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Systems

IBM 4300 Processors Summary and Input/Output & Data Communications Configurator

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Preface

This publication is intended to give a general understanding of the IBM 4300 Processors. It is divided into five sections:

- Sections 1 to 3 explain the concepts of the processors and give an overview of their structure and most important features.
- Section 4 describes the individual 4300 Processors.
- Section 5 presents the input/output and data communications configurator for the 4300 Processors.

Because each section is built on information presented in preceding sections, it is preferable to read the sections in the order of presentation. A basic knowledge of data processing systems, such as given in the *Introduction to IBM Processing Systems,* GC20-1684, is assumed.

The Processor Summary deals only with the components that make up the basic 4300 Processors. For information about attachable I/O devices, teleprocessing facilities and appropriate programming systems, please refer to the following IBM publications:

- *IBM Input/Output Device Summary,* GA32-0039
- *IBM Data Communications Device Summary,* GA27-3185
- *IBM Introduction to DOS/VSE,* GC33-5370
- *IBM Virtual Machine Facility/370: Introduction,* GC20-1800
- *IBM OS/VS1 Planning and Use Guide,* GC24-5090

More detailed information about 4300 Processors is given in the *IBM 4300 Processors Principles of Operation for ECPS:VSE Mode,* GA22-7070, and *IBM 4331 Processor Functional Characteristics and Processor Complex Configurator,* GA33-1526 (when available), and *IBM 4341 Processor Functional Characteristics and Processor Complex Configurator,* GA24-3672.

For information related to the System/370 mode of operation selectable on 4300 Processors, see *IBM System/370 Principles of Operation,* GA22-7000.

A list of abbreviations and a glossary of terms that do not appear in the *IBM Data Processing Glossary,* GC20-1699, is included.

Illustrations

Terms not included here are defined in the *IBM Data Processing Glossary,* GC20-1699.

CA	communications adapter
ECC	error checking and correction
I/O	input/output
op code	operation code

Instruction Formats

RR	register to register
RS	register and storage
RX	register and indexed storage
S	implied operand and storage
SI	storage and immediate operand
SS	storage to storage

Programming Systems, Subsystems and Languages

DOS/VS	disk operating system/virtual storage
DOS/VSE	disk operating system/virtual storage extended
ECPS	extended control program support
OS/VS1	operating system/virtual storage 1

alter/display: A function that allows data in certain storage areas to be displayed and altered at the operator console.

block multiplexing: The transmission of data to multiple I/O devices by the real-time interleaving of records in block form.

buffer storage: An area of storage set aside for temporary use to compensate for differences in the rate or time of data transmission.

byte multiplex mode: The transmission of data to multiple I/O devices by the real-time interleaving of bytes.

byte-oriented operand: A feature that allows certain operands to reside on any byte boundary.

clock comparator: A hardware feature that causes an interruption when the time-of-day clock has equaled or exceeded a specified value.

command retry: A channel and control-unit procedure that causes a command to be retried without requiring an I/O interruption.

commercial instruction set: A combination of instructions of the standard instruction set and the decimal instructions.

compatibility feature: A feature, also called an emulator, that allows an IBM system to execute programs written for another IBM system or device.

CPU timer: A hardware feature that measures elapsed processor time and causes an interruption when a previously specified amount of time has passed.

data acquisition and control: The process of identifying, isolating, and gathering source data and providing the correct facility for its transmission.

data transfer rate: The number of bytes (or packed decimal digits and signs) transferred per second.

decimal arithmetic: Arithmetic operations performed on decimal numbers.

error checking and correction (ECC): The detection, in the processor, and correction of all single-bit errors, plus the detection of double-bit and some multiple-bit errors.

extended control program support:DOS/VSE mode (ECPS:VSE mode): An implementation of the virtual storage concept that uses an internal table to map locations in virtual storage to the underlying processor storage.

extended floating-point number: A floating-point number with a 112-bit fraction. This is approximately 34-decimal-place precision.

extended-precision floating point: A facility that provides operations on extended floating-point numbers.

field length: The length of a specified area in a record used for a particular category of data.

fixed-length data format: format in which data is present in units of equal and unvarying length.

floating-point facility: A processor feature that has at its disposal four 64-bit floating-point registers and the instructions to perform floating-point arithmetic.

high-speed buffer storage: Storage that provides fast access to a block of instructions and operands fetched from processor storage.

interruption: The re-direction of processing of a program through an external or internal event, for example, because of the completion of data transfer from an I/O device.

interruption, classes of: The six classes of interruption are: program, supervisor call, external, restart, machine check, and I/O.

interruptions, disallowing of: The delaying or prevention of an interruption.

interval timer: A timer that reduces the contents of the fullword at location 80 (processor storage) at regular intervals. The interval timer causes a request for an external interruption when it steps from positive to negative.

I/O adapter: A part of some machines that allows specific I/O devices to be attached to the processor directly instead of by a separate channel and control unit.

I/O interface: The physical and the logical connection between the channel and the I/O control unit.

model-dependent: Relates to a program or procedure that requires the use of specific hardware.

nonshared subchannel: A division of a channel data path that can control only one I/O device.

operator's control panel: A panel, mounted on the console or processor, that provides the operator with manual control of the processor.

packed format: A data format in which a byte may contain either two decimal digits or one decimal digit and a sign.

processor storage: The storage where data and instructions actually reside when they are accessed by the processor and channel programs.

reloadable control storage: Storage used for microcode that controls the processor, plus channel functions and features. The microcode is loaded into the reloadable control storage from the diskette as an initial microcode load procedure.

selector mode: One of two modes in which a block multiplexer channel can operate, the other being multiplex mode.

shared subchannel: A division of a channel data path that can control one or more I/O devices.

storage access width: The number of bytes fetched each time processor storage is accessed.

storage cycle time: The time required to process a reference to processor storage.

subchannel: The channel facility required for sustaining a single I/O operation.

system diskette facility: A diskette I/O facility used to load microcode.

time-of-day clock: A clock in the machine that is used to indicate the date and time of day.

universal instruction set: A combination of instructions of the commercial instruction set and the floating point instructions.

unprivileged instruction: An instruction that is valid in both the problem and the supervisor states, as contrasted to a privileged instruction that is valid only in the supervisor state.

virtual address: An address that refers to virtual storage and must, therefore, be mapped to a location in processor storage when the address is used.

virtual storage: Addressable space that appears to the user as processor storage, from which instructions and data are mapped into processor storage locations. The size of virtual storage is limited by the addressing scheme of the computing system and by the amount of auxiliary storage available, rather than by the actual number of processor storage locations.

zoned decimal format: A data format in which a zone accompanies each decimal digit, except in the low-order byte position which is occupied by a sign and decimal digit.

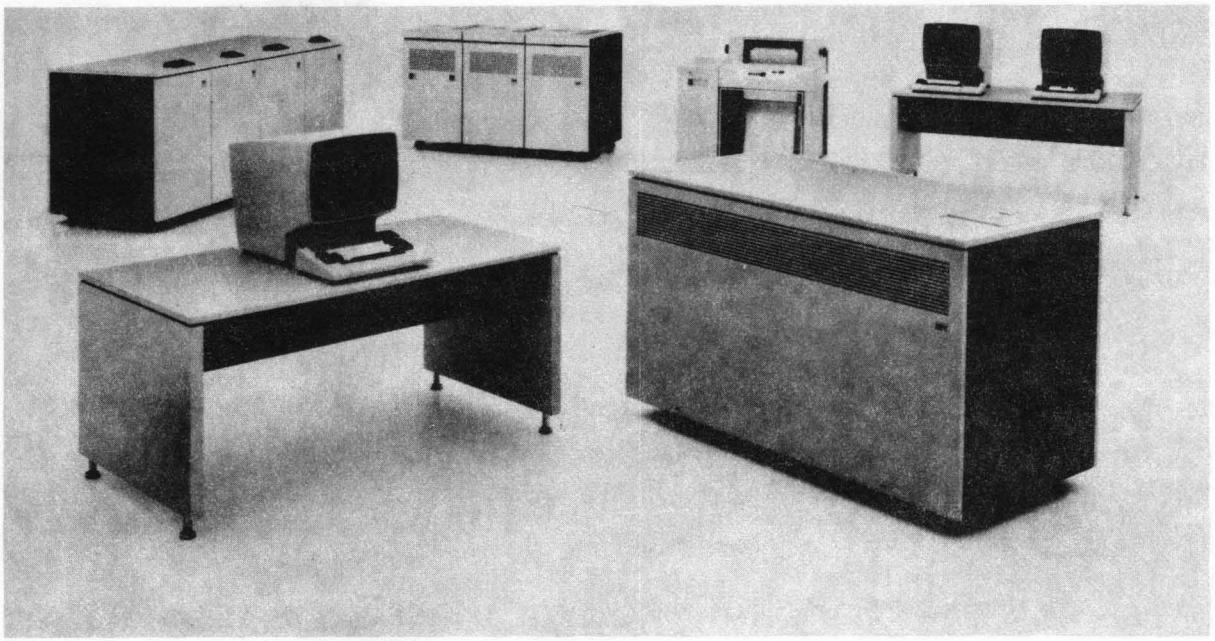

Figure 1-1 IBM 4331 Processor with Input/Output Devices.

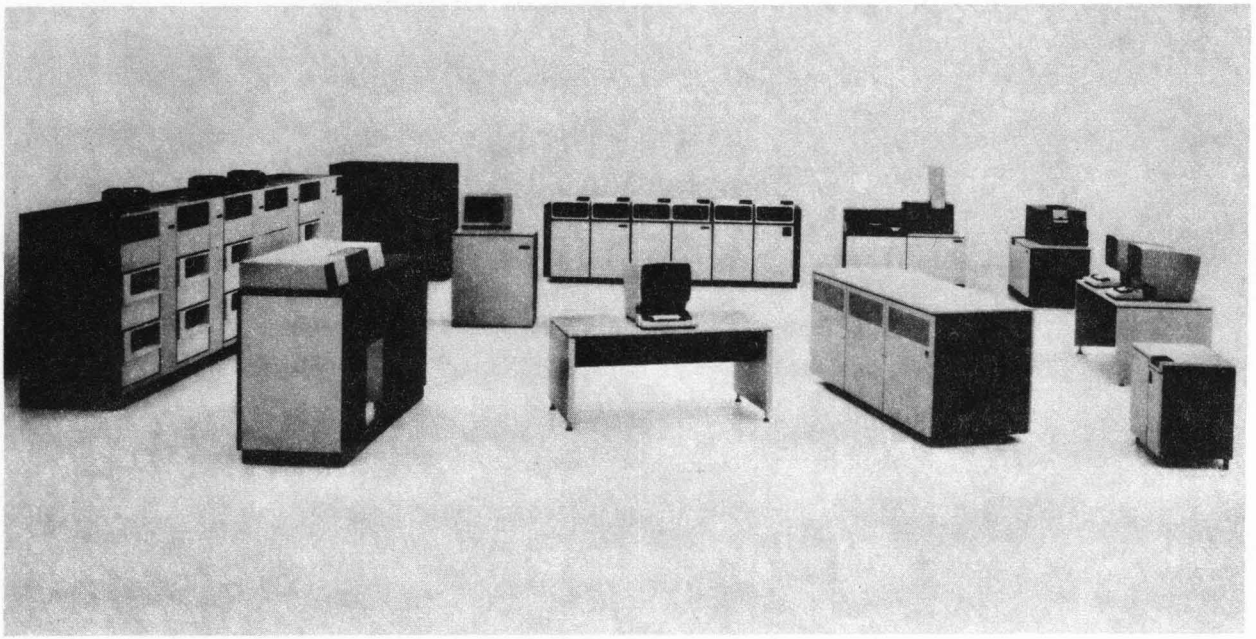

Figure 1-2 IBM 4341 Processor with Input/Output Devices.

The IBM 4300 Processors (Figures 1-1 and 1-2) are compact, general-purpose data processors for users who require a small to medium-sized installation. The 4300 Processors are compatible, which allows users freedom in varying the size and configuration of their installations to meet changing needs. Improved performance, ease of operation and increased flexibility are available through a variety of advanced features.

The 4300 Processors offer the following advantages compared with the System/370:

- Faster internal performance
- Increased processor storage
- Simpler storage mapping for DOS/VSE users
- Faster addressing of virtual storage by channels when DOS/VSE is used
- More economical use of floor space

Processor Concepts

The 4300 Processors present a new facility for controlling storage, available when DOS/VSE is used. This facility creates a single virtual storage of up to 16,777,216 bytes, which the processor and the channels address directly by one uniform set of virtual addresses. In contrast to the storage concept of the System/370, the virtual storage is mapped onto the actual storage of the machine by the hardware.

The storage-controlling facility of the 4300 Processors is associated with new instructions and interruptions by which the control program determines which parts of virtual storage have been made addressable. These instructions, interruptions, and internal machine procedures are available as an alternative to the dynamic address translation and channel indirect data addressing of System/370 (which are also available on the 4300 Processors).

The 4300 Processors also present a new status-saving function (machine save) which preserves the processor state and the first 2,048 bytes of storage. Machine save replaces the store status function of the System/370.

If multiple virtual storages are not required, the 4300 Processors offer the following benefits over the System/370:

- Simpler storage-mapping, with more of the function performed automatically.
- Improved control-program performance because the virtual addresses of channel programs are translated by hardware.

The programming of the 4300 Processors has been simplified in comparison to the System/370 by omitting a number of model dependencies and the following functions:

- Multiprocessing and associated instructions
- Machine-check logout and full channel logout

These model-dependent logouts are replaced by internal facilities for error diagnosis.

Modes of Operation

The two modes of operation available are ECPS:VSE and System/370 mode. The mode is selected at initial microcode load (IML) time.

ECPS:VSE Mode allows operation of an appropriately generated DOS/VSE.

System/370 Mode allows operation of any program written for System/370 and System/360 that follows the rules described in the section "Compatibility" of *IBM System/370 Principles of Operation,* GA22-7000. In this mode, two mutually-exclusive performance options are available.

ECPS:VS1 Assist, available on some 4300 Processors, is a hardware assist that reduces the processor time needed to execute certain frequently used supervisor functions in VS1.

ECPS:VM/370 Assist is a hardware assist that reduces the processor time needed to execute certain frequently used supervisor functions in VM/370.

The 4300 Processors are processors with storage, an operator console and input/output (I/O) devices. These I/O devices are attached to the processor either by *channels* (through control units and the standard I/O interface) or, on some processors, by *I/O adapters.* Whether local or remote, the I/O units operate under program control. The *IBM Input/Output Device Summary,* GA32-0039, gives detailed information about the local I/O devices that are attachable to 4300 Processors, and the *IBM Data Communication Device Summary,* GA27-3185, informs you about the remote devices that can be attached.

Figure 2-1 shows the organization of a typical installation with 4300 Processor.

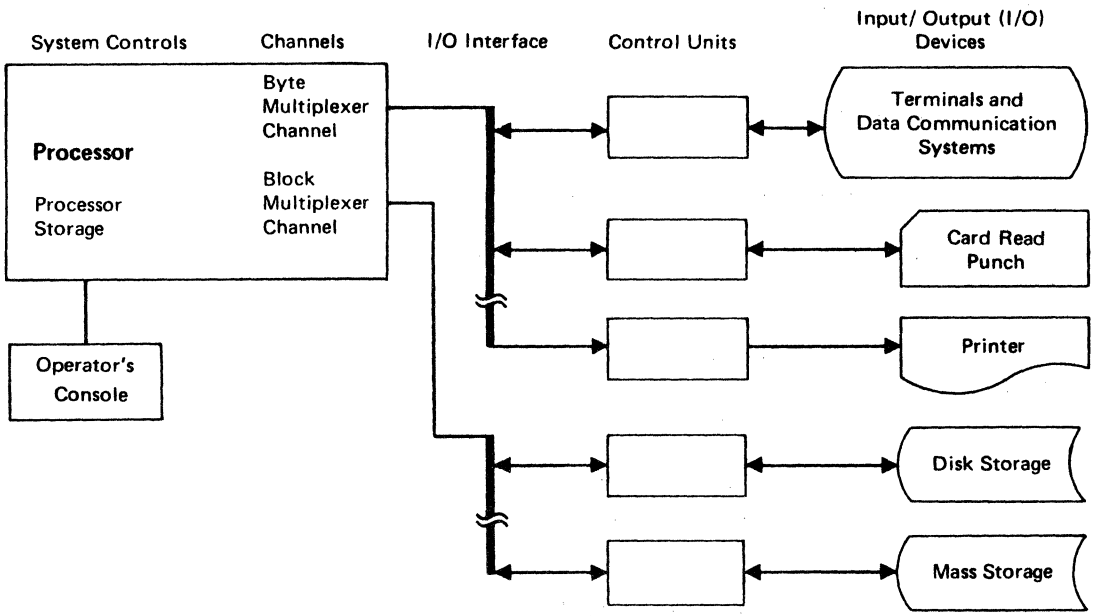

Figure 2 - 1. Organization of a Typical Installation with 4300 Processor

Machine Control

Operation is controlled by programs residing in storage, and by an operator console with control panel and keyboard/display that allows manual intervention by the operator.

Program Control

The information determining the state and controlling the operation of the processor resides in a program-status word and in control registers. Additional status and control information appears in permanently-assigned processor-storage locations.

Operator's Control Panel

The control panel gives the operator manual control of certain processor functions that cannot conveniently be handled by the regular keys on the keyboard/display. These controls include indicator lights and buttons.

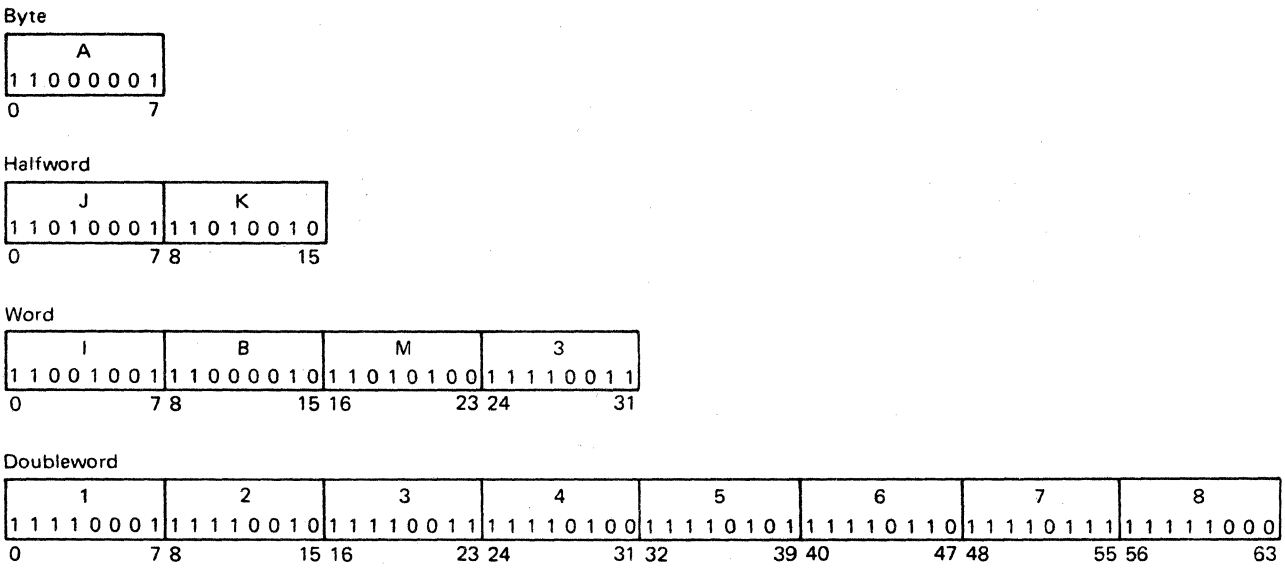

Figure 2 - 2. Basic Fixed - Length Data Formats (with EBCDIC - Coded Data)

Data Formats

The machine processes data in multiples of eight bits. Each eight-bit unit of data is called a *byte,* the basic building block of all formats in 4300 Processors.

A *field* is composed of one or more bytes. The *halfword, word* and *doubleword* are fields of consecutive bytes; a halfword has two bytes, a word has four bytes, and a doubleword has eight bytes. These fields make up the basic fixed-length data formats (Figure 2-2).

Data formats are either fixed-length or variable-length. During processing, the field length is either implied by the operation to be performed, or it is stated explicitly as part of the instruction.

Data Representation

In 4300 Processors, data (whether numeric, alphabetic, or alphameric) is processed in multiples of an eight-bit byte. The data may be in binary form (as numeric data for most scientific computations) or it may be in a binary *code.* Coding permits data to be represented by characters (for example, 1, 2, A, B and *) on devices such as card readers, visual display units, and printers. These devices are code-dependent; that is, their operation depends on the code used to represent the characters.

The eight-bit byte provides coding for as many as 256 characters, which allows for future code expansion and permits 4300 Processors to accept most current and future codes. The character code used internally and transmitted to and from I/O devices is the extended binary-coded-decimal interchange code (EBCDIC). The bit positions in EBCDIC (Figure 2-3) are numbered the same as those of bytes (left to right, 0-7).

Processor Storage

Processor storage provides the processor with fast-access data storage. Both data and programs must be loaded into processor storage (from input devices) before they can be processed. Processor storage is volatile, that is, the contents are lost during the power-down sequence.

Note: The term processor storage refers to the physical packaging of the storage. Some locations of processor storage are, however, reserved for special purposes and are not available to the program. When it is important to refer to the accessible storage, the term main storage is used.

Addressing

All byte locations in storage that are accessible to the program are consecutively numbered starting with 0; each number is the address of a different byte location. A group of bytes in storage is addressed by the lowest-numbered byte location of the group. The number of bytes in the group is either implied by the instruction format or explicitly defined by the instruction itself. The addressing arrangement uses a 24-bit binary address, which gives 4300 Processors the capability of addressing up to 16,777,216 bytes of storage.

EBCDIC Bit Order
0 1 2 3 4 5 6 7

Bit Positions 0123 — Bit Positions 4567

0123 \ 4567	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
0000																
0001																
0010																
0011																
0100	Blank										¢	.	<	(	+	|
0101	&										!	$	*	)	;	¬
0110	–	/										,	%	_	>	?
0111											:	#	@	'	=	"
1000		a	b	c	d	e	f	g	h	i						
1001		j	k	l	m	n	o	p	q	r						
1010			s	t	u	v	w	x	y	z						
1011																
1100		A	B	C	D	E	F	G	H	I						
1101		J	K	L	M	N	O	P	Q	R						
1110			S	T	U	V	W	X	Y	Z						
1111	0	1	2	3	4	5	6	7	8	9						

Figure 2-3. EBCDIC Character Codes (Excluding Control Characters)

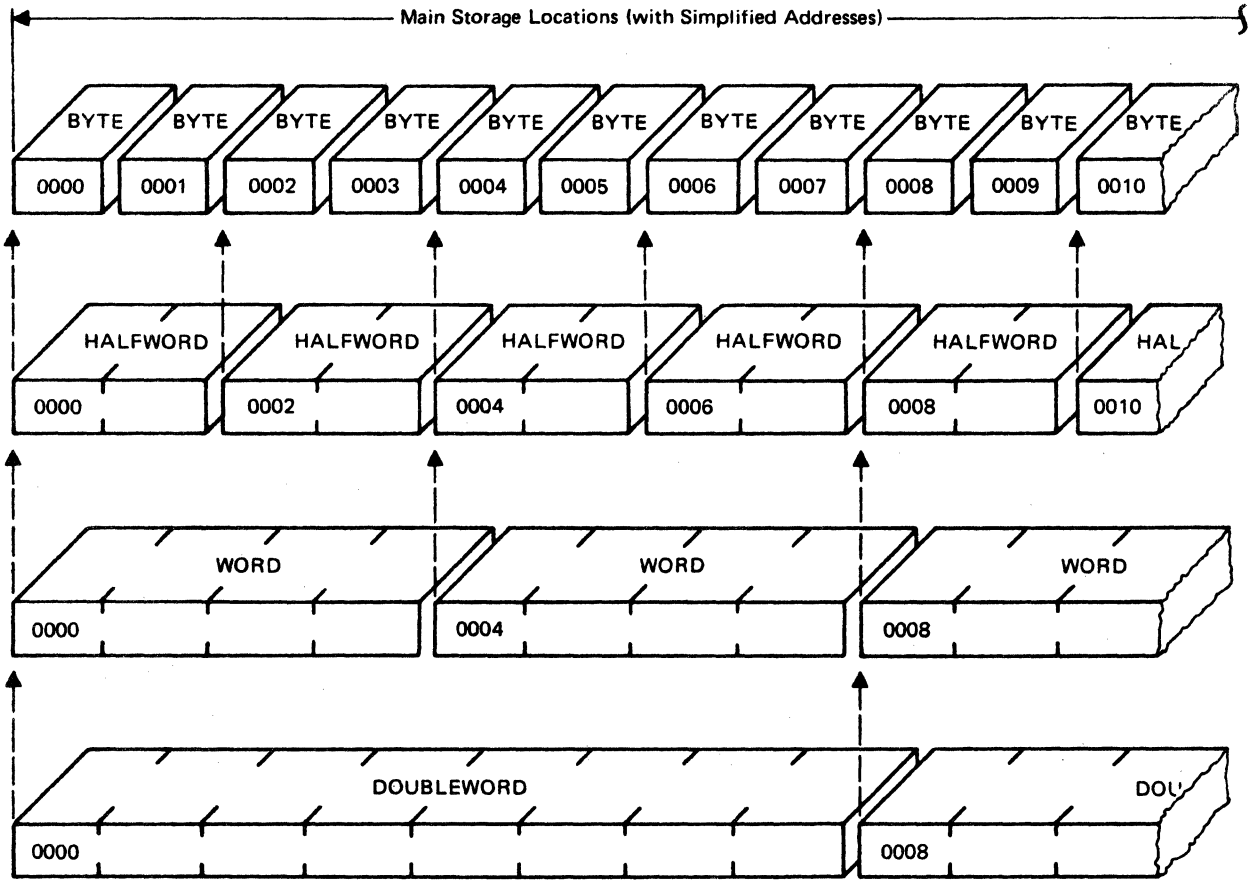

Figure 2 - 4. Principle of Integral Boundaries in Processor Storage

Data Positioning

Restrictions on data positioning in processor storage depend on several factors, such as whether the data field is *variable* or *fixed length.* With some exceptions, fields may be positioned on any byte boundary in processor storage. For good performance, it is generally advisable to position fixed-length fields on *integral boundaries,* so that unnecessary storage accesses are avoided. The *byte-oriented operand* function which is described in Section 3, allows most fixed-length fields to be positioned on byte boundaries rather than only on *integral boundaries.* Using other than integral boundaries affects performance because extra storage access is required.

A boundary is integral for a unit of data when its processor storage address is a multiple of that unit's length in bytes. For example, halfwords (two bytes) should have processor storage addresses that are multiples of 2. Figure 2-4 shows integral boundaries for the common units of data, with processor storage addresses as four-digit decimal numbers (0000, 0001, 0002, and so on) rather than as the 24-bit binary numbers that are actually used. Sequential addresses for halfword integral boundaries are shown in Figure 2-4 as 0000, 0002, 0004, etc. Words (four bytes) on integral boundaries have addresses that are multiples of 4 (shown in Figure 2-4 as 0000, 0004, 0008, etc), and doublewords (eight bytes) on integral boundaries have addresses that are multiples of 8 (shown in Figure 2-4 as 0000, 0008, etc).

Performance Factors

The storage units of 4300 Processors vary in capacities, access widths, and cycle times. Depending on the model, storage capacities range from 512K (524,288) bytes to 4,096K (4,194,304) bytes, some of which may, however, be dedicated to microcode. (In this manual, 1K=1,024.)

Storage Access Width is the number of bytes transferred to or from processor storage in each access. As access width increases, the quantity of data that may be transferred per unit time increases. The width for each processor is given in the description of individual processors in the section '4300 Processors'.

Storage Cycle Time is the length of time that processor storage is busy when a reference is made to it. Generally, the shorter the cycle time, the greater the number of operations that can be performed in any time interval. The storage cycle times are given in the description of individual processors in the section '4300 Processors'.

High-speed Buffer Storage is a buffer storage with a higher access rate than processor storage. It is used for storing blocks of instructions and operands. Once accessed, a block is kept in the buffer for as long as the access rate to that block justifies. There is thus a high probability that frequently used instructions and operands will be found in the high-speed buffer, with consequent benefits to performance.

Instruction Processing Functions

The processor is the controlling center of the installation. It provides facilities for:

- Addressing processor storage (described under 'Data Representation' and 'Addressing').
- Fetching and storing data.
- Arithmetic and logical processing of data.
- Executing instructions in a desired sequence.
- Initiating communication between processor storage and I/O devices.

Three types of programmable registers are provided by the processor: general, floating-point, and control. The 16 *general registers* and 4 *floating-point registers* are accessible to the problem programmer and are capable of receiving data, holding it, and permitting operations on it. The general registers are used primarily for binary (fixed-point) arithmetic, logical, and addressing operations. The floating-point registers are used only for floating-point arithmetic. The *control registers* provide for the handling of information used to control some processor operations. These registers are accessible to the control program by way of specific instructions.

Arithmetic and Logical Operations

The arithmetic and logical operations fall into four classes:

- Decimal (fixed-point) arithmetic
- Binary (fixed-point) arithmetic
- Floating-point arithmetic
- Logical operations

These classes differ in the data formats and field lengths used, in the registers involved, and in the operations provided.

Decimal Arithmetic

Decimal arithmetic, used principally for commercial applications, is performed on signed decimal data. Generally, decimal data entering and leaving the processor via devices such as card reader-punches and printers is in *zoned format* (Figure 2-5). For processing and for compact storage in direct access and magnetic-tape devices, however, decimal data is in *packed format* (Figure 2-6). Packing fits two decimal digits (or one digit and sign) per byte. Because only four bits are needed to express one decimal digit, packing permits more efficient handling of decimal data.

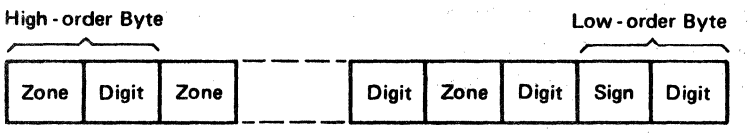

Figure 2 - 5. Zoned Decimal Number Format

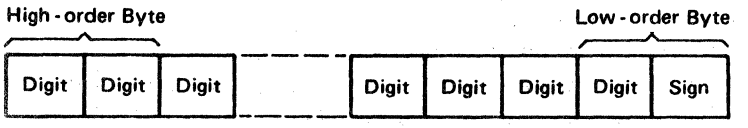

Figure 2 - 6. Packed Decimal Number Format

Packed data is taken from processor storage, processed, and returned to storage without the data passing through any general registers; this is called *storage-to-storage* processing. The decimal field length, specified by the instruction, can be as much as 31 digits and sign, all packed in up to 16 bytes.

Binary Arithmetic

Binary arithmetic is used to perform arithmetic operations both on data and on storage addresses. The basic arithmetic operand is the 32-bit signed binary integer (a 31-bit integer with a leftmost sign bit, as shown in Figure 2-7). Halfword operands can be specified in many operations where a fullword is not needed, thus improving the use of storage. Addition, subtraction, and comparison may also be performed on 32-bit unsigned binary integers.

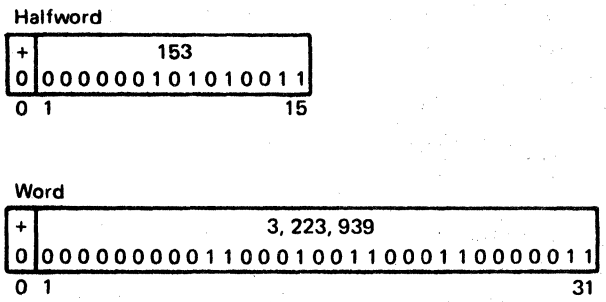

Figure 2 - 7. Binary Number Formats (with Signed Binary Data)

The 16 general registers, each 32 bits wide, are used for binary arithmetic operations. For full product and dividend precision two adjacent registers are coupled, effectively doubling the register width.

Floating-Point Arithmetic

Floating-point arithmetic, used primarily in scientific applications, greatly increases the speed, precision, and efficiency of computations. In 4300 Processors, this form of numeric representation can express positive or negative values from about 10^{-78} to about 10^{76}.

Floating-point numbers may be short (24-bit fractions, with about seven-decimal-place precision), long (56-bit fractions, with about 17-decimal-place precision), or extended (112-bit fractions, with about 34-decimal-place precision). Floating-point fractions are made up of hexadecimal (base 16) digits, each consisting of four bits and having equivalent decimal (base 10) values of 0-15. The *short format* (Figure 2-8) usually reduces execution times and increases the number of operands that can be stored, the *long format* (Figure 2-9) provides greater precision, and the *extended format* (Figure 2-10) provides twice the precision of the long format.

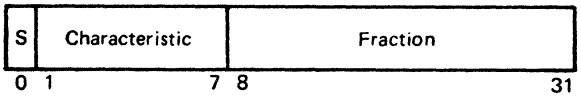

Figure 2-8. Short Floating-Point Number Format

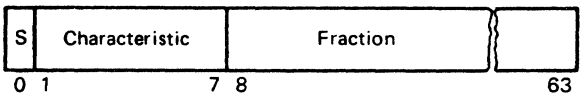

Figure 2-9. Long Floating-Point Number Format

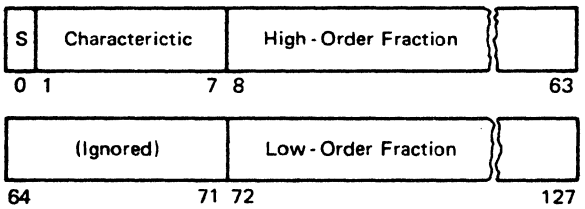

Figure 2-10. Extended Floating-Point Number Format

Four floating-point registers, each 64 bits wide, are provided. The availability of these registers eliminates much fetching and storing of intermediate results. The 16 general registers are also used, primarily for indexing and address arithmetic.

Logical Operations

The logical operations provide 4300 Processors with the ability to manipulate logical quantities. The manipulations include: comparing, testing, translating (character for character), editing (sign and punctuation control), and moving logical data. The data may have either a fixed- or variable-length format. (Figures 2-11 and 2-12). *Fixed-length data,* processed through the general registers, may be one, four, or eight bytes long; *variable-length data,* processed storage to storage, can extend to 256 bytes, even longer for some operations.

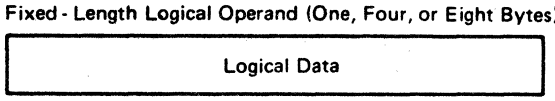

Figure 2-11. Fixed-Length Logical Format

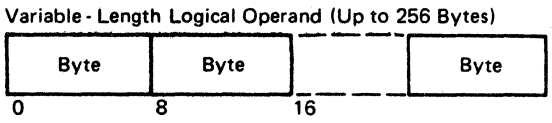

Figure 2-12. Variable-Length Logical Format

Instruction Execution Sequence

Normally the processor executes instructions in the order of their sequence in storage. A change in this sequential operation can be caused by using special instructions such as 'branch' instructions or by interruptions (see "Interruption System" in this section).

Instruction Formats

The processor accesses processor storage to obtain the instructions and operands needed to execute programs and to return the results. The instructions may be of several different formats, identified by the format codes RR, RX, RS, S, SI, and SS (Figure 2-13).

RR denotes a register-to-register operation. The operands are in general registers, and the result replaces the first operand.

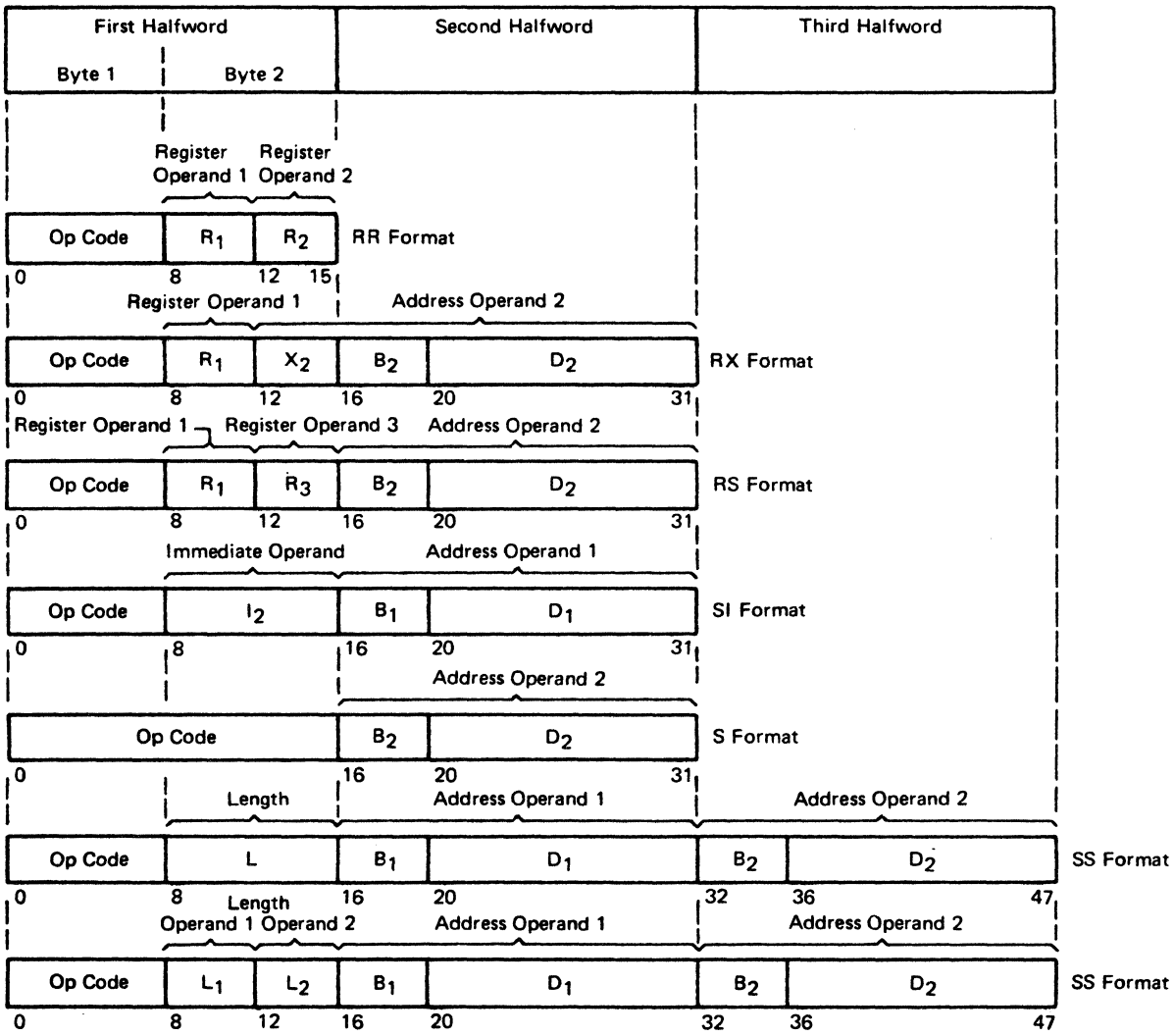

Figure 2-13. Basic Instruction Formats

RX denotes a register-and-indexed-storage operation. The first operand is in a general register, and the second operand is in a processor storage location. This format includes a quantity for indexing the processor storage address; the quantity is contained within a general register, which is used as an index register and specified by the instruction. The result of an RX operation may replace the first operand or the second operand, depending on the instruction.

RS denotes a register-and-storage operation. The first operand is in a general register, the second operand is in processor storage, and a third may be specified by another general register.

S denotes an operation using an implied operand and storage.

SI denotes an immediate-operand-and-storage operation. The first operand is one byte of data carried in the instruction itself (the immediate operand), and the second operand is in processor storage.

SS denotes a storage-to-storage operation. Both operands are in processor storage.

Generally, the first byte of each of these formats gives the operation code (the "op code"), which identifies the operation to be performed; for S-format instructions, however, the first *two* bytes may be used for the op code.

Input/Output

An input/output operation transfers data between processor storage and an I/O device. An I/O operation is initiated by a program instruction that addresses an I/O device and transfers a command to it. Direct-attached devices receive this command immediately; on channel-attached devices, a *control unit* receives the command via the standard I/O *interface,* decodes it, and starts the I/O device.

Channels

Channels direct the flow of data between processor storage and the I/O devices, thus enabling the processor to read, write and compute all at the same time by relieving the processor of direct communication with these devices. Channels communicate with I/O devices through control units.

The 4300 Processors have two types of channels: byte multiplexer channels and block multiplexer channels. Functionally, the channel data path is divided into *subchannels.* To a programmer, each subchannel is a separate channel, and can be programmed as such.

Some subchannels can control several I/O devices, whereas others can control only one; these are called *shared* and *nonshared* subchannels, respectively.

I/O Adapters

Some 4300 Processors can also have I/O devices attached by I/O adapters. The I/O adapter takes the place of both channel and control unit, but only for a limited type and number of devices.

Byte Multiplexer Channels

Byte multiplexer channels separate the operations of high-speed devices from those of lower-speed devices. High-speed devices operate in burst mode, low-speed devices operate in byte multiplex mode. The mode of operation is determined by the I/O device and the channel.

Byte multiplexer subchannels may operate in either byte or burst mode. In *byte multiplex* mode, the single data path of the channel can be shared by a large number of lower-speed I/O devices (such as card readers, printers, and terminals operating concurrently); the channel receives and sends data to the I/O devices on demand. *Burst* mode is forced by devices such as magnetic tape units or disks and is not under the control of the programmer. Such high-speed devices, having established a logical connection with a channel, usually stay connected to it for the duration of data transfer and thereby force the channel into burst-mode state.

Byte multiplexer channels may be of either the shared or nonshared type. In byte mode, each subchannel can operate one low- or medium-speed I/O device concurrently with the other subchannels, provided the total load on the channel does not exceed the channel capacity. In burst mode, one byte multiplexer subchannel monopolizes the byte multiplexer channel for the duration of a data transfer operation and operates one higher-speed I/O device.

Block Multiplexer Channels

Block multiplexer channels can concurrently operate many high-speed I/O devices on a single data path.

Block multiplexer channels operate either with block multiplexing inhibited or allowed. The inhibition of block multiplexing is functionally equivalent to selector channel operation, permitting attachment of all the I/O devices which can attach to selector channels. With block multiplexing allowed, these channels permit interleaving (multiplexing) of channel programs for high-speed devices in such a way that channel programs can be initiated sooner and channels can be freed earlier than would be possible with selector channels. The byte multiplexer channels differ primarily in that the block multiplexer channels can operate with much faster I/O devices, and they transfer larger quantities of data per transmission. These quantities are referred to as *blocks*, and may include a number of records.

Block multiplexer channels provide a number of subchannels of the shared or nonshared type. The maximum data rates for block multiplexer channels vary with the processors and channel options available.

I/O Devices

I/O devices fall into a number of categories, some of which overlap. They are used in and for:

- Auxiliary storage
- Machine and manual (keyed) input, both local and remote
- Teleprocessing
- Reading (or output) of external documents and displays
- Process control
- Data acquisition

Many I/O devices function with an external medium, such as a punched card or magnetic tape. Others handle only electrical signals, such as those in process-control and data acquisition systems.

Control Unit Function

The control unit function provides the logic circuitry and the storage areas (buffers) needed to operate the attached I/O devices. To the user, most control unit functions cannot be distinguished from I/O device functions.

The control unit function may be part of the I/O device or the processor (I/O adapters), or it can be a separate physical unit. Its effect is to change the standard signals on the channel to the specific signals needed by the I/O device.

Standard I/O Interface

The term standard I/O interface refers to the common command format and sequence of control signals that are used in exchanging data between I/O units and storage through channels and control units. The physical connection (cables with signal wires) is also called the standard I/O interface. The interface allows the exchange of I/O information independent of the type of I/O device connected. Certain I/O devices that do not use the standard I/O interface do, however, use the same command format and therefore appear to the programmer as channel-attached.

Interruption System

When a system resource requires attention, or when equipment or program errors occur, a control program is automatically called to handle the situation. This intervention is controlled in 4300 Processors by the interruption system via control registers and *program status words* (PSWs).

As soon as an interruption occurs, the *"old" PSW* containing status information and an identification of the cause of the interruption, are stored at a fixed location. The processor then automatically fetches a *"new" PSW* from a different fixed location. Each class of interruption uses two fixed PSW locations in processor storage: one to receive the old PSW when the interruption occurs, and the other to supply the new PSW that governs the servicing of that class of interruption.

After the interruption has been serviced, the processor is restored by the control program to the status it had before the interruption. For this purpose the old PSW is restored as *"current" PSW.*

Classes of Interruptions

The interruption system separates interruptions into six classes:

Program interruptions are caused by various kinds of programming errors or other conditions; the exact condition is identified in an interruption code.

Supervisor Call interruptions are caused when the program issues an instruction to pass control to the part of the control program, called the *supervisor,* which performs the supervisory functions associated with a task.

External interruptions are caused by certain external events, such as the time-of-day clock reaching a preset value, by the CPU timer going to zero after a preset interval of time, or by the operator pressing the interrupt key.

I/O interruptions are caused by an I/O unit ending an operation or otherwise needing attention. Identification of the device and channel causing the interruption is stored in the I/O old PSW or in a special storage location; in addition, the status of the device and channel is stored in a fixed location.

Machine Check interruptions are caused when the checking circuits detect an equipment malfunction.

Restart interruptions are caused by the operator activating the restart function at the keyboard.

Disallowing of Interruptions

Most interruptions may be either *allowed* or temporarily *disallowed.* Some are always allowed. When an interruption is disallowed, it is either delayed or does not take place, the outcome depending mainly on the class of interruption. The following interruptions can be disallowed:

- I/O interruptions
- External interruptions
- Some program interruptions
- Machine-check interruptions

Disallowed I/O or external interruptions remain pending. Disallowed machine-check interruptions remain pending or cause a check-stop, depending on severity.

Supervisor call interruptions, restart interruptions, and most program interruptions

cannot be disallowed and are always accepted.

Priority of Interruptions

During the execution of an instruction, several interruptive events may occur simultaneously. In this situation competing interruption requests are serviced in a fixed order of priority.

Storage Concepts

The 4300 Processors have a physical storage called *processor storage.* Processor storage is accessed by means of a mapping device which is used by one of the following two facilities:

- One-level addressing facility in ECPS:VSE mode to create a single virtual storage
- Dynamic address translation facility in System/370 mode to create a single or multiple virtual storages

Storage control therefore depends on the mode of processor operation.

Processor Storage

Processor storage is the physical storage where data and instructions reside at the time they are accessed by the processor and the channels. However, some processor storage may not be available to the user. In some processors, part of processor storage is used for microcode and address translation tables, the amount depending on the configuration. In the 4341 Processor, processor storage is supported by a high-speed buffer storage in which frequently used data and instructions are stored for high-speed access.

One-level addressing

One-level addressing is a storage-control facility, availaible in the ECPS:VSE mode, that allows both the processor and the channel programs to uniformly address a single virtual storage of up to 16M bytes. Virtual storage is normally larger than the underlying real storage. A supervisory control program is required for controlling which parts of virtual storage are currently mapped onto processor storage. This control is dynamic and transparent to the other programs except for the time delay caused by translation.

Dynamic Address Translation

Another storage control facility called *dynamic address translation* (DAT), compatible with System/370, and available in the System/370 mode, allows the processor to address multiple apparent storages of up to 16M bytes each. Thus,

one or more virtual storages map onto real storage, and real storage, depending on the model, either corresponds directly to or maps onto processor storage (where the program resides at execution).

The virtual storages can be accessed by the processor programs only. The channel programs can only access real storage. When dynamic address translation is not used in System/370 mode, there is no virtual storage, and all programs use real storage.

This section describes the more important standard functions and optional features of 4300 Processors, listed under the main elements of the processor.

Some features are standard for some 4300 Processors and optional for others, and some features are available to only certain processors. (See Section "4300 Processors" for the features available on a specific processor.)

Processor Storage Functions

Processor storage includes all storage where data and instructions reside when they are accessed by the processor or the channels.

Processor Storage Capacities

Processor storage capacities vary from 512K bytes (524,288 bytes) to 4M bytes (4,194,304 bytes), depending on the processor model. Processor storage also includes space for internal needs such as work areas, microcode, and the address translation table.

Storage Protection

Key-controlled storage protection (store and fetch) prevents the unauthorized changing or use of the contents of processor storage. *Store protection* prevents the contents of storage from being altered by storage addressing errors in programs or by input from I/O devices. *Fetch protection* prevents the unauthorized fetching of data and instructions from processor storage. As many as 16 processor storage areas can be protected at one time. The key-controlled storage protection function, including store protection and fetch protection, is standard on all 4300 Processors.

Protection is achieved by dividing storage into 2,048-byte blocks and by associating a *storage key* (Figure 3-1) with each block. The storage key contains four *access-control bits* and one *fetch-protection bit.* The storage key may be thought of as a lock. Each block of storage, therefore, has its own "lock". Two instructions are provided for assigning and inspecting the key, whose access-control bits form a four bit *code.* The same code may be used by many blocks, using binary values 0000-1111.

A user's right of access to storage is identified by a four-bit *access key* (Figure 3-1). The access key may be thought of as the key for the "lock". During a processor-storage reference (storing or fetching), the storage key is compared with the access key associated with the reference. Access to the location is granted only when the four access-control bits of the storage key match the access key, or when the access key is zero (0000). The fetch-protection bit of the stor-

age key determines whether fetch protection is operative for the storage block associated with that key. If the bit is 1, fetch protection is operative; if it is 0, it is inoperative.

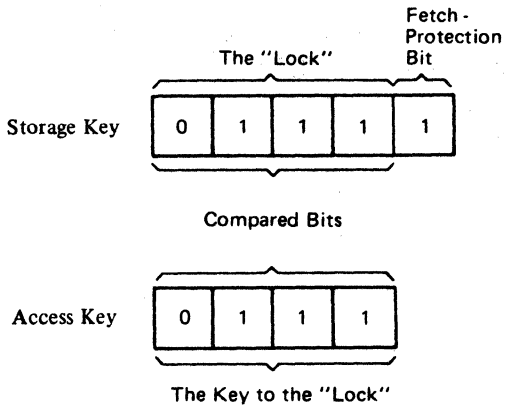

Figure 3 - 1. Storage Key and Access Key, Showing Matching Keys

Processor Functions

Instruction Sets

The 4300 Processors have three instruction sets: the standard, commercial, and universal (Figure 3-2).

The *standard instruction set* includes all instructions that are not part of any separately defined feature. These instructions provide the basic processing capability of the processors.

The *commercial instruction set* includes the standard instruction set and the decimal instructions.

The *universal instruction set* includes the commercial instruction set and the floating-point instructions.

The instruction set is fully described in the *IBM 4300 Processors Principles of Operation, for ECPS:VSE Mode,* GA22-7070, and in the *IBM System/370 Principles of Operation,* GA22-7000, for the System/370 mode.

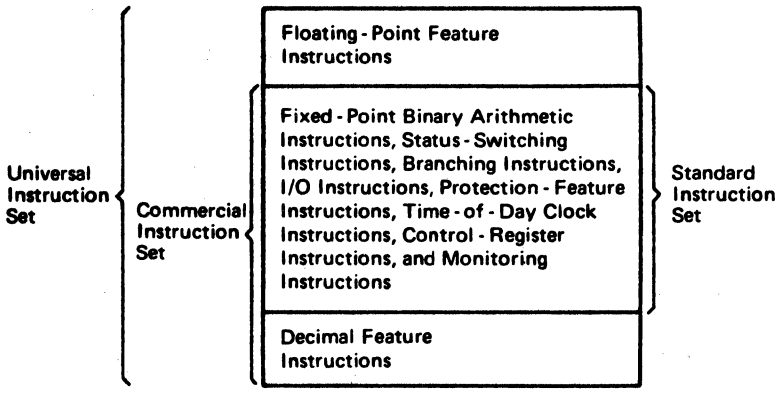

Figure 3 - 2. Instruction Sets for 4300 Processors

Time-of-Day Clock and Clock Comparator

The time-of-day clock provides a precise measure of time suitable for accurate elapsed time measurements and time-of-day indication. The clock's binary value, updated each microsecond in bit position 51, or the equivalent, can be interrogated or set by instructions. The total clock cycle is approximately 143 years.

The clock comparator is used to cause an external interruption when the time-of-day clock has reached a preset value.

CPU Timer

The CPU timer measures elapsed processing time with high resolution. It may be set by an instruction to the desired elapsed-time value. When the value is decremented to zero, an external interruption is generated.

Interval Timer

The interval timer occupies a fullword in storage that is decremented every 1/300 of a second. When the value reaches zero, an external interruption is generated.

Byte-Oriented Operand

Before describing this function, a distinction needs to be made between privileged and unprivileged instructions, some of which refer to fixed-length data fields. Essentially, *privileged* instructions are those used solely with control pro-

grams, whereas *unprivileged* instructions are used in processing or problem programs, as well as in control programs.

The byte-oriented operand feature removes the integral-boundary restriction from fixed-length fields referenced by most *unprivileged* instructions, permitting the fields to be located in processor storage on byte boundaries. Whenever possible, however, these fixed-length fields should be located on integral boundaries, because this gives optimum performance.

Extended Control Program Support: VSE Mode (ECPS:VSE Mode)

The ECPS:VSE mode provides a new simplified method of mapping virtual storage to the underlying processor storage. All storage addressing for both the processor and I/O channels is virtual. The unprivileged (problem-state) instructions in this mode are fully compatible with those of System/370.

This standard function of the 4300 Processors requires DOS/VSE for support.

System/370 Mode

The System/370 mode, which includes dynamic address translation, allows the user to address multiple virtual storages, each up to 16,777,216 bytes in size. In this mode, both the unprivileged (problem-state) and privileged (supervisor-state) instructions are fully compatible with those of System/370, so that all System/370 programs which comply with certain compatibility requirements can be run on a 4300 Processor.

Store Status and Program Reset

The store status and program reset facilities include a reset function that does not destroy the contents of the programmable registers and a store status function that places the contents of the programmable registers into processor storage. The store status function is available only in the System/370 mode.

Machine Save

The machine save function saves the current processor status and the status and contents of processor storage page zero for subsequent retrieval by programming. Machine save is available only in ECPS:VSE mode.

Basic Control Mode

Basic control (BC) mode provides a PSW format which is compatible with that of System/360.

Extended Control Mode

Extended control (EC) mode provides for an expanded PSW format, which is

used for all except System/360 programs.

Program Event Recording

Program event recording (PER), a debugging aid, is controlled by bit 1 of the EC-mode program status word (PSW). PER allows the program to be alerted to:

- Successful execution of a branch instruction
- Alteration of the contents of designated general registers
- Fetching of an instruction from the contents in designated locations of processor storage or alteration to them

Conditional Swapping

Conditional swapping, by means of the Compare and Swap (CS) and the Compare Double and Swap (CDS) instructions, provides for the controlled sharing of common storage areas by programs that operate in a configuration using multiprogramming.

PSW Key Handling

PSW key handling allows the four-bit PSW key, which is part of the current PSW, to be inserted into general register 2 by means of the Insert PSW Key (IPK) instruction; or the PSW key may be replaced by means of the Set PSW Key from Address (SPKA) instruction.

Clear I/O

Clear I/O allows the use of the Clear I/O (CLRIO) instruction, which causes the current operation with the addressed device to be discontinued and the state of the operation at that time to be indicated in the stored channel status word (CSW).

External Signal

The external signal feature provides external interruption lines which request and identify responses from the processor to interruptions signaled from external sources.

Channel Features

Channel-to-Channel Adapter

The channel-to-channel adapter available on some 4300 Processors provides a path for data transfers between two channels and synchronizes such transfers,

providing processors with inter-channel communication.

The channels are usually on separate processors. Connecting a channel of one processor to a channel of another has the effect of interconnecting two processors.

The adapter uses one or two control-unit positions on each of the two connected channels, but only one channel need have an adapter.

Channel Command Retry

Command retry, a control-unit-dependent feature on some channels of 4300 Processors, can cause a faulty channel command to be retried without requiring an I/O interruption. The number of retries is device-dependent.

Processor Features

Compatibility Features for other IBM Devices

Features are available for transferring programs written for existing IBM configurations to certain configurations of 4300 Processors. These programs are mainly channel programs for certain I/O devices and console devices that are configured on existing IBM systems but not on 4300 Processors. There is also a feature for running programs written for the 1400-series on the 4331 Processor.

4331 Processor

The 4331 Processor (Figure 4-1) is a medium-sized, general-purpose machine employing integrated circuitry and advanced processor design. It consists of a single processor with multiprogramming capability and can operate in either the *ECPS:VSE mode* with a single virtual storage of up to 16,777,216 bytes or in the *System/370 mode,* with multiple virtual storages of up to 16,777,216 bytes each. Either of these two operating modes can be selected by the operator. Other major functions and features of the 4331 Processor include:

- An attachment for an *operator console,* which consists of a display screen, a keyboard and control panel. This type of operator console provides ease and flexibility of operation.
- *I/O adapters* (direct attachments) for selected I/O devices, which can eliminate the need for channels and external control units, therefore increasing the compactness of the installation.
- An attachment for a *system diskette facility* associated with the operator console, for loading processor microcode, channel microcode, and diagnostic programs.
- An attachment for a *diskette 2D drive* which is available to the user as an I/O device.

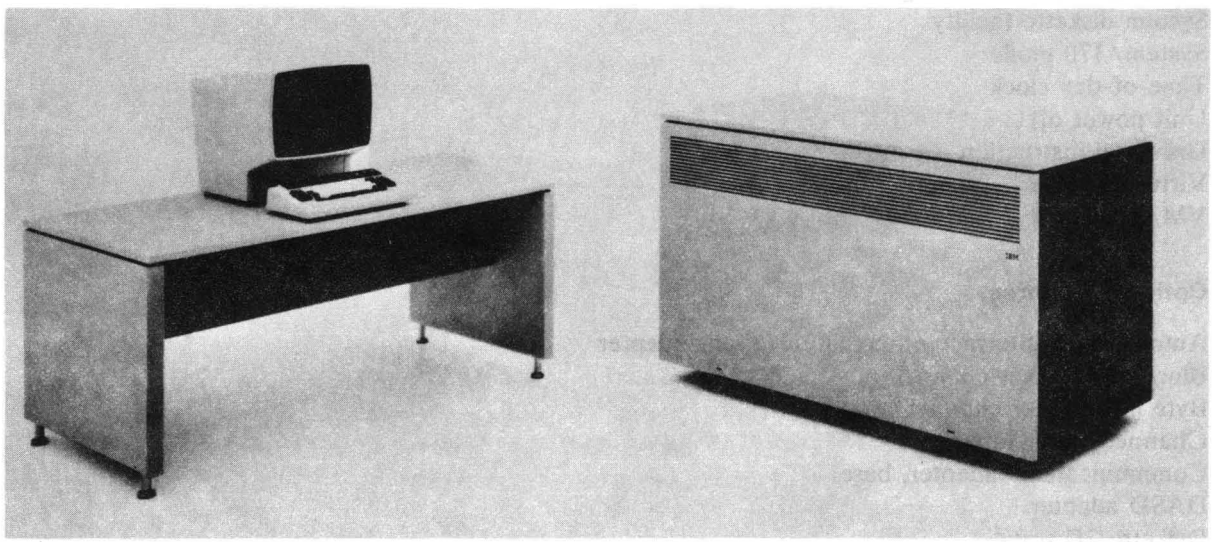

Figure 4-1 4331 Processor

Standard Functions

Audible alarm
Byte-oriented operands
Channel command retry on block multiplexer channel
Channel identification
Channel indirect data addressing in System/370 mode
Clock comparator
Control registers
CPU timer
Display/printer adapter
Display/printer adapter expansion
Dynamic address translation
EC and BC mode
Error checking and correction in processor storage
Extended control program support: VSE mode
Extended precision floating point arithmetic
Interval timer
Key-controlled storage protection
Machine check handling
Maintenance subsystem
Monitoring
Move inverse
OS/VS1 compatibility
Processor identification
Program event recording
PSW key handling
Reloadable control storage
System diskette facility
System/370 mode
Time-of-day clock
Unit power off
Universal instruction set
Virtual storage
VM/370 assist

Optional Features

Autocall unit interface on communications adapter
Block multiplexer channel
Byte multiplexer channel
Channel power interface
Communications adapter, base
DASD adapter
Diskette 2D drive
EIA/CCITT interface
External signal

High-speed modem adapter
Katakana workstation support
Line attachment base for clocked modems
Line attachment base for nonclocked modems
Local attachment interface
Printer-keyboard mode
System/3 data import mode
1200 bps integrated modem:
    Nonswitched
    Nonswitched with switched network backup and auto answer
    Nonswitched with switched network backup and manual answer
    Switched with auto answer
    Switched with manual answer
1401/1440/1460 compatibility feature
2311/2314/2319-3310 Direct Access Storage compatibility feature
3277 emulation on 3278 display
3340 direct attachment
5424 attachment
8809 Magnetic Tape Unit adapter

Prerequisite

IBM 3278 Model 2A Display Console.

Processor Components

The IBM 4331 Processor is a single processor, with its processor storage and a number of channels. The processor is the controlling center of the machine. It controls processor storage and uses microcode to execute instructions (control, general, floating point, decimal and I/O instructions). The microcode is loaded from the system diskette and stored partly in reloadable control storage and partly in processor storage.

I/O devices can be attached to the 4331 Processor in two ways: by *I/O adapters* which allow direct connection of I/O devices, and by *multiplexer channels* that allow connection of I/O devices via the I/O interface and control units.

Directly attached I/O devices are attached to the processor through the following: The direct access storage devices use the *DASD attachment:* the magnetic tape units use the *8809 Magnetic Tape Unit adapter:* the multi-function card unit is attached via the *5424 adapter:* teleprocessing lines are connected to the processor via the *communications adapter:* work stations and line printers are connected by the *display/printer adapter* and the display/printer adapter *expansion feature.*

The 4331 Processor can be fitted with two types of multiplexer channel: byte multiplexer and block multiplexer. The *byte multiplexer* channel is designed for concurrent operation of a large number of relatively slow I/O devices in byte interleave mode. The *block multiplexer* channel is designed for relatively fast devices that transfer blocks of data in bursts.

Instruction Sets

The universal instruction set is standard.

Error Checking and Correction

With the error checking and correction function in processor storage, single and double bit errors are automatically detected, and all single bit errors are corrected.

Processor Storage

Storage Capacity: The processor storage capacity of the Model I1 is 524,288 bytes and of the Model J1 is 1,048,576 bytes.
Storage Cycle Time: 0.9 microsecond for four bytes in the read cycle; 1.3 microseconds for four bytes in the write cycle.
Storage Access Width: The storage access width is four bytes.

Channels

When installed, the optional channels are incorporated in the processor. The 4331 can have one *block multiplexer* channel with 32 non-shared subchannels and eight shared subchannels. The data rate on the block multiplexer channel is up to 0.5 megabytes/sec.

The 4331 Processor can also have one *byte multiplexer* channel with up to 31 subchannels, of which eight can be shared. The number of subchannels in the byte multiplexer is reduced by two for the DASD adapter, two for the magnetic tape unit adapter, one for each CA line, and one for the block multiplexer channel. The byte multiplexer channel operates in interleaved mode at speeds of up to 18 kilobytes/second (kbs) in single byte mode, 36 kbs in dual byte mode, 62 kbs in 4-byte mode, and 0.5 megabytes/second in burst mode.

Basic Configuration

The minimum configuration for the 4331 consists of: the processor, an operator console, one direct access storage device, one line printer and one unit-record input device. If the 3310 is the only direct access storage device installed, one magnetic tape unit must also be available.

Processor Control

The controls of the processor are grouped at the operator console, which consists of a *display,* a *keyboard* and a *control panel.* From the console, the operator is able to start and stop the processor and to display and alter selected information in storage. After completing the initial microcode load (IML) procedure, the operator can load object programs from I/O devices via the keyboard and display.

The operator console of the 4331 Processor can be operated under the command set of the 3277/3278 Display Station or the 1052/3210/3215 Printer Keyboards. The command set is selected at IML time.

The operator console is controlled by the display/printer adapter.

DASD Adapter

The DASD adapter allows the direct attachment of up to 16 spindles of *IBM 3310 Direct Access Storage,* or, when the 3340/3344 direct attachment is installed, eight spindles of *IBM 3340/3344 Direct Access Storage.* A mixture of 3310s and 3340s is possible.

8809 Magnetic Tape Unit Adapter

The magnetic tape unit adapter allows the direct attachment of up to six *8809 Magnetic Tape Units* Model 1A, 2, and 3.

5424 Multifunction Card Unit Adapter

This adapter allows any model of the *IBM 5424 Multifunction Card Unit* to be attached directly to the 4331 Processor.

Communications Adapter (CA)

The CA allows the direct attachment of any combination of up to *eight teleprocessing lines,* using start/stop, synchronous data link control, or binary synchronous line control. Any two control procedures can be installed together. Operating speeds are up to 9600 bps, or up to 64,000 bps over the V35 interface (56,000 bps in USA).

Display/Printer Adapter

The display/printer adapter controls the operator console and up to seven devices (fifteen when the display/printer adapter expansion feature is installed). These devices include the *IBM 3278-2 Keyboard/Display,* the *IBM 3287 Terminal Printer* Model 1 or 2, and a maximum of two *IBM 3289 Printers* Model 4.

Programming Support

The 4331 Processor is supported by DOS, DOS/VS, DOS/VSE, OS/VS1, VM/370 systems and related user programs written to run on a System/370 machine.

Note: Please refer to your IBM representative for the appropriate release numbers.

4341 Processor

The 4341 (Figure 4-2) is a powerful and versatile performer as a commercial, scientific, data acquisition, teleprocessing, and general purpose processor. It offers virtual storage, System/370 compatibility, large scale integrated technology, and large processor storage. The processor is air-cooled. Arithmetic, logic and control functions are provided as well as storage, channels and diskette drive. (The diskette drive is not available to the user as an I/O device).

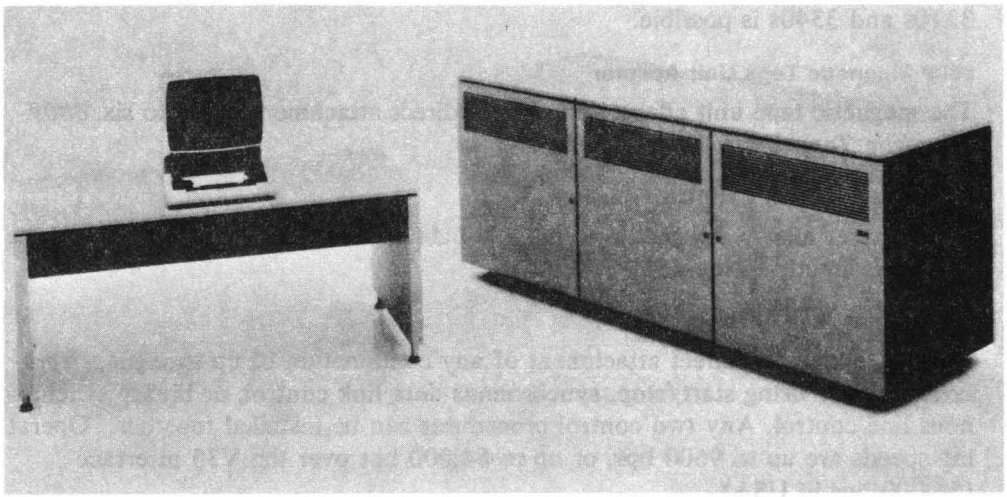

Figure 4-2 4341 Processor

Standard Features

Block multiplexer channels (two)
Byte multiplexer channel (one)
Byte-oriented operands
Channel command retry
Clock comparator and CPU timer
Control registers
CPU identification
Dynamic address translation
EC and BC modes
Error checking and correction in processor storage
Extended control program support: VSE Mode
Extended control program support: VM/370 Assist
Extended control program support: VS1 Assist
Extended precision floating-point arithmetic

External signal
High-speed buffer storage (cache)
Instruction retry
Interval timer
Key-controlled storage protection
Machine check handling
Program event recording
PSW key handling
Reloadable control storage
Support processor
System diskette drive
System/370 mode
Time-of-day clock
UCWs 128-1024
System/370 universal instruction set
Virtual storage

Optional Features

Three additional block-multiplexer channels
Channel-to-channel adapter
Channel control unit positions additional

Prerequisite

IBM 3278 Model 2A Display Console.

Processor Components

The 4341 Processor consists of a single processor with its processor storage and channels.

Channels

Six channels in two groups are available. Group 1 (standard) consists of one *byte multiplexer* channel and two *block multiplexer* channels. The latter have a block transfer rate of up to two million bytes per second for each channel. Group 2 (optional) consists of three block multiplexer channels. A single channel block transfer rate of up to two million bytes/second is available on two of the three optional channels and one million bytes/second on the other optional channel.

Channel-to-Channel adapter

One channel-to-channel feature is optionally available to interconnect two channels. The adapter uses one control unit position on each of the connected channels.

Console

The console provides for interaction with the 4341 Processor for operation and maintenance. The operator control panel is integrated into the primary display

console keyboard. The console is the means to turn power on and off, to perform initial microcode load (IML), initial program load (IPL), and to start and stop processor operations.

The console also allows the operator to manually control such functions as storage displaying and altering, address comparing, normal processing, or instruction stepping. The console indicates to the operator both proper operations and any malfunctions that occur.

For maintenance and service support the console can display and store the status of the 4341 Processor complex and other valuable servicing information. The console also provides a means for using diagnostic tools.

Two console modes are available: *display mode* and *printer-keyboard mode.* Three additional devices may be attached as optional consoles. They may be 3278 Model 2A Display Consoles without the operator control panel, or 3287 Terminal Printers Model 1 or 2, or any combination thereof.

System Diskette Drive

The system diskette drive allows both IML of system microcode and recording of errors for diagnosis.

Support Processor

The support processor provides for automatic analysis of failure symptoms. The result of this "self-diagnostic" is a processor- generated eight-digit *reference code* which contains information to guide the customer engineer to the failing unit. This reference code is not only logged on the system diskette, but is displayed on the display console to alert the operator.

Compatibility

Any program written for System/370 will operate on the 4341 Processor in System/370 mode, provided that it (1) is not time-dependent, (2) does not depend on system facilities (storage size, I/O equipment, optional features, etc.) being present when the facilities are not included in the configuration, (3) does not depend on features or facilities (interruptions, operation codes, etc.) being absent when the facilities are included in the 4341 Processor, and (4) does not depend on results or functions which are defined in the "Principles of Operations" to be unpredictable or model-dependent.

Any program written for the 4300 Processor in ECPS:VSE mode will operate on the 4341 Processor, provided that it follows the above rules.

Any program written for System/360 will operate on the 4341 Processor in System/370 mode, provided that it follows the above rules and does not depend on functions that differ between System/360 and System/370.

For more details, see the *IBM System/370 Principles of Operation,* GA22-7000, or the *IBM 4300 Processor Principles of Operation for ECPS:VSE Mode,* GA22-7070.

Programming Support

Programming support for the 4341 Processor is provided by DOS/VS, DOS/VSE, OS/VS1, and VM/370. For more information on programming support, refer to the appropriate programming publications.

Introduction

This configurator, intended as a guide and reference for system planners, provides information about the attachment of current local and remote input/output (I/O) equipment used in 4300 Processors. See the *IBM Input/Output Device Summary,* GA32-0039, for descriptions of input/output devices, and the *IBM Data Communications Device Summary,* GA27-3185, for descriptions of telecommunications devices.

Information on both locally and remotely attached equipment is presented in this configurator. The presentations are separated for clarity, and both are arranged in two ways: by equipment category (such as direct access storage devices, display devices, and printers) and by machine numbers (such as 2314, 3330, and 3420).

Local Input/Output Equipment

The following input/output (I/O) devices, control units and systems can be operated locally as part of some or all 4300 Processors (as described later in this manual). The equipment is arranged first by category, and then in chart form (by device or system number). The chart, together with the legend and notes that follow it, provides information about the local attachment of current IBM equipment.

Local Input/Output Equipment Categories

Audio Communications Devices

7770 Audio Response Unit Model 3

Auxiliary Processors

3838 Array Processor Models 1-3

Character Recognition Devices

1255 Magnetic Character Reader Models 1-3
1287 Optical Reader Models 1, 3 and 5
1288 Optical Page Reader Model 1
1419 Magnetic Character Reader Model 1
3881 Optical Mark Reader Model 1
3886 Optical Character Reader Model 1
3890 Document Processor Models A1-A6, B1-B6
3895 Document Reader/Inscriber Models 1 and 2

Control Units

2314 Storage Control Models A1 and B1
2803 Tape Control Models 1-3
2804 Tape Control Models 1-3
2821 Control Unit Models 1-3, 5 and 6
2822 Paper Tape Reader Control Model 1
2835 Storage Control Model 2
2840 Display Control Model 2
2841 Storage Control Model 1
3255 Display Control Model 1
3258 Control Unit Model 1
3803 Tape Control Models 1 and 2
3811 Control Unit Model 1
3830 Storage Control Models 2 and 3

Data Transmission Multiplexers/Controllers

2701 Data Adapter Unit Model 1
3272 Control Unit Models 1 and 2
3274 Control Unit Models 1A, 1B and 1D
3704 Communications Controller Models A1-A4
3705 Communications Controller. All models
3791 Controller Models 1C, 2A and 2B

Direct Access Storage Devices

2305 Fixed Head Storage Model 2
2311 Disk Storage Drive Model 1
2314 A-Series Direct Access Storage Facility:
    2312 Disk Storage Model A1
    2313 Disk Storage Model A1
    2318 Disk Storage Model A1
2314 B-Series Direct Access Storage Facility:
    2319 Disk Storage Models B1 and B2
3310 Direct Access Storage Models A1, A2, B1 and B2
3330 Disk Storage Models 1, 2 and 11
3333 Disk Storage and Control Models 1 and 11
3340 Direct Access Storage Facility Models A2, B1 and B2
3344 Direct Access Storage Models B2 and B2F
3350 Direct Access Storage Models A2, A2F, B2, B2F, C2 and C2F

Diskette Input/Output Devices

3540 Diskette Input/Output Unit Models B1 and B2

Display Devices

2250 Display Unit Models 1 and 3
3251 Display Station Model 1
3277 Display Station Models 1 and 2
3278 Keyboard/Display Models 1-4

3278 Model 2A Display Console

Magnetic Character Inscribers

(See Character Recognition Devices)

Magnetic Character Readers

(See Character Recognition Devices)

Magnetic Tape Devices

2401 Magnetic Tape Unit Models 1-6 and 8
2415 Magnetic Tape Unit and Control Models 1-6
2420 Magnetic Tape Unit Models 5 and 7
2816 Switching Unit Model 1
3410 Magnetic Tape Unit Models 1-3
3411 Magnetic Tape Unit and Control Models 1-3
3420 Magnetic Tape Unit Models 3-8
8809 Magnetic Tape Unit Models 1A, 2 and 3

Optical Readers

(See Character Recognition Devices)

Printers

1403 Printer Models 2, 7 and N1
1443 Printer Model N1
3203 Printer Model 5
3211 Printer Model 1
3284 Printer Model 1 and 2
3286 Printer Model 1 and 2
3287 Terminal Printer Model 1 and 2
3288 Line Printer Model 2
3289 Line Printer Model 1, 2 and 4
3800 Printing Subsystem Model 1

Punched Card Devices

1442 Card Read Punch Model N1
1442 Card Punch Model N2
2501 Card Reader Models B1 and B2
2520 Card Read Punch Model B1
2520 Card Punch Models B2 and B3
2540 Card Read Punch Model 1
3505 Card Reader Models B1 and B2
3525 Card Punch Models P1-P3
5424 Multifunction Card Unit Models A1 and A2,
(Japan only: Models K1-K3)

Punched Tape Devices

2671 Paper Tape Reader Model 1

Systems

3250 Graphics Display System
3270 Information Display System
3790 Communication System
3850 Mass Storage System

Attachment Data for Local I/O Devices and Control Units

Input/output Device or Control Unit				*Means of Attachment to 4300 Processor*		*No. of I/O Devices or Lines*
No.	*Models*	*Name*	*Attaches to*	*4331*	*4341*	*Attachable*
1255	1-3	Magnetic Character Reader	S/360/370 Adapter	m	b*m*	1 per system
1287	1,3	Optical Reader	--->	b*m*	b*m*	8 per system
	5	Optical Reader	--->	b*m*	b*m*	*D
1288	1	Optical Page Reader	--->	b*m*	b*m*	8 per system
1403	2,7,N1	Printer	2821-1,-2,-3, -5	*b*m *M	*b*m	*R
1419	1	Magnetic Character Reader	S/360 Adapter (#7720)	m	b*m*	*D
			S/360 Adapter (# 7730)	m	m	*D
1442	N1	Card Read Punch	--->	b*m*	b*m*	*D
	N2	Card Punch	--->	b*m*	b*m*	*D
1443	N1	Printer	--->	b*m*	b*m*	*D
2250	1	Display Unit	--->	m	b*m*	*D
	3	Display Unit	2840-2	b*m*	b*m*	4 per 2840
2305	2	Fixed Head Storage *N	2835-2	-	See 2835-2	2 per 2835
2311*	1	Disk Storage Drive	2841-1	b	b	8 per 2841 *S
2312*	A1	Disk Storage	2314-A1	See 2314-A1		*H
2313*	A1	Disk Storage	2314-A1	See 2314-A1		*H
2314*	A-Series	Direct Access Storage Facility *H	--->	b	b	9 drives *D
	B-Series	Direct Access Storage Facility	--->	b	b	9 drives *I
	A1	Storage Control	--->	See 2314 A-Series		9 drives *H
	B1	Storage Control	--->	See 2314 B-Series		9 drives *I
2318*	A1	Disk Storage	2314-A1	See 2314 A-Series		*H
2319*	B1	Disk Storage	2314-B1	See 2314 B-Series		*I
	B2	Disk Storage	2314-B1 (via 2319-B1)	See 2314 B-Series		*I

Input/output Device or Control Unit				*Means of Attachment to 4300 Processor*		*No. of I/O Devices or Lines*
No.	*Models*	*Name*	*Attaches to*	*4331*	*4341*	*Attachable*
2401	1-3	Magnetic Tape Unit	2803/04-1,-2	bm	b	*L
	4,5	Magnetic Tape Unit	2803/04-2	bm	b	*L
	6	Magnetic Tape Unit	2803/04-2	bm	b	*L
	8	Magnetic Tape Unit	2803/04-3	bm	b	*L
2415	1-6	Magnetic Tape Unit and Control	--->	bm	b	*D
2420	5,7	Magnetic Tape Unit	2803-2	bm	b	*L
2501	B1,B2	Card Reader	--->	bm	bm	*D
2520	B1	Card Read Punch	--->	bm	bm	*D
	B2,B3	Card Punch	--->	bm	bm	*D
2540	1	Card Read Punch	2821-1,-5,-6	bm	bm	*R
2671	1	Paper Tape Reader	2822-1	bm	bm	1 per 2822
2701	1	Data Adapter Unit	--->	bm	bm	4 lines max
2803	1-3	Tape Control *K	--->	See 2401 and 2420		*L
2804	1-3	Tape Control *K	--->	See 2401 (4341 only)		*L
2816	1	Switching Unit	2803-1, 2	bm	b	*T
2821	1-3,5,6	Control Unit	--->	See 1403 and 2540		*R
2822	1	Paper Tape Reader Control	--->	See 2671		1 2671
2835	2	Storage Control	--->	-	b	2 per channel
2840	2	Display Control	--->	See 2250-3		4 2250-3's
2841*	1	Storage Control	--->	See 2311		*S
3203	5	Printer and Control	--->	bm	bm	*D
3211	1	Printer	3811-1	bm	bm	1 per 3811
3250		Graphics Display System	3258-1	See 3258-1		
3251	1	Display Station	3255-1,3258-1	See 3258-1		2 per 3255
3255	1	Display Control Unit	3258-1	See 3258-1		4 per 3258
3258	1	Control Unit *G	--->	b	b	
3270	-	Information Display System	--->	See 3272		*O

Input/output Device or Control Unit				*Means of Attachment to 4300 Processor*		*No. of I/O Devices or Lines*
No.	*Models*	*Name*	*Attaches to*	*4331*	*4341*	*Attachable*
3272	1,2	Control Unit	--->	*b*m *M	*b*m	*O
3274	1A,1B,1D	Control Unit	--->	*b*m	*b*m	*O
3277	1,2	Display Station	--->	See 3270		*O
3278	1-4	Keyboard/Display	3274	*b*m	*b*m	*O
	2	Keyboard/Display	--->	i	-	*Q
	2A	Display Console	--->	i	i	*Q
3284	1,2	Printer	3272, 3274	See 3272, 3274		*O
3286	1,2	Printer	3272, 3274	See 3272, 3274		*O
3287	1,2	Terminal Printer	3272, 3274	See 3272, 3274		*O
	1,2	Terminal Printer	--->	i	i	*Q
3288	2	Line Printer	3272, 3274	See 3272, 3274		*O
3289	1,2	Printer	3274	See 3274		*O
	4	Printer	--->	i	-	*Q
3310	A1, A2	Direct Access Storage	--->	i	-	*E
3330	1,2,11	Disk Storage	3333-1,11	See 3333-1,11 (4341 only)		3 per 3333
3333	1,11	Disk Storage and Control	3830-2,3	-	b	*C
3340	A2	Direct Access Storage	3830-2	-	b	4 per 3830 *B
			--->	i	-	*B
	B1,B2	Direct Access Storage	3340-A2	See 3340-A2 (4341 only)		3 per 3340 *B
			--->	i	See 3340-A2	*B
			--->	i	-	*A
3344	B2,B2F	Direct Access Storage	3340-A2	See 3340-A2 (4341 only)		3 per 3340 *B
3350	A2,A2F	Direct Access Storage	3830-2	-	b	*J
	B2,B2F	Direct Access Storage	3350-A2,-A2F	See 3350-A2,A2F (4341 only)		*J
	C2,C2F					*J
3410	1	Magnetic Tape Unit	3411-1	bm	b	3 per 3411-1
	2	Magnetic Tape Unit	3411-2	bm	b	5 per 3411-2
	3	Magnetic Tape Unit	3411-3	bm	b	5 per 3411-3
3411	1-3	Magnetic Tape Unit and Control	--->	bm	b	*D
3420	3,5,7	Magnetic Tape Unit	3803-1,2	b	b	*L
	4,6,8	Magnetic Tape Unit	3803-2	b	b	*L
3505	B1,B2	Card Reader	--->	*b*m *M	*b*m	*D
3525	P1-P3,	Card Punch	3505-B1,B2	*b*m *M	*b*m	*D

Input/output Device or Control Unit				*Means of Attachment to 4300 Processor*		*No. of I/O Devices or Lines*
No.	*Models*	*Name*	*Attaches to*	*4331*	*4341*	*Attachable*
3540	B1,B2	Diskette Input/Output Unit	--->	bm	bm	*D
3704	A1-A4	Comm. Controller	Chan Adptr Type 1	m	m	32 lines
3705	All	Comm. Controller	Chan Adptr Type 1	m	m	352 lines
			Chan Adptr Type 2,3 *P	m	*b*m	352 lines
3790		Communications System	--->	See 3791		
3791	1C,2A,2B	Comm. Controller	--->	m	m	*D
3800	1	Printing Subsystem	--->	*b*m	*b*m	*D
3803	1,2	Tape Control	--->	See 3420		*L
3811	1	Control Unit	--->	See 3211		1 3211
3830	2	Storage Control	--->	See 3330,3333, *B 3340,3350 (4341 only)		
	3	Storage Control	--->	See 3333,3851 (4341 only)		*C
3838	1-3	Array Processor	--->	-	b	*D
3850		Mass Storage System	--->	See 3851 (4341 only)		*C
3851	A1-A4 B1-B4	Mass Storage Facility	3830-3	-	b	*C
			--->	-	b*m*	*C
3881	1	Optical Mark Reader	--->	m *M	m	*D
3886	1	Optical Character Reader	--->	b*m* *M	b*m*	*D
3890	A1-A6 B1-B6	Document Processor	--->	*b*m	*b*m	
3895	1,2	Optical Reader/ Inscriber	--->	m	m	
5424	A1,A2 K1-K3,	Multifunction Card Unit	--->	i	-	1 per system *U
7770	3	Audio Response Unit	--->	m	m	48 lines
8809	1A, 2, 3 B1,B2	Magnetic Tape Unit	--->	i	-	*F

Legend

i	I/O adapter
b	Block multiplexer channel
m	Byte multiplexer channel
b*m*	Italics denote preferred channel for attachment.
--->	See information in the "Means of Attachment" column
-	Not applicable
*	May not be available

Notes on Local Equipment

*A When the DASD attachment and the System/3 data import feature are installed in the 4331 Processor, 3348 data modules recorded on an IBM System/3 Model 12 or 15 can be read into storage. Writing on the 3348 modules is not possible.

*B The 3340-A2 and -B2 each have two disk drives; the 3340-B1 has one. The 3344-B2 and -B2F each have two disk drives. Generally, a 3340-A2 can attach a total of three 3340-B1s and/or -B2s and, in certain configurations, 3344-B2s and/or -B2Fs, for a maximum of eight drives per string. One or two 3344-A2s can be attached to a 3830 Storage Control Model 2.

*C The 3330 and 3333 Models 1 and 11 have two disk drives, and the 3330 Model 2 has one. One 3333 can attach up to three 3330s for a maximum of eight drives per 3333. Up to four 3333s can attach to a 3830-3.

*D No special restrictions; depends on the number of available system channel control unit positions and, for some units, on channel loading considerations.

*E A maximum of four 3310 strings (each with two or four spindles) can be attached to the DASD adapter.

*F A maximum of six 8809s can be attached to the 8809 adapter.

*G Operates in selector mode, not in block multiplex mode.

*H A 2314 A-Series Direct Access Storage Facility (DASF) consists of a 2314 Storage Control Model A1 and combinations of Model A1 units of 2312, 2313, and 2318 Disk Storage, forming a single interconnected unit. Each 2312-A1 provides one disk storage drive, each 2313-A1 four drives, and each 2318-A1 two drives. A full-configuration 2314 A-Series, which consists of two 2313s and one 2312, has eight drives and one spare.

*I A 2314 B-Series Direct Access Storage Facility consists of a 2314 Storage Control Model B1, one 2319 Disk Storage Model B1, and up to two units of 2319 Disk Storage Model B2, forming a single interconnected unit having

three, six, or nine (eight active, one spare) disk drives. Each 2319-B1 and -B2 has three drives.

*J The 3350-A2, -A2F, -B2, -B2F, -C2, and -C2F each have two drives. A 3350 string can be formed by attaching one of the two following combinations to a 3350-A2 or -A2F for a maximum of eight drives: (1) up to three 3350-B2 or -B2F units or (2) one or two 3350-B2 or -B2F units and (at the end of the string) one 3350-C2 or -C2F unit. As many as four 3350 strings can be attached to a 4341 Processor through the 3830-2 Storage Control.

*K The 2803 is a single-channel control unit; the 2804 is a two-channel control unit. A 2804 requires one control-unit position on each of two channels in the same system.

*L Up to eight:

800-bpi drives (2401-1 to -3) per 2803-1 or 2804-1.
800- and 1600-bpi drives (2401-1 to -6 and 2420-5, -7) per 2803-2.
800- and 1600-bpi drives (2401-1 to -6) per 2804-2.
800- and 1600-bpi drives (3420-3,-5,-7) per 3803-1 or -2.
2401-8's per 2803-3 or 2804-3.
6250-bpi or 6250/1600-bpi drives (3420-4,-6,-8) per 3803-2.

The 3803 tape switching features permit switching of as many as sixteen 3420s among two, three, or four 3803s.

*M Must be set to burst mode when attached to byte multiplexer channel.

*N One or two modules of 2305 Fixed Head Storage and a 2835 Storage Control form a 2305 Fixed Head Storage facility, a single interconnected unit.

*O A locally attached 3270 Information Display System has a 3272 Control Unit Model 1 or 2 that directs the operation of various combinations of up to thirty-two 3277 Display Stations Models 1 and 2, 3284 and 3286 Printers Models 1 and 2, and 3288 Line Printers Models 2. The 3272-1 controls only Model 1 devices, but the 3272-2 controls both Model 1 and 2 devices.

Through the 3274, up to 32 of the following terminals can be controlled.

3277-1,2 Display Station
3278-1,2,3,4 Display Station
3284-1,2 Printer
3286-1,2 Printer
3287-1,2 Printer
3288-2 Line Printer
3289-1,2 Line Printer

*P Neither channel adapter type 2 nor channel adapter type 3 attaches to 3705-A1, -B1, -C1, or -D1.

*Q The 4341 Processor allows for the direct attachment of the prerequisite 3278 Model 2A Display Console, and three additional devices as optional consoles. The additional devices may be 3278-2As without the operator's control panel, or 3287-1 or -2 terminal printers, or any combination thereof.
The display/printer adapter on the 4331 Processor allows for attachment of the prerequisite 3278-2A display console and up to seven (fifteen with optional feature) of the following devices:

3278-2	Display Station
3287-1,2	Terminal Printers
3289-4	Printers

Any combination is allowed, provided (1) only seven (with optional feature, fifteen) devices are installed, and (2) no more than two 3289s are installed.

*R One 1403 and one 2540 per 2821-1.
One 1403 per 2821-2.
Two (or, with a third printer control, three) 1403s per 2821-3.
Two (or, with a third printer control, three) 1403s and one 2540 per 2821-5.
One 2540 per 2821-6.

*S The basic 2841 can control as many as eight 2311s.

*T The 2816 permits switching of as many as eight magnetic tape drives (2401 Models 1-6 and 2420s) among four 2803s. With a second 2816 and 16-drive addressing, 4,8,12 or 16 drives can be switched among two, three, or four 2803s.

*U 5424-K1, K2 and K3 are for Japan only.

Remote Input/Output Equipment

The following IBM equipment can be operated in a data communications environment as part of some or all 4300 Processors (as described later in this manual). They are arranged first by category, and then in chart form (by device or system number). The chart, together with the legend and notes that follow it, provides information about the remote attachment of current IBM equipment.

Remote I/O Equipment Categories

Audio Communication Devices

7770 Audio Response Unit Model 3*

Control Units for Display Devices

3271 Control Unit Models 1, 2, 11 and 12
3274 Control Unit Model 1C
3276 Control Unit Display Station Models 1-4 and 11-14

Data Encryption Devices

3845 Data Encryption Device Models 1-3 and 11-13
3846 Data Encryption Device Models 1-3, 12 and 13

Data Terminal Devices

1001 Data Transmission Terminal
2740 Communications Terminal Models 1 and 2
2741 Communications Terminal
3614 Consumer Transaction Facility Models 1, 2, 11 and 12
3735 Programmable Buffered Terminal
3767 Communications Terminal
3780 Communications Terminal

Data Transmission Multiplexers

2701 Data Adapter Unit**
3704 Communications Controller**
3705 Communications Controller**

Display Devices

3275 Display Station Models 2 and 12
3276 Control Unit DIsplay Station Models 1-4 and 11-14
3277 Display Station Models 1 and 2
3278 Display Station Models 1-4

Modulator/Demodulator Devices

2711 Line Adapter Unit***
3872 Modem***
3874 Modem***
3875 Modem***

Systems

1030 Data Collection System
1050 Data Communication System
2770 Data Communication System
3270 Information Display System
3600 Finance Communication System
3630 Plant Communications System
3650 Retail Store System
3660 Supermarket Key-Entry System
3660 Supermarket Scanning System
3740 Data Entry System
3770 Data Communication System
3790 Communication System
4300 Processors
    4331 Processor
    4341 Processor
5230 Data Collection System
8100 Information System
System/3 Models 4, 6, 8, 10, 12 and 15
System/7
System/32
System/360
    Models 20-75
System/370
    Models 115-168
    3031 Processor
    3032 Processor
    3033 Processor

*For attachment to a channel of the 4300 Processors for operation with one or more attached inquiry type terminals.

**For attachment to a channel of the 4300 Processors to control data communications with remote I/O devices.

***For attachment at each end of a data communication line to modulate or demodulate the signal.

Attachment Data for Remote I/O Devices and Terminal Systems

Terminal			*Remote Attaching*	*Local Attaching*	*Local Processor*	
No.	*Models*	*Name*	*Unit *E*	*Unit*	*4331*	*4341*
1001	1	Data Transmission Terminal	-	7770	m	m
1030	-	Data Collection System	1031#	2701	b*m*	b*m*
				3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
1050		Data Communication System	1051#	2701	b*m*	b*m*
				3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				--->	i	-
2740	1,2	Communications Terminal	-	2701	b*m*	b*m*
2741	1	Communications Terminal	-	3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				--->	i	-
2770	-	Data Communication System	2772#	2701	b*m*	b*m*
2780	1-4	Data Transmission Terminal	-	3704,3705 *A	m	m
3270	-	Information Display System	3271-1,-2#	3705 *B	*b*m	*b*m
				--->	i	-
3275	2	Display Station	-			
3270	-	Information Display System	3271-11,12#	3704,3705 *A	m	m
3275	12	Display Station	-	3705 *B	*b*m	*b*m
3270	-	Information Display System	3274-IC	2701	b*m*	b*m*
3276	1-4, 11-14	Control Unit Display Station	-	3704,3705 *A	m	m
				3705 *B	*b*m	*b*m

Terminal No.	Terminal Models	Name	Remote Attaching Unit *E	Local Attaching Unit	Local Processor 4331	Local Processor 4341
3600	-	Finance Communication System	3601-1,-2A,-2B, -3A,-3B#	3704,3705 *A	m	m
			3602-1A, -1B#			
3614	1,2, 11,12	Consumer Transaction Facility	-	3705 *B	*b*m	*b*m
3630		Plant Communications System	3631-1A,1B	3704, 3705 *A	m	m
			3632-1A,1B	3705 *B	*b*m	*b*m
3650	-	Retail Store System	3651-A50, -B50#	3704,3705 *A	m	m
3660	-	Supermarket Scanning System	3651-A60, -B60#	3705 *B	*b*m	*b*m
		Supermarket Key-Entry System	3661-1#	--->	i	-
				2701	b*m*	b*m*
3735	1	Programmable Buffered Terminal	-	3704,3705 *A	m	m
3740	-	Data Entry System	3741-2, 3747#	3705 *B	*b*m	*b*m
				--->	i	-
3767	1,2	Communication Terminal	-	3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				---> *C	i	-
3770	-	Data Communication System	-	2701 *D	b*m*	b*m*
				3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				---> *D	i	-
3780	1	Communications Terminal	-	2701	b*m*	b*m*
				3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				--->	i	-
3790	-	Communication System	3791#	3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
5230	-	Data Collection System	5231#	--->	i	-
				2701	b*m*	b*m*
-	-	System/7	5010#	3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				--->	i	-

No.	*Terminal Models*	*Name*	*Remote Attaching Unit *E*	*Local Attaching Unit*	*Local 4331*	*Processor 4341*
-	-	System/32	5320#	2701	b*m*	b*m*
				3704,3705 *A	m	m
				3705 *B	*b*m	*b*m
				--->	i	-
-	4	System/3	5404#			
-	6	System/3	5406#			
-	8	System/3	5408#			
-	10	System/3	5410#			
-	12	System/3	5412#			
-	15	System/3	5415#			
-	20	System/360	-	2701	b*m*	b*m*
-	25	System/360	2701,3704,3705,i	3704,3705 *A	m	m
-	22-75	System/360	2701,3704,3705	3705 *B	*b*m	*b*m
-	115-138	System/370	2701,3704,3705,i	--->	i	-
-	145-168	System/370	2701,3704,3705			
3031	-	Processor Complex (Part of System/370)	2701,3704,3705			
3032	-	Processor Complex (Part of System/370)				
3033	-	Processor Complex (Part of System/370)				
4300		Processors				
-	4331		2701,3704,3705,i			
-	4341					
8100	8130	Information System	3704, 3705 *A		m	m
	A21-24, 8140 A31-34, A41-44, A50-54		3705 *B		*b*m	*b*m

Legend:

b Block multiplexer channel.
m Byte multiplexer channel.
b*m* Italics denote preferred channel for attachment.
i I/O adapter (communications adapter).
---> See the information in the 'Local Processor' columns.
Part of the remote system.
+ The local attaching units are:
    2701 Data Adapter Unit
    3704 Communications Controller
    3705 Communications Controller
    7770 Audio Response Unit Model 3
- Not applicable.

Notes:

*A 3705 equipped with a channel adapter type 1.

*B 3705 equipped with a channel adapter type 2 or type 3 (channel adapters type 2 and type 3 are mutually exclusive).

*C 3767 equipped with Start/Stop.

*D 3770 equipped with SDLC/BSC Switch Control.

*E Communication facility, which includes the communication line with a signal modulation/demodulation device (modem) at each end.

IBM 4300 Processors
Summary and Input/Output and Data Communications Configurator

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