBM is well on its way toward establishing its virtual storage operating systems as the standard systems software for the System/370.

The only areas in which these IBM users gave IBM overall ratings that were slightly less than good (i.e., below 3.0) were the categories of Technical Support and Application Programs. A number of users expressed dissatisfaction with the support they received for new software products, such as the early releases of the virtual storage operating systems and the VSAM access method. It became clear from the comments made by the System/370 users who were early implementors of the virtual storage systems software that, although IBM has been eager to lead its customers into the promised land of virtual storage, it hasn't always managed to provide them with guides who were acquainted with the territory. Users felt that the IBM support personnel had not had enough experience with the new software in the early releases. On the other hand, IBM's Field Engineering organization was given high ratings for the breadth and availability of its services.

The majority of these respondents were extremely pleased with the reliability of the System/370 hardware. Although some users indicated that they had experienced some difficulties, hardware reliability was cited more than any other characteristic as the major advantage of the System/370 product line. It is obvious from the responses of these IBM customers that they regard the dependability and reliability of their hardware as one of the major successes of the System/370 product line.

Opinions on the reliability of IBM's virtual storage operating systems were far less uniform. On the whole, the DOS/VS users expressed great satisfaction with the ease of installation of the operating system and the relatively effortless conversion from DOS, while opinions on the reliability of OS/VS1 were divided almost 50-50 between those who reported difficulties with the initial releases of OS/VS1 and those whose implementation was relatively trouble-free. The IBM systems software

requests. VSAM has Class A support as an SCP component of DOS/VS, and was released in June 1973.

The Virtual Telecommunications Access Method (VTAM) is IBM's primary terminal access method and the base for future developments of teleprocessing support under DOS/VS and OS/VS. As a replacement for BTAM, TCAM, and QTAM, VTAM controls communications terminal connections and data transfers between those terminals and the user's application programs via a 370X Communications Controller. Upward compatibility is provided among all of the IBM virtual storage operating systems. Among the features of VTAM are: (1) Network Control Program (NCP) support of the 370X Communications Controllers, including dynamic sharing of terminals, lines, and the controllers themselves among user programs; (2) support of TCAM under TAM for OS/VS only; (3) terminal monitoring facilities to handle log-on requests and collect communications network accounting information; and (4) integration of the Teleprocessing On-Line Text Executive Program (TOLTEP). VTAM has Class A support as an SCP component of DOS/VS, and is now scheduled for release in March 1975. The minimum DOS/VS System required for VTAM is 96K bytes.

DOS/VS Release 29, released in February 1974, provides the following enhancements: 1) a Generic Device Assignment feature that allows input/output to be assigned by device type, device class, or an address list to provide a limited degree of device independence in user programs and permit pooling of I/O devices; 2) a Shared Virtual Area (SVA) that contains relocatable and re-entrant program phases that can be shared by all partitions in the system; 3) support for the Block Multiplexer Channel on System/370 Model 125 and larger central processors and for the 3340 Direct Access Storage Facility, 3203 and 5203 Printers, 3450 Diskette Input/Output Unit, 3420 Model 4, 6, and 8 Magnetic Tape Units, 5425 Multi-Function Card Unit, and the 3780 Data Communications Terminal for remote job entry; and 4) a new Core Image Library Format that permits variable-length directory entries that contain all information pertinent to the phase and places the highest key on a directory track in the supervisor to speed retrievals.

The most current version of DOS/VS, Version 30, includes the following enhancements:

- Support for Rotational Position Sensing on System/370 Models 115 through 158 through a link to a Rotational Position Sensing module located in the Shared Virtual Area.
- Availability of Block Multiplexer Channel operation for the System/370 Model 115.
- A simplified system generation procedure that uses user-supplied control information and catalogued procedures, and tape and disk intermediate storage to reduce card input/output.
- User exits in the Job Control Language to permit user modification of the statement parameters and the insertion of user-written routines for system security and integrity.
- Procedures to simplify forms changes within jobs for the 1403, 3203, 3211, and 5203 Printers.
- Modifications in the job accounting procedure to provide data on main memory utilization for programs executing in the real and virtual modes and start and stop times for multiple steps within a job.
- Support for the POWER/VS facility.

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products in which the most bugs were encountered were OS/VS2 Release 1 and VSAM, although users stated that they were very pleased with the conceptual implementation of VSAM.

In commenting on the IBM systems software product lines, users also remarked that they were less than satisfied with the time-sharing capabilities provided by the Time-Sharing Option (TSO), and that they would like to see IBM provide a good macro-based telecommunications language and structural programming capabilities for higher-level languages. Many respondents were also displeased with the high overheads incurred by the System/370 operating systems, both in main memory and central processor utilization. A few installations had taken steps to "tune" their operating systems in order to achieve more efficient utilization of their hardware configurations, and everyone who was interviewed expressed an intention to do so in the future.

The operating system overhead undoubtedly contributes to another frequently recurring remark cited as a disadvantage of the System/370 product line—the high cost of the equipment. The majority of these users appeared to realize that they were paying premium prices in order to acquire computer equipment from the dominant computer manufacturer, and that the design of the IBM operating systems usually adds more dollars in hardware costs to their data processing budgets.

Is it worth it? The great majority of the respondents to the Datapro survey seemed to think so, since 93 percent of these users rated their overall satisfaction with their systems as either good or excellent. Individuals who were interviewed by telephone also stated that in spite of some initial tribulations, on the whole, the virtual storage operating systems had met their expectations. In addition, many users were using software packages supplied by independent software companies as substitutes for IBM software that failed to meet their needs, and have found ways to cut costs by acquiring their systems from third-party leasing companies and substituting lower-cost plug-compatible peripheral equipment wherever possible. Moreover, many users are withholding their final judgment until IBM delivers its long-awaited data communications software for the System/370. □

- **DOS/VS Assembler Language support for the Compare and Swap and Compare Double and Swap instructions, required for operation of VTAM.**

POWER/VS: An extension of the earlier POWER spooling system available for DOS, POWER/VS executes under DOS/VS on a System/370 computer with at least 96K bytes of main memory. In contrast to the previous version of POWER, POWER/VS executes in the virtual mode and acquires real processor storage on an as-needed basis. It can control programs operating in both the real and virtual modes.

POWER/VS resides in one DOS/VS partition and can provide spooling of unit record input/output and priority scheduling for from one to four programs with lower dispatching priority. Jobs to be scheduled for execution are queued in user-assigned classes by priority within each class. Jobs can be assigned by class to specific partitions for execution, or partition-independent job classes can be utilized to achieve more balanced scheduling of all partitions. Operator commands permit the operator to modify the order in which jobs in the job queues are scheduled for execution. Job input can be retained in the queues to permit repeated execution of a job.

Printer and punched card output can be spooled to magnetic tape or disk drives, and is grouped into output classes that can be the same or different from the parent job class. A segmented output capability allows large volumes of output from a job to be segmented to permit the output to be overlapped with the completion of processing of the job. Multiple copies of output can be requested, and job output can be retained for production of additional copies. Direct-access storage devices supported by POWER/VS include the 2314, 2319, 3330/3333, and 3340.

The POWER/VS remote job entry facility can support concurrent operation of 25 terminals, including the 3780 Data Communications Terminal, the 2780 Data Communications Terminal, and the 2770 Data Communications System. Data transmission is in ASCII or EBCDIC code over leased, switched, or privately owned lines in point-to-point configurations. POWER/VS was released in September 1974.

OPERATING SYSTEM/360: OS is a comprehensive and general-purpose operating system for the larger 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 transitions 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.

Also available for OS/MVT is a Time-Sharing Option (TSO). This extension, announced in November 1969,

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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 (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 IBM's Information Management System (IMS), 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). (Refer to Report 70E-491-01, IMS, for full information.)

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 (ASP-III) (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 was the last major functional release for OS/MFT and OS/MVT. Though these versions have been "functionally stabilized," subsequent maintenance releases to Release 21 will add support for a limited number of new I/O devices.

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 can support 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 (JES1) 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.

OS/VS1 Release 3.1, the most recent version of OS/VS1, includes support for System/370 Models 165-II and 168 and for the 3705 Network Control Program through the TCAM Level 5 access method. New peripheral devices supported in Release 3 include the following: the 3330 Model 11, 3333 Model 11, and 3340 Direct Access Storage Devices, 3420 Models 4, 6, and 8 Magnetic Tape Units, 3890 Document Processor through QSAM, 3886 Optical Character Reader, and the 2781 Card Punch through the Remote Terminal Access Method.

Release 3 of OS/VS1 also incorporates a variety of enhancements, including support for the VTAM access method, Installation-Specified Selection Parameters that

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allow system programmer manipulation of job input and output classes and job priorities, and a PAGE TUNE command that allows modification of the paging algorithm through the console. Dynamic dispatching permits alteration of the dispatching priorities (that is, the order in which executing tasks are given CPU attention) of selected tasks. The indicated tasks' requirements for input/output and central processor time are monitored and modified in order to give highest priority to input/output-bound tasks.

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 144K 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, 3330, 3333, or 3340 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 Release 1 include support of a maximum 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 3704 or 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 Release 1. With its availability under VS2 Release 1, 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 Release 1 has been upgraded to Programming Service Classification A. ASP Version 3 support is available under VS2 Release 1, 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 JES1 provided for VS1 is not available under VS2 Release 1. Otherwise, VS2 Release 1 is upward-compatible with OS/MFT, OS/MVT, and OS/VS1, except for the Conversational Remote Job Entry (CRJE) facility, which is not supported.

The minimum real memory requirement for a basic batch version of VS2 Release 1 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 was delivered in December 1972.

Release 2 of OS/VS2, released in August 1974, is a major functional enhancement over Release 1 that features support of: 1) multiprocessing for Model 158 MP and 168 MP systems; 2) larger virtual storage, with up to 16 million bytes of addressable space for each of up to 63 concurrent users; 3) a HASP-like version of the Job Entry System (JES2); 4) an ASP-III-like version of the Job Entry System (JES3); and 5) Virtual Telecommunications Access Method (VTAM) support of the 370X Communications Controllers in Network Control Program (NCP) mode.

With JES2—an optional job entry and control system that is upwardly compatible with HASP—a "tightly coupled" multiprocessing system can be supported using either two identically configured Model 158 MP systems or two not-necessarily-identical Model 168 MP systems. In tightly coupled mode, each processing unit shares the combined main storage.

Under JES3—which is upwardly compatible with ASP Version 3—a master or "global" system using OS/VS2 Release 2 can control a "loosely coupled" network of up to four slave or "local" systems running under OS/VS2 Release 1, OS/VS2 Release 2, or OS/MVT ASP as main processors. Each local system can be either a single processor or a tightly coupled pair of processors using JES2 under VS2 Release 2. In loosely coupled mode, the global processor controls the scheduling, automatic spooling, interleaved job entry from intelligent terminals, and pre-execution volume fetch and setup for the local processors, but does not share main memory with them.

For either tightly or loosely coupled multiprocessing, VS2 Release 2 provides a virtual I/O (VIO) paging mechanism for temporary data sets, private virtual storage of up to 16 million bytes for individual TSO users, a new System Activity Measurement Facility (MF/1) in addition to SMF to measure CPU, channel, I/O device, and paging activity as well as I/O contention and CPU/channel overlap, and extensive system integrity control measures.

Other features supported under OS/VS2 Release 2 include:

- Workload Management Routines which monitor the use of processing resources in the system and allocate resources to jobs or time-sharing users in order to meet installation-specified processing objectives for jobs.
- Resource-Use Routines, a set of algorithms that monitor the use of system resources and recommend scheduling changes to the control function algorithm to optimize the utilization of system resources. Functions include input/output load balancing, adjustment of CPU utilization, maximum utilization of main memory, and removal of pages that have not been referenced within a specified amount of their CPU execution time. An Automatic Priority Group algorithm manipulates the dispatching priority within the system in order to allocate higher dispatching priority to jobs that are input/output-bound. Values collected by the workload management routines and the resource-use algorithms are evaluated by the control function algorithm against installation-supplied parameters to provide for system tuning.
- Multiple Virtual Address Spaces that provide each system user with a private address space of 16 million bytes for increased multiprogramming capabilities.
- Deadline Scheduling under JES3 that dynamically alters the scheduling priority of jobs in order to meet completion deadlines. Priority aging, in which JES3 automatically increases the priority of jobs that have been rejected for scheduling a specified number of times, also is provided under JES3.
- A Network Job Processing capability to permit the transmission of program input and output (but not jobs) between compatible JES3 installations.
- Recovery capabilities for multiprocessing configurations that include alternate path retry, dynamic device reconfiguration, manual switching of peripheral devices between central processors, and alternate CPU recovery under control of the functioning central processor.
- Increased emphasis on system integrity and security to prevent programs not executing in the supervisor state, in system keys 0 through 7, or under the Authorized Program Facility from bypassing storage and fetch protection, accessing password-protected data without the appropriate password, or gaining control of the system in an authorized state.

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OS/VS2 Release 2 is available for Models 145, 155-II, 158, 158 MP, 165-II, 168, and 168 MP with JES2. The release data for JES3, however, is not available from IBM at this writing.

Either JES2 or JES3 is required with VS2 Release 2. With concurrent batch and time-sharing under JES2, VS2 Release 2 runs in an absolute minimum 768K-byte system (with reduced functional capability and limited performance), and more comfortably in at least 1024K bytes of real storage. OS/VS2 Release 2 can also be used for uniprocessor systems, most commonly with JES2, where very large virtual storage, VIO, or other functional enhancements of Release 2 over Release 1 are required.

VSAM support is provided for all 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.

VTAM support is provided for OS/VS1 and OS/VS2 Release 2 only, and is similar to VTAM support under DOS/VS. OS/VS1 VTAM was delivered in November 1974, and OS/VS2 VTAM is scheduled for delivery in March 1975.

OS/360 facilities that are not supported by any 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-64/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 became 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.

DOS/VS COBOL, released in February 1974, executes under Release 29 (or later) of DOS/VS in approximately 60K bytes of virtual storage. DOS/VS COBOL provides all the facilities of the full DOS ANS (1968) COBOL plus the following additional facilities: 1) support for the VSAM access method; 2) support for the 5425 Multi-Function Card Unit, 3886 Optical Character Reader, 3340 Disk Storage, 5203 and 3203 Line Printers, and 3540 Diskette Input/Output Unit; 3) a syntax-checking feature for fast source program scanning for syntax errors; 4) symbolic debugging; 5) an optional object-code optimizer; and 6) optional alphabetized cross-referenced listings. Release 2 of DOS/VS COBOL also includes the capability to use the DOS/VS Sort/Merge program plus several source code listing and analysis functions.

For OS/360 and OS/VS, Full ANS COBOL is available in either Versior 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

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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.

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/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. The DOS FORTRAN IV Library Option 1, a Program Product released in February 1974, is required for support of the new peripheral devices available under DOS/VS Release 29.

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 seven different data access modes: BSAM, QSAM, BISAM, QISAM, BDAM, QTAM, and VTAM.

The DOS/VS PL/1 Optimizing Compiler, released in February 1974, provides language extensions beyond those of the PL/1 D (Version 4) and PL/1 F subsets, including compile-time preprocessing, arrays of structures, a DEFAULT statement, file variables, and data-directed input/output. The new PL/1 compiler also provides support for VSAM, additional debugging aids, optimization of object code, support for peripheral devices supported under DOS/VS Release 29, the ability to access ASCII files, and communication between PL/1 object modules and FORTRAN, COBOL, and Assembler language object modules. The DOS/VS PL/1 Optimizing Compiler requires a maximum virtual partition of 65K bytes, but can compile in 44K bytes with degraded performance.

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. A virtual storage version of BASIC, for operation under DOS/VS, OS/VS1, OS/VS2, and VM/370, was added in June 1974.

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. Effective December 15, 1973, the ALGOL F Compiler and ALGOL F Library were demoted from service classification A to C, thus ending free support for these Program Products.

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.

An enhanced RPG II for DOS/VS systems is designed to provide more efficient program execution and support for new peripheral devices, and includes features to contribute to the ease of use of the compiler. The new RPG II compiler contains over 30 functional enhancements, including edit codes, spanned records, AND/OR calculations, single-dimension arrays, use of the console to display messages and input data, use of dual I/O areas for ISAM files, and the capability for object programs compiled to process ISAM files to handle VSAM files using the VSAM

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The Model 158 Processing Unit provides up to 4 million bytes of MOS main storage and is available in both uniprocessor and dual-processor (MP) configurations. A feature of the Model 158 is its CRT display console with light-pen input. An 8-drive 3330 Disk Storage subsystem is in the background.

Compatibility Interface. The RPG II compiler can execute in a background partition under DOS Release 24 or in a batched-job foreground partition with Release 25 or later, and requires a minimum of 14K bytes with disk work files.

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 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 are offered for both DOS and OS. In addition, a new DOS/VS Sort/Merge is available for DOS/VS Release 29 and later releases.

The DOS/VS Sort/Merge provides all the functional capabilities of the DOS Sort/Merge plus support for the 3340 Disk Storage Facility, 3330/3333 Disk Storage (including Rotational Position Sensing), SAM data sets, and the 3410, 3411, and 3420 Magnetic Tape Units. It also includes the capability to operate in both background and foreground partitions, the ability to be invoked by COBOL, PL/1, or the Auto Report Feature of RPG II, and the ability to sort or merge on control fields with mixed data formats. DOS/VS Sort/Merge requires a minimum virtual or real partition of 16K bytes.

The enhanced OS/VS version of the Sort/Merge utility program, called OS-SM1, provides additional features and improved performance over the OS Sort/Merge program. It fully supports the 3330, 3330 Model 11, and 3340 Disk Storage Facilities, ASCII-formatted files on 9-track magnetic tape, input and output on QSAM-supported devices, and expanded exit facilities to assist the user in writing his own code additions. OS/VS Sort/Merge requires a minimum of 32K bytes of main storage; a larger allocation of main memory is required for the use of VSAM files.

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

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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.

3704/3705 COMMUNICATIONS CONTROLLER SOFTWARE: In its native mode, a 370X Communications Controller runs under control of a Network Control Program (NCP) that resides in a minimum of 48K bytes of other administrative support for NCP must be performed on a System/370 host processor using OS/MFT or OS/MVT in a partition or region of 48K to 50K bytes. Under DOS, the 370X can be operated in a 270X emulation mode only. A virtual storage version of the Network Control Program, NCP/VS, is planned for use in conjunction with VTAM under DOS/VS as well as OS/VS. NCP/VS will provide all the capabilities of NCP plus the capability for simultaneous 270X emulation and NCP operation. (Refer to Reports 70D-491-31 and -32 for full descriptions of the 3704/3705 Communications Controllers and the associated software.)

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. A full list of FDP's and IUP's with prices, dates when support ends, and reference manual numbers can be found in the *IBM Computer Information Card for FDP's and IUP's* (GB21-9949).

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. Also see the comprehensive report on IBM Program Products – Applications (Report 70E-491-21) and the detailed reports on the two IBM Program Products of broadest general interest: IMS (Report 70E-491-01) and CICS (Report 70E-491-02).

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 are for short-term leases and include equipment maintenance.

SMALL MODEL 115 DISK SYSTEM: This typical Model 115 configuration consists of a 65K Processing Unit, 3203 Model 1 Printer (600 lpm), 5425 Model A2 MFCU (reads 500 cpm, punches 120 cpm), 3340 Model A2 Direct Access Storage Facility (2 drives plus control), and two 3348 Model 70 Data Modules (140 million bytes total capacity). Monthly rental and purchase prices are approximately $6,600 and $264,900, respectively.

SMALL MODEL 125 DISK SYSTEM: Consists of 98K Model 125 Processing Unit, 3340 Direct Access Storage Facility (2 drives, 140 million bytes), 3504 Model A1 Card Reader (800 cpm), 3525 Model P1 Card Punch (100 cpm), and 1403 Model 7 Printer (600 lpm). Monthly rental and purchase prices are approximately $8,500 and $377,800, respectively.

MODEL 125 TAPE/DISK SYSTEM: Consists of 131K Model 125 Processing Unit, 3340 Direct Access Storage Facility (four drives, 280 million bytes), six 3410/3411 Model 3 Magnetic Tape Units and Control (80KB), 3504 Model A2 Card Reader (1200 cpm), 3525 Model P3 Card Punch (300 cpm), 1403 Model N1 Printer (1100 lpm), and 5213 Console Printer. Monthly rental and purchase prices are approximately $13,700 and $563,600, respectively.

SMALL MODEL 135 DISK SYSTEM: Consists of 98K Model 135 Processing Unit with Integrated File Adapter, 3340 Direct Access Storage Facility (two drives, 140 million bytes), 3505 Model B1 Card Reader, 3525 Model P2 Card Punch, 3211 Printer, and 3210 Model 1 Console and Printer-Keyboard. Monthly rental and purchase prices are approximately $12,100 and $515,200, 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, 3340 Direct Access Storage Facility (four drives, 280 million bytes), eight 3420 Model 3 Magnetic Tape Units (120KB) and dual-channel tape controls, 3505 Model B2 Card Reader, 3525 Model P3 Card Punch, 3211 Printer, and 3210 Model 1 Console Printer-Keyboard. Monthly rental and purchase prices are approximately $24,400 and $1,029,700, respectively.

MODEL 145 TAPE/DISK SYSTEM: Consists of 262K Model 145 Processor with Integrated File Adapter and two Selector Channels, 3340 Direct Access Storage Facility (four drives, 280 million bytes), eight 3420 Model 3 Magnetic Tape Units (120KB) and dual-channel controls, 2540 Card Read Punch, 3211 Printer, and 3210 Model 1 Console Printer-Keyboard. Monthly rental and purchase prices are approximately $31,000 and $1,327,000, respectively.

EXPANDED MODEL 145 TAPE/DISK SYSTEM: Consists of 524K Model 145 Processing Unit with four Selector Channels, Block Multiplexer Channel and Word Buffer Features, 3047 Power Unit, eight-drive 3330 Model 11 Disk Storage Facility (1.6 billion bytes), twelve 3420 Model 5 Magnetic Tape Units (200KB) and two tape controls, two 2540 Card Read Punches, two 2311 Printers, and 3215 Console Printer-Keyboard. Monthly rental and purchase prices are approximately $47,900 and $2,129,500, respectively.

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MODEL 158 TAPE/DISK SYSTEM: Consists of 1048K Model 158 Processor with four Block Multiplexer Channels and two Byte Multiplexer Channels, four-drive 3340 Direct Access Storage Facility (with 2 million bytes of fixed-head storage and 278 million bytes of moving-head storage), four-drive 3330 Model 1 Disk Storage Facility (400 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 $3,000,000, 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, six-drive 3340 Direct Access Storage Facility (with 3 million bytes of fixed-head storage and 416 million bytes of moving-head storage), four-drive 3330 Model 11 Disk Storage Facility (800 million bytes), twelve 3420 Model 6 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 $119,700 and $5,495,800, 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 wihout 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 numerous Field-Developed Programs and Installed User Programs for the System/370.

SUPPORT: IBM Systems Engineering assistance is available to System/370 users at a basic rate of $35.75 or $44.75 per hour, depending upon the size and complexity of the system.

EDUCATION: IBM "Professional Courses" are 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 Monthly Availability Charge (MAC) 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 percent of the basic hourly rate (i.e., 10 percent of 1/176 of the monthly rental for each hour of extra use).

FIXED-TERM LEASE PLAN: This 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 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 (even for a model upgrade) 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 rental due, whichever is less).

EXTENDED-TERM LEASE PLAN: This plan, introduced on March 1, 1972, is a more flexible lease plan under which "selected machines" are offered. The plan has a basic contract period of 24 months and offers monthly charges approximately 15 percent 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, 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 during the first six months of the lease, to four times the monthly charge during the second six months, to three times the monthly charge during the third six months, to the smaller of twice the monthly charge or the remaining amount due during the last six months of the initial contract period or during any extension.

TERM LEASE PLAN: This long-term CPU leasing plan, announced in March 1973, has a base term contract period of 48 months. It is currently available only for the System/370 virtual storage central processors (Models 115, 125, 135, 145, 158, and 168) and their associated channels, consoles, power units, power and coolant distribution units, and multisystem units. For all these machines, the monthly charges under the Term Lease Plan are the same as the basic monthly rental charges under IBM's standard short-term lease.

The key advantage of the Term Lease Plan is that it permits unlimited use of the equipment with no additional use charges. Other significant provisions include: unlimited one-year extensions after the initial 48-month contract period; a single extension of less than one year; and purchase option accruals of up to 50 percent of the purchase price. Field-installable feature and model changes can be made at any time during the contract period. Termination charges for early discontinuance of a machine or feature are equal to the lesser of: (1) 25 percent of the Term Lease Plan monthly charge multiplied by the remaining months of its base term, or (2) 12.5 percent of the Term Lease Plan monthly charge multiplied by the total number of months in its base term (i.e., 48). IBM's 10 percent Educational Allowance applies to the Term Lease Plan.

The Term Lease Plan is offered under the terms of a new amendment and supplement to the Agreement for IBM Machine Service. These agreements can be executed at the time of the order, at any time during the on-order cycle, or after the equipment is installed.

On February 3, 1975, IBM announced a modification to the purchase price provision of the Term Lease Plan that adds an escalator clause to agreements signed on or after January 8, 1975. The escalator clause permits IBM to impose a non-compounded 5 percent per year price increase on the Monthly Availability Charge after expiration of the first year of the contract.

PURCHASE OPTIONS: Effective August 1, 1974, IBM extended its Purchase Option Plan to allow users renting

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► under the Monthly Availability Charge (MAC), Extended-Term Plan (ETP), and Fixed-Term Plan (FTP) to accumulate up to 36 months of purchase option credits toward the purchase of the equipment. The total amount accrued cannot exceed 50 percent of the purchase price of the equipment at the date of purchase. There was no change in the 48-month Term Lease Plan, which already permits the accumulation of purchase credits through 48 months to a maximum of 50 percent of the purchase price. Previously, the Monthly Availability Charge contract permitted accumulation of up to 12 months of purchase option credits, and the Fixed-Term Plan and Extended-Term Plan included provision for accumulation of up to 24 months of purchase option credits.

PRICE INCREASE: In September 1974, IBM announced a price increase of six to eight percent on the rental and purchase prices of most of its equipment, and eight percent on charges for maintenance, data processing education, Program Products, Systems Engineering services, and Field Engineering hourly (per call) services. The new purchase prices and rates for Field Engineering hourly services become effective on September 18, 1974, while the remainder of the increases became effective on January 1, 1975. Prices for the System/360, the 1130, the 1800, and the System/370 Model 155 and 165, as well as the 3767 Communications Terminal, the 3770 Data Communications System, and the System/3 Model 8, were not affected. In addition, there was no increase in the purchase prices of the System/370 Model 115 and 125 central processors. Rental prices for the System/370 Model 115 and 125 were increased by six percent; both rental and purchase prices for the System/370 Model 145, 158, and 168 were increased by eight percent.

The hourly rates for Field Engineering equipment and programming services outside the scope of an IBM agreement rose eight percent. The new rates that apply to Class 1 equipment, which includes key entry and most terminal equipment, are $30.50 per hour for service during normal IBM working hours and $39.50 per hour for service at other times. For Class 2 equipment, which includes unit record and accounting machines and most components of the 1130, 1620, 1800, and System/3, System/7, and System/360 Model 20 systems, the new hourly rates are $35.75 and $46.50. For Class 3 equipment, which includes most components of the System/360 (Models 22 and above), System/370, 1400 Series, and 7000 Series systems, the new hourly rates are $40.75 and $53.00.

New Systems Engineering hourly rates are $28.00 for the Basic skill classification, $35.75 for the General skill classification, $44.75 for the Complex skill classification, and $33.25 for a Group Workshop. ■