IBM System/370

MANAGEMENT SUMMARY

IBM's System/370 product line is estimated to account for over 45 percent of the currently installed computer systems in the United States. The System/370 family of medium-to-large-scale computer systems included a total of 23 central processor models. However, competitive pressures and technological advances have caused most of these models to be superseded, leaving only four models currently in production: Models 115 and 115-2, in limited new production, and Models 138 and 148, in new production. Recently, the purchase and lease prices for Models 138 and 148 were reduced, possibly indicating either a softening in customer demand for these relatively low-cost, high-performance processors or the imminent introduction of their replacements. The new Model 3031, 3032, and 3033 Processors are seen by some as the first members of IBM's successor to the System/370 line, while others view the three new systems simply as evolutionary products that will continue the lifespan of the eight-year-old System/370 family.

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 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 ▷

The eight-year old IBM System/370 computer family includes 23 distinct processor models, although only 4 of the 23 are currently produced: the Model 115 and 115-2, in limited new production, and the Model 138 and 148, in new production. The other models are now marketed on an as-available basis. This comprehensive report summarizes the entire System/370 line, both past and present, and includes IBM's latest contract provisions along with a summary of the experience of 864 System/370 users.

CHARACTERISTICS

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

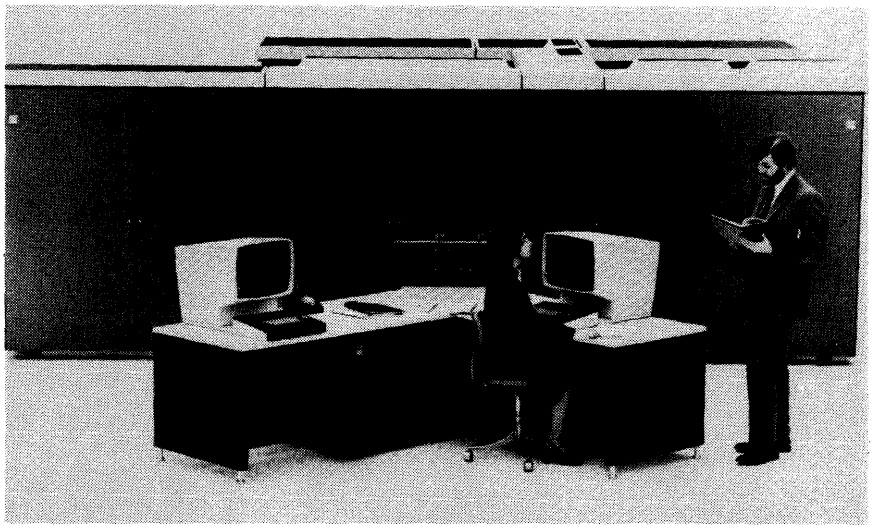
MODELS: System/370 Model 115 through Model 195. At this writing, Models 138 and 148 are in new production and Model 115 is in limited new production. Models 135, 145, 155, 158, 165, and 168 are not in new production and are sold on an as-available basis only. Model 195 is no longer marketed. See table on following pages for a summary of the processor models and their characteristics.

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"



Successor, evolutionary extension, or both? The Model 3033 Processor, along with the subsequently announced 3031 and 3032 Processors, represents a new chapter in the System/370 story. This new processor provides about 80 percent greater performance than the Model 168-3 Processor and includes groups of integrated channels instead of the externally mounted channels employed by the previous large-scale System/370 models.

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CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS

	Model 115	Model 115-2	Model 125	Model 125-2	Model 135	Model 135-3
SYSTEM CHARACTERISTICS						
Date of first introduction	March 1973	Nov. 1975	Oct. 1972	Nov. 1975	March 1971	June 1976
Date of first delivery	1st Qtr. 1974	Aug. 1976	April 1973	Feb. 1976	May 1972	1st qtr. 1977
Virtual storage capability	Standard	Standard	Standard	Standard	Standard	Standard
Number of central processors	1	1	1	1	1	1
Principal operating systems	DOS/VS	DOS/VS	DOS/VS	DOS/VS	DOS/VS, OS/VS1	DOS/VS
Production status	Limited new production	Limited new production	Not in new production	Not in new production	Not in new production	Not in new production
MAIN STORAGE						
Storage type	Semicond. (MOS)	Semicond. (MOS)	Semicond. (MOS)	Semicond. (MOS)	Semicond. (bipolar)	Semicond. (bipolar)
Read cycle time, nanoseconds	480	480	480	480	770	540
Write cycle time, nanoseconds	480	480	480	480	935	608
Bytes fetched per cycle	2	2	2	2	2 or 4	2 or 4
Storage interleaving (maximum)	None	None	None	None	None	None
Minimum capacity, bytes per system	65,536	65,536	98,304	98,304	98,304	262,144
Maximum capacity, bytes per system	196,608	393,216	262,144	524,288	524,288	524,288
Increment size, bytes	32,768	32,768-131,072	32,768 or 65,536	32,768-131,072	49,152 to 131,072	65,536 or 131,072
BUFFER STORAGE						
Cycle time, nanoseconds	—	—	—	—	—	—
Bytes fetched per cycle	—	—	—	—	—	—
Minimum capacity, bytes	None	None	None	None	None	None
Maximum capacity, bytes	None	None	None	None	None	None
PROCESSING UNIT						
Machine cycle time, nanoseconds	480	480	480	480	275-1485	275-1485
Relative performance level (estimated)	1.00	1.40	1.45	1.80	2.90	3.80
Processing unit features:						
Control storage, bytes	20,480 to 28,672	12,288 to 20,480	12,288 to 20,480	16,384 to 24,576	24,576 to 49,152	131,072
Clock Comparator & CPU Timer	Standard	Standard	Standard	Standard	Optional	Optional
Direct Control	No	No	No	No	Optional	Standard
Dynamic Address Translation	Standard	Standard	Standard	Standard	Standard	Standard
Floating Point	Optional	Optional	Optional	Optional	Optional	Optional
Extended Precision Floating Point	Optional	Optional	Optional	Optional	Optional	Optional
High-Speed Multiply	No	No	No	No	No	No
Integrated 2319 Disk Control	No	No	No	No	Optional	Optional
Integrated 3330 Disk Control	No	No	Standard	Standard	Optional	No
Integrated 3340/3344 Disk Control	Std. 3340	Standard	Std. 3340	Standard	Optional	Optional
Integrated 3350 Disk Control	No	No	No	No	No	No
Integrated 1403 Printer Control	No	No	Optional	Optional	Optional	Optional
Integrated 3203 Printer	Optional	Optional	Optional	Optional	No	No
Integrated 5203 Printer	Optional	Optional	No	No	No	No
Integrated Card I/O	Optional	Optional	Optional	Optional	No	No
Integrated Communications Control	Optional	Optional	Optional	Optional	Optional	Optional
Compatibility features:						
IBM 1401/1440/1460 Compatibility	Optional	Optional	Optional	Optional	Optional	Optional
IBM 1410/7010 Compatibility	No	No	No	No	No	No
IBM 7070/7074 Compatibility	No	No	No	No	No	No
IBM 7080 Compatibility	No	No	No	No	No	No
IBM 709/7090/7094 Compatibility	No	No	No	No	No	No
IBM 360/20 Compatibility	Optional	Optional	Optional	Optional	Optional	Optional
OS/DOS Compatibility	No	No	No	No	Standard	Standard
IBM 1052 & 2311 Compatibility	Optional	Optional	Optional	Optional	No	No
CHANNELS						
No. of Selector Channels per system	None	None	None	None	0 to 2	None
No. of Block Multiplexer Channels	None	None	None	None	0 to 2	0 to 2
No. of Byte Multiplexer Channels	0 or 1	0 or 1	0 or 1	0 or 1	1	1
Maximum total I/O data rate, bytes/second	900,000	900,000	900,000	900,000	2,400,000	2,600,000

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CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS (Continued)

	Model 138	Model 145	Model 145-3	Model 148	Model 155	Model 155-II
SYSTEM CHARACTERISTICS						
Date of introduction	June 1976	Sept. 1970	June 1976	June 1976	June 1970	Aug. 1972
Date of first delivery	Nov. 1976	July 1971	2nd qtr. 1977	Jan. 1977	Feb. 1971	April 1973
Virtual storage capability	Standard	Standard	Standard	Standard	No**	Standard
Number of central processors	1	1	1	1	1	1
Principal operating systems	DOS/VS, OS/VS1	DOS/VS, OS/VS1, OS/VS2	DOS/VS, OS/VS1	DOS/VS, OS/VS1, OS/VS2	DOS/VS, OS/MFT, OS/MVT	DOS/VS, OS/VS1, OS/VS2
Production status	New production	Not in new production	Not in new production	New production	Not in new production	Not in new production
MAIN STORAGE						
Storage type	Semicond. (MOS)	Semicond. (bipolar)	Semicond. (bipolar)	Semicond. (MOS)	Core	Core
Read cycle time, nanoseconds	710-770	540	540	405	2070	2070
Write cycle time, nanoseconds	935	608	608	540	2070	2070
Bytes fetched per cycle	2	4 or 8	4 or 8	4	16	16
Storage interleaving (maximum)	None	None	None	None	None	None
Minimum capacity, bytes per system	524,288	164,840	196,608	1,048,576	262,144	262,144
Maximum capacity, bytes per system	1,048,576	2,097,152	2,031,616	2,097,152	2,097,152	2,097,152
Increment size, bytes	524,288	49,152 to 262,144	126,976 to 524,288	1,048,576	131,072 to 524,288	131,072 to 524,288
BUFFER STORAGE						
Cycle time, nanoseconds	—	—	—	—	115	115
Bytes fetched per cycle	—	—	—	—	2	2
Minimum capacity, bytes	None	None	None	None	8,192	8,192
Maximum capacity, bytes	None	None	None	None	8,192	8,192
PROCESSING UNIT						
Machine cycle time, nanoseconds	275-1485	203-315	180-270	180-270	115	115
Relative performance level (estimated)	3.9	5.45	7.1	7.7	10.0	10.0
Processing unit features:						
Control storage, bytes	131,072	32,768 to 65,536	131,072	131,072	Not spec'd.	Not spec'd.
Clock Comparator & CPU Timer	Standard	Optional	Optional	Standard	No**	Standard
Direct Control	Optional	Optional	Optional	Optional	Optional	Optional
Dynamic Address Translation	Standard	Standard	Standard	Standard	No**	Standard
Floating Point	Standard	Optional	Optional	Standard	Standard	Standard
Extended Precision Floating Point	Standard	Optional	Optional	Standard	Optional	Optional
High-Speed Multiply	No	No	No	No	No	No
Integrated 2319 Disk Control	No	No*	Optional	No	No	No
Integrated 3330 Disk Control	No	Optional	No	No	No	No
Integrated 3340/3344 Disk Control	Optional	Optional	Optional	Optional	No	No
Integrated 3350 Disk Control	No	No	No	No	No	No
Integrated 1403 Printer Control	Optional	No	No	No	No	No
Integrated 3203 Printer	Optional	No	No	Optional	No	No
Integrated 5203 Printer	No	No	No	No	No	No
Integrated Card I/O	No	No	No	No	No	No
Integrated Communications Control	Optional	No	No	No	No	No
Compatibility features:						
IBM 1401/1440/1460 Compatibility	Optional	Optional	Optional	Optional	Optional	Optional
IBM 1410/7010 Compatibility	No	Optional	Optional	Optional	Optional	Optional
IBM 7070/7074 Compatibility	No	No	No	No	Optional	Optional
IBM 7080 Compatibility	No	No	No	No	No	No
IBM 709/7090/7094 Compatibility	No	No	No	No	No	No
IBM 360/20 Compatibility	Optional	No	No	No	No	No
OS/DOS Compatibility	Standard	Standard	Standard	Standard	Optional	Optional
IBM 1052 & 2311 Compatibility	No	No	No	No	No	No
CHANNELS						
No. of Selector Channels per system	None	1 to 4	None	None	None	None
No. of Block Multiplexer Channels	2	1 to 4	1 to 4	4	2 to 5	2 to 5
No. of Byte Multiplexer Channels	1	1	1	1	1 or 2	1 or 2
Maximum total I/O data rate, bytes/second	2,600,000	5,300,000	5,300,000	5,000,000	5,400,000	5,400,000

* 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.

**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-II.

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CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS (Continued)

	Model 158	Model 158-3	Model 158 MP	Model 158-3 MP	Model 165	Model 165-II
SYSTEM CHARACTERISTICS						
Date of introduction	Aug. 1972	March 1975	Feb. 1973	March 1975	June 1970	Aug. 1972
Date of first delivery	April 1973	Sept. 1975	March 1974	Sept. 1975	April 1971	Dec. 1973
Virtual storage capability	Standard	Standard	Standard	Standard	No*	Standard
Number of central processors	1	1	2	2	1	1
Principal operating systems	DOS/VS, OS/VS1, OS/VS2	DOS/VS, OS/VS1, OS/VS2	OS/VS2 Release 2	OS/VS2 Release 2 & Release 3	OS/MFT, OS/MVT	OS/VS1, OS/VS2
Production status	Not in new production	Not in new production	Not in new production	Not in new production	Not in new production	Not in new production
MAIN STORAGE						
Storage type	Semicond. (MOS)	Semicond. (MOS)	Semicond. (MOS)	Semicond. (MOS)	Core	Core
Read cycle time, nanoseconds	1035	1035	1035	1035	2000	2000
Write cycle time, nanoseconds	690	690	690	690	2000	2000
Bytes fetched per cycle	8 or 16	8 or 16	8 or 16	8 or 16	8	8
Storage interleaving (maximum)	None	None	None	None	4-way	4-way
Minimum capacity, bytes per system	524,288	524,288	1,048,576	1,048,576	524,288	524,288
Maximum capacity, bytes per system	6,291,456	6,291,456	12,582,912	12,582,912	3,145,728	3,145,728
Increment size, bytes	524,288 or 1,048,576	524,288 or 1,048 576	524,288 or 1,048,576	524,288 or 1,048,576	524,288 or 1,048,576	524,288 or 1,048,576
BUFFER STORAGE						
Cycle time, nanoseconds	115	115	115	115	80	80
Bytes fetched per cycle	2	2	2	2	4	4
Minimum capacity, bytes	8,192	16,384	8,192	16,384	8,192	8,192
Maximum capacity, bytes	8,192	16,384	8,192	16,384	16,384	16,384
PROCESSING UNIT						
Machine cycle time, nanoseconds	115	115	115	115	80	80
Relative performance level (estimated)	15.0	16.4	27.0	29.4	34.5	34.5
Processing unit features:						
Control storage, bytes	Not spec'd.	Not spec'd.	Not spec'd.	Not spec'd.	Not spec'd.	Not spec'd.
Clock Comparator & CPU Timer	Standard	Standard	Standard	Standard	No*	Standard
Direct Control	Optional	Optional	Optional	Optional	Standard	Standard
Dynamic Address Translation	Standard	Standard	Standard	Standard	No*	Standard
Floating Point	Standard	Standard	Standard	Standard	Standard	Standard
Extended Precision Floating Point	Optional	Optional	Optional	Optional	Standard	Optional
High-Speed Multiply	No	No	No	No	Optional	No
Integrated 2319 Disk Control	No	No	No	No	No	No
Integrated 3330 Disk Control	Optional	Optional	Optional	Optional	No	No
Integrated 3340/3344 Disk Control	Optional	Optional	Optional	Optional	No	No
Integrated 3350 Disk Control	No	No	No	No	No	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	Optional	Optional	Optional	No	No
IBM 1410/7010 Compatibility	Optional	Optional	Optional	Optional	No	No
IBM 7070/7074 Compatibility	Optional	Optional	Optional	Optional	Optional	Optional
IBM 7080 Compatibility	No	No	No	No	Optional	Optional
IBM 709/7090/7094 Compatibility	No	No	No	No	Optional	Optional
IBM 360/20 Compatibility	No	No	No	No	No	No
OS/DOS Compatibility	Optional	Optional	Optional	Optional	No	No
IBM 1052 & 2311 Compatibility	No	No	No	No	No	No
CHANNELS						
No. of Selector Channels per system	None	None	None	None	0 to 6	0 to 6
No. of Block Multiplexer Channels	2 to 5	2 to 5	4 to 10	4 to 10	0 to 11	0 to 11
No. of Byte Multiplexer Channels	1 or 2	1 or 2	2 to 4	2 to 4	0 to 2	0 to 2
Maximum total I/O data rate, bytes/second	Not spec'd.	Not spec'd.	7,500,000	7,500,000	8,000,000	8,000,000

*Virtual storage 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.

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CHARACTERISTICS OF THE SYSTEM/370 PROCESSOR MODELS (Continued)

	Model 168	Model 168-3	Model 168 MP	Model 168-3 MP	Model 195
SYSTEM CHARACTERISTICS					
Date of introduction	Aug. 1972	March 1975	Feb. 1973	March 1975	July 1971
Date of first delivery	Aug. 1973	June 1975	March 1974	June 1975	2nd qtr. 1973
Virtual storage capability	Standard	Standard	Standard	Standard	No
Number of central processors	1	1	2	2	1
Principal operating systems	OS/VS1, OS/VS2	OS/VS1, OS/VS2	OS/VS2 Release 2 & Release 3	OS/VS2 Release 2 & Release 3	OS/MVT
Production status	Not in new production	Not in new production	Not in new production	Not in new production	No longer marketed
MAIN STORAGE					
Storage type	Semicond. (MOS)	Semicond. (MOS)	Semicond. (MOS)	Semicond. (MOS)	Core
Read cycle time, nanoseconds	480	480	480	480	756
Write cycle time, nanoseconds	480	480	480	480	756
Bytes fetched per cycle	8	8	8	8	8
Storage interleaving (maximum)	4-way	4-way	4-way	4-way	16-way
Minimum capacity, bytes per system	1,048,576	1,048,576	2,097,152	2,097,152	1,048,576
Maximum capacity, bytes per system	8,388,608	8,388,608	16,777,216	16,777,216	4,194,304
Increment size, bytes	1,048,576	1,048,576	1,048,576	1,048,576	1,048,576
BUFFER STORAGE					
Cycle time, nanoseconds	80	80	80	80	54
Bytes fetched per cycle	4	4	4	4	8
Minimum capacity, bytes	8,192	32,768	8,192	32,768	32,768
Maximum capacity, bytes	16,384	32,768	16,384	32,768	32,768
PROCESSING UNIT					
Machine cycle time, nanoseconds	80	80	80	80	54
Relative performance level (estimated)	41.8	45.5	75.3	81.8	86.4
Processing unit features:					
Control storage, bytes	Not spec'd.	Not spec'd.	Not spec'd.	Not spec'd.	Not spec'd.
Clock Comparator & CPU Timer	Standard	Standard	Standard	Standard	No
Direct Control	Standard	Standard	Standard	Standard	Standard
Dynamic Address Translation	Standard	Standard	Standard	Standard	No
Floating Point	Standard	Standard	Standard	Standard	Standard
Extended Precision Floating Point	Standard	Standard	Standard	Standard	Standard
High-Speed Multiply	Optional	Optional	Optional	Optional	Standard
Integrated 2319 Disk Control	No	No	No	No	No
Integrated 3330 Disk Control	Optional	Optional	Optional	Optional	No
Integrated 3340/3344 Disk Control	Optional	Optional	Optional	Optional	No
Integrated 3350 Disk Control	Optional	Optional	Optional	Optional	No
Integrated 1403 Printer Control	No	No	No	No	No
Integrated 3203 Printer	No	No	No	No	No
Integrated 5203 Printer	No	No	No	No	No
Integrated Card I/O	No	No	No	No	No
Integrated Communications Control	No	No	No	No	No
Compatibility features:					
IBM 1401/1440/1460 Compatibility	No	No	No	No	No
IBM 1410/7010 Compatibility	No	No	No	No	No
IBM 7070/7074 Compatibility	Optional	Optional	Optional	Optional	No
IBM 7080 Compatibility	Optional	Optional	Optional	Optional	No
IBM 709/7090/7094 Compatibility	Optional	Optional	Optional	Optional	No
IBM 360/20 Compatibility	No	No	No	No	No
OS/DOS Compatibility	No	No	No	No	No
IBM 1052 & 2311 Compatibility	No	No	No	No	No
CHANNELS					
No. of Selector Channels per system	0 to 6	0 to 6	0 to 12	0 to 12	0 to 6
No. of Block Multiplexer Channels	0 to 11	0 to 11	0 to 22	0 to 22	0 to 13
No. of Byte Multiplexer Channels	0 to 2	0 to 2	0 to 4	0 to 4	0 to 2
Maximum total I/O data rate, bytes/second	16,000,000	16,000,000	28,000,000	28,000,000	3,000,000

NOTE: Models 3031, 3032, and 3033, the newest System/370 processors, are described on page 70C-491-04s through 70C-491-04u.

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manufacturer to use an all-semiconductor main memory, Model 145 extended the concept of microprogrammed control to a new high in flexibility.

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 was 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 was a slightly upgraded version of the earlier System/360 Model 195.

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.*

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 featured virtual storage capabilities, used low-cost MOS main memories, and offered 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 supported the new virtual storage capabilities and were functional extensions of the earlier DOS, OS/MFT, OS/MVT, and CP-67 systems, respectively.
- Integrated disk controls that reduced the cost of using the high-performance 3330 disk drives in Model 135, 145, 158, and 168 systems, plus redesigned control logic permitting 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 offered most of the same processing facilities, had the same virtual storage capabilities, and used the same DOS/VS and/or DOS software. It continued the IBM trend 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 boasted two significant facilities that were not present in the larger Model 135 and 145 systems: a standard operator console with CRT display, and independent "satellite" processors that permit simultaneous

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

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

CHECKING: All data paths between the central processor and main storage are parity-checked by byte. When data is stored, an error-correcting code is substituted for the parity bits. (An 8-bit modified Hamming code is appended to each 8-byte "doubleword" of data.) When the data is retrieved, single-bit errors are detected and corrected automatically, 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 Models 138, 148, and the larger models (see table).

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

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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.
- 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 offered 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.
- 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 facilities.

During the spring and summer of 1973, IBM again extended the lower end of its general-purpose product line downward by announcing the System/370 Model 115. 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 Model 115 Processing Unit, a virtual storage computer that represented a major 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.

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)*

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 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 instructions are available to support VTAM on Models 135, 145, 155-II, 158, 165-II and 168:

Compare and Swap
Compare Double and Swap

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

The Direct Control feature, available as an option on Models 135 through 158-3 MP and standard on Models 165 through 195, adds two more instructions, Read Direct and Write Direct.

Finally, four 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: Average execution times, in microseconds, for some representative instructions are as follows:

	115	125	138	148	168-3
Add (32-bit binary)	14.5	9.7	2.6	1.7	0.33
Multiply (32-bit binary)	189.9	143.4	25.2	16.0	0.66
Divide (32-bit binary)	210.26	245.5	40.9	31.1	3.28
Load (32-bit binary)	11.3	7.7	2.2	1.1	0.19
Store (32-bit binary)	11.8	82.0	2.2	1.2	0.21
Add (6-digit packed decimal)	107.6	47.8	36.2	8.2	1.17
Compare (6-digit packed decimal)	92.3	46.3	26.8	7.3	1.05

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The Model 115 is the entry point to the System/370 product line. This smallest member of the family, announced in March 1973, is still essentially unchanged and is the subject of considerable current speculation regarding its successor system.

- 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.

- 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).

- 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 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 in September 1974 a price hike of 6 to 8 percent applicable to nearly all of the System/370 processors and peripherals.

In 1975 the System/370 product line continued to evolve and mature. IBM startled industry observers in March 1975 by quietly abandoning the use of the term "Future Systems," or "FS," as the code name for its next generation of computer systems. The disclosure generated an enormous amount of speculation in the computer industry about both the motive for dropping the label and its effect on the timing of the introduction of IBM's new product line. While the answer was certainly not forthcoming from IBM, the company did provide a clue a few weeks later with the announcement of two enhanced

	115	125	138	148	168-3
Add (short floating-point)	51.6	53.0	11.1	5.7	0.80
Multiply (short floating-point)	168.9	190.7	23.5	15.5	0.70
Divide (short floating-point)	231.5	231.0	31.8	25.7	2.95
Add (long floating-point)	64.8	66.9	10.0	7.1	0.83
Multiply (long floating-point)	472.5	565.8	28.4	38.5	1.29
Divide (long floating-point)	713.8	641.6	75.8	80.4	7.73

Instruction timings for the Model 168-3 were derived by scaling the times given for the Model 158-1. All floating-point instructions are data-dependent and may vary substantially from the average timings given. No allowance has been made for CPU degradation due to channel interference.

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 and Model 115-2 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 and Model 125-2 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			20K 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, 135-3, 138, 145, 145-3, 148, 158, and 158-3 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

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processor models—the Model 158-3 and Model 168-3—and Release 3 of the OS/VS2 Operating System for the large-scale processor models in the System/370 product line. The 3800 Printing Subsystem, a competitor for the Xerox 1200 Computer Printing System and the Honeywell Page Printing System, joined the System/370 product line in April 1975 as a very high-speed on-line printer.

Later in the year, IBM turned its attention to the smaller System/370 central processors. In July 1975 the company announced a reduction in the purchase prices for the System/370 Model 115 and Model 125 processors as well as a sizeable collection of peripheral devices, including the 2740, 2741, and 2790 communications terminals, the 3330 and 3330 Model 11 Disk Drives, the 3340 Direct Access Storage Facility, and the 3420 Magnetic Tape Unit. This was closely followed by the announcement of the new high-performance 3350 Direct Access Storage and the 3344 Add-On Direct Access Storage and the 3344 Add-On Direct Access Storage for the 3340 Direct Access Storage Facility. Finally, in November 1975, IBM introduced the replacements for the price-reduced Models 115 and 125. The new Model 115-2 and Model 125-2 processors feature faster internal performance, improved input/output capabilities, and larger main memory (for the Model 115-2).

In 1975 IBM began in earnest to supply the actual building blocks for its Systems Network Architecture (SNA) framework. In June the company formed the System Communication Division and assigned it complete responsibility for the development and manufacture of all computer-related communications systems and terminals. The new division released a succession of communications software enhancements, including the Virtual Storage Personal Computing system, an interactive time-sharing system aimed at nonprogrammers. In November 1975, IBM supplied additional inducement to its users to move into the SNA teleprocessing environment by announcing the 3705-II Communications Controller, which offers performance improvements at substantially reduced costs.

In September 1975, IBM initiated another round of price increases among the mainframe manufacturers by announcing an increase of 4 percent in the rental and purchase prices of most of its data processing products and 9 percent for its maintenance services.

The highlight of 1976 was the introduction of two new processing units, the Model 138 and 148, although these were by no means the only significant products revealed.

The first new development of the year, unveiled by IBM in February 1976, was the Model 168 Attached Processor System (APS), based on the Model 168-3 CPU and the 3062 Attached Processor. An attached processor is essentially an individual procesing unit *without* I/O capabilities. Hence, the enhanced system offers an increase in internal performance nearly equal to that of a multiprocessor configuration, but at a lower cost, since the attached processor does not have its own main memory

containing all the control microprograms required for a specific installation.

The control storage for a Model 165, Model 168, or 168-3 consists of 2K 108-bit control words written in read-only storage (ROS) and 512 words of RCS. The IBM 7070/7074, 7080, 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.

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.

Models 135-3, 138, 145-3, and 148 each have 131,072 bytes of RCS with expansion capabilities.

DYNAMIC ADDRESS TRANSLATION: This facility, which is standard in all Models except the 155, 165, and 195, 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 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: All models except the 155, 165, and 195 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 permamently 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 through -04e 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

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or the various I/O channels and support facilities. The trade-off occurs in throughput, since both processors must share the memory and I/O facilities of the host. The 3062 Attached Processor is further strengthened by the addition of a 32K-byte high-speed buffer storage (cache memory). The Model 168 APS provides internal performance levels 1.5 to 1.8 times that of a single Model 168-3 processor. The introduction of the Model 168 APS was interpreted as a reaction to the replacement of several large-scale 370 systems by the increasingly successful Amdahl 470V/6.

In May 1976, IBM announced reductions in the purchase prices of several products and product features, and, most significantly, in the purchase price of its MOSFET memory. The memory price reductions affected the System/370 Model 115, 125, 158, and 168 systems, with the biggest incremental memory price cuts being made on the larger systems. The average price reduction for the Model 158 and 168 systems was about 35 percent, with the price of one megabyte of incremental memory dropping from $263,000 to $170,000. On the Model 115 and 125 systems, 32K increments were reduced from $7,900 to $5,400, a decrease of about 32 percent.

Also in May 1976, shortly after announcing the reduced memory prices, IBM introduced new processing units for the System/370 Model 115-2 and 125-2 systems that offer expanded main memory capacities. The Model 115-2 system now offers an additional processor size of 384K bytes, while the Model 25-2 system is now available in two additional processor sizes of 384K and 512K bytes. The additional storage is also available for installed models through field upgrades. According to IBM, the increased processor storage sizes allow Model 115-2 and 125-2 users to implement an expanded DOS/VS DB/DC environment under CICS and DL/1 or an interactive environment under VSPC APL, FORTRAN, or BASIC, in addition to batch; achieve throughput improvements in environments with heavy paging on the smaller processor storage sizes; and improve system utilization in environments formerly constrained from additional multiprogramming due to insufficient processor storage.

On June 30, 1976, IBM announced the addition of two new CPU models to the System/370 family—the Model 138 and Model 148. The new models offered increases in internal performance of approximately 28 to 43 percent over their respective predecessors, the 370/135 and 370/145; yet the prices of the new systems were much lower than those of the Model 135 and 145 systems—about 45 percent less for purchase and some 22 percent less on rental. The 138 and 148 systems use MOSFET main memories and control stores, whereas the 370/135 and 145 employed bipolar memory technology. The reloadable control store in both the 138 and 148 systems is 128K bytes—five times the amount available in the 370/135 and four times that used in the 370/145.

At the same time that IBM introduced the Model 138 and 148 systems, it also announced that existing Model 135 and 145 systems could be upgraded to "the internal

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 two additional instructions plus 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 only the six interrupts for the Model 115, 115-2, 125, and 125-2).

High-Speed Multiply is available only on the Model 165, 168, and 168-3. It reduces the time required for long-precision floating-point and fixed-point multiple instructions. For Model 165, the times are reduced from 1.87 to 0.61 microseconds and from 0.78 to 0.42 microseconds, respectively.

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

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

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

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

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performance levels" of the new systems, although they would not have all of the features. Designated the 370/135-3 and 370/145-3, respectively, the upgraded models offered essentially the same internal performance as the Model 138 and Model 148. The enhanced 135's and 145's provided many of the features found in the new systems, but the extended control-program support, 128K bytes of control memory, and APL assist were not included.

In late October 1976, the Model 158 Attached Processor System was unveiled. This enhanced system was widely viewed as IBM's response to one of the Itel/National Semiconductor plug-compatible mainframes, the AS/5-3 multiprocessing system. The Model 158 APS used the 115-nanosecond Model 3052 Attached Processor to form a tightly coupled dual-processor system. As with the Model 168 APS, it provided an intermediate step for users who required greater processing capabilities but could not justify the move to a full multiprocessor (two 158's) system. The increase in system internal performance realized by the addition of a Model 3052 Attached Processor was the same as that gained in the Model 168 APS, namely, 1.5 to 1.8 times the performance of a single-CPU system. Along with the attached processor for the 158, IBM also expanded the maximum memory capacity of the Model 158 CPU from four million to six million bytes, in one-million byte increments.

Another 1976 announcement that paralleled the Model 168 APS and Model 158 APS systems was the Model 3838 Array Processor. This specialized auxiliary processing unit, designed for use with either a Model 158 or Model 168 CPU, performs high-speed vector operations plus other sophisticated analytic functions used in seismic trace processing. This more specialized unit differs from the Model 3052 and Model 3062 Attached Processors by having its own main memory, whereas the two attached processors share memory with the host system. But aside from the memory and instruction set differences, these three processors function similarly in their respective systems.

In November 1976, IBM announced a series of software program products that permit System/370's to be effectively linked together in a multi-computer networking facility. These program products were released under the name Advanced Communications Function (ACF), which should not be confused with the 1972 Advanced Function announcement (virtual storage) or the 1974 Advanced Function for Communications (SNA and SDLC). Briefly, the announcement included expanded versions of TCA, VTAM, and NCP (for the 3705 communications front end) that include the capabilities for establishing linkages among a group of computers. But these were not the only announcements made around this time. The Network Job Entry facility for JES2 (OS/VS MVS) was also upgraded to provide some networking-like features.

During 1977 and early 1978, most of the changes to the System/370 line involved selectable units that provide

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.

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, 125-2, 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 or 125-2. 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 or 115-2. 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, 115-2, 125,

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enhancements to the OS/VS2 and VM/370 operating systems. Several hardware products were either placed in a lower production status or withdrawn from marketing. Some of the more significant products that were affected included the Model 115-2, changed from "new" to "limited new" production; the Model 195, withdrawn from marketing; and the Models 155 and 165, also withdrawn from marketing. IBM also revised its maintenance and software licensing contracts and released on entirely new Agreement for Lease or Rental of IBM Machines (LRA).

The most significant additions to the IBM computer product line during 1977 and early 1978 were the introduction of the Model 3031, 3032, and 3033 Processors and the addition of support for these new units to the OS/VS2 and VM/370 operating systems. These selectable unit modifications are seen as a new ploy to thwart the growing inroads of the manufacturers of plug-compatible replacements for the IBM central processors.

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 was a bold new technique pioneered by IBM. In fact, the concept was more than a decade old and had 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

and 125-2 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, 135-3, 145, 145-3, 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.

Models 138 and 148 use a display console consisting of 1920-character CRT display and keyboard, with provisions for attaching a 3286 Model 2 Printer for hard-copy output. Both systems have three console modes: Printer-Keyboard Mode, Display Mode, and 115/125 Console-Display-Emulation Mode.

Printer-Keyboard Mode uses the keyboard for input and the CRT display for output. A 3286 Printer is recommended for this mode, but not required. The CRT, keyboard, and printer appear to the system as a 3215 Console Printer-Keyboard. This mode is supported by DOS, DOS/VS, OS/360, OS/VS, and VM/370.

Display Mode also uses the keyboard for input and the CRT display for output. The optional 3286 Model 2 Printer has a separate address and requires MCS support or equivalent. The printer appears to the Model 138 or 148 system as a 3213 Console Printer. Display Mode is not supported by DOS/VS.

In 115/125 Console-Display Emulation Mode, the keyboard and CRT display are used for input and output as in the other two modes. However, the CRT can display only 12 lines of 56 characters. When the 3286 Printer is employed, it emulates a 5213 Model 1 Printer and acts as a slave to the display console. For DOS/VS systems, the operating software must be Release 28 or greater.

Models 158 and 158-3 use an operator display console, which is supplied along with the Processing Unit as standard equipment. It contains a CRT display, keyboard, light pen, two Console Files, and microcode control storage. A stand-alone 3213 Printer, rated at 85 characters per second, can be added as an optional hard-copy output unit.

Every Model 165, 168, and 168-3 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 alpha-

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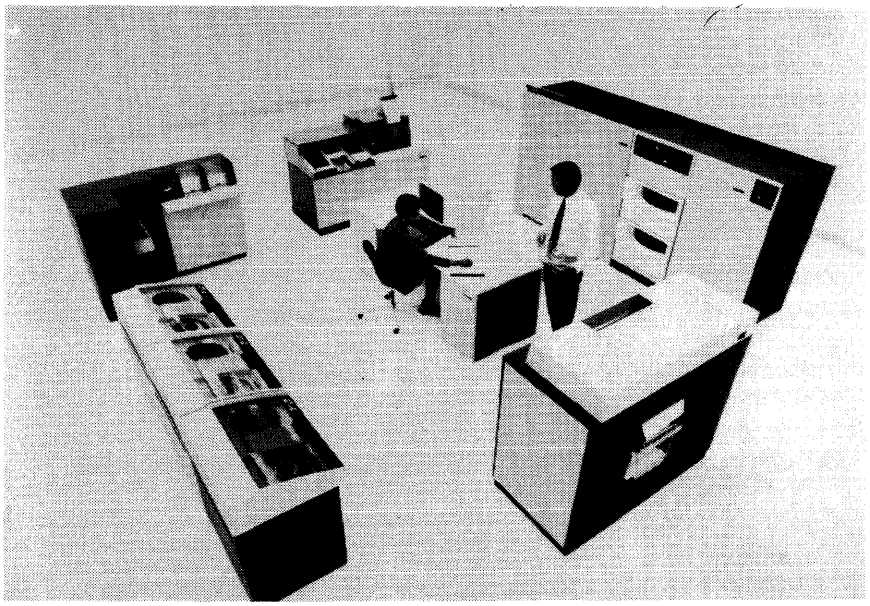

The System/370 Model 125 provides a 45 percent performance improvement and greater configurability than the entry-level Model 115. This tape/disk configuration features 3410 Magnetic Tape Units (left) and 3333 Model 1 Disk Drives (right background).

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. (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.

numeric 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 (20KBS), Model 2 (40KBS), or Model 3 (80KBS)
3420 Magnetic Tape Subsystem, Model 3 (120KBS) or Model 5 (200KBS).

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

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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.

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:

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 or Selector Channels are available for the Model 115.

INPUT/OUTPUT CONTROL (MODEL 115-2)

The Model 115-2 also uses internal Input/Output Processors (IOP's), in place of conventional I/O channels, 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 115-2 installation.

A 3340 Direct Access Storage Facility with two to eight disk drives can be connected to a Model 115-2 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 (20KBS), Model 2 (40KBS), or Model 3 (80KBS)
3420 Magnetic Tape Subsystem, Model 3 (120KBS), Model 5 (200KBS), or Model 7 (320KBS).

Only one card unit and one line printer can be connected to a Model 115-2 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 115-2. 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 25,000 bytes/second in byte-interleaved mode and 29,000 bytes/second in burst mode. An Extended Byte Multiplexer Channel is a prerequisite for installation of the Byte Multiplexer channel on the Model 115-2. 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 or Selector Channels are available for the Model 115-2.

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- 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.

- 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

At the System/370's height of product maturity, there were 23 distinct central processor models, including both uniprocessor (UP) and multiprocessor (MP) models of the larger systems. During the past two years, most of these models have been withdrawn from new production by IBM, leaving only the Models 115, 115-2, 138, and 148 in production at this writing. In fact, even the 115 and 115-2 are in *limited* new production, indicating that these entry-level models may soon be superseded.

The characteristics of the four System/370 models still in production and the new 303X processors are described in the following paragraphs, and the characteristics of the entire System/370 line are summarized in the charts on the second through fifth pages of this report.

Model 115, the smallest System/370 processor, was replaced by the Model 115-2 in November 1975. The original Model 115 itself was a relatively recent addition to the family, having been announced in March 1973 to narrow the gap between IBM's System/3 and System/370 computer families.

INPUT/OUTPUT CONTROL (MODELS 125 & 125-2)

In place of conventional I/O channels, Model 125, like the smaller Model 115, uses internal Input/Output Processors (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. The Model 125-2 can accommodate up to 8 additional 3340 Disk Drives for a maximum on-line capacity of 16 drives. A 4K DASF Control Storage Extension is required for configuring more than eight disk spindles on a Model 125-2 and is mutually exclusive with the 1403/3202 Carriage Control and any feature combination requiring the 8K Control Storage Extension. 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, Model 1 (20 KBS), Model 2 (40 KBS), or Model 3 (80 KBS)
3420 Magnetic Tape Subsystem, Model 3 (120 KBS) or Model 5 (200 KBS)
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
5213 Printer, Model 1
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 or 125-2. 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 or Selector Channels are available for the Model 125 or 125-2.

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.

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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 continued 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 read/write diskette drive.

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 (20KBS), Model 2 (40KBS), or Model 3 (80KBS),

- 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.

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 channel data transfer rate is 1,300,000 bytes/second, permitting a combined data rate of 2,600,000 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, that are available in three shared/non-shared configurations.

The upgrade Model 135-3 and the Model 138 each have one byte multiplexer channel, with 64 subchannels, that is functionally identical with that in the Model 135. Like its Model 135 counterpart, the byte multiplexer channel can be expanded to 256 subchannels at no additional cost. Unlike the 135, the 135-3 and the 138 do not have selector channels as such. Instead, each can have up to two block multiplexer channels, which are actually the same as the Model 135 selector channels converted to block multiplexer operation. Devices that cannot use the block multiplex capabilities will function as if attached to a selector channel.

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.

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consisting 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 and optical readers. The maximum data rate for 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 originally marketed the Model 115 as a growth system for users of the IBM System/3, 1130, and System/360 Models 20, 22, and 25. Conversion to the Model 115 was relatively simple for System/360 Model 22 and 25 users, reasonably straightforward for 360/20 users who took advantage of an integrated 360/20 emulator for the Model 115, but far from easy for users of the architecturally dissimilar System/3 and 1130 computers.

As originally announced, the Model 115 offered only two main storage capacities: 65K or 98K bytes. That 98K limitation on real main storage capacity in a DOS/VS system was suspect from the very time of its announcement. 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.

In November 1975, IBM introduced a new version of the smallest member of the System/370 line. *Model 115-2* featured enhanced internal performance that was about 55 to 75 percent faster than the original Model 115, and a new 262K-byte main storage capacity. The capacity has since been increased to 393K bytes. In addition, the Model 115-2 can be equipped with twice the disk storage of the original Model 115: up to eight Model 3340/3344 spindles, or a total capacity of 1.8 billion bytes, compared to 279 million bytes for the Model 115-0. A 3340 String Switch feature allows the 115-2 to share its direct access storage with another System/370 computer, permitting the system to perform as a backup system for a larger configuration. System/370 Model 115 systems can be field-upgraded to the Model 115-2.

The Model 115-2 achieves its superior performance through a rearrangement of its architecture in which the original Machine Instruction Processor (MIP) was replaced by a separate Instruction Processing Unit (IPU) and an Input/Output Processor (IOP), which acts as a dedicated controller for the 3340 Direct Access Storage Facility. In addition, the number of translation lookaside buffers was increased from 8 to 16 in the new processor to improve virtual storage operation. The Model 115-2 also includes a new multiplexer channel with a data transfer rate of 25K bytes per second in the byte mode, up from 19K bytes per second in the Model 115-0, although the maximum burst mode data transfer rate remains 29K bytes per second.

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.

Models 145-3 and 148 have channel configurations similar to those of the Model 135-3 and 138. Each has one byte multiplexer channel with 64 subchannels, which can be expanded to 256 subchannels at no extra cost. Both systems feature from one to four block multiplexer channels which are actually converted selector channels. These block multiplexer channels differ slightly from those used in Models 135, 135-3, and 138 by permitting expansion up to 512 subchannels. The basic block multiplexer channel is supplied with 64 subchannels and can be expanded in groups of 16. Again, no charge is made for the expansion. For the Model 145-3, one block multiplexer channel is provided with the system and up to three more can be purchased. For the Model 148, four block multiplexer channels are standard and no expansion is possible. The same word buffer that is optional on the Model 145 is available as an option for the Model 145-3 and is standard on the Model 148.

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 Model 158-3 has an expanded subchannel capability on both Byte and Block Multiplexer Channels which permits 16 or 32 devices to be assigned to a shared subchannel. The total number of shared subchannels available for the Model

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With the announcement of the System/370 Model 115-2 (and the Model 125-2, which was announced on the same date), IBM introduced the possibility of cardless System/370 configurations, with the substitution of a 3590 Diskette I/O Unit for a card reader for both data entry as well as job control language, maintenance diagnostics, and other forms of data entry.

Models 138 and 148, introduced in June 1976, offered increases in internal performance of approximately 28 to 43 percent over their respective predecessors, the 370/135 and 370/145, at prices much lower than those of the Model 135 and 145 mainframes—about 45 percent less for purchase and some 22 percent less for rental. Both systems employ MOSFET main memories and control storage instead of the bipolar memories used in the 370/135 and 145. The reloadable control store in both the 138 and 148 is 128K bytes—five times the capacity of the 370/135 and four times that of the 370/145.

The Model 138 is offered with either 524K or 1 million bytes of main memory, 128K bytes of reloadable control store, a 1920-character display console, one byte multiplexer channel, one block multiplexer channel, extended control-program support, and VS APL performance assists. IBM claims the Model 138 offers approximately a 29 to 36 percent internal performance increase over the System/370 Model 135.

The standard Model 148 configuration consists of either 1 or 2 million bytes of main memory, 128K bytes of control store, a display console, one byte multiplexer channel, four block multiplexer channels, a word buffer, extended control-program support, and VS APL performance assists. The 148 is estimated to yield a 28 to 43 percent internal performance improvement over the System/370 Model 145.

The System/370 Models 138 and 148 both have a 1920-character input/output display console and keyboard for operator communications. The CRT can accommodate 24 80-character lines of information. In addition, two printers, the 3286-2 and the 3287, may be added for hard-copy output. The 3286 is a 66-cps unit that provides storage for up to 1920 characters. The 3287 features bi-directional printing at speeds of 80 cps (Model 1) or 120 cps (Model 2).

Both the 138 and 148 also provide native attachment capability for one or two 3203 Model 4 Printers. The 3203-4 is a stand-alone version of the 1200-lpm 3200 Model 2 printer currently used with System/370 Models 115 and 125.

All I/O units that can be attached to a System/370 Model 135 are also available on the Model 138 with the exception of the 3210 and 3215 console printer-keyboards. Attachment of the 2319 disk storage units is available only as part of a 2314 Series B Direct Access Storage Facility. Similarly, all I/O units that can be attached to a System/370 Model 145 are also available on

158-3 Block Multiplexer Channel is 40, or 32 with a second Byte Multiplexer Channel.

The optional Integrated Storage Control, available for the Model 158, 158-3, 168, or 168-3 Processing Unit, provides two separate data paths, each capable of accommodating up to 32 IBM 3330, 3340, or 3350 series disk drives.

A Model 165, 165-II, 168 or 168-3 system can include a maximum of six 2860 Selector Channels, two 2870 Byte Multiplexer Channels, and/or eleven 2880 Block Multiplexer Channels. The total number of I/O channels is limited to 7 in the basic system and 12 if the Extended Channels feature is installed.

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

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

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

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

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

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. The Model 158-3 can be configured with asymmetric storage capacities in combinations of 1, 2, 3, or 4 million bytes of main memory per processor. 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. Multiprocessor models of the Model 158 and Model 158-3 can be interconnected in multiprocessor configurations, although in this case asymmetric storage capacities are not supported. Model 158-3 MP Processing Units include an Alternate Power Down feature which allows a Processing Unit and its associated console and channels to be removed from operation and its main memory placed on-line to the remaining Processing Unit.

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the Model 148 with the exception of the 3210 and 3215 console printer-keyboards.

Extended control-program support is a hardware assist that reduces the CPU time needed to execute certain frequently used supervisor functions in both VM/370 and OS/VS1. IBM states that this new feature can reduce the amount of VM/370 supervisor-state time by up to 55 percent, and that a reduction of 13 to 18 percent in OS/VS1 supervisor-state time has been measured on a Model 138, and 9 to 20 percent on a Model 148.

Both the Model 138 and Model 148 also provide an APL assist. This feature is, in effect, an APL emulator that replaces functions performed by the APL software interpreter to provide improved performance for applications when running in conjunction with the VS APL Program Product.

Models 3031, 3032, and 3033: The March 1977 announcement of the high-powered Model 3033 Processor, and the subsequent announcement of Models 3031 and 3032 in October 1977, are believed to represent IBM's first major efforts to stem the increasing inroads of the plug-compatible computer vendors—Amdahl, Itel, and Control Data Corporation. But perhaps even more significant than the introduction of these new processors with enhanced price/performance characteristics was the accompanying announcement of IBM's new System/370 System Extensions. These enhancements are firmware (control storage) implementations of certain frequently executed portions of the control programs. By implementing these software modules in control storage, the processing unit requires less time to execute them, which frees more processor time for executing applications programs.

Two new versions of OS/VS2 (MVS) and VM/370, designated MVS/SE and VM/SE and designed to fully exploit the System/370 Extended facilities, were also announced, and OS/VS2 (SVS) was later modified in the same way. For VM/SE, throughput is aided by an improved paging and scheduling algorithm. The new algorithm improves the performance of systems with many logged-on users, some of whom are idle; of storage-bound systems with long-running interactive programs and high multiprogramming levels; and of systems that need more paging space. MVS/SE provides improved performance control through reductions in processor-to-processor interaction and reductions in processor execution time for frequently performed sections of the control program. In addition, new selectable units are available for MVS dumping that schedule dumps closer to the times of errors and provide increased operator controls over the dumping service. The new system extensions also provide improved reliability for both VM and MVS systems by providing new levels of storage protection to critical storage locations used by the control programs.

Users of System/370 Model 158, 158-3, 168, and 168-3 systems can also share in the new enhancements. The Model 7730 System/370 Extended facility can be added to

A Model 158 APS (Attached Processor System) consists of a Model 158 or Model 158-3 A-series central processor plus a Model 3052 Model 1 Attached Processing Unit and a 3056 Model 1 Remote Console. The 3052 APU is controlled by reloadable control storage and features a 115-nanosecond processing cycle and 16K bytes of high-speed buffer storage. Unlike the 3062 APU used in the Model 168 APS systems, the 3052 APU can execute all System/370 instructions, including Read Direct and Write Direct. It also has provisions for adding Extended Precision Floating-Point facilities. The unit also has dynamic address translation and can access 6,291,456 bytes of main storage on the host system. An integral storage control unit controls the shared-access environment between the host system and the APU. The 3052 also has provisions for the 1401/1440/1460, 1410/1470, and OS/DOS compatibility options. All system I/O functions are performed by the Model 158 host processor. Conversion to a Model 158 APS involves changing from a standard Model 158 processor to a Model 158 AP processor.

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. Model 168 MP and Model 168-3 MP Processing Units can be interconnected in a multiprocessor configuration.

The Model 168-3 Attached Processor System includes a Model 168-3 host central processor plus an additional Model 3062 Model 1 Attached Processing Unit and a Model 3067 Model 5 Power and Coolant Distribution Unit. The 3062 APU features an 80-nanosecond processing cycle, a 32K-byte high-speed buffer storage, and a Translation Lookaside Buffer, and has the capability to execute all System/370 instructions except those associated with the Direct Control facility. Also included in the APU are a storage control element for accessing up to 8 million bytes of system main memory and communications logic to control the shared accessing of main storage between the 168-3 central processor and the APU. All input/output operations are performed by the Model 168-3 central processor. Model 168-3 central processors can be field-upgraded to the Model 168 Attached Processor System, and Model 168 Attached Processor Systems can be intermixed with Model 168 single-processor and Model 168 MP systems in loosely coupled configurations.

The 3838 Array Processor is an auxiliary processing unit for use with either a 370/158 or 370/168. The array processor performs high-speed vector arithmetic in parallel with the host processor. It is attached through a standard block multiplexer channel. Minimum system requirements include a 9-track, 1600-bpi magnetic tape subsystem plus OS/VS2 MVS Release 3.7 and selectable units for Scheduler, Supervisor 1, Supervisor 2, 3838 Vector Processing Subsystem Support (VPSS), Vector Processing Subsystem (independent release), and Job Entry Subsystem 2 (JES2) or Job Entry Subsystem 3 (JES3).

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

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these processing units, as well as to the 3052 and 3062 Attached Processors. In typical uniprocessor systems, IBM says the addition of the Extended facility reduces supervisor time by 20 to 27 percent and increases throughput by 14 to 18 percent. In multiprocessor and attached processor systems, throughput improvements ranging from 17 to 20 percent have been measured.

The new 3031 Processor provides about 1.2 times the performance obtained from a 370/158-3, and the 3032 yields about 2.75 times the performance of the 158-3. Thus, the 3032 provides performance nearly equal to that of a 370/168-3, while the 3031's performance level falls somewhere between those of the 370/158-0 and the 370/165. The 3031 is further estimated to provide 10 times the performance of the 370/138 and about 3 times that of the 370/148.

Major enhancements in the 3031 and 3032 Processors include additional high-speed buffer (cache) memory—32,768 bytes instead of 16,384—and the two most significant features of the 3033 Processor: integrated channels and the System/370 Extended Facility microcoded operating system functions.

The basic 3031 Processor System consists of a 115-nanosecond CPU with 2 megabytes of error-correcting memory and 32K bytes of cache memory; 6 integrated channels (1 byte multiplexer and 5 block multiplexers); extended-precision floating-point; and the Virtual Memory Assist, the OS/VS1 Extended Control Program Support (ECPS), and the System/370 Extended Facility microcode enhancements. Memory can be expanded to 6 megabytes in 1-megabyte increments. Optional features offered with the 3031 include the 1850 Channel-to-Channel Adapter and the 3274 Direct Control Feature.

Operating systems supporting the 3031 processor include DOS/VS, OS/VS1, OS/VS2 (SVS and MVS), and VM/370, including the MVS/System Enhancements that provide additional performance increases through the System/370 Extended Facility.

The basic 3032 consists of an 80-nanosecond CPU with 2 megabytes of error-correcting memory, 32K bytes of cache memory, and the other features noted above for the 3021. Memory for the 3032 can be expanded from the basic 2 megabytes to 6 megabytes in 2-megabyte increments, and the I/O subsystem can be expanded from the basic 6 channels to 12 integrated channels by adding the 3850 Extended Channels feature. Also available as options are the 1850 Channel-to-Channel Adapter and the 7850 Two-Byte Interface. Operating system support for the 3032 Processor is the same as for the 3031.

The Model 3033 Processor features a 64K-byte buffer storage and a 58-nanosecond processor cycle time. Available with 4, 6, or 8 megabytes of error-correcting memory, it is claimed to yield performance levels about 1.6 to 1.8 times greater than the 370/168-3 with its 80-nanosecond processor. Aside from being priced substantially lower than a similarly configured 168, the 3033

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 tables on the second through fifth pages of this report.

MASS STORAGE

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

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

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

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

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

Model A1—three disk drives (87 million bytes) and associated control for attachment to a Model 135, 135-3, or 145 via the Integrated File Adapter (IFA). Note that the IFA, a featured capability of the original Models FED through I of the 145 Processing Unit, is not available for the newer 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 or 135-3 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 (135 through 195).

Model B2—three additional disk drives (87 million bytes) for attachment to the 2319 Model B1 in a 2314-B DASF (135 through 195).

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

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features a new concept in I/O channels (for IBM) and an Extended Facilities feature designed to provide greater system throughput. To eliminate a great disparity in price/performance ratio, IBM simultaneously reduced the purchase prices of both the 370/158 and 168 by 30 percent. Even with the lower prices on the earlier models, the 3033 is still less expensive than the 168.

The I/O channels offered with the 3033 represented a "first" for IBM. Instead of a basic complement of byte multiplexers and block multiplexers, augmented by additional channels purchased individually as options, the 3033 is offered with 12 channels as standard. Four additional channels can be purchased as an option. The 12-channel standard offering makes the basic 3033 much closer to the Amdahl 470V/6, which features 16 channels in its basic system. The 3033's 12 standard channels are divided into two 6-channel groups, each consisting of 5 block multiplexers and 1 byte multiplexer. The four optional channels are available in two configurations: four block multiplexers or three block multiplexers and one byte multiplexer.

The channels are functionally independent of one another, and the block multiplexers can support data rates of up to 1.5 million bytes per second (or up to 3 million bytes per second if the optional Model 7850 Two-Byte Interface Feature is added). Each channel can support up to 256 subchannels, and two channel-to-channel adapters can be attached for inter-processor communications. Using the new channels, a typical 3033 configuration requires about one-half the space and about 30 percent less power and air circulation than a similar Model 168 configuration.

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—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. However, IBM subsequently attacked and obliterated this product-line deficiency with its customary thoroughness. Two fundamentally different types of System/370 multiprocessing are now supported: tightly coupled and loosely coupled.

A "tightly coupled" multiprocessing system features two Model 158, 158-3, 168, or 168-3 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

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, 135-3, 145, or 145-3 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.

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 or 125-2 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 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

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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 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.

Another, less costly method of multiprocessing is provided by the System/370 Attached Processor Systems. Currently, only Models 158 and 168 support these auxiliary units. An attached processor is essentially a duplicate processing unit without memory or I/O. It aids system performance by relieving compute-bound systems, but cannot improve I/O-bound systems since it must share both memory and I/O with the host system. Its advantage over full multiprocessing systems is reduced cost. Adding a 3052 Attached Processor to a Model 158 adds about $380,000 to the hardware cost, while an extra Model 158 to make a Multiprocessing System adds about $1,500,000. In similar fashion, a Model 3062 Attached Processor for a Model 168 system is purchase-priced at $1,078,000, and presents a saving of more than $1 million over the $2,221,000 price tag of an extra Model 168 processing unit. And these prices reflect *minimum* systems for both models.

Still another type of multiprocessing, albeit much more specialized, can be achieved by employing a Model 3838 Array Processor, a highly specialized auxiliary processor that connects to a host Model 158 or 168 in a manner similar to the Model 3052 and 3062 Attached Processors. The 3838 differs, however, by having its own memory (256K to 1024K bytes) and an instruction set designed for performing vector and array operations as well as sophisticated analytical functions. This system is intended for seismic data reduction.

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 were 540 nanoseconds per 4-byte or 8-byte fetch and 607.5 nanoseconds per 4-byte store.

Model 135 used the same bipolar memory technology as the Model 145, with a cycle time of 770 nanoseconds per 2-byte write operation.

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 135-3 or 138 via the Integrated File Adapter; to a Model 145 H2, HG2, 12, IH2, JI2, or K2; a Model 145-3; or a Model 148 via the Integrated Storage Control; to a Model 145 FED, 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 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, 135-3, or 138), a 3345 Model 3, 4, or 5 Storage and Control Frame (on Model 145), or an Integrated Storage Control (on Model 145-2, 145-3, 148, 158, 158-3, 168, or 168-3). Model 155 and 165 processors must include the optional Dynamic Address Translation feature.

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.

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In later Model 145 Processing Units introduced in February 1973 (Models HG2 through J2) and June 1974 (Models J12 and K2), and later Model 135 Processing Units introduced in July 1973 (Models H through I), IBM employed considerably denser bipolar memory circuits that substantially reduced the CPU floor-space requirements and enabled 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 that had been required with the earlier 393K and 524K Model 145 mainframes was not used with the newer models. Power and air conditioning requirements of the new chips were also substantially lower. The older, less dense chips, however, continued to be used for the first 262K bytes of storage in each processor. For capacities in excess of 262K bytes, IBM offered the new, denser Model 145 memory, which then had 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 Model 135 continued to incorporate the original 128-bit bipolar chips for the first 192K bytes. Expanded memories (above 192K bytes) used the new denser chips. The denser 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 averaged nearly 48 percent lower than for the older-technology storage.

In designing the Model 135 and 145 memories, IBM chose bipolar LSI technology over 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 memory at that time. It is clear that these doubts were soon resolved, because the newer Model 115, 125, 138, 148, and 158 systems all use metal-oxide semiconductor field-effect transistor (MOSFET) memories.

IBM's MOSFET memories permitted greater circuit densities than were achievable with bipolar circuitry. 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 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. These 2048-bit chips also form the memory for the Model 138 and 148 central processor.

The chief advantage of the bipolar LSI technology over MOS is higher potential operating speed, usually 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.

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" Model 11 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 costs $17,140. 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 168-3, 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, 115-2, 125, or 125-2 via direct attachment, to a System/370 Model 135, 135-3, or 138 via the Integrated File Adapter, to a System/370 Model 145, 145-3, 148, or 158 via the Integrated Storage Control, or to a System/370 Model 135, 145, 155-II, 158, or 158-3 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 115-2, 8 on a Model 125, 16 on a Model 125-2, 16 on a Model 135, 32 on a Model 145, and 64 (in 2 subsystems) on a Model 158, 158-3, 168, or 168-3. Up to 32 drives (4 strings of 8) can be connected to a 3830 Model 2 Storage Control. The use of 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.

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In May 1976, IBM announced significant reductions in the purchase prices of its MOSFET memory. The memory price reductions affected the System/370 Model 115, 125, 158, and 168 systems, with the biggest incremental memory price cuts being made on the larger systems. The average price reduction for the Model 158 and 168 systems was about 35 percent. In March 1977, IBM announced another 35 percent cut in the purchase, lease, and rental prices of the MOSFET memory for the Model 115, 125, 138, 148, 158, and 168 systems.

RELOADABLE CONTROL STORAGE

The microprograms that control all the internal operations of the Models 115 through 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 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.

Until recently, the cost of adding RCS to these systems was substantial. For example, the addition of the 3330 Integrated File Adapter to a Model 135 required at least one, and possibly two, 12K RCS extensions, at a monthly rental of $252 each. In the Model 145, RCS is an extension of main memory, and any increase beyond the basic 32K bytes is accompanied by an equivalent reduction in the system's main memory capacity. However, recent

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 Model 125-2 systems, the first eight spindles can operate in the compatibility mode, while spindles 9 through 16 can operate in native mode only. An optional String Switch feature on the 3340 Model A2 permits a System/370 Model 115-2 or Model 125-2 to share a maximum of two 3340 Model A2 DASF strings with any other System/370 central processor with the exception of the Model 115 and Model 125.

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:

	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

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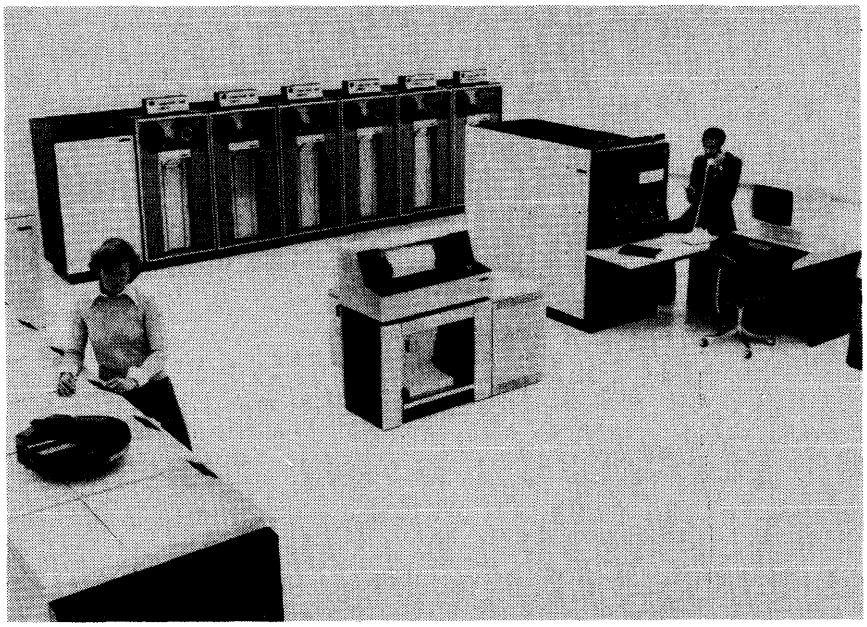

The Model 138 is one of the two System/370 processor models still in new production at this writing. This very popular medium-scale model was excluded until recently from the wave of price cuts that followed IBM's introduction of the Model 3033 Processor.

sharp declines have drastically reduced the cost of RCS, and the new Models 138 and 148 plus the upgrade Models 135-3 and 145-3 all have 128K bytes of RCS, providing space for many more additional features than was possible with Models 115 through 135.

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

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.

3344 DIRECT ACCESS STORAGE: Announced in July 1975, the 3344 Direct Access Storage units expand the storage capacity of the 3340 Direct Access Storage Facility and can be intermixed with 3340 Model B1 and B2 units in a 3340 subsystem. Each 3344 Model B2 or B2F is a two-drive unit with a capacity of 560 million bytes (279,558,144 bytes per drive). The Model B2 attaches to a 3340 Model A2 and can be intermixed with 3340 Model B drives and 3344 Model B2F units in any combination of up to three B units per 3340 Model A2. The 3344 Model B2F has the same attachment capabilities as the 3344 Model B2 but has 1,004,160 bytes of fixed-head storage per spindle, or 2,008,320 bytes per dual-drive unit. The maximum 3340 subsystem includes one 3340 A2 unit and three 3344 Model B2 or B2F units for a total of 1.8 billion bytes per string.

Each of the two drives in a 3344 Model B2 or B2F unit is equivalent in format and capacity to four logical 3348 Model 70 Data Modules. The average seek time for the moving-head storage is 25 milliseconds, average rotational delay is 10.1 milliseconds, and data transfer rate is 885,000 bytes per second. Standard features include Read-Only Switch, Rotational Position Sensing, and Full-Track Read Command.

A maximum of one 3340/3344 Direct Access Storage subsystem can be attached to a System/370 Model 135, 135-3, or 138 through an Integrated File Adapter. A maximum of two 3340/3344 strings can be attached to a 3830 Model 2 controller, to a Model 3145 or 3345 Integrated Storage Control on a System/370 Model 145, 145-3, or 148, or on each path of a System/370 Model 158, 158-3, 168, or 168-3 Integrated Storage Control. Programming support is provided under DOS/VS, OS/VS1, OS/VS2, and VM/370. The Model 3344 is not available for System/370 Model 115 or 125 systems.

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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 through 148 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.

Along with performance and compatibility, IBM is strongly stressing increased reliability in the System/370. Admitting that the System/360 initially failed to operate

3350 DIRECT ACCESS STORAGE: Announced in July 1975, the 3350 Direct Access Storage provides high-speed, large-capacity storage on nonremovable disks for System/370 Models 135 through 168-3.

There are four models of the 3350: the Model A2, A2F, B2, and B2F. Models A2 and A2F each contain two disk drives and an associated controller plus the logic and power supply for attachment of up to three additional 3350 Model B2 and/or Model B2F dual-disk units. Models A2F and B2F each include 1,144,140 bytes of fixed-head storage per drive (or over 2 million bytes of fixed-head storage per dual-drive unit). The average seek time for the data which is accessed by movable read/write heads, and for all of the data on the Model A2 and B2 drives, is 25 milliseconds. All models have an average rotational delay of 8.4 milliseconds and a data transfer rate of 1,198,000 bytes per second.

A standard Selective Format feature allows each Model 3350 drive to operate either in 3350 native mode or in 3330 Model 1 or 3330 Model 11 compatibility mode, with the following capacities:

	Native Mode	3330 Model 1 Compat. Mode	3330 Model 11 Compat. Mode
Bytes per track	19,069	13,030	13,030
Tracks per logical cylinder	30	19	19
Logical cylinders per drive	555	2 x 404	808
Capacity per drive (MB)	317.5	2 x 100	200

In the 3330 Model 1 and Model 11 compatibility mode, the fixed-head storage capacity of Models A2F and B2F is 742,710 bytes per drive. Other standard features include Rotational Position Sensing, error correction of single data error bursts of up to four bits, Command Retry, Read-Only Switch, and Write Format Release. An optional String Switch feature permits a 3350 subsystem to be attached to two 3830 Model 2 Control Units, 3345 Storage and Control Frames, or Integrated Storage Controllers on one central processor or two different central processors.

A 3350 subsystem must include one Model A2 or A2F drive, and can be attached to a System/370 Model 135 through 168-3 Central Processor (but not to the non-VS Model 155 or 165). A Word Buffer (Feature 8810) is required on the System/370 Model 145, and an Expanded Control Store (Feature 2152) and Register Expansion (Feature 6111) are prerequisites for attachment to the 3830 Model 2 Control Unit or the Model 158, 158-3, 168, or 168-3 Integrated Storage Controller. Full programming support for the 3350 is provided under the OS/VS1, OS/VS2, and VM/370 operating systems. DOS/VS supports the 3350 only in the 3330 Model 1 compatibility mode.

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).

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

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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 standard feature in Models 115 through 168-3, is a dynamic debugging facility that aids in system maintenance by monitoring selected program events and triggering interrupts when they occur.

PERIPHERAL EQUIPMENT

IBM has developed a number of noteworthy mass storage and input/output units primarily for use with the System/370 which represent significant improvements in performance and economy as well as major advancements in peripheral technology. One of the first examples was the high-performance 3330 Disk Storage Facility. This was followed by the double-density 3330 Model 11, and then by the unique 3340 Direct Access Storage Facility that incorporates both fixed and moving heads and a new removable sealed cartridge which incorporates the disks, access arms, read/write heads, and spindle.

Other new peripheral devices include the 3344 Direct Access Storage (which is equivalent to four 3340 Direct Access Storage drives), the ultra-large-capacity 3850 Mass Storage System, the 3350 Direct Access Storage Facility (a large-capacity, fixed-disk replacement for the 3330 Disk Storage Facility), the 2,000-lpm 3211 Printer, the super-fast 3800 Printing Subsystem, the low-priced 3411 Magnetic Tape Subsystem, the highly cost-effective 3420 Magnetic Tape Units (including 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, 115-2, 125, 125-2, 138, and 148 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.

3330 Disk Storage: This logical extension of the design concepts employed in the earlier 2314 Direct Access Storage Facility 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 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 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

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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 double-density versions of its 3330 Disk Storage: the 3333 Model 11 Disk Storage and Control, the 3330 Model 11 Disk Storage, and the 3336 Model 11 Disk Pack. The 200-million-byte-per-pack units can be connected to System/370 Model 135 through 168 OS/VS systems. 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. 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.

3340/3344 Direct Access Storage Facility: Unveiled in March 1973 concurrently with the Model 115, the 3340 featured 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 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.

A fixed-head feature for the Model 3340 Direct Access Storage Facility was announced in March 1974, allowing the 3340 to function as a replacement for the high-priced Model 2305 Fixed Head Storage Facility as a paging medium for System/370 configurations running under the virtual storage operating systems. The 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 disk 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 fixed-head units are available for the System/370 Models 115 through 168-3.

The complexity of the Data Modules used with the 3340 makes them the most expensive interchangeable storage media to reach the EDP marketplace in many years. IBM took a step toward lowering the cost per byte for these units with the announcement of the 3344 B2 and B2F Direct Access Storage units, which use nonremovable storage media and attach to a 3340 A2 unit to provide

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.

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.

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additional storage capacity. Each 3344 B2 or B2F is a two-drive unit with a capacity of 560 million bytes (280 million per drive). A maximum 3340 string includes one 3340 A2 unit and three 3344 B2 or B2F units for a total of 1.8 billion bytes. Each 3344 drive is equivalent in format and capacity to four logical 3348 Model 70 Data Modules. In addition, the Model B2F includes 1,004,160 bytes of fixed-head storage per spindle.

Models 145 through 168-3 can support two 1.8-billion-byte 3340/3344 strings for a total on-line capacity of 3.6 billion bytes. Models 115-2, 125-2, 135, 135-3, and 138 can also support two strings, *but* only one string can contain 3344's. The maximum on-line capacity for these systems is 2.4 billion bytes.

3350 Direct Access Storage Facility: Announced along with the 3344 in July 1975 as a higher-capacity and more cost-effective replacement for the IBM 3330 Model 1 and Model 11 Disk Storage Units, the 3350 has a capacity of approximately 317.5 million bytes per drive on nonremovable disks. The maximum subsystem has a total capacity of 2.54 billion bytes.

There are four models of the 3350, of which two (the -F units) use both fixed- and moving-head access mechanisms and two use only moving heads. Models A2 and A2F are two-drive units that attach to System/370 Model 135, 155-II, and 165-II systems through the 3830 Model 2 Controller and to System/370 Models 145, 158, and 168 through either the Integrated Storage Controller or the 3830 Model 2 Controller. Each 3350 Direct-Access Storage subsystem must include one A2 or A2F unit. Up to three B2 or B2F units, each of which also contains two drives, can be added to the subsystem to achieve the maximum of eight drives, or a storage capacity of over 2.5 billion bytes, per 3350 subsystem. The 3350 Models A2F and B2F include 1,144,140 bytes of fixed-head storage per drive (or over 2 million bytes of fixed-head storage per dual-drive unit).

A standard Selective Format feature allows each 3350 drive to operate either in 3350 native mode or in 3330 Model 1 or 3330 Model 11 compatibility mode, although storage capacities are reduced in the compatibility mode of operation. Other standard features include Rotational Position Sensing, error correction of single data error bursts of up to four bits, Command Retry, Read-Only Switch, Write Format Release, and Full-Track Read Command. DOS/VS provides support for the 3350 in 3330 Model 1 compatibility mode only.

3850 Mass Storage Subsystem: The 3850 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

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: Introduced in November 1970, the 3420 units incorporate 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 cartrdige 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 tachometers control the reel motors' speeds for smoother winding. Read access times are considerably faster

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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.

Software support for the 3850 is provided for the OS/VS1 and OS/VS2 operating systems under the standard access methods for direct-access data sets (except ISAM). The 3850 obviously is aimed at installations with large tape libraries; 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: Introduced in March 1973, these high-performance units advanced the state of the art in magnetic tape recording. The new models of the 3420 Magnetic Tape Units and 3803 Tape Control 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 tripled the amount of information that could 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 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. The 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 115 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 115 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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data transfer rates and access times of the new units, have helped to ensure the continued widespread utilization of magnetic tape equipment despite the ever-increasing popularity of disk pack drives.

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. In November 1975, IBM unveiled the 3705-II, an enhanced version that features MOS memory and improved performance at a lower cost than the original 3705.

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.

Model 115-2, 125-2, 135, or 135-3 users can control small communications networks withut the need for a separate communications controller by installing the Integrated Communications Adapter—another example of the flexibility and economy that can result from micro-programmed control. The ICA uses a combination of hardware logic and microcode to control up to 12 lines in the Model 115-2, up to 22 lines in the Model 125-2, or up to 8 lines in the Model 135 or 135-3.

Virtually the entire complement of IBM communications terminals can be connected to a System/370—as can literally hundreds of terminals from independent suppliers.

In September 1974, IBM announced its Advanced Function for Communications through Systems Network Architecture (SNA). This facility promises to be the foundation for the future 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

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 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 an improved 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 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.

3540 DISKETTE INPUT/OUTPUT UNIT: Reads and writes IBM diskettes ("floppy disks") as an on-line I/O unit for use with System/370 Models 115 through 158-3. 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 25 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 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.

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Network Architecture 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 System/32 and System/34 small business computer systems.

The new SDLC line protocol 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.

SOFTWARE

Users of the virtual-storage System/370 processors (Models 115 through 168 MP) can choose from three operating systems—DOS/VS, OS/VS1, and OS/VS2—which have evolved from the DOS, OS/MFT, and OS/MVT systems used with the System/360. These three original systems can also be used with the System/370 computers; however, they require the 370 processors to operate in Basic Control Mode, precluding the use of the virtual storage capabilities of these machines. IBM discontinued support of OS/MFT and OS/MVT in 1976.

The three VS operating systems 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, 145-3, 148, 155-II, 158, 158 MP, 165-II, 168, and/or 168 MP processors.

Another operating system, VM/370, manages the real resources of a System/370, including CPU time, to create and control multiple concurrent virtual machines by permitting the use of multiple operating systems.

DOS/VS is an upward extension of DOS that supports virtual storage, permits up to seven jobs to be processed simultaneously, includes a 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 seven 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

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. Usable 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 control unit, and can be connected directly to any System/370 I/O channel. The 3505 reads cards photoelectrically, in column-by-column fashion, in either EBCDIC or card image mode. Vacuum-assisted friction feeding is used in place of the conventional "picker knife" feeding. If a card fails to feed, three retries are made automatically before a misfeed indication is given. The 3505 has a 3000-card file feed hopper and two 1750-card stackers. Whenever one stacker becomes full, cards are automatically directed to the other stacker while the operator empties the first one. A third, program-selectable 1750-card stacker is optional.

The 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

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DOS/VS, was released to users in June 1973. The most current version is Release 34.

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.

OS/VS2 Release 1 was a significantly improved version of OS/MVT. In addition to supporting a full 16 million bytes of virtual storage, VS2 handles up to 63 protected batch user regions or 42 TSO user regions, compared with a maximum of 15 regions for MVT.

An important distinction was made with the introduction of OS/VS2 Release 2. OS/VS2 was effectively divided into two operating systems and will be maintained as such. OS/VS2 versions prior to Release 2 (currently up to 1.7) are now known as OS/VS2 Single Virtual Systems, or SVS, while OS/VS2 Release 2 and above are now known as OS/VS2 Multiple Virtual Systems, or MVS.

Release 2 of OS/VS2 represented a dramatic improvement in the capabilities of the operating system. Principally, Release 2 provides for multiple virtual storages (up to 15 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, TSO operation, and HASP requires a minimum of 768K 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 1,536K 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. On Model 168 MP systems, control of the I/O channels attached to a nonfunctioning central processor can be assumed by the remaining operating central processor to continue input/output operations on all input/output channels. 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 on ASP Version III or its upward extension JES2) operates to distribute all or part of the combined pool of system resources among jobs in a single input stream.

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, 115-2, 125, or 125-2 via the Integrated 2560 Attachment; it cannot co-exist with a directly connected 3525 Card Punch or 5425 MFCU.

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, 115-2, 125, or 125-2.

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, 115-2, 125, or 125-2 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 or 125-2, 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

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A later version of JES3, for OS/VS2 Release 3, distributed in October 1975, further extended the capabilities for loosely coupled multiprocessing by providing support for up to eight System/370 central processors operating under OS/VS2 Release 3 or later with JES3, plus additional ASP processors to a maximum of 32 processors. A Dynamic System Interchange feature also permits an operator to assign the global functions to any properly configured JES3 local processor in the event of a failure of the original global processor.

Another important addition to OS/VS2 Release 2, the Alternate CPU recovery (ACR) facility, extends system availability in multiprocessing systems. This facility permits a non-failing CPU to attempt recovery processing for the operating system without the use of the malfunctioning CPU. Channels or subchannels can be reset and I/O operations retried through a new recovery facility, and a storage recovery facility permits logical isolation of failing main memory sections. Memory is de-allocated in 4K-byte blocks when failures are detected.

OS/VS2 (MVS) Release 3, another major functional enhancement of the operating system, was released in March 1975. Among the key new items included in OS/VS2 Release 3 is the JES2 Multi-Access Spool facility, which allows from two to seven systems operating under OS/VS2 Release 3 to share JES2 job queues and input/output queues maintained on shared direct-access storage devices. Release 3 also provides important enhancements to VTAM, including dynamic sharing of network resources among multiple VTAM application programs and support for the 3600 Finance Communication System, 3650 Retail Store System, and 3790 Communication System SDLC communications terminals.

In OS/VS2 Release 3, IBM also introduced two additional availability-improvement features for the Model 168 Multiprocessing Systems. The Channel Reconfiguration Hardware (CRH) facility permits the channels attached to a stopped CPU to be accessed through a specific channel interface of the remaining CPU. This permits the system resources connected to one side of a multiprocessing configuration to still be made available to the remaining CPU, thus preventing a total system shutdown. With the use of this feature, all system channels remain accessible to the active CPU. The second availability-improving feature is a new locking structure that provides multiple locks within the control program. Older versions permitted only one lock, which prevented all users from accessing queues and control blocks, even for valid reasons. Under the new system, users can access control areas for their address spaces, although they are prevented from using the same access to other user control areas.

Virtual Machine Facility/370 (VM/370) divides a System/370's real resources among two or more virtual machines. Each virtual machine, in turn, can run under any of the System/370 operating systems and is protected from failures in other virtual machines. VM/370, which is based upon CP-67/CMS for the 360/67, also includes a

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 attachment 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 a System 370 Model 115, 115-2, 125, 125-2, 138, or 148 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 three models;

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Conversational Monitor System that provides a general-purpose time-sharing capability.

VM/370 should be useful in the development of new systems, conversion from one operating system to another, and provision of economical backup facilities. Its use in a pure production environment, however, will usually be ruled out by the 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 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 data communications access method that was announced 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. VTAM is available for DOS/VS, OS/VS1 and Release 3 of OS/VS2 and provides an upward-compatible application program interface for all three operating systems.

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. IBM later added the Extended Telecommunications Module (EXTM) to CICS for DOS/VS to provide an interface between a 3704/3705 Communications Controller operating under NCP/VS and the IBM 3600 Finance Communications system as well as other non-SNA terminals.

The *Telecommunications Control System—Advanced Function* for the OS/VS1 and OS/VS2 operating systems provides facilities for communication between terminals or multiple computers in a communications network and supports enhanced sharing of terminals among TCAM or TCAM/VTAM applications programs, including CICS/VS and IMS/VS.

rated print speeds with the standard 48-character set are 600 lpm for Model 1 and 1200 lpm for Model 2 and Model 4. Certain perferred character set arrangements permit speeds of up to 770 lpm for Model 1 and 1550 lpm for Model 2 and Model 4. Character sets containing from 30 to 240 characters can be used. The Universal Character Set feature, with a 240-position buffer, is standard. All 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.

Models 1 and 2 are used with the Model 115, 115-2, 125, and 125-2 processing units, while the 3203 Model 4 is for use with Model 138 and 148 processing units. A single 3203 Printer, Model 1 or 2, can be connected to a Model 115, 115-2, 125, or 125-2 Processing Unit via the appropriate Integrated 3203 Printer Attachment. Up to two 3203 Model 4's can be attached to a Model 138 or 148.

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

The 3211 Printer has a standard 132-character line that can be expanded to 150 print positions. Horizontal spacing is 10 characters/inch, and vertical spacing is 6 or 8 lines/inch. A 180-position forms control buffer, loadable from main storage, defines vertical format control operations, eliminating the need for a carriage control tape. Skipping speed is at least 30 inches per second, with acceleration to a maximum speed of 90 inches per second after 7 lines have passed. Forms ranging from 3.5 to 18.75 inches in width and from 3 to 24 inches in length can be handled. A powered forms stacker automatically compensates for the 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 115-2 or a System/3 Model 8 or 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

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The *DOS/VS Entry-Level Time-Sharing System,* announced along with the enhanced Model 115-2 and Model 125-2 central processors, provides facilities for on-line program development and execution for users of the smallest computers in the System/370 product line.

IBM's *Virtual Storage Personnel Computing (VSPC)* is a time-sharing capability that is designed to make the System/370 "more approachable" to individuals who do not have a programming background. Particular targets for this software are current users of the Interactive Terminal Facility, CALL-OS, and APL-360. VSPC includes a simple command language for data and source program manipulation and can also be used with three new separately priced compilers – VS APL, VS BASIC, and VS FORTRAN. The system also includes an input editor for file creation and maintenance, a conversational remote job entry facility, and a library capability that enables users to assign various access authorizations to data files.

In 1976, IBM announced support for selected SNA terminals through the TCAM access method under OS/VS1 and OS/VS2. Previously, TCAM had to operate as a subset of VTAM in order to enable TCAM users to communicate with SNA terminals. In addition, users of OS/VS2 Release 1.7 are provided with VTAM support; VTAM previously was available only under OS/VS2 Release 3. Finally, IBM now supports VTAM for applications programs running under TSO, VSPC, CICS/VS under OS/VS2, and IMS/VS under OS/VS2.

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. Finally, in 1976, IBM officially notified users that support for OS/MFT and OS/MVT was being discontinued. 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.

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 or 115-2 Processing Unit via the 4653 Integrated 3203/5203 Printer Attachment.

3800 PRINTING SUBSYSTEM: This high-speed non-impact printer, announced in April 1975, can operate on-line to a System/370 Model 145 through 168-3 operating under the OS/VS1 or OS/VS2 operating system. The printer uses an electrostatic process, referred to as "electro-photographic," using a helium-neon laser as a light source. A revolving mirror deflects the laser beam to generate a line scan; the laser beam is deflected (modulated) away from the mirror to produce a horizontal dot pattern. A vertical dot pattern is established because the mirror is faceted. Data characters received from the central processor and stored in the buffer are encoded into the dot matrix form through one or more character set patterns stored on a diskette drive.

The 3800 comes with definitions on the diskette for seven character styles, including Gothic (sans serif equivalent to the IBM 1403 or 3211 print style), Katakana (Japanese ideographs), OCR-A Size 1, OCR-B, Text 1 (upper case), Text 2 (lower case), and Format (special graphic for drawing form lines). The fonts are composed of from 37 to 64 characters or symbols, and except for Katakana, include a space character. Gothic, Katakana, and Format fonts come in three sizes corresponding to horizontal pitches of 10, 12, and 15 characters per inch. The others come in 10-pitch size only. Separate fonts are provided for all three Gothic sizes and for Text 1 and Text 2 for underscored characters.

The 3800 uses conventional single-ply continuous computer forms in any combination of 10 specific widths from 6.5 to 14.875 inches and 5 specific lengths from 3.5 to 11 inches. The pages-per-minute print rates and peak lines-per-minute rates are listed below for all five standard form lengths:

Form length, inches	Maximum lines/page 6 lpi	8 lpi	Peak speed, lpm 6 lpi	8 lpi	Peak pages/min.
3.5	15	20	8,180	10,900	545
5.5	27	36	9,370	12,490	347
7	36	48	9,810	13,080	273
8.5	45	60	10,100	13,470	224
11	60	80	10,410	13,880	173

Vertical spacing is six or eight lines per inch, under program control. A Forms Overlay feature operates under program control to produce document and report formats, designs, or other constant data and to merge format with data. The Copy Modification Function permits copies to be identified with specific legends or addresses, or additions or deletions to be made to each copy under program control. Channel switching can be performed manually through the 2914 Manual Switch Model 1 or the 8170 Two-Channel Switch. Automatic switching is performed by the 8171 Dynamic Two-Channel Switch, which can be used with two channels on a single central processor for alternate path selection or to share the printer between two processors in a tightly coupled multiprocessing system. Special optional features include 127 Writable Character Generation Storage Positions (Feature 5401), which adds 127 positions to the standard 128 to allow up to 255 graphics to be printed, and the 6148 Remote Switch Attachment, which attaches the 8170 Two-Channel Switch to a configuration control panel.

The 3800 attaches to a Byte or Block Multiplexer Channel of a System/370 Model 145 through 168-3 VS computer.

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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 was designed around a dual-processor, HASP-like multiprocessing system; an alternate ASP-III-like network multiprocessing mode of system operation is also available. In both cases, significant 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 and beyond.

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 compability options run under control of the regular operating system, enabling emulator jobs to be processed as part of a multiprogramming mix.

The swing from the System/360 to System/370 has been marked by a noteworthy *lack* of conversion problems, and it is a near-certainty that the forthcoming conversions from the System/370 to the new 3030X series processors will be equally smooth. 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 and 303X architecture to that of the

Attachment via a non-dedicated Selector Channel is not recommended. Initial customer deliveries were made in July 1976. Additional details about the 3800 can be found in Report 70D-491-51.

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 through 158-3 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 Models 115, 115-2, 125, and 125-2 systems. Five models of the 1287 are available:

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

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

Model 3: Same as Model 1, with added capability of reading the alphanumeric 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 through 158 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

System/360, coupled with the use of essentially the same peripheral equipment and software, ensures comparatively smooth, straightforward conversions this time.

PRICING AND SUPPORT

Most of the existing System/360 software facilities were delivered prior to IBM's June 1969 unbundling announcement and are therefore available to System/370 users at no additional cost. But most System/370 users will find it advantageous—and in many cases essential—to use the improved assemblers, compilers, sort routines, and other software products that have been introduced during the past nine 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.

In April 1977, IBM introduced the *Agreement for IBM Licensed Programs* to replace the previous *License Agreement for IBM Program Products.* The new agreement incorporates terms and conditions from previous agreements and amendments and provides one license agreement for all IBM licensed programs. In many instances, the provisions of the new agreement are the same as those of the old agreement, but have been reworded for clarity. The new agreement does, however, include six new provisions, including a *location* license to supplement the *installation* license of the old agreement; a restructured program services scheme that consists of three basic service plans, each with three specified periods; revised warranty conditions; specification of the operating environment; and a disclaimer limiting IBM's liability for damages.

The new location license provision is similar to the provision in the installation license that enables customers to use a licensed program on any other machine in the same location as the designated machine, but defines "location" as a single mailing address contained within a single building instead of a single room or contiguous rooms.

IBM's revised warranty conditions stipulate that the program product will conform to its Licensed Program Specifications when shipped to the customer *if* properly used in a Specified Operating Environment. The agreement does not warrant that the functions contained in the program will meet the customer's requirements or will operate in the combinations which may be selected for use by the customer, or that all program defects will be corrected. The Specified Operating Environment is stated in the Licensed Program Specifications, and program services for a licensed program being operated in other than the specified operating environment may be limited.

IBM has redesignated its Limitation of Liability clause to a Limitation of Remedies that limits its liability for damages to the customer to the greater of $25,000 or any charges which would be due for the first 12 months' use of the licensed program that caused the damage.

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 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 either off-line or on-line with a System/370 Model 135 through 168 under OS/VS. 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

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IBM customers with current license agreements may either continue under the old agreement or convert to the new agreement. Upon conversion, Category A program services are converted to Central Service plus Local Service and Category B services are converted to Central Service. All licensed IUP's or FDP's are converted to Central Service until a designated calendar date, while IUP's and FDP's with extended support provisions are converted to Central Service that is available indefinitely.

In May 1977, IBM instituted a certification policy aimed at curtailing the flourishing business of speculative orders, in which speculators would place orders for IBM equipment with long delivery times and later sell the delivery positions to genuine users with immediate needs. This "underground" business enterprise has existed since the days of the System/360 and continued briskly with the advent of the System/370 systems. IBM's June 1976 announcement of the 370/138 and 370/148 systems evoked a sharp increase in these speculative orders, causing duplication of orders and unreliable production scheduling information. The practice further accelerated with the April 1977 announcement of the 3033 Processor, causing IBM to require prospective buyers to certify their "intentions to be the user of each machine after it is installed or to be the owner of each machine after its installation for use by another." The buyer is also required to notify IBM of any change in intention and cancel the order. Orders for IBM equipment that requires user certification are also subject to a preliminary credit review, which must be satisfactorily completed prior to acceptance and scheduling.

It is important to note that the multiprocessing and networking facilities now available for 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

Datapro's most recent annual survey of general-purpose computer users, conducted late in 1977, yielded responses from 864 System/370 users who collectively owned, rented, or leased 1130 separate computer systems. The characteristics of the user population and a composite of the ratings expressed by these users are presented in the following paragraphs and tables.

The system population was distributed as follows:

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-491-11 through 70D-491-45 in the Peripherals section of DATAPRO 70.

COMMUNICATIONS CONTROL

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 original 3705 Communications Controller is a minicomputer-based front-end processor that can have from 16K to 240K bytes of core memory and control up to 352 communications lines. It is available in 20 models with varying storage sizes and line capacities. Customer shipments began in July 1972.

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 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.

In November 1975, IBM announced an enhanced version of the 3705, which offers significant price/performance

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USERS' RATINGS IN TERMS OF WEIGHTED AVERAGES

	Ease of Operation	Reliability of Mainframe	Reliability of Peripherals	Responsiveness of Maintenance Service	Effectiveness of Maintenance Service	Technical Support	Operating Systems	Compilers and Assemblers	Applications Programs	Ease of Programming	Ease of Conversion	Overall Satisfaction
Model 115 & 115-2	3.4	3.7	3.4	3.4	3.2	2.8	2.8	3.0	2.7	3.4	2.7	3.1
Model 125 & 125-2	3.2	3.7	3.5	3.3	3.3	3.0	2.9	3.1	2.9	3.0	3.0	3.2
Model 135 & 135-3	3.2	3.7	3.3	3.3	3.2	3.0	2.9	3.1	2.8	3.0	2.8	3.1
Model 138	3.2	3.7	3.2	3.2	3.1	3.0	2.9	3.1	2.8	3.0	3.0	3.1
Model 145 & 145-3	3.3	3.5	3.2	3.3	3.2	3.0	2.9	3.1	2.7	2.9	2.8	3.1
Model 148	3.2	3.6	3.3	3.4	3.3	3.1	2.9	3.1	2.7	3.0	2.9	3.1
Model 155	3.3	3.5	3.1	3.3	3.2	2.8	2.9	3.1	2.7	2.9	2.7	3.1
Model 158 & 158-3	3.3	3.6	3.3	3.4	3.2	3.0	3.1	3.1	2.8	3.0	2.8	3.2
Model 165	3.3	3.4	2.9	3.1	3.1	2.9	2.9	3.3	2.9	3.2	3.0	3.1
Model 168 & 168-3	3.2	3.3	3.2	3.4	3.1	3.1	3.0	3.2	2.8	3.0	2.8	3.1
Other System/370 models	3.3	3.8	3.4	3.6	3.4	3.4	2.6	2.8	3.1	3.1	2.6	3.4
System/370 totals (864 users)	3.3	3.6	3.3	3.3	3.2	3.0	3.0	3.1	2.8	3.0	2.8	3.1
Non-IBM totals (499 users)	3.4	3.3	2.7	3.0	2.8	2.4	3.3	3.2	2.7	3.3	3.0	3.1

Basis for computing Weighted Averages is 4 for each user rating of Excellent, 3 for Good, 2 for Fair, and 1 for Poor.

Model 115 & 115-2	36 systems
Model 125 & 125-2	51 systems
Model 135 & 135-3	118 systems
Model 138	59 systems
Model 145 & 145-3	181 systems
Model 148	49 systems
Model 155	56 systems
Model 158 & 158-3	224 systems
Model 165	15 systems
Model 168 & 168-3	67 systems
Model unspecified	8 systems

It is significant to note that this year's user survey is the first Datapro survey to include user ratings of the System/370 Models 138 and 148.

The weighted averages of the ratings supplied by these System/370 users in 12 important performance categories are presented in the "Users' Ratings" table for each processor model represented in the survey population.

The distribution of operating systems among the survey respondents was as follows:

DOS	23
OS/MFT	10
OS/MVT	32
OS unspecified	18
DOS/VS	387

improvements over the original model, now designated the 3705-I. The new 3705-II has a storage capacity of from 32K to 256K bytes of metal oxide semiconductor (MOS) memory and has a faster processor cycle time of 1.0 microseconds (compared to 1.2 microseconds for the 3705-I). Other new features include a high-speed Communications Scanner, an upgraded Channel Adapter that transfers data in blocks of up to 32 characters, and increases in the supported transmission speeds to 9600 bits per second in synchronous mode and a maximum transmission rate of 56K bits per second. The 3705-II is available in 32 different models depending upon the storage capacity, and was first delivered in August 1976.

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.

When connected to a System/370 computer, a 370X can use either the Network Control Program (NCP) or the 2701/2/3 Emulation Program. NCP/VS, for virtual environments, includes all of the facilities of the original NCP and also has the Partitioned Emulation Programming Extension (PEP) capability which permits operation in the NCP Mode and Emulation mode concurrently.

The 370X Controllers are supported under VTAM, the principal access method for communications support under DOS/VS and OS/VS. The major advantages of NCP operation through VTAM include the capabilities for dynamic allocation of terminals, lines, and the 370X Controllers among multiple applications programs and for simultaneous operation in the Emulation and NCP modes within one 370X. In addition, the 370X can be configured and used as a remote concentrator. Communication between a remote 370X and a local 370X connected to the host computer is over a leased line operating synchronously in the full-duplex mode at 4800 bits per second or in half-duplex mode at up to 50,000 bits per second.

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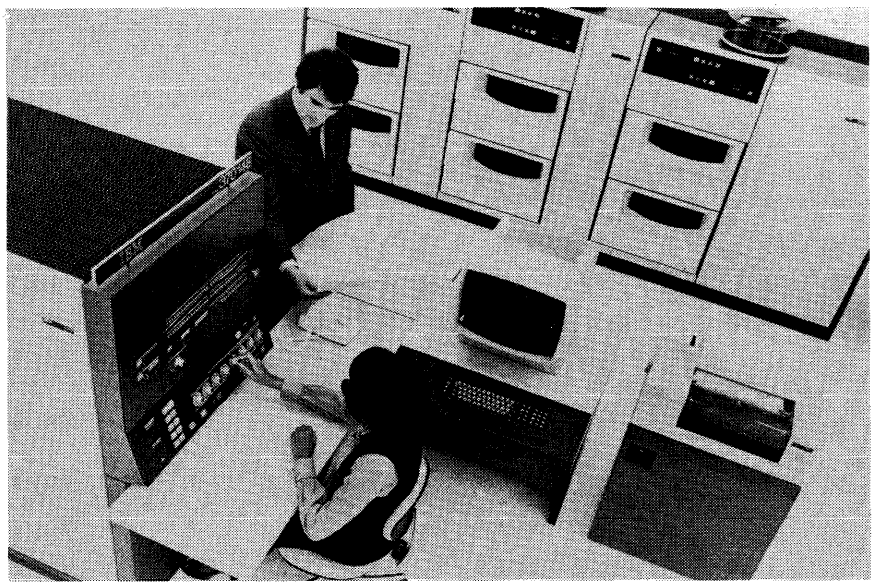

The System/370 Model 148, announced concurrently with the Model 138, replaced the 370/145 by providing a 42 percent performance increase at a 45 percent reduction in price. Like the Model 138, the 370/148 is offered in only two memory sizes, whereas earlier System/370 processors were available in as many as 12 different memory sizes.

OS/VS1	190
OS/VS2 (SVS)	70
OS/VS2 (MVS)	116
OS/VS2 unspecified	8
OS/VS unspecified	14
VM/370	33
Others	6

Despite IBM's discontinued support for DOS, OS/MFT, and OS/MVT, 83 users still found one of these operating systems able to fulfill their needs—although, as noted in last year's user survey, the number of users faithful to these older operating systems dwindles each year.

The virtual memory operating systems accounted for nearly 87 percent of the user population (785 users), of which 43 percent were employing DOS/VS and an almost equal percentage were using one of the three OS/VS systems. The number of VM/370 users (33) showed a sharp gain over the previous year's survey.

Of the total survey population, about 34 percent of the systems were purchased, 30 percent were on various IBM rental or leasing arrangements, and 36 percent were acquired through third-party leases. This year's results showed a sharp decline in the number of systems rented from IBM and an equal increase in the number of systems obtained through third-party lease agreements, indicating a continuation of the trend toward third-party leasing. The Model 158 and 158-3 systems are the most popular among the responding users, leading the other System/370 models in both numbers of purchased systems and numbers of systems on third-party leases.

The users' length of experience with their System/370 computers and other distinguishing characteristics of their installations can be summarized as follows:

With the announcement of the 3705-II in November 1975, IBM also added on additional software enhancement that permits PEP to support concurrent operations in a dual-processor environment in which one central processor supports communications through VTAM (or TCAM through VTAM) in the NCP mode and the other central processor supports communications via a non-VTAM control program which operations under the Emulation Program. When NCP or NCP/VS 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.

The Advanced Communication Function for NCP, ACF/NCP/VS (and related Systems Support Programs, for all operating systems), announced in November 1976, added capabilities that are significant for multi-system users. Multiple System/370's can be interconnected via full- or half-duplex SDLC protocol lines linking their respective local 3705's. Any mix of VS operating systems is permissible. Transmission to a host CPU can be passed through interconnected 3705's to a down-stream CPU without any involvement of the host or intermediate CPU's. To utilize ACF/NCP/VS, an Advanced Communication Function for VTAM and TCAM is necessary.

ACF/VTAM supports CICS/VS, IMS/VS, Power/VS, JES1/RES, JES2/RJE, TSO, VSPC, SSS, and BTP user programs. ACF/TCAM supports CICS/VS, TSO, SSS, and user programs.

Another ACF feature is the capability for up to four CPU's to share a single 3705-II. Channel Adapter Types 2, 3, or 4 can be used. If more than two are used, they must all be Type 4. The computers must be at the same location, but can employ any mix of VS operating systems. The access method can be ACF/VTAM or ACF/TCAM. More than one channel adapter can be connected to one CPU, and each channel can be serviced by a different access method. This arrangement permits different terminals on the same line to communicate with different computers and/or to utilize different access methods.

A third ACF capability supports a new hardware feature, Remote Program Loader-II (RPL-II). RPL-II can be attached to a 3705-II along with up to three channel adapters. With this attachment, a controller that normally operates as

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Model	Average Length of Time in Use, months	Average Main Memory Size, kilobytes	Average Disk Storage Size, megabytes	Average No. of Interactive Terminals per System	Average No. of Remote Batch Terminals per System
115 & 115-2	27	176	273	2	1
125 & 125-2	40	252	410	7	1
135 & 135-3	43	333	99	7	2
138	7	734	810	17	2
145 & 145-3	41	664	1453	15	4
148	5	1122	1401	110	4
155	44	1732	2598	103	15
158 & 158-3	28	2250	3245	62	17
165	65	4103	3181	95	21
168 & 168-3	24	4804	2969	139	22
All models	32	1469	2508	46	9

Business data processing was again the most frequently encountered primary application, increasing slightly from 92 percent a year earlier to nearly 94 percent, while program development and data communications were the next two most frequently encountered applications with 51 percent and 46 percent, respectively. Data base management followed with 38 percent of the user population indicating this type of usage.

As in previous years, COBOL was by far the most widely used System/370 programming language and was being used by 747 (86 percent) of the respondents. FORTRAN and PL/1 were the next popular languages, with 214 users (25 percent) reporting FORTRAN usage and 185 users (21 percent) using PL/1. Surprisingly, in this time of well-developed compilers and language processor support programs, 163 users (19 percent) were still using the System/370 Assembler to meet at least some of their program development needs.

The overall weighted average user ratings (System/370 totals) for the 12 performance categories showed almost no change from the previous survey. Although the ratings for individual models changed slightly, the overall weighted averages for all models remained unchanged in 11 categories and improved by 0.1 point in the twelfth, the category of Applications Programs. Three categories—Operating Systems, Applications Programs, and Ease of Conversion—which System/370 users have traditionally rated somewhat less than "good" (below 3.0), fared no better this year. The two System/370 models with the highest composite ratings were the Model 125 and Model 158.

The comments noted on many of the users' responses closely echoed the high and low points of the survey. As in the previous survey, Mainframe Reliability was collectively rated the highest of the 12 categories and was also the highest-rated aspect for each of the individual models. Not coincidentally, then, the most frequent positive comment noted on the survey questionnaires concerned the System/370's reliability.

IBM's maintenance service, while collectively rated slightly lower than the System/370's reliability, was also the subject of many positive comments. Many users, in commenting on the System/370's reliability, pointed out

a local controller can also function as a remote to another controller. This enables the rerouting of a deactivated or failed host computer's traffic to other CPU. In the remote state, any communication links to controllers other than the newly assigned local are not supported.

Other ACF capabilities include inbound pacing of traffic from terminals with logical units, such as 3770 programmable terminals; activating and deactivating of channel trace via an operator panel function; and concurrent tracing of up to eight lines attached to a 3705-II.

The multi-System/370 user can create a fully interconnected network with minimal hardware changes and virtually no change to application programs via ACF software. ACF apparently will take users toward relegating one CPU to the job of traffic controller, freeing all other CPU's for applications processing.

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 or 115-2 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 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 form 45.5 to 600 bits/second (though the maximum number of 600-bps lines 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 or 125-2 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 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

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that IBM's service was the major reason behind the high reliability ratings. Evidently, the various 370 models have not been totally without failures, but the IBM customer engineers' efforts have kept the effects of these malfunctions to tolerable levels.

On the negative side, users of all models complained most frequently about operating software overhead and about the IBM applications programs in general, and these complaints are reflected in comparatively low ratings for all three software categories.

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

To help answer the inevitable question of how the System/370 compares to its competition from the other mainframe computer vendors, the bottom line of the users' ratings table shows the composite ratings for all non-IBM systems that were obtained during the same survey. In the categories of Mainframe Reliability, Peripheral Reliability, Responsiveness of Maintenance Service, and Effectiveness of Maintenance Service, IBM's efforts were rated higher than the collective efforts of the rest of the industry. And, while Applications Programs are a weak point with IBM, they are even weaker for the rest of the mainframe vendors. The non-IBM segment of the industry outpaced IBM's ratings in Ease of Operation, Operating Systems, Compilers and Assemblers, Ease of Programming, and Ease of Conversion, indicating that the other mainframe vendors have successfully concentrated on some of IBM's weaknesses.

Despite the complaints we've noted, the majority of the users clearly feel the System/370 is worth its price. Their overall satisfaction received an average rating of 3.1, the same as in the previous year's survey and the same as the collective rating earned by all the other mainframe vendors.□

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 135/138 INTEGRATED COMMUNICATIONS ADAPTER: This optional feature permits up to eight communications lines to be connected directly to a Model 135, 135-3, or 138 Processing Unit, without the need for the usual separate communications controller. When the ICA is installed, each line appears to the CPU 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 terhminal adapters, and the features employed.

The Model 135/138 ICA provides up to eight line adapters in any combination of the following three types:

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

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

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

7770 AUDIO RESPONSE UNIT: Provides audio responses, in recorded human-voice form, to digital inquiries from pushbutton telephones or other inquiry-type terminals. Usable with Models 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, 115-2, 125, 125-2, 135, 135-3, 138, 145, 145-3, 148, 155-II, 158, 165-II, 168, and 168-3 can (and usually do) 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

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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/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.)

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, but has been discontinued in favor of DOS/VS. It is still in use on a few of the installed System/370 computers and on many of the earlier System/360's.

Multiprogramming, data communications, MICR processing, or COBOL compilation under DOS requires a minimum of 24K bytes. The Storage Protection feature is also required for multiprogramming.

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

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

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

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

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

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.

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, 115-2, 125, and 125-2, 30K bytes for the System/370 Models 135, 138, 145, 155-II, and 158; and 32K bytes for the System/370 Model 148.

Also added to DOS/VS was 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 recoding.

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

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types of indexing, including non-dense, key compression, replication, high-level main storage, and low-level with data; (2) distributed free space at the time the data set is created to eliminate ISAM-like overflow and automatically reclaim deleted record space; (3) master catalog with device independence; (4) password data set security protection; and (5) a variety of utility services, including an ISAM/SAM data set conversion facility and an ISAM Interface Program that maps ISAM requests into corresponding VSAM requests. VSAM has Class A support as an SCP component of DOS/VS, and 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. The minimum DOS/VS System required for VTAM is 96K bytes.

DOS/VS Release 29, released in February 1974, added 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.

DOS/VS Version 30 included 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.
- DOS/VS Assembler Language support for the Compare and Swap and Compare Double and Swap instructions, required for operation of VTAM.

Release 31 of DOS/VS was distributed in March 1975 and contained additional peripheral device support and improvements in the operating system's data base/data communications facilities, including the following:

- The use of alternate indexes in VSAM, which allows applications programs to access records through keys other than prime keys, to reduce requirements for sorting and maintaining data in multiple sequence.
- Relative Record Data Sets, in which records are accessed through VSAM using the record number as the key in place of an index.
- GET previous retrieval and update processing using descending key values, relative record numbers, or relative byte addresses.
- Reusable Data Sets to allow data sets to be reused without being deleted and defined.
- Spanned records that exceed a control interval in size.
- Catalog recovery capabilities.
- User catalogs.
- Automatic close at End of Job.

In addition, Release 31 supplied facilities for workload balancing in communications environments with concurrent batch processing, VTAM support for the 3650 Retail Store System and the 3790 Communication System, and POWER/VS support for the 3540 Diskette I/O unit as an input device for spooled SYSIN files or spooled data files.

DOS/VS Release 32, distributed in September 1975, contained the following enhancements:

- An optional fast CCW translate feature to improve DOS/VS performance.
- Support for the 3741 Data Station Model 2 and 3741 Programmable Work Station Model 4 as remote job entry terminals under POWER/VS.
- A high-speed stand-alone dump for dumping all of main storage on direct-access storage or magnetic tape in order to perform an immediate IPL to restore system operations.
- Support for the Model 3344 and 3350 Disk Storage Drives in compatibility mode, in which the 3344 operates as four 70-million-byte 3340 Disk Storage Drives and the 3350 operates as two 3330 Model 1 Disk Storage Drives.
- Switched network support for SNA devices on switched SDLC links for dial-up lines under VTAM.
- Expansion of VTAM support for remote 3704/3705 communications controllers to include leased and switched connection of SNA/SDLC terminals.

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- Support for the 3270, 3770, and 3767 SDLC terminals.

DOS/VS Release 34, distributed in May 1977, added support for native 3350 and 3330-11 Disk Drives, the 3277 Display Operator Console, the 3800 Printing Subsystem, and the POWER/VS 3790 RJE/SNA Workstation. Improvements were also made in the areas of VSAM Access Method Services, extensions to the Environmental Recording and Editing Program (EREP) to include the Model 158 EREP reports and the Model 135 and 138 Summary reports, and enhancements to POWER/VS functions. Two new functions, the DOS/VS Installation Productivity Option (IPO) and the DOS/VS Advanced Functions, were added. The Installation Productivity Option is a program product developed by IBM to reduce the time required to install future DOS/VS enhancements. The DOS/VS Advanced Functions significantly improve the operating system by expanding the number of user partitions to seven and providing dynamic partition balancing. Other improvements include asynchronous operator communications, a faster linkage editor, private library device independence, and improved linkage to VM/370 Enhancements.

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.

The POWER/VS remote job entry facility can support concurrent operation of 25 terminals, including the 3780 Data Communication Terminal, 2780 Data Transmission Terminal, 2770 Data Communication System, 3770 Data Communication System, and the System/32 computer (functioning as a 3770). All terminal types can operate concurrently. Remote entry support for transmission via the Synchronous Data Link Control (SDLC) is provided for the 3771, 3773, 3774, 3775, and 3776 Communications Terminals and the System/32 (as a 3770). The 3784 Line Printer, 3521 Card Punch, 3501 Card Reader, and 2502 Card Reader are also supported, although concurrent operation of the printer and card punch on a single transmission from POWER/VS to the terminal is not allowed. The VTAM application program interface is used to support the SDLC terminals to permit multiple applications to transmit to and from a terminal on a per-session basis, and multi-point operation is supported. 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.

IBM discontinued support for both OS/MFT and OS/MVT in 1976, placing all of its software support emphasis upon the virtual storage operating systems.

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, 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

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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.

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. (IBM announced the discontinuance of support for both OS/MFT and OS/MVT in 1976.)

OS/VS2, in turn, was effectively divided into two separate operating systems with the introduction of OS/VS2 Release 2 in December 1972. OS/VS2 releases prior to Release 2 (currently up to 1.7) are now known as OS/VS2 Single Virtual Systems (or SVS), while OS/VS2 Release 2 and above are now known as OS/VS2 Multiple Virtual Systems (or MVS.)

OS/VS1: In addition to the basic facilities offered by OS/MFT, OS/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 debuffer used to identify and correct VS1 programming failures.

OS/VS1 Release 3.1 included 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 included 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 2780 Card Punch through the Remote Terminal Access Method.

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

OS/VS1 Release 4 was made available in March 1975 and contains new and enhanced peripheral device support plus

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new functional capabilities. Among the new devices supported under Release 4 are the 3540 Diskette Input/Output Unit as a SYSIN or SYSOUT device and the 3611 Passbook Printer as a component of the 3600 Finance Communication System. In addition, enhanced support is provided to allow printing on punched output of the 3525 Card Punch and for QSAM for the 3890 Document Processor. VSAM enhancements in OS/VS1 Release 4 include catalog recovery, alternate indexes, relative record data sets, GET previous (a logical backward processing capability), reusable data sets, spanned records, and sharing of VSAM control blocks and buffers by more than one data set. Release 4 also includes enhanced functions for operation of OS/VS1 under VM/370.

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Support for communications processing under OS/VS1 is provided under the Basic Telecommunications Access Method (BTAM), the Telecommunications Access Method (TCAM), and the newer Virtual Telecommunications Access Method (VTAM). TCAM provides general-purpose teleprocessing support for the 270X communications controller and can also operate in conjunction with VTAM to achieve compatibility for applications which used the TCAM 3704/3705 network control mode support provided in previous operating system releases. In a TCAM/VTAM network, input/output requests issued by TCAM applications programs are intercepted and routed to VTAM for processing. VTAM provides support for communications networks operating under control of the 3704/3705 Communications Processors operating in the Network Control Program Mode, and for locally attached 3270 Display Stations or 3790 Communications Systems. In February 1976, IBM announced modifications to TCAM, scheduled for release in 1977, that allow it to communicate directly with SNA terminals, including the 3767, 3270, 3770, and 3600 terminals, without using VTAM. VTAM includes the Teleprocessing On-Line Test Executive Program (TOLTEP) for performing on-line testing of selected terminals concurrently with other processing programs.

VTAM under OS/VS1 provides support for the terminals that operate with IBM's new Synchronous Data Link Control (SDLC) protocol, including the 3270 Information Display System, 3600 Finance Communication System, 3650 Retail Store System, 3770 Data Communication System, 3790 Communication System, and the System/32 (supported as a 3770), plus the 2260, 2791, 3270, and 3790 terminals as local terminals. A System/370 executing VTAM under OS/VS1 requires a minimum of 256K bytes of real main memory.

The most current version of OS/VS1 is Release 6, made available in October 1976. This may be the last "release" of OS/VS1 due to IBM's introduction of the *selectable unit*. Selectable units are small microcode packages that add new features or enhance existing software systems. Instead of introducing new releases of a particular software package with several enhancements and new features, IBM will now make available various selectable units, thereby giving users the option of whether or not to take advantage of new developments as their needs dictate. Selectable units can be applied only to OS/VS1, Release 6 and above.

OS/VS2: This large-scale operating system, initially released in December 1972, is a significantly improved version of OS/MVT. The enhancements of OS/VS2 Release 1 (SVS) 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 and 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 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 JES 2, 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.

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:

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- 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.

In OS/VS2 Release 3, released in March 1975, from two to seven systems can share the JES2 job queues and input and output queues stored on shared direct-access storage devices in what is referred to as a JES2 Multi-Access Spool environment. The JES2 Multi-Access Spool permits sharing of the workload or a JES2-controlled pool of peripheral devices among the central processors in the configuration, each of which operates asynchronously within the configuration. Jobs can be routed to any or all systems in the configuration, and one system can recover the workload of another failing processor and can assume control of the communications and unique unit record equipment of a failing system in order to continue processing of the jobs entered in the spooling queue. Conversely, a single processor can be assigned to operate in the independent mode, in which it will process only jobs that are specifically routed to it. A single processor can also be isolated for testing and diagnostics.

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.

JES3, released in October 1975, is an upward extension of the Asymmetric Multiprocessing System (ASP) that provides extensive automation of the scheduling and operator functions of up to four VS2 Release 2 systems, any one of which may be a shared-storage multiprocessor system. Any one of the systems, which must be operating under OS/VS2 Release 2, can act as the global processor, but OS/MVT and OS/VS2 Release 1 processors can also be supported in the configuration. Both local and remotely entered jobs are scheduled from a centralized work queue through a single operator interface. Special features of JES3 include centralized scheduling of pooled input/output devices, including the use of priorities for the allocation of device types, automatic scheduling of an interdependent job network, deadline scheduling, time-sharing and remote job entry, plus support for a master console and multiple secondary consoles.

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. For OS/VS data set sharing, VSAM provides protection for multiple intra-region updates only.

Communications support under OS/VS2 is provided by the Basic Telecommunications Access Method (BTAM), Telecommunications Access Method (TCAM), and Virtual Telecommunications Access Method (VTAM, under Release 3). OS/VS2 VTAM support is similar to that provided under DOS/VS and OS/VS1.

Modifications to the OS/VS2 software announced in February 1976, permit the 3767, 3270, 3770 and 3600 SNA terminals to be accessed solely through TCAM without requiring a VTAM interface to the operating system. In addition, VTAM support for the 3767, 3270, and 3770 SNA terminals for operation under the Time Sharing Option, Virtual Storage Personal Computing, CICS/VS, and IMS/VS was also announced in February 1976. The TCAM support for SNA terminals under OS/VS2 Release 2 for interactive and CICS/VS applications programs was scheduled for delivery in the third quarter of 1976, and for IMS/VS in the second quarter of 1977.

Remote job entry under OS/VS2 is supported under JES2 and JES3, and includes facilities for multileaving transmission between the host computer and intelligent remote terminals including the IBM System/360 and System/370 central processors, the IBM 1130, and the System/3 processor models.

OS/VS2 operates on the System/370 Model 145 through 168 MP virtual storage systems. Release 2 operates with reduced functional capabilities and restricted performance in a system with 768K bytes of main memory, can perform the minimum batch processing functions in a system with 1,024K bytes of memory, and requires 1,536K bytes of main memory to perform concurrent batch and TSO operations with JES2.

The current release of OS/VS2 (MVS) now stands at Release 3.7. This may well be the last "release" of this operating system due to IBM's recent introduction of the selectable unit. Selectable units are small microcode packages that add new features or enhance existing software systems. Instead of introducing new releases of a particular software package with several enhancements and new features, IBM will now make available various selectable units, thereby

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giving users the option of whether or not to take advantage of new developments as their needs dictate. Selectable units can be applied only to OS/VS2, Release 3.7 and above.

The modifications to OS/VS2 that permit the use of selectable units also permit easier user modifications to the operating system through the System Modification Program (SMP). This program uses the same library mechanism employed to install selectable units, to allow users to make modifications to the operating system. A record of user modifications is maintained in the Control Data Set, for purposes of recovery from improper modifications. The information contained in the Control Data Set is limited to the module name and other modules affected by the change. A copy of the previous version is not generated automatically and must be initiated prior to the change.

SELECTABLE UNITS: These microcode packages are collections of new and changed modules and macros that provide enhanced program functions, performance improvements, or hardware support. Selectable units are provided independently of software packages and are installable through the INSTALL macro. This new concept permits IBM to make available new, enhanced, or modified OS/VS1 or OS/VS2 (MVS) components on an individual basis instead of packaging them in large program packages.

Selectable units were first announced for use with the 3031, 3032, and 3033 Processors through the System/370 Extended Facility and for use with the Model 158 and 168 through the System/370 Extended Feature. These microcode enhancements, in conjunction with the Systems Extensions program products made available for OS/VS1, MVS, and VM/370, yield significant performance increases. IBM states that, in an MVS system, supervisor-state execution time is reduced by 20 to 27 percent, uniprocessor throughput is improved by 14 to 18 percent, and multiprocessor system throughput is improved by 17 to 20 percent.

A list of the currently released selectable units for OS/VS1 and MVS, and their descriptions, follows. The numbers in parentheses following the descriptions indicate other selectable units that are prerequisites for a particular unit.

Selectable Unit No.	Description
VS1	
1	Environmental Recording, Editing, and Printing (EREP) Program Modifications
2	Telecommunications Access Method (TCAM) Level 10
3	Subsystem Support Services Release 5
4	Support for 3895 Document Reader/Inscriber
5	3850 Mass Storage Subsystem (MSS) Program Enhancements
6	Support for 3838 Array Processor Vector Processing Subsystem (VPSS) (1)
22	System Modification Program (SMP) Release 3
MVS	
1	Virtual Telecommunications Access Method (VTAM) Level 2
2	Telecommunications Access Method (TCAM) Level 9
3	Job Entry Subsystem 2 (JES2) Release 4
4	Scheduler Improvements
5	Supervisor Performance Enhancements 1
6	Support for 370/168 Attached Processor Systems
7	Supervisor Performance Enhancements 2
8	Data Management
10	Support for 3800 Page Printer
11	Time Sharing Option (TSO) Command Package
12	Job Entry Subsystem/3 (JES/3) Release 2 Support for 3850 MSS (4, 5, 7, 12, 16)
13	TSO/Virtual Telecommunications Access Method (VTAM)
14	Resource Access Control Facility (RACF) Release 1
15	System Modification Program
16	Support for Scheduler and I/O Supervisor (4, 5, 7)
17	Service Data Improvements
18	Job Entry Subsystem/3 (JES/3) Release 2.1
19	JES/2 Network Job Entry (NJE) Release 1
20	Resource Measurement Facility Version 1
21	Subsystem Support Services Release 4
22	JES/2 Network Job Entry (NJE) Release 2
23	JES/2 Network Job Entry (NJE) Release 3
24	3850 Mass Storage Subsystem Program Enhancements (4, 5, 7, 16)
25	JES/2 Release 4.1 Support for 3790 Remote Job Entry
26	JES/3 Remote Job Processing
27	Environmental Recording, Editing, and Printing (EREP) Program Modifications
29	Support for 3838 Array Processor Vector Processing Subsystem (VPSS) (3 or 12 and 18, 4, 5, 7, 16, 27)
30	Support for 3895 Proofing System (4, 5, 7, 16, 27)
32	System Security Support for RACF (4, 5, 7, 8, 16)
33	MVS Dumping Improvements (5, 7, 17)
34	Advanced Communications Function (ACF)/VTAM Network Support
35	Advanced Communications Function (ACF)/VTAM Network Support
36	Telecommunications Access Method (TCAM) Level 10
37	Subsystem Support Services Release 5 and TCAM Level 10
41	Direct Access Storage Device Dump Restore (DASDR) Release 1
44	Advanced Communications Function (ACF)/TCAM Network Support
45	Network Operations Support
46	Advanced Communications Function (ACF)/TCAM
47	Support for Attached Processor Subsystems on 370/158 and 370/168; superseded by SU51
48	3800 Page Printer, 12 Lines per Inch Feature (5, 10, 3 or
49	Resource Access Control Facility Release 2
50	MVS/System Extensions (4, 5, 7, 16, 17, 27, 33, 51, 55)
51	Support for Models 3031, 3032, and 3033 Processors (5, 7, 27)
52	Resource Measurement Facility Version 2
55	Hardware Recovery Enhancement
58	Support for Time Sharing Option (TSO)/VTAM (1)
59	Advanced Communications Function (ACF) for TCAM
60	MVS Data Management Support (4, 5, 7, 8, 16)
63	System Modification Program Release 3

VIRTUAL MACHINE FACILITY/370: VM/370 is a system control program (SCP) that manages a computing system's resources (CPU, storage, and input/output devices) so that all are available to many users at the same time. Each user has at his disposal the functional equivalent of a real, dedicated computing system. VM/370 is designed for use on System/370 Models 135, 138, 145, 148, 155-II, 158, 165-II, and 168, which have the Dynamic Address Translation feature and Extended Control Mode option.

VM/370 is the System/370 version of CP-67/CMS, which performs similar functions on a System/360 Model 67. Like its predecessor, VM/370 provides virtual machines and virtual storage, the ability to run multiple operating systems concurrently, and a conversational, time-sharing system.

VM/370 has two major elements: the control program (CP), which controls the resources of the real computer to provide multiple virtual machines, and the Conversational Monitor System (CMS), a subsystem that gives users a wide range of conversational time-sharing facilities, including creation and management of files and compliation, testing, and execution of problem programs.

While the VM/370 control program manages the concurrent operation of the virtual machines, one of the standard System/370 operating systems manages the work flow within each virtual machine. Because each virtual machine

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executes independently of other virtual machines, each one may use a different operating system, or a different release of the same operating system.

The operating systems that can run in VM/370 virtual machines include Batch or Single User Interactive DOS, DOS/VS, OS/MFT, OS/MVT, OS/VS1, OS/VS2, and OS-ASP, as well as the multiple-access APL/DOS-360 and the Conversational Monitor System (CMS). 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 control program provides each of these operating systems with virtual device support and virtual storage. The operating systems themselves execute as if they were controlling real devices and real storage, but they must not violate any restrictions.

Each virtual machine has its own virtual storage space, which may be as small as 8K bytes or as large as 16 million bytes, or any size in between that is a multiple of 4K bytes. Each virtual machine can refer only to its own virtual storage; this restriction protects each virtual machines's storage from the activities of other virtual machines. The size of each virtual storage space is defined in the virtual machine's directory entry and may differ among virtual machines.

The control program provides CPU resources to each active virtual machine through time-slicing. The operating system in each virtual machine can be either single-task or multi-task. The virtual CPU can be run in either Basic or Extended Control mode. Extended Control mode includes all the facilities necessary to run VM/370 as the virtual machine's operating system. The virtual machines can execute all 370 instructions except Read Direct and Write Direct. The Diagnose instruction is also reserved for special program communication with the control program.

A virtual machine can support the same devices that a real machine can. Virtual devices are logically controlled by the virtual machine and not by VM/370. Input/output (I/O) operations, and any error recovery processing, are normally the complete responsibility of the virtual machine operating system.

Virtual and real device addresses may differ. CP converts virtual channel and device addresses to real channel and device equivalents and performs necessary data translations. However, all virtual devices must have real counterparts, such as disk-to-disk and tape-to-tape. Some virtual devices (such as tape units) must have a one-to-one relationship with a real counterpart. Others may be mapped to portions of a real device (for example, a virtual disk may occupy all or part of a real disk). Several virtual disks can exist on one real disk.

Multiple-access and single-user systems are two kinds of interactive systems that can run under VM/370. Multiple-access systems run in one virtual machine and directly service many interactive terminals. A user of a multiple-access system issues the Dial command instead of the Log-on command to connect his terminal with the virtual machine running the multiple-access system. Once the terminal is connected, the user issues statements in the command language associated with the multiple-access system only. Systems that can be run interactively by a single user include the Conversational Monitor System and any operating system that can run on a virtual machine. A time-sharing environment is created when VM/370 creates multiple virtual machines, each controlled by a copy of CMS. These systems operate concurrently with each other as well as with other conversational or batch systems. CMS is useful for program development and problem-solving.

The directory entry contains two sizes for each virtual machine: its normal size and a maximum size. The normal size must be at least 8K bytes. The maximum size must be no larger than 16 million bytes. Both sizes must be multiples of 4K. The virtual machine usually uses the amount of storage defined as its normal size. However, the user may temporarily redefine his virtual storage size to any value that is a multiple of 4K but not greater than his maximum size.

Storage in the virtual machine is logically divided into 64K-byte segments, which in turn are logically divided into 4K-byte pages. For each virtual machine, CP creates and maintains a set of segment and page tables to describe the virtual storage and to reflect the allocation of the virtual storage pages to page frames in real storage. These tables are used by the Dynamic Address Translation feature to locate the real storage addresses.

The heavily used portions of VM/370 are kept in real storage, but only frequently referenced virtual storage pages are kept in real storage. A page can be brought into any available page frame; the necessary relocation is done during program execution by CP, using dynamic address translation. The active pages from all logged-on virtual machines and from the pageable routines of VM/370 compete for available page frames. When the number of page frames available for allocation falls below a threshold value, the control program determines which virtual storage pages currently allocated to real storage are relatively inactive and initiates suitable page-out operations for them.

Inactive pages are maintained on a direct-access storage device. If a page has not changed, it remains allocated in its original direct-access location and is paged into real storage from there the next time the virtual machine refers it.

Paging is done on demand by the control program. No attempt is made to anticipate what pages might be required by a virtual machine. While a paging operation is being performed for one virtual machine, another virtual machine can be executing. All paging operations are initiated and performed by the control program and require no action by the virtual machine.

The operating system controlling a virtual machine may execute in Extended Control mode, permitting it to create and control virtual storage of its own, in addition to the CP-assigned virtual storage. Operating systems that can do this include OS/VS1, OS/VS2, DOS/VS, and VM/370.

The VM/370 System Assembler is distributed as a part of the VM/370 system and is required for installation and maintenance. The compilers that can execute under CMS include OS PL/1, OS COBOL, and OS FORTRAN IV. The compilers are invoked within the conversatinal environment of CMS; the normal mode of execution is to run the compilation to completion, type any diagnostic messages at the terminal, and make the listing file available for inspection at the terminal or for printing on the real printer. Most object programs produced and compiled under CMS can be executed under CMS for direct problem-solving. Programs that use certain OS system functions, described below, must be run under the appropriate operating system.

To support the OS compilers, CMS simulates the execution of many of the OS macros. The sequential, direct, and partitioned access methods are logically simulated; the data records are physically maintained in the chained 800-byte blocks that are standard to CMS, and are processed internally to simulate OS data set characteristics. Many OS Supervisor Call functions are also simulated. OS macros that are not simulated include those that support the Indexed Sequential Access Method and the telecommunications access methods. Functions related to multi-tasking are either ignored by CMS or modified to achieve single task execution.

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Release 2 of VM/370, distributed in March 1975, contained a new system program component called the Remote Spooling Communications Subsystem (RSCS), which permits multiple remote spooling operations to run concurrently in a single virtual machine. RSCS supports the 2770, 2780, 3770, and 3780 communications terminals, HASP workstations, and central processors running under HASP, ASP, RES, and JES2, and JES3. Other enhancements provided in Release 2 include support for the 3340 Direct Access Storage Facility for spooling, paging, and virtual disk space, and an enhancement to the Conversational Monitor System that allows on-line terminal users to read, but not modify, DOS data files. The VM/370 Measurement Facility was also added to the operating system in March 1975 to provide data at the console on system load conditions. Another March 1975 addition to CMS was support for remote 3270 display devices as virtual machine operator consoles.

Release 3, the most current version of VM/370, was initially distributed in October 1975. It added support of the VSAM indexed file capability to high-level language programs executing under CMS. Later enhancements include support for the 3350 and 3344 Disk Drives and a batch job forwarding capability for HASP II systems, available on an RPQ basis.

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.

VIRTUAL STORAGE PERSONAL COMPUTING (VSPC): Announced in December 1975, VSPC is a separately priced interactive program product that operates under the DOS/VS, OS/VS1, and OS/VS2 operating systems and includes three separately priced higher-level languages—VS APL, VSPC FORTRAN, and VS BASIC. VSPC includes an English-language command language to provide an easy-to-use user interface with the system, and includes facilities for managing each user session. The system also includes a command list facility which enables users to define sets of command sequences to be stored under an English-language identification, and an input editor for file creation and maintenance. A library facility provides facilities for restricting access to user files, including a private library category for private user files, a project library category for access by a selected group, and a public library category to allow access to the data by all users with authorized access to the system. Access to the system is controlled by user ID codes and passwords, and a system control function allows the installation manager to control the allocation of system resources, including processor time and library storage space. VSPC also includes a conversational remote job entry facility that permits users to submit longer-running jobs and retrieve the output from a remote terminal.

VSPC operates under the DOS/VS, OS/VS1, and OS/VS2 operating systems and uses VTAM for terminal access and VSAM for library support. In addition, there are currently 11 separately priced applications programs available for the system, including Business Analysis/BASIC, Math/BASIC, Stat/BASIC, and APL Minipert for conversational critical path analysis. User terminals include the 3767 and 2741 Communications Terminals, the 3770 and 1050 Data Communication Systems, and the 3270 Information Display System. A restricted version of VSPC with support for a limited number of user terminals can execute on a System/370 Model 115 or Model 125 equipped with 256K bytes of main memory. Implementation of the full version of VSPC under OS/VS1 requires a 370/135 or larger processor with a minimum of 384K bytes of main memory; under OS/VS2, a 370/145 or larger with a minimum of 2,048K bytes of main memory is required.

First customer delivery of VSPC under OS/VS1 occured during the second quarter of 1976, under OS/VS2 during the third quarter of 1976, and under DOS/VS during the fourth quarter of 1976. First customer shipments of VS APL, VSPC FORTRAN, and VS BASIC were made in the second quarter of 1976.

INFORMATION MANAGEMENT SYSTEMS: IMS provides the capabilities for generating and accessing a data base, with automatic cross-referencing among data records. IMS/VS operates under the OS/VS1 or OS/VS2 operating system. IMS-2 (IMS/360) provides the same basic functions as IMS/VS (although IMS/VS contains many more capabilities) and operates under OS/MFT or OS/MVT—or, with fixed pages, under OS/VS1 or OS/VS2. Both IMS/VS and IMS-2 offer on-line message processing with the optional on-line inquiry with IQF (Interactive Query Facility) or GIS/VS (General Information System) and batch inquiry with GIS or GIS/VS are available. In addition, a data language (DL/1), whose function is to register user I/O coding with simpler commands to IMS, is provided.

The same basic data base facilities are provided for DOS/VS users with DL/1 DOS/VS. However, its only available data communications extension is linkage to CICS/DOS/VS (Report 70E-491-02). IMS/VS can also link to CICS/VS, and IMS-2 to CICS/OS Standard, but they must then forego their own data communications features and, more significantly, IQF.

IBM released DL/1 Entry in July 1975. It is a compatible subset of DL/1 DOS/VS and is upward-compatible from another IBM data base management system, VANDL-1. VANDL-1 is now a class C product, having been downgraded from class B when DL/1 Entry was announced. DL/1 Entry also supports a communications interface to CICS/VS.

All of the foregoing programs are written in Assembly language and offer their DB facilities to users of COBOL, PL/1, and Assembly language.

The data base environment within IMS provides for a "separation" between the data and each user program. This concept of data independence implies that changes to the data base—such as the inclusion of new fields, changes in record length of description, and physical reorganization into new structures or different device types—need not be accompanied by corresponding changes in what is likely to be a large number of individual application programs that access the data base.

In order to achieve data independence, a common symbolic program linkage and data base description is used that supports five primary types of data-base access or I/O operations:

- Retrieve a unique segment (GET UNIQUE).
- Retrieve the next sequential segment (GET NEXT).
- Replace the data in an existing segment (REPLACE).
- Delete the data in an existing segment (DELETE).
- Insert a new segment (INSERT).

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These operations can be performed on one or more hierarchically related segments or data elements in a logical data base record. Each of the operations is invoked by a Data Language/1 (DL/1) command. (The appropriate DL/1 command is indicated in parentheses above.) DL/1 works with a data base description (DBD) produced by the off-line IMS utility program that creates the data base. The DBD provides the "mapping" from the logical structure of the data base (as viewed by the application program) to the physical structure of the data base (as kept on a storage device by OS). The logical data structure of IMS is based upon segments: an IMS data base consists of 1 to n data base records; a data base record consists of 1 to n segments of up to 4095 segment types and up to 15 segment levels. There is one root segment per data base record and 0 to n occurrences of dependent segments per parent.

Four primary physical data organizations are provided in IMS:

- Hierarchical Sequential Access Method (HSAM)—an extension of basic serial tape and disk file processing (SAM). This method offers limited data independence and no interrelatability of the data base through "pointers." In order to insert a data base record, the data base must be copied up to that point, the new record written, and the rest of the data base copied. Each record is physically present in the serial order in which it logically appears in the data base.

- Hierarchical Indexed Sequential Access Method (HISAM)—provides an imbedded hierarchy of ISAM-like data sets that are related by sets of symbolic pointers or keys. The distinguishing aspect of HISAM (or HSAM), as opposed to the hierarchical direct methods described below, is that all segments in a physical data base record are "related by physical juxtaposition." For HISAM, this means that a direct-access relationship is established between all of the physical blocks containing the segments belonging to a given data base record. An Overflow Sequential Access Method (OSAM) physically contains the segments that cannot fit in the HISAM logical record. OSAM is based upon standard OS physical data sets and combines the best features of both BSAM and BDAM: concurrent sequential and direct access for retrieval, in-place updating as well as addition at the end of a data set, data set "end" recognition, secondary extent definition for data sets, etc. IMS/VS also provides support for certain VSAM data sets on disk; that is, VSAM data sets and single-segment HISAM data bases will share a common stored record format. HISAM does not yield particularly good results in an on-line environment.

- Hierarchical Direct Access Method (HDAM)—stores data in a physical tree structure with all segments in a physical data base record related by direct addresses. Segments can be interrelated to each other as physical twins (multiple occurrences of the same segment type under a given parent), physical parents (segment immediately above), or physical children (first and last occurrence of each segment type immediately subordinate) through chains of pointers. HDAM uses OSAM as a base for data storage and provides very effective access to dependent segments—especially in teleprocessing environments —at some overhead cost in terms of data base size.

- Hierarchical Indexed Direct Access Method (HIDAM) provides an ISAM index to data physically stored in OSAM format. The ISAM index contains the key of a root segment and a direct address to the root segment, while the actual storage of data is done in OSAM data sets. Because the data base index and the actual base are kept on two separate data sets, reorganization of the index separately from the data is facilitated. HIDAM is the most generally appropriate and most often used data organization method for IMS applications.

In addition to the above data structures and access methods, the basic batch-oriented version of IMS (also called "DL/1 Data Base" or the DB system), can be augmented with data communications capability to produce a transaction-drive system. The DB system is prerequisite to the DC Feature ("IMS teleprocessing"). The resulting full-scale IMS is known as the DB/DC system, and can handle both batch and on-line operations concurrently. A DB/DC system can have a wide variety of physical terminals, each of which can have one or more logical or symbolic names. Individual security parameters can be associated with each terminal's logical name.

As an alternative to the IMS Teleprocessing option, a DB/DC system can be put together using the Customer Information Control System. CICS generally provides similar functional capabilities with lower overhead in some environments. CICS was designed for relatively short program modules of about 2K to 6K bytes, while the IMS Teleprocessing option is better suited to 20K-byte modules or larger. The CICS/IMS interface has been available since early 1972.

Also available for full DB/DC IMS systems is the Interactive Query Facility (IQF). IQF is a basic query langauge that offers the capability for on-line retrieval and display of data in an IMS data base. IQF consists of retrieval phrases that define, delete, list, sort, count, total, limit, and query the data base, the "when" qualifier to establish criteria for data selection; and a basic complement of relational (EQ, NE, LT, GT, LE, GE), logical (AND, OR), and arithmetic (+, -, /, *) operators. Other handy features of IQF include null words (e.g., THE, OF, FOR) set up by "define" phrases, literal and numeric constants, segment synonyms, etc.

The IQF utility is run when putting the IMS system together and for subsequent index creation or modification. IQF can be used only with the IMS DC Feature. It is not supported by CICS. IQF can be used in conjunction with the more powerful query capability of the Generalized Information System (GIS/2)—a full-scale information system—although no direct relationship between IQF and GIS/2 exists.

GIS/2 and GIS/VS, with the DL/1 Query Support Feature, can be used to produce tailored processing modules that permit batch and on-line operations upon IMS data bases as well as a variety of other data file types. GIS is actually a sort of "super RPG" that accepts report format and query selection criteria as input and produces an object deck plus Job Control Language (JCL) as output. These GIS object modules can be executed under control as batch programs only. Full GIS query capabilities (except LIST RECORD and HOLD RECORD) are supported for IMS data bases.

A Bill Processor Bridge System is also available that converts Bill of Material Processor (BMP 360A-ME-60X) and Data Base Organization and Maintenance Processor DBOMP 5736-XX4) files into IMS data bases.

IMS/VS can be used on System/370 Models 145, 155-II, 158, 165-II, and 168. In addition to the user's application programs, IMS/VS itself requires a minimum region or partition size of 90K for DB only or 350K for DB/DC. When it is incorporated with the user's application programs, practical minimum main storage requirements are 384K bytes for OS/VS1, 512K for OS/VS2 Release 1, and 768K for OS/VS2 Release 2 or 3. With the Data Communications feature added, these systems would require approximately 512K, 768K, and 1024K bytes, respectively. Also required are an OS/VS1 or OS/VS2 system console, at least one 2400 or 3400 series 9-track tape unit, and direct-access space for system libraries and working storage. With 2316 packs, the

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DB system requires from 125 to 175 cylinders, depending on the release number, and the DB/DC system requires from 225 to 248 cylinders. With 3336 packs, from 83 to 115 cylinders are required for the DB system and 158 to 240 cylinders for the DB/DC system. Also, one of the following nonswitched devices is required to support the IMS/VS Master Terminal: 2740 Communications Terminal with Station Control feature, 1050 Data Communications System with 1052 Printer-Keyboard, or 3270 Information Display System.

IMS-2 operates on System/360 and 370 computers with a minimum of 128K bytes for DB and 256K for DB/DC under MFT. Under MVT, the system requires 256K for batch-only DB and 512K for DB/DC. Under OS/VS, minimum real storage requirements for DB are 384K for OS/VS1 and 512K for OS/VS2. For DB/DC, the requirements are 512K and 768K, respectively. In addition, the DB system requires one 7- or 9-track magnetic tape unit and from 115 (DB) to 185 cylinders (DB/DC) of 2316 disk space for system libraries and working storage space. The DB/DC system requires an additional non-switched 1050 Data Communication System or 2740 Communication Terminal and two 9-track tape units.

In addition to the above requirements, IQF requires a message processing region of 50K. A batch IMS region of at least 200K is required to run the IQF utility. This is based on a SORT work area size of 44K. If a larger work area size was specified at SYSGEN time, an increase must be made to the minimum region size for the IQF utility.

DL/1 DOS/VS requires a System/370 Model 125, 135, or 145 with a minimum of 98K bytes for a batch system or 163K with CICS. The practical minimum number of 2K pages for batch DL/1 is 30 with all functions except logical relationships and secondary indexing, and 40 for all functions. With CICS, these figures are 45 pages and 70 to 100 pages, respectively. Also required are a DOS/VS system console, two 9-track tape units, and 75 cylinders of 2316 disk storage space (or equivalent) for a batch system. For a CICS system, 150 cylinders of 2316 (or equivalent) disk storage space are required.

DL/1 Entry, a subset of DL/1 DOS/VS, runs on a System/370 Model 115 or larger under DOS/VS and requires at least a 96K processor. It affords the user a CICS interface along with many of the features of DL/1 DOS/VS. DL/1 Entry is a superset of, and upward-compatible with, VANDL-1.

See Report 70E-491-01 for more details on IMS.

CUSTOMER INFORMATION CONTROL SYSTEM: CICS is a general-purpose data communications monitor that operates in a single partition or region of an IBM System/360 or 370 under DOS or OS (or their VS counterparts) to control multiple on-line user terminals and applications. By consolidating the required communications interfaces and I/O and control functions, CICS isolates the user's applications programs from the communications environment and, to a considerable degree, from the operating system itself.

Written in Assembler language, CICS provides transaction processing support for data base management or file control programs written in Assembler, PL/1, or COBOL, thus allowing on-line applications to be developed without significantly greater difficulty than similar batch programs. In addition to supporting several external data base management structures (e.g., IMS's DL/1, DBOMP) CICS includes some native data management capabilities.

The DOS and OS Standard versions of CICS are multi-thread systems, while the DOS Entry version is a single-thread system. These three versions of CICS will be down-graded to Class C system support as of December 1977. All three versions operate as a single task within a partition or region under multiprogramming or in a dedicated environment. The internal structure of CICS sets up a sort of intrapartition "multiprogramming" environment that is under direct CICS control. Many of the storage management and program management modules in CICS function in a way similar to that of comparable OS/MVT modules. In fact, CICS is often compared to MVT and bears a striking internal resemblance to the structure of that operating system.

The DOS/VS and OS/VS versions of CICS are analogous, respectively, to the DOS Standard and OS Standard versions. The VS versions have been enhanced from a functional point of view, and optimized to run more efficiently in a paged environment than the real-memory versions would.

The CICS partition or region is physically divided into two types of main storage:

- Static Storage, in "high" memory, which contains the CICS Nucleus, service programs, control tables, access methods, and resident user-written applications programs; and

- Dynamic Storage, in the rest of the partition or region, which contains work areas, I/O buffers, applications programs to be processed, the storage cushion, and certain additional control areas. The size of Dynamic Storage greatly influences CICS throughput and response time.

CICS features four specialized data management functions:

- Terminal Management—a Terminal Control Program (TCP) handles communications between terminals and applications programs. All versions of CICS use BTAM for terminal data management, with TCAM also available for the OS Standard versions. TCP also handles terminal error recovery, device-dependent control functions, transmission facility control, and the simulated terminal capability.

- File Management—the File Control Program handles data base operations, including data set open/close, retrieval, browsing, exclusive control, and 2-level segmentation. Other file management functions include external data base manager interfaces to DL/1, DBOMP, etc.

- Transient Data Management—for storage of data to be used for subsequent processing. Extra-partition data transfers are also accommodated for system statistics, etc. This facility can also be used for message switching, data collection, and logging.

- Temporary Storage Management—controls "scratch pad" areas in main memory and temporary data storage areas on direct-access devices.

A high-level language pre-processor is used to convert CICS macros or user-written assembler routines into high-level language for subsequent compilation. The CICS/DOS Maintenance and Linkage Editor performs functions similar to those of the DOS Librarian and Maintenance and Linkage Editor for the CICS partition; this CICS module maintains the Relocatable Program Library with create, copy, delete, condense, link edit, and display functions. The Dump Utility operates in batch mode to format CICS dumps.

In addition to the basic CICS functions described above, more than a dozen other system service functions are

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provided by ancillary application-level programs; these include Sign On/Sign Off (an optional security module), Master/Supervisor Terminal Authorization, system statistics (useful in reconstruction as well as control and audit procedures), abnormal condition handlers, orderly system shutdown, Asynchronous Transaction I/O Processors (ATP) for Standard CICS only, trace facilities (an optional module for debugging environments), dynamic open/close, and time-of-day controls. Of particular interest in the ATP facility, a sort of RJE capability without a Job Control Stream that allows transactions and data to be batched for processing. The ATP facility is designed for high-speed data entry terminals.

The Extended Telecommunications Modules Feature, when added to CICS/DOS/VS, offers support under NCP/VS for multiple 3704 and 3705 Communications Controllers in both local and remote environments. It also supports many of the SNA and pre-SNA devices. The 3601 Finance Communications Controller along with its associated loop of devices is supported by EXTM. Emulation mode and NCP/VS mode can exist in the EXTM environment, but dynamic switching of lines between these two modes is not supported. EXTM can coexist with BTAM in the same system without affecting the operation of either facility.

CICS/OS/VS also gives the user the ability to share network resources with other VTAM communications application programs. By using VTAM's read-ahead capabilities, and by providing a direct interface between the application program and the terminal control program, the system provides for more terminal I/O overlap.

CICS runs on System/360 or 370 computers under DOS, OS (MFT or MVT), OS/VS1, OS/VS2, and on VM/370 configurations. Specific main memory requirements are totally dependent upon the features and functions desired in the CICS configuration. Minimum memory requirements, in a real or virtual system are: CICS/DOS Entry—30K bytes; CICS/DOS Standard—44K; CICS/OS Standard Version 2—64K; CICS/VS—48K real memory, 96K virtual memory. In a VS environment, a more realistic or "typical" requirement figure would be 134K bytes of real memory or 300K bytes of virtual memory.

CICS/DOS Entry will function on a System/360 Model 25 or above, CICS/DOS Standard on a Model 30 or above, CICS/OS Standard on a Model 40 or above, CICS/DOS/VS on a System/370 Model 125 or above, and CICS/OS/VS on a Model 135 or above.

In addition, each version of CICS requires at least one magnetic tape unit, 2.5 million bytes of direct-access storage (for CICS libraries and working storage), and one "Master Terminal." (The latter is a "logical" unit requirement and does not necessitate a separate, full-time terminal.)

See Report 70E-491-02 for additional details on CICS.

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

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

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

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

Under DOS/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.

The new VS BASIC, announced with the VSPC time-sharing software, replaced the currently supported BASIC language for both batch and interactive processing. It can be used with CMS under VM/370, with the Time-Sharing Option (TSO) under OS/VS2, and in the batch mode of operation under all of the IBM virtual storage operating systems.

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.

VS APL, announced in December 1975, is an enhancement of APL/360 that executes under OS/VS1 or OS/VS2 and can also be used with the CMS component of VM/370. VS APL also includes the Data Analysis-APL Feature which allows use of the APL character set on the 3277 Model 2 Display Station and the APL Graphics Feature for the 3767 Communication Terminal.

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 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

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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 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 offered for use in conjunction with VTAM under DOS/VS as well as OS/VS. NCP/VS provides 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

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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. Also see 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 115-2 DISK SYSTEM: This typical Model 115-2 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 $6,900 and $233,925, respectively.

SMALL MODEL 125-2 DISK SYSTEM: Consists of 98K Model 125-2 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 $8,420 and $305,500, respectively.

MODEL 125-2 TAPE/DISK SYSTEM: Consists of 131K Model 125-2 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 $12,870 and $448,600, respectively.

MODEL 138 TAPE/DISK SYSTEM: Consists of 524K Model 138 Processing Unit with Integrated File Adapter and CRT console, 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 3286 Model 1 66 cps Printer. Monthly rental and purchase prices are approximately $22,500 and $703,770, respectively.

MODEL 148 TAPE/DISK SYSTEM: Consists of 1048K Model 148 Processor with Integrated File Adapter and CRT console, 3340 Direct Access Storage Facility (six drives, 420 million bytes), eight 3420 Model 3 Magnetic Tape Units (120KB) and dual-channel controls, 2540 Card Read Punch, 3211 Printer, and 3286 Model 1 66 cps Printer. Monthly rental and purchase prices are approximately $32,714 and $1,150,850, respectively.

MODEL 158-3 TAPE/DISK SYSTEM: Consists of 1048K Model 158-3 Processor with four Block Multiplexer Channels and one Byte Multiplexer Channel, 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 $70,900 and $2,330,100, respectively.

MODEL 168-3 TAPE/DISK SYSTEM: Consists of 2097K Model 168-3 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 $123,379 and $4,189,000, respectively.

WARRANTY: Most System/370 equipment is warranted for one year. Under the warranty terms, IBM will maintain the equipment in good working order or restore the machines to good working order in the event of a malfunction. In all situations of non-performance of IBM machines where repair, adjustment, or replacement does not cause the equipment to operate as warranted, IBM's liability for damages is limited to the greater of $100,000 or the purchase price of the stated machine.

MAINTENANCE: IBM offers both contract and on-call maintenance support. The basic monthly maintenance charge includes any period of 9 consecutive hours between 7:00 a.m. and 6:00 p.m. Monday through Friday. Customers may also purchase extended maintenance coverage that includes 12, 16, 20, or 24-hour coverage on weekdays, Saturdays, Sundays, and holidays. A premium is also charged for 9-hour, 5-day maintenance in which the 9-consecutive-hours period falls outside the 7:00 a.m. to 6:00 p.m. limits. The following table shows the percentage premium that is added to the basic monthly maintenance charge for extended maintenance coverage. Most System/370 equipment is in Machine Groups A and D.

PERCENTAGE PREMIUMS FOR EXTENDED MAINTENANCE COVERAGE

Monday through Friday

Machine Group	9 hrs.	12 hrs.	16 hrs.	20 hrs.	24 hrs.
A	10	14	18	22	26
B	10	16	22	28	34
C	10	19	28	37	46
D	10	12	14	16	18
Saturday					
A	4	5	7	8	9
B	5	6	8	10	11
C	8	9	11	13	15
D	4	5	7	8	9
Sunday					
A	5	7	9	11	12
B	6	8	10	12	14
C	9	11	14	16	18
D	5	7	9	11	12

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On-call maintenance service is charged at hourly rates that are shown in the following table. The majority of System/370 equipment is in Maintenance Class 3.

	Normal Working Hours	Outside Normal Working Hours
Class 1	$45.00	$53.00
Class 2	53.00	62.00
Class 3	60.00	70.00

In addition, DPD Systems Engineering Services (SES) are available at $50.00 per hour.

LEASE TERMS: The IBM *Agreement for Lease or Rental of IBM Machines,* instituted in April 1977, defines three usage plans by which monthly charges are determined. IBM assigns each machine to one of these three plans.

Plan A provides the customer with up to 176 hours of billable time per month. Time used in excess of that amount is charged at an hourly rate that is 1/176th of the Monthly Rental Charge (MRC) multiplied by the Additional Use Charge Percent (usually 10 percent).

Plan B includes unlimited usage of the unit in the Monthly Rental Charge or Monthly Lease Charge.

Plan C monthly charges are determined by multiplying the amount of *processing* performed by the machine (not the time in use) by the Monthly Use Charge specified for the particular unit. The processing is measured by a meter attached to the unit. The monthly charges include all equipment maintenance, insurance charges, and property taxes.

The most significant change brought about by the new agreement was the ability to include equipment with differing lease terms on a single lease contract and the special long-term lease plans that had been offered under several amendments to the previous lease agreement. Specifically, the Extended Term Plan (ETP), Fixed Term Plan (FTP), Term Lease Plan (TLP), and Alternate Term Plan (ATP) were discontinued. However, the new agreement permits lease terms similar to those of the discontinued plans to be routinely implemented. Customers with existing term plan agreements can continue with those contracts and extend them in accordance with their provisions. IBM has stipulated final termination dates beyond which none of these discontinued plans may be extended. These dates are listed below.

Extended Term Plan	April 3, 1980
Fixed Term Plan	April 3, 1981
Term Lease Plan	April 3, 1982
Alternate Term Plan	April 3, 1983

Customers having no new agreement after these dates will revert to the Monthly Availability Charge under the previous lease agreement.

PURCHASE OPTIONS: In August 1974, IBM extended its Purchase Option Plan to allow users renting 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. The 48-month Term Lease Plan also 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. Under terms of the new lease agreement, users purchasing their rented or leased systems may apply between 50 and 60 percent of the accumulated monthly charges to the purchase price. The specific percentage allowed is dependent upon the equipment.

SOFTWARE: IBM has five designations for its software products: System Control Programs (SCP), Program Product (PP), Application Programs (PPA), Field-Developed Programs (FDP), and Installed User Programs (IUP).

System Control Programs provide those functions which are fundamental to the operation and maintenance of a system (e.g., loader, scheduler, supervisor, and data management) and include the DOS/VS and OS/VS operating systems and the VM/370 Virtual Machine Facility. SCP's are provided to IBM customers at no charge and to non-IBM customers for nominal distribution costs (namely, the cost of the media and a duplication charge). IBM customers also receive full IBM software support, which includes all updates, temporary fixes, and generally all enhancements to the software packages.

SCP's are modified by Selectable Units (SU's), which are microcode packages that implement the same types of enhancements that were formerly provided by subsequent releases of software packages. At present, SU's are also provided at no charge, but only to IBM customers with the appropriate equipment.

Program service is still divided into three categories, but has been designated as Central Service, Local Service, and Local Assistance instead of the A, B, and C categories used in the old agreement. The Central Service offers software support similar to that of Category "B" in the previous agreement, and Local Service is similar in provisions to the "A" category. With Central Service, customers document software problems and submit them to specified IBM service locations for analysis. The service locations respond by issuing defect correction information, which may take the form of corrected code, a notice of availability of corrected code, correction documentation, or a bypass. Local Service includes support from IBM personnel who will either make a reasonable attempt to resolve the problem by applying a local fix or providing a bypass, or will document the defect and submit it for Central Service action. Local Assistance is similar in scope to Local Service but is subject to the *availability* of IBM personnel. Each of these service categories will be offered for one of three time periods: until discontinued by IBM upon six months notice, until a designated calendar date, or for a specified number of months.

Program Products include all language processors, communications support programs, and utility programs, and are licensed separately. Monthly license charges are listed under "Software Prices" and include full IBM software support. The MVS/System Extensions and the VM/System Extensions enhancements to the OS/VS2 (MVS) and VM/370 SCP's are designated as Program Products and are also licensed separately. Application Programs (PPA's) are problems and industry-oriented software packages that are also licensed separately, including full support. 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 $45.25 per hour.

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.■