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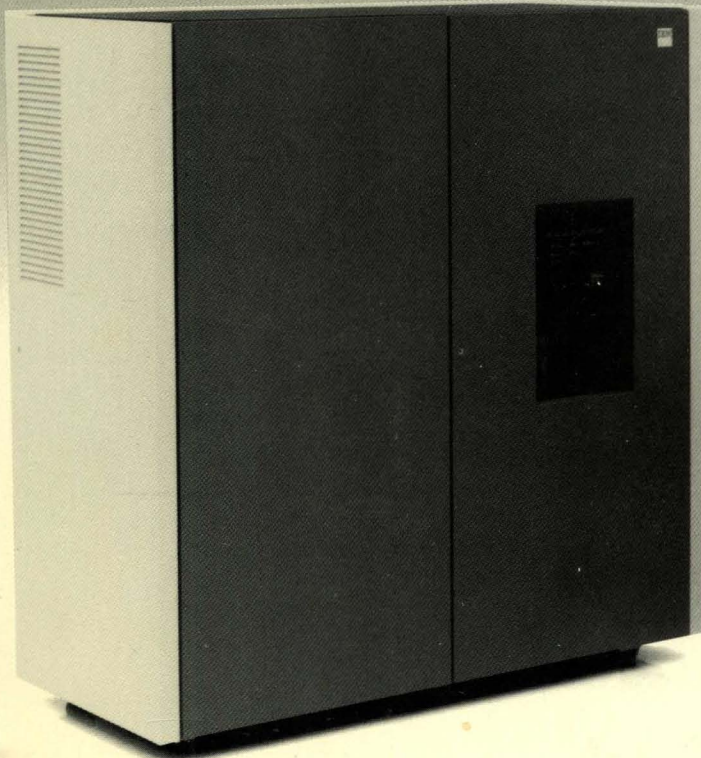
4381 Processor
Model Groups 1 & 2
Functional
Characteristics

IBM

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Preface

This reference document is designed for system analysts and programmers and contains information about processor features, input/output characteristics, system configurations, and the functions of integrated I/O devices. Only those items that are unique to the 4381 Processor are discussed in detail. Other information can be found in the prerequisite and associated publications listed below.

It is assumed the reader has performed some of the tasks described in the prerequisite publications and has also had programming experience with IBM System/360, System/370, 4300, or similar processors.

Prerequisite Publications

- *IBM System/370 Principles of Operation*, Order No. GA22-7000
- *IBM 370 XA Principles of Operation*, SA22-7085
- *IBM 4381 Processor Summary and Input/Output Data Communications Configurator*, GA24-3950.

Associated Publications

- *A Guide to the IBM 4381 Processor*, GC20-2021
- *IBM 4300 Processors Installation Manual—Physical Planning*, GA24-3667
- *IBM 4381 Processor Model Groups 1 and 2 Channel Characteristics*, GA24-3948
- *IBM 4381 Processor Operations Manual*, GA24-3949 (part of GA24-3982)
- *IBM 4381 Processor Problem Analysis Guide*, GA24-3955
- *IBM 3270 Information Display System Component Description*, GA27-2749
- *IBM 3270 Information Display System Color and Programmed Symbols*, GA33-3056
- *Introduction to Programming the IBM 3270*, GC27-6999
- *IBM 3268 Printer Planning and Site Preparation Guide*, GA27-3266
- *IBM Disk Pack and Cartridge Handling Procedures*, GA26-5756
- *IBM Diskette—General Information Manual*, GA21-9182
- *IBM Multiply—Add Facility*, GA22-7082
- *IBM System/370 Special Feature Description: Channel-to-Channel Adapter*, GA22-6983
- *4381 Processor Input/Output Configuration Program User's Guide and Reference*, GC24-3964.

Note that the *IBM 4381 Processor Operations Manual*, GA24-3949, is part of assembly kit GA24-3982; GA24-3949 includes only the document text. If you order GA24-3982, you receive an assembled kit (GA24-3982), which includes a binder, tabs (GX24-3974), and binder inserts (GX24-3971). If you use the document number (GA24-3949) to order this document, you receive *only* the document text (no binder, tabs, or inserts).

Ordering the System Library

The following books comprise the system library for the 4381 Processor; all these books are stocked in Mechanicsburg according to their respective order numbers; also, the following books are stocked under assembly kit number GA24-3981. If you order GA24-3981, you receive the following books (including this one) in a specially designed binder (including tabs and a Table of Contents, GX24-3973) with inserts for the cover and spine (GX24-3969). Naturally, you can order each document individually (for example, if you just want another copy of this manual, use GA24-3947). You can also order the tabs (and the Table of Contents) and inserts individually. (Use GX24-3969 to order the binder inserts; use GX24-3973 to order the tabs and Table of Contents.)

- *IBM 4300 Processors, Installation Manual—Physical Planning*, GA24-3667

- *IBM 4381 Processor Summary and Input/Output & Data Communications Configurator*, GA24-3950

- *IBM 4381 Processor Model Groups 1 and 2 Functional Characteristics*, GA24-3947

- *IBM 4381 Processor Model Groups 1 and 2 Channel Characteristics*, GA24-3948

- *A Guide to the 4381 Processor*, GC20-2021

- *IBM 4381 Processor Input/Output Configuration Program User's Guide and Reference*, GC24-3964
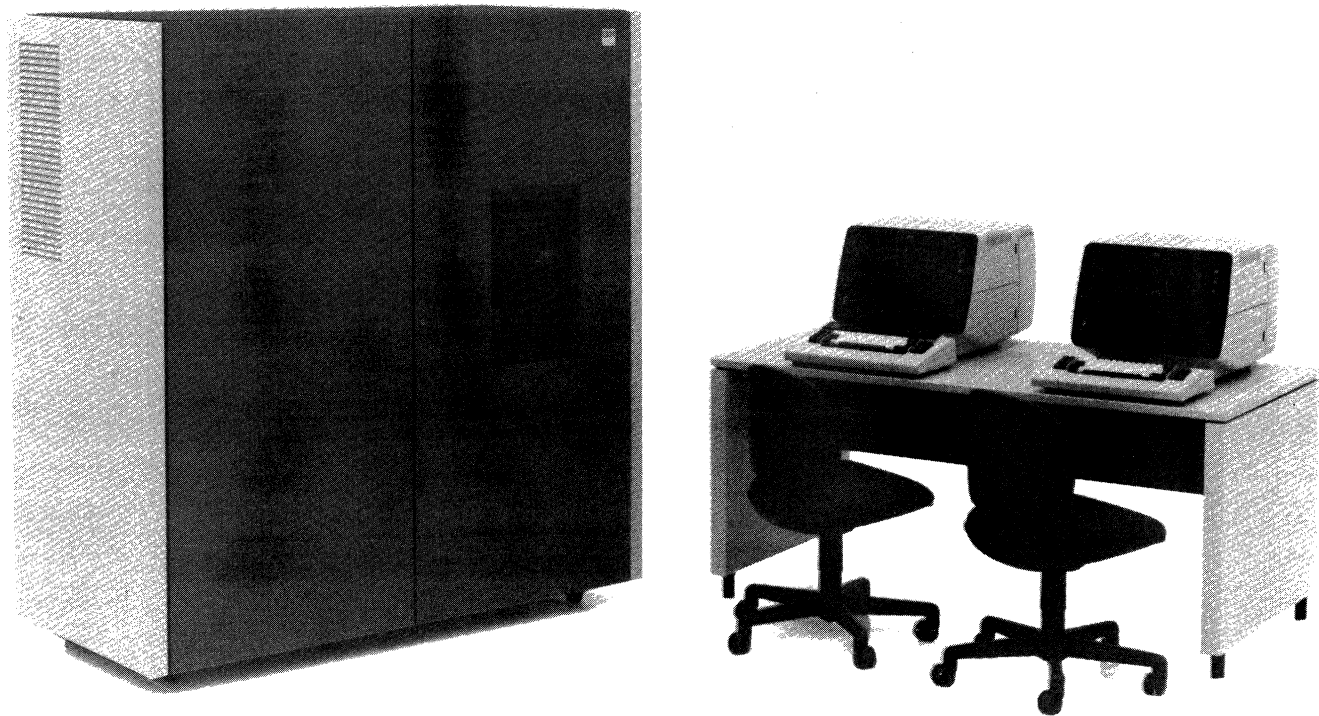
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Figure 1. IBM 4381 Processor with Display Consoles

Introduction

The IBM 4381 (Figure 1) is a powerful, versatile processor supplying large system performance in an air-cooled intermediate machine. The 4381 is designed to have the reliability, performance, and convenience necessary for business, engineering and/or scientific applications.

A new high density, module-on-board packaging technique eliminates the need for logic cards in the processing unit. This packaging technique, combined with 4381's upright design, minimizes the floor space required for the processor.

The 4381 Model Group 1 is designed for the user who requires a processor with greater capability than the 4341, but who does not require the increased commercial and scientific performance of the 4381 Model Group 2.

The 4381 Model Group 2, due to a larger high-speed buffer, operates at a higher performance rate than the 4381 Model Group 1. The 4381 Model Group 2 is designed to meet the requirements of those users whose needs do not yet reach the capabilities of the 3083 Model E.

Highlights

Some of the facilities and features of the 4381 Processor include:

- Two system diskette drives
- An internal processor cycle time of 68 nanoseconds
- 4 to 16 megabytes of main storage
- Reloadable control storage
- High-speed storage buffer
- Eight-byte parallel data flow (16 bytes between main storage and the high-speed buffer)
- Six I/O channels (standard), with six additional channels available as an option
- Engineering Scientific Assist
- Elementary Math Library Assist   (Model Group 2 only)
- Remote support facility (RSF), including the remote operator console facility (ROCF).

See "IBM 4381 Processor Configurator" on page 16 for a complete list of standard and optional features.

Prerequisites

The processor requires one 3278 Model 2A or 3279 Model 2C Color Display Console, equipped with a keyboard and an operator control panel (OCP). The display console, keyboard, and operator control panel form the primary (system) display console for turning power on and off and controlling processor operation.

Modes of Operation

Either of two operational modes can be selected at initial microcode load (IML) time:

- System/370 mode

    This runs programs used on System/370 and 4300 processors that do not violate the exceptions noted under "Compatibility."

- 370-XA mode

    This is used with the extended architecture (XA) operating systems.

Programming Support

When the 4381 Processor is operating in System/370 mode, support is supplied by:

- DOS/VSE
- OS/VS1
- MVS/SP
- VM/SP
- ACP/TPF.

When the 4381 Processor is operating in 370-XA mode, support is supplied by:

- MVS/XA
- VM/XA Migration Aid.

For more information on programming support, including descriptions and release levels, see your IBM representative.

Compatibility With Other IBM Processors

Any program written for IBM System/370 or 370-XA mode can operate on the 4381 Processor in System/370 mode or 370-XA mode, as long as the program:

- Is not time-dependent.

- 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.

- Does not depend on system facilities (interruptions, operation codes, etc.) being absent when the facilities are included.

- Does not depend on results or functions that are defined in the appropriate *Principles of Operation* manual to be unpredictable or model-dependent.

4381 Processor Unit

Data Representation

The 4381 is both character and word oriented. The basic addressable unit of information is a *byte*. A byte contains eight *bits* that can be used to represent one character or two decimal digits. This allows efficient use of storage and also gives you highly effective input/output rates for decimal data, variable field lengths, broad and flexible code conversion, and decimal arithmetic.

Four bytes (32 bits) of information combine to form a *word*. 32-bit words and 16-bit halfwords are used for fixed-point arithmetic; 32-bit words and 64-bit doublewords are used for floating-point arithmetic. Functions such as *translate* and *edit* can be implemented using this data representation.

Data Flow

Figure 2 shows a simplified data flow of the IBM 4381. The dotted lines in the figure represent optional features. Except for the display console and optional console devices, all the functional units in the data flow figure are in the processor frame.
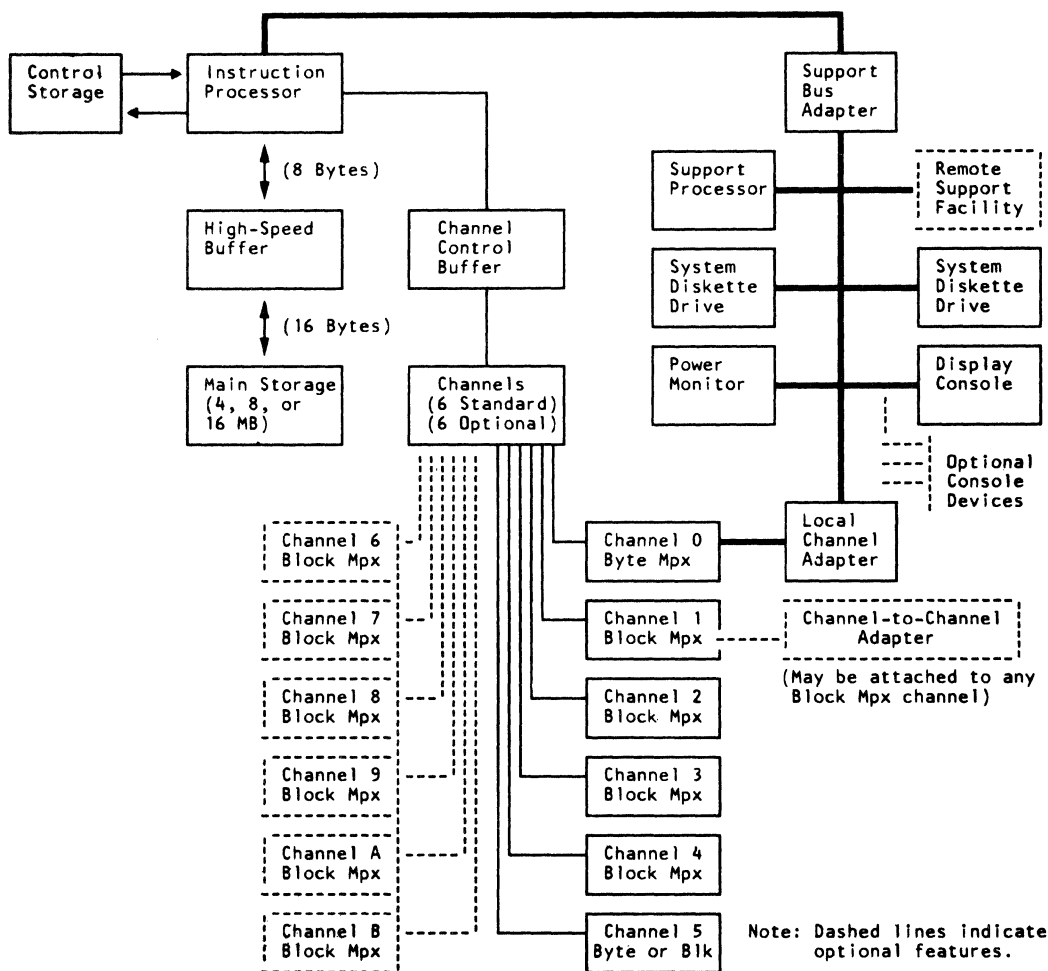
Figure 2. Simplified 4381 Data Flow

Instruction Processor

The instruction processor executes program instructions; it has an 8-byte data flow and is controlled by the microcode in control storage. The internal processor cycle time is 68 nanoseconds. The major components of the instruction processor include registers, a local storage facility, an arithmetic logical unit (ALU), and an 8-byte shifter.

Local Storage

Local storage is an array that is 8 bytes wide by 256 words deep. Dedicated portions of local storage contain 16 general purpose registers, 4 floating point registers, 12 channel areas, and a branch and link/trap save area. The remaining portion of local storage is used as working registers.

Arithmetic Logical Unit (ALU)

The arithmetic logical unit has an access width of eight bytes. The ALU performs binary addition and subtraction, as well as logical AND, OR, and EXCLUSIVE OR operations on data inputs.

Byte Shifter

The byte shifter moves data to the right or left. During a shift operation, data can be wrapped. Also, binary 1s or 0s can be inserted. The byte shifter performs zoned and/or packed decimal operations of pack and unpack functions.

Reloadable Control Storage

Control storage is a reloadable area containing the microcode to control the standard and installed optional features of the 4381. This storage area is not available to the user. The information in control storage can only be loaded under control of the support processor. The appropriate microcode can be selected by the operator at IML (initial microcode load) time so that the processor operates in the proper mode for program execution.

High-Speed Buffer

The high-speed buffer is a storage area that can be accessed faster than main storage. Blocks of instructions and operands from main storage that are frequently accessed are held in the high-speed buffer. This improves processor performance on repetitive references to storage.

The high-speed buffer is controlled by microcode and is not part of user-addressable storage.

Main Storage

The 4381 Processors Model Groups 1 and 2 are available in three storage sizes:

Model	Storage Size
Model L01 and L02	4 megabytes
Model M01 and M02	8 megabytes
Model P01 and P02	16 megabytes

The information in main storage is not saved when processor power is turned off.

Storage Access

The main storage to the high-speed buffer data path is sixteen bytes wide. The data path is parity checked *and* error checked and corrected (ECC). ECC consists of single-bit error detection and correction, and single- and double-bit error detection across each half of the sixteen-byte path. (See "Error Checking And Correction (ECC)" on page 50.)

Permanently Assigned Storage Areas

Bytes 0 through 511 of real storage are permanently assigned for PSWs, CSWs, etc. These are necessary for program operation. The content of this area depends on the selected mode (System/370 or 370-XA). For more information on this storage area, refer to the appropriate *Principles of Operation* publication listed in "Prerequisite Publications" in the Preface.

System Storage Requirements

A portion of main storage is required for dynamic tables. This reduces the amount of main storage available for user programming. Depending on the processor configuration and mode of operation, the reduction of available main storage may be from 61,440 bytes to 491,520 bytes. The *actual* storage reduction can be determined using Figure 3.

If operating in System/370 mode —

    Storage Reduction = 53,248 Bytes + 64(U) + B

    Where: U = The number of UCWs installed. (Minimum number of
                    UCWs is 128, even though less are installed.
                    The maximum number of UCWs is 2,048.)

          B = The number of additional bytes necessary to make
                    the total number of bytes (storage reduction)
                    divisible by 4,096.

If operating in 370-XA mode —

    Storage Reduction = 102,400 Bytes + 70(C) + 180(S) + B

    Where: C = The number of control units attached. [Minimum is
                    128, even though less are attached. Maximum is
                    257 (256 plus 1 for microcode usage).]
          S = The number of subchannels assigned. [Minimum
                    number is 128, although less can be assigned.
                    Maximum is 2,049 (2,048 plus 1 for micro-
                    code usage).]
          B = The number of additional bytes necessary to make
                    the total number of bytes (storage reduction)
                    divisible by 4,096.

Figure 3. System Storage Requirements

Support Processor

The support processor has the services necessary for processor initialization, monitoring, and maintenance. The support processor is connected to the instruction processor through the *support bus adapter* and the *local channel adapter*.

The integrated adapters and a logic element communicate with console I/O devices and other elements of the processor for microcode loading, messages, and routine checking facilities. The support processor maximizes system availability by automating and simplifying failure diagnosis.

System Diskette Drives

The 4381 Processor has two diskette drives that have removable diskettes. The diskettes contain the microcode for initialization, system operation, and running diagnostics. They also supply storage areas for retaining error log and analysis data.

At initial microcode load (IML) time, the microcode for system operation is loaded from the diskettes into control storage. This data is not accessible to the programmer.

Diskette Wear

Diskettes supply a convenient method for data handling and storage. However, diskettes wear with normal use; handle your diskette with care. For further information on caring for diskettes, refer to the *IBM Diskette—General Information Manual*, GA21-9182.

Power Monitor

The power monitor controls and monitors processing unit power. If a failure occurs, the power monitor (through the support processor) supplies an error log and reference code that identifies the failure. During the initial stages of the power-on sequence, diagnostic tests automatically run to check the operation of the power monitor.

Display Console

The display console is the principal device for the operator to communicate with the system. An operator control panel is integrated in the keyboard of the display console. The operator uses the display console to control system operation and observe both system and display console status.

The display console can be either a 3278 Model 2A Display Console or a 3279 Model 2C Color Display Console. Both uppercase and lowercase characters can be entered and displayed.

Optional Console Devices

In addition to the primary (system) display console (which has the operator control panel integrated in the keyboard) that is needed for processor operation, up to three optional console devices can be attached to the processor. (Refer to the *IBM 4300 Processors Installation Manual—Physical Planning*, Order No. GA24-3667, for information about the customer access area to attach optional console devices.) These devices can be any combination of:

- 3278 Model 2A Display Consoles

- 3279 Model 2C Color Display Consoles

- 3268 Printers, Model 2

- 3287 Printers, Model 1, 1C, 2, or 2C.

The optional display consoles do not have the operator control panel integrated in the keyboard, as does the primary (system) display console. However, system operation and manual processor functions, such as display/alter operations, can be done from the additional display consoles.

The optional printers supply a hard-copy output of system control communications. The 3268 Printer Model 2 is a single color printer. It operates at up to 340 characters-per-second and can be manually selected to print at 10 or 16.7 characters-per-inch and 3, 4, 6, or 8 lines-per-inch. The 3287 Printer Models 1 and 1C operate at 80 characters-per-second. The 3287 Printer Models 2 and 2C operate at 120 characters-per-second.

The 3279-2C Color Display Console and 3287 Printer Models 1C and 2C supply a color graphics for the 4381 output display. Color implementation is controlled by the application program.

Remote Support Facility (RSF)

This facility (if it is installed and you have customer authorization) allows an on-site service representative to communicate with a remote IBM support system. Using this facility, the service representative can search a data bank for the latest service aids and information. Also, remote service personnel (through an IBM remote support site) can perform online diagnosis as if they were at the customer's site. Logout data stored on the system diskette drives can be saved at the remote support site for later offline analysis. Microcode patches can also be applied from the remote site.

For connection information, refer to the *IBM 4300 Processors Installation Manual—Physical Planning*, GA24-3667.

Remote Operator Console Facility

The remote operator console facility is an optional feature that is an extension of the remote support facility (RSF). When ROCF is in use, the remote support facility previously described cannot be used.

In a distributed data processing (DDP) environment, the remote operator console facility allows personnel at the host site to dial-up and control the remote system. This control is accomplished through system operation functions such as IML, IPL, Reset, Restart, and manual display/alter requests.

ROCF includes a password verification function that protects against unauthorized access to the remote 4381. If a higher level of data security is required, an external encryption device may be attached to the dial-up link.

If the optional keylock feature is installed on the system console, the host site can control the remote 4381. Unauthorized personnel cannot access the system.

To use the remote operator console facility, the remote system must be equipped with a customer supplied auto-answer modem and data access arrangement

(DAA). (For details, refer to the *IBM 4300 Processors Installation Manual—Physical Planning*, GA24-3667.) Communication with the remote operator console facility is through an IBM 3275 Display Station, or programming support provided by IBM program products. (See "Support for Remote Operator Consoles" on page 45.)

After the remote system is successfully initialized, normal transfer of data and control information between the host and remote system should be handled through a conventional communication network (for example, 270X or 370X communication controllers).

Channels

The channels transfer data between main storage and input/output devices. A channel input or output operation is initiated by the instruction processor. The channels can run concurrently with the instruction processor, and the processor resumes program processing after channel operation begins. When the end of an input/output operation completes, the channel signals the processor. Information concerning the success or failure (status) of the operation is passed to the processor for use by the program.

The 4381 has six standard channels with six additional channels available as an option. For detailed input/output channel information, see "Channel Description and Operation" on page 9.

Channel Control Buffer

The channel control buffer holds the control data for each channel while it is operating with an I/O unit. The channel control buffer contains space for two 32-bit control words to each channel.

Channel Data Buffer

Each channel has a 256-byte channel data buffer. This is a temporary holding area for data being transferred between main storage and I/O devices connected to the channels. Depending on the data length and address boundary, data is transferred in 64-byte blocks or partial blocks.

Channel-to-Channel Adapter

The optional channel-to-channel adapter synchronizes the data path between two processors. The adapter requires three control unit positions on each of the channels, but only one of the connected channels requires the adapter to be installed. The adapter is attached to a block multiplexer channel on the 4381. The other system can be any System/370 or 4300 Processor. (Refer to "Channel-to-Channel Adapter" under "4381 Model Dependent Information" on page 45 for details on interface signal specifications.)

The adapter operates in burst mode and transmits data at the rate of the lower-speed channel. The adapter is selected and responds the same way as any control unit. The adapter accepts and decodes commands from the channel; however, it differs from a control unit since it does not use these commands to operate and control input/output devices. Instead, the adapter uses the commands to open a path between the two channels it connects and then synchronizes the operations between the two channels.

For more information, refer to the *IBM System/370 Special Feature Description: Channel-to-Channel Adapter*, GA22-6983.

Channel Description and Operation

Standard Input/Output Attachment

The 4381 Processor uses the standard System/370 and 4300 method to connect the channels to I/O devices or control units. The channels are integrated. They share control storage, main storage, and the arithmetic logic unit with the processor. The 4381 uses two types of input/output channels: *byte multiplexer* and *block multiplexer*.

Byte Multiplexer Channels

Byte multiplexer channels have a single data path that can be fully used by one I/O device (*burst mode*) or shared by many I/O devices (*multiplex mode*). In burst mode, the device and channel remain connected for a relatively long period of time. In multiplex mode, a channel remains connected to any one device for a relatively short period of time; typically long enough to transfer only one byte or a small number of bytes of information. When multiple I/O devices concurrently share a byte multiplexer channel, the operations are in multiplex mode. Each device is selected (one at a time) for the transfer of a byte, or a few bytes, to or from main storage.

Some control units are designed to operate on the byte multiplexer channel in burst mode or in multiplex mode. Other control units allow the mode to be set during system installation.

Block Multiplexer Channels

Block multiplexer channels can operate in either *block multiplex* mode or *selector* mode. Block multiplex mode allows concurrent operation of many I/O devices. This mode is for high speed burst operations. In block multiplex mode, each device is selected one at a time, similar to the byte multiplexer channel being shared by multiple low speed I/O devices. The channel can disconnect from a device during periods of unproductive activity, such as disk seeking and record positioning.

In selector mode, the channel does not disconnect from an I/O device until the operation is complete. The channel is considered *busy* the entire time it is connected to an I/O device, even though no data transfer is occurring.

High-Speed Transfer

This facility enables faster data transfer on block multiplexer channels. It includes the use of two additional tag lines (*data-in* and *data-out*) that are used alternately with the normal *service-in* and *service-out* lines for data transfer. Because of the higher speed data transfer, a control unit can be a greater distance from the channel than would otherwise be possible.

Data Stream Mode

Data stream mode is an extension of the hardware protocol for I/O data transfer, which permits faster data transfer rates and increased channel-to-control unit cable length. Data stream mode can operate on any block multiplexer channel, up to the maximum specified data rate (see "Channel Data Rates" on page 10).

Channel Command Retry

Channel command retry is a channel and control unit procedure that can cause a command retry without requiring an I/O interruption. It applies only to block multiplexer channels. The control unit determines if the last command can be retried, based on factors such as whether operator intervention or program reorientation is required before retry.

I/O Error Alert

On both block multiplexer and byte multiplexer channels, an additional selection (formerly tag) line called *disconnect-in* gives control units the ability to alert the processor of a malfunction that prevents the control unit from correctly signaling over the I/O interface. Disconnect-in can be activated by a control unit only when it is connected to the channel (has the *operational-in* line active). The channel performs a selective reset in response to disconnect-in and indicates to the operating system the incident of disconnect-in.

4381 Channel Configuration

The input/output configurations for the IBM 4381 are shown in Figure 4 on page 11. The basic channel set (standard) consists of one byte multiplexer channel (Channel 0) and five block multiplexer channels (Channels 1 through 5). The display console and any other optional console devices (displays or printers) are attached to Channel 0. Channel 5 can be configured as a second byte multiplexer channel.

The full channel set (optional) supplies six additional channels (Channels 6 through B) for a total of 12 channels. These channels are all block multiplexer channels; none can be selected as a byte multiplexer channel.

Channel Data Rates

The 4381 channels operate on a time sharing basis. Each channel is assigned a time slot to minimize the impact on each channel's throughput in relation to other channel loading. Each channel's block multiplexer data rate is not affected by the other channels. Channel data rates are shown in Figure 4 on page 11.

Basic Channel Set (6 Channels)

Channel	Channel Type	Maximum Data Rate
0	Byte Multiplexer	(See below)
1	Block Multiplexer	3 Megabytes/Second
2	Block Multiplexer	3 Megabytes/Second
3	Block Multiplexer	3 Megabytes/Second
4	Block Multiplexer	3 Megabytes/Second
5	Block Multiplexer (or Byte Multiplexer)	2 Megabytes/Second (See below)

Full Channel Set (6 Channels)

Channel	Channel Type	Maximum Data Rate
6	Block Multiplexer	2 Megabytes/Second
7	Block Multiplexer	2 Megabytes/Second
8	Block Multiplexer	1 Megabyte/Second
9	Block Multiplexer	1 Megabyte/Second
A	Block Multiplexer	1 Megabyte/Second
B	Block Multiplexer	1 Megabyte/Second

Byte Multiplex Channels 0 and 5 (Byte Mode Operation)

These data rates are with no other channel activity. For data rates with other channel activity, see *IBM 4381 Processor Model Groups 1 and 2 Channel Characteristics*, GA24-3948.

Byte-Mode Type	Maximum Data Rate
Single-Byte Transfer	30 Kilobytes/Second
Two-Byte Transfer	60 Kilobytes/Second
Four-Byte Transfer	120 Kilobytes/Second

Byte Multiplex Channels 0 and 5 (Burst Mode Operation)

For buffered devices only. Unbuffered burst mode devices are not supported.

Operation	Average Data Rate
Input (Read)	2 Megabytes/Second
Output (Write)	$\dfrac{DR}{1 + DR}$ (for DR equal to or less than 2 Mb/second)

DR = Data rate of device in Megabytes/Second

Note: These data rates assume small interface and control unit generated delays.

Figure 4. Channel Configurations and Data Rates

Channel Operation

Once a program initiates a channel operation, channel activity is controlled by microcode and hardware circuits. This includes the initial selection for the I/O device and the handling of interruptions, channel status, and data transfer. The processor can resume program processing while the channel is handling the input/output operation.

All data transferred between main storage and an I/O device passes through the channel data buffer. Each channel has 256 bytes of channel data buffer. Depending on the data length and address boundary, data may be transferred in:

- 64-byte blocks
- A partial block to line up to a 64-byte address boundary
- A partial block to complete a data transfer
- A partial block for very short records
- A partial block for byte multiplex operation.

System/370 Subchannels

A subchannel is a facility that sustains a single I/O operation and can be either shared or unshared. An unshared subchannel has the facilities to operate only one I/O device. A shared subchannel supplies facilities to operate one of an attached set of I/O devices.

Before a subchannel can operate with an I/O device, it must have certain control information for the device. This information is stored in the upper portion of main storage in one of the following:

- A set of unit control words (if operating in System/370 mode), or

- An input/output configuration data set (IOCDS), if operating in 370-XA mode.

System/370 Unit Control Words (UCW)

The UCW contains the control information necessary for a channel to perform input/output operations to an attached device. Each device or control unit requires an assigned UCW. However, some UCWs can be shared by multiple devices. Some examples of UCW assignments include:

- A single control unit that controls one I/O unit requires one UCW. An example is the 1403 Printer Model N1.

- A single (physical) unit that contains several control units must have a UCW for each control unit. An example is a 2821 Control Unit that handles functions for the 1403 Printer, 2540 Card Reader, and the 2540 Card Punch (three UCWs are required).

- A single control unit that controls several devices requires a UCW for each device. An example is the 3830 Storage Control, which is used with 3330 disk storage devices.

- If a single control unit serves several I/O devices, *one at a time*, all devices serviced by the control unit can share the UCW assigned to that control unit. An example is a 3272 Control Unit with attached 3277 displays.

System/370 UCW Pool

A maximum of 256 I/O unit addresses is available on each channel, except for Channel 0. Channel 0 can have a maximum of 240 I/O unit addresses because addresses hex 0F0 through hex 0FF are reserved for console devices and internal functions.

Up to 2,048 UCWs can be configured. A minimum storage allocation of 8,192 bytes is reserved for the first 128 UCWs. (Each UCW occupies 64 bytes.) If more than 128 UCWs are required, additional groups of 64 UCWs can be assigned (up to the maximum 2048). Each group of 64 additional UCWs reduces the usable main storage by 4,096 bytes:

Number of UCWs	Main Storage Required
128	8,192 Bytes
next 64	+4,096 Bytes
next 64	+4,096 Bytes
etc.,	etc.,
up to: 2,048	up to: 131,072 Bytes

Refer to the *IBM 4381 Processor Operations Manual*, GA24-3949, for information about the generation of UCWs.

System/370 Channel UCW Directory

Each channel has a channel directory. The directory has 256 entries, one for each possible device address (hex 00—hex FF) on the channel. Each entry contains the reference number of its associated UCW and one or more of the following characteristics:

Characteristic	Indicates
UNA	This entry was not assigned to an I/O device by the user (UNA = unassigned).
SHR	A shared UCW
SEL	A device that operates in selector mode
BYT	A device that operates in byte multiplexer mode
BLK	A device that operates in block multiplexer mode
SIOFQ	If a busy condition is detected during the selection of the device, the I/O operations (initiated by a Start I/O Fast Release to this subchannel) can remain pending at the subchannel.
DST	A control unit or device attached to a control unit that can operate in data streaming mode.

Figure 5 (Part 1 of 2). Channel UCW Characteristics

Characteristic	Indicates
INV	Channel 5 has been changed from a byte multiplexer channel to a block multiplexer channel or from a block multiplexer channel to a byte multiplexer channel, and the entry is now invalid for that channel type.

Figure 5 (Part 2 of 2). Channel UCW Characteristics

System/370 UCW Assignment

UCWs for console devices (such as the 3278-2A) are preassigned. The logical addresses for these devices are assigned by the operator. All other I/O devices must be described to the processor. This information is stored in the UCW directory tables.

All UCW assignments are written onto the system diskette and become effective after subsequent IMLs. UCW reassignments for console devices become effective immediately (without a re-IML).

System/370 Device Considerations

Devices that share a control unit and operate in selector mode can use one shared UCW on the channel. The SEL mode bit must be active in the directory entry.

Devices capable of running in block multiplexer mode may use an *unshared* UCW for each actual device attached, or one *shared* UCW for all devices attached to the control unit. Normally, UCWs for the block multiplexer channel are unshared, with SEL mode off.

Devices (such as the IBM 3272 Control Unit) require one exclusive UCW for each control unit on the channel. Each 3277 attached to that control unit then shares that control unit's UCW. The SHARED bit must be on in the directory entry for that UCW.

Magnetic tape devices use a shared UCW and operate in selector mode.

The channel-to-channel adapter is treated as a control unit, and requires one block multiplexer UCW.

Input/Output Configuration Data Set (IOCDS)

When operating in 370-XA mode, The UCW directory used for channel control in System/370 mode is replaced by an Input/Output Configuration Data Set (IOCDS). This IOCDS is created using the I/O configuration program (IOCP). The input to the IOCP is a card deck or tape record generated by the user for system generation. Specific instructions concerning generation of the IOCP input deck or tape are contained in the *IBM 4381 Processor Input/Output Configuration Program User's Guide and Reference Manual*, GC24-3964.

To run the IOCP, you must perform an IML in System/370 mode from the diskette. The input reading device must be loaded and made ready with the modified system generation deck or tape, which contains the required channel and device information for the system. The I/O configuration program reads and performs a syntax check on the input record data set. If the input is acceptable,

IOCP builds the I/O configuration data set (IOCDS), which is a channel hardware description used by the 4381 Processor during channel operation when it is running in 370-XA mode.

The I/O configuration data set is written onto the diskette in S/370 mode and loaded into main storage when the system is IMLed in 370-XA mode.

An output device can be selected to print a report of the generation process. Detailed procedures concerning operating and error messages are found in the *IBM 4381 Processor Operations Manual*, GA24-3949.

370-XA Mode Subchannels

In 370-XA mode, there can be a maximum of 2048 subchannels. Each subchannel requires 128 bytes of storage. Additionally, 64 bytes of storage are required for each physical control unit attached to the system.

Processor and System Configuration

IBM 4381 Processor Configurator

The following three figures supply an overview of the available processor facilities through a list of prerequisites, standard features, and optional features. References are provided to show where further information can be found in this publication or related publications. Refer to the Preface for a complete list of related publications.

Prerequisite Console Device	Reference
IBM 3278-2A Display Console, or IBM 3279-2C Color Display Console (with the Operator Control Panel)	"Display Console" on page 22

Figure 6. Console Device Prerequisites

Standard Features	Reference
Two System Diskette Drives	"System Diskette Drives" on page 6
68 to 136 ns Processor Cycle Time	"Instruction Processor" on page 4
4 Megabytes of Main Storage	"Main Storage" on page 4
32K High-Speed Buffer Storage	"High-Speed Buffer" on page 4
Branch and Save	Principles of Operation manual.
Channel Indirect Data Addressing	Principles of Operation manual.

Channels:
   One Byte Multiplexer Channel and
   Five Block Multiplexer Channels, or
   Two Byte Multiplexer Channels and
   Four Block Multiplexer Channels
	"Channel Description and Operation" on page 9

Channel Command Retry	"Channel Command Retry" on page 10
Clear I/O	Principles of Operation manual
Clock Comparator and CPU Timer	"Timer and Clock Resolution" on page 46
Conditional Swapping	Principles of Operation manual
Control Registers	Principles of Operation manual
Data Streaming	"Data Stream Mode" on page 9
Decimal Instructions	Principles of Operation manual
Dual Address Space Facility	Principles of Operation manual
Dynamic Address Translation (In System/370 Mode)	Principles of Operation manual

Eight-Byte Parallel Data Flow
   16 Bytes between Main Storage
   and the High-Speed Buffer
	"Data Flow" on page 3

Figure 7 (Part 1 of 3). Standard Features

Standard Features	Reference
Elementary Math Library Assist (Model Group 2 only)	"Elementary Math Library Assist (Model Group 2 only)" on page 45
Engineering Scientific Assist	"Engineering Scientific Assist" on page 45
Error Checking and Correction (ECC)	"Error Checking And Correction (ECC)" on page 50
Error Retry	"Error Retry" on page 49
Extended	Principles of Operation manual
Extended Precision Floating Point	Principles of Operation manual
External Signal	Principles of Operation manual
Fast Release	Principles of Operation manual
Floating-Point Instructions	Principles of Operation manual
Halt Device	Principles of Operation manual
High-Speed Transfer	"High-Speed Transfer" on page 9
Interval Timer	"Timer and Clock Resolution" on page 46
Limited Channel Logout	Principles of Operation manual
Machine Check Handling	"Implementation of Machine Check Handling" on page 48
I/O Error Alert	Principles of Operation manual
Move Inverse Function	Principles of Operation manual
Modes: System/370 370-XA	"Modes of Operation" on page 2
Multiprocessing (see note)	Principles of Operation manual
Program Event Recording	Principles of Operation manual, also see "PER" on page 46
PSW Key Handling	Principles of Operation manual
Recovery Extensions	Principles of Operation manual
Reloadable Control Storage	"Reloadable Control Storage" on page 4
Storage Protection (store and fetch)	Principles of Operation manual
Segment Protection	Principles of Operation manual
Service Signal	Principles of Operation manual
Start I/O Fast Queuing	Principles of Operation manual
Storage Key Instruction Extensions	Principles of Operation manual
Store Status (System/370 Mode)	Principles of Operation manual
Subchannels (up to 2048)	"System/370 Subchannels" on page 12
Support Processor	"Support Processor" on page 6
System/370 Universal Instruction Set	Principles of Operation manual
Test Block	Principles of Operation manual

Figure 7 (Part 2 of 3). Standard Features

Standard Features	Reference
Time-of-Day Clock	"Timer and Clock Resolution" on page 46
Virtual Storage	Principles of Operation manual

Figure 7 (Part 3 of 3). Standard Features

Note: The multiprocessing extension and the initial microprogram load (IML) SIGP order are not provided. In System/370 mode, the CPU reset and initial CPU reset SIGP orders are not supported.

Optional Features	Reference
8 or 16 Megabytes of Storage	"Main Storage" on page 4
Six Additional Channels	"4381 Channel Configuration" on page 10
Up to Three Additional Console Devices	"Optional Console Devices" on page 6
Channel-to-Channel Adapter	"Channel-to-Channel Adapter" on page 8
Remote Support Facility	"Remote Support Facility (RSF)" on page 7
Remote Operator Console Facility	"Remote Operator Console Facility" on page 7

Figure 8. Optional Features

Minimum Configuration for Hardware System Maintenance

The following minimum system configurations are required for hardware maintenance. The individual system control programs (SCPs) have their own minimum requirements, depending on the SCP type and release level.

Minimum Configuration with Removable Direct Access Storage

Figure 9 shows the minimum system configuration necessary for hardware maintenance when using *removable* direct access storage.

- **4381 Processor**

- **3278-2A Display Console or 3279-2C Color Display Console**
  (with the Operator Control Panel)

- **Access to one of the following groups of devices:**

  - 1 card image I/O device* (for 370-XA only) and
  - 2 direct access devices** and
  - 1 hard-copy output device,

  or:

  - 1 card image I/O device* (for 370-XA only) and
  - 1 direct Access device** and
  - 1 magnetic tape device*** and
  - 1 hard-copy output device,

  or:

  - 1 card image I/O device* (for 370-XA only) and
  - 3 magnetic tape devices*** and
  - 1 hard-copy output device.

Figure 9. Minimum Configuration with Removable Direct Access Storage

Card Image is defined as:

- Any supported card reader (2501, 2540, 3505), or

- A magnetic tape drive with provisions for entering card-image formatted records onto a magnetic tape (2400, 2420, 3410, 3411, 3420), or

- The ability (supplied by the customer through his operating system facilities) to create card-image format on either tape or diskette. (A diskette is not a supported card image device in 370-XA mode.) The customer must supply an operator to key the card images at the direction of the service representative.

When operating in XA mode, a diskette is not a supported card image device. A line printer is required for IOCP error message printout generation. (Printers supported by IOCP are the 1403, 3202-5, and 3211.)

** Must be a removable Direct Access Storage Device (DASD) (3330 or 3340).

***If 2400 Series, seven track, magnetic tape drives are used— data conversion features (No. 3228 and 3236) must be installed on the 2803 or 2804 Tape Control Unit.

Minimum Configuration with Unremovable Direct Access Storage

Figure 10 shows the minimum system configuration necessary for hardware maintenance when using an *unremovable* direct access storage device (DASD). A set of cylinders on an unremovable drive (other than the system residence drive) must be made available for the generation and maintenance of service programs. This space must be allocated for initial installation, for modifications to the configuration, and for the application of maintenance facility updates.

- **4381 Processor**

- **3278-2A Display Console or 3279-2C Color Display Console**
  (with the Operator Control Panel)

- **Card Image I/O device*** (for 370-XA only)

- **Unremovable Direct Access Storage Device:**
  - 1 tape drive and a 3350 with the first 40 cylinders
    dedicated while required or,
  - 1 tape drive and a 3375 with the first 30 cylinders
    dedicated while required, or
  - 1 tape drive and a 3380 with the first 32 cylinders
    dedicated while required, or
  - 3 tape drives with any fixed-block DASD or non-supported
    DASD.

  Note: These figures represent the maximum space required
  and are for planning purposes only.

  After use by the service representative, the customer may need
  to reformat this drive.

- **Magnetic Tape device**

- **Hard-copy Output device**

Figure 10. Minimum Configuration with Unremovable Direct Access Storage

Card Image is defined as:

- Any supported card reader (2501, 2540, 3505), or

- A magnetic tape drive and provisions for entering card-image formatted records onto a magnetic tape (2400, 2420, 3410, 3411, 3420), or

- The ability (supplied by the customer through his operating system facilities) to create card-image format on either tape or diskette. (A diskette is not a supported card image device in 370-XA mode.) The customer must supply an operator to key the card images at the direction of the service representative.

When operating in XA mode, a diskette is not a supported card image device. A line printer is required for IOCP error message printout generation. (Printers supported by IOCP are 1403, 3202-5, and 3211.)

Operational Requirements

In all configurations, each processor must use IBM programs (or equivalent) that provide for error recording, with elements for handling machine check interruptions and recording the status of the processor when a failure is detected. Routines for error recording are in some of the following system control programs:

- DOS/VSE

- OS/VS1

- VM/SP

- MVS/SP.

If your system configuration does not match any of the above requirements, IBM's ability to service your system can be impaired. This inability to service your system can affect system availability.

System Residence and Maintenance Storage Requirements

Optimal performance and maximum availability are obtained when a disk storage facility is provided. The DOS/VSE, OS/VS1, MVS/SP and VM/370 operating systems *require* a disk storage facility. These storage requirements are attached through a block multiplexer channel.

A portion of main storage is required for dynamic tables. However, this reduces the amount of main storage available for user programming.

Display Console

Physical Description

The IBM 3278-2A Display Console (or the IBM 3279-2C Color Display Console) is the principal device for the operator to communicate with the system. The primary (system) display console consists of:

- Display screen

- Keyboard, and

- Operator control panel (one operator control panel/system).

Display Console Screen

The console screen and keyboard allows you to communicate with the system. The operating system may use the display screen to pass messages to the operator, present operating modes for selection and further definition, and to display information accessed or entered at the keyboard. The 3279-2C Color Display Console displays the same information as the 3278-2A. The 3279-2C can display the information in up to four colors (red, green, blue, and white) for improved readability.

The display console (3278-2A or 3279-2C) has a screen size of 2000 characters (25 lines of 80 characters each). The bottom line (line 25) of the display screen is used exclusively for indicating *display console status*. The remaining portion of the display screen is partitioned into two regions (Figure 11 on page 23). The upper 20-line region is used and managed by the operating system. Line 21 is used as a delimiter and does not contain any information. Lines 22 through 24 are reserved for displaying *system status*. The system and display console status areas (lines 22 through 25) are not available to the user.
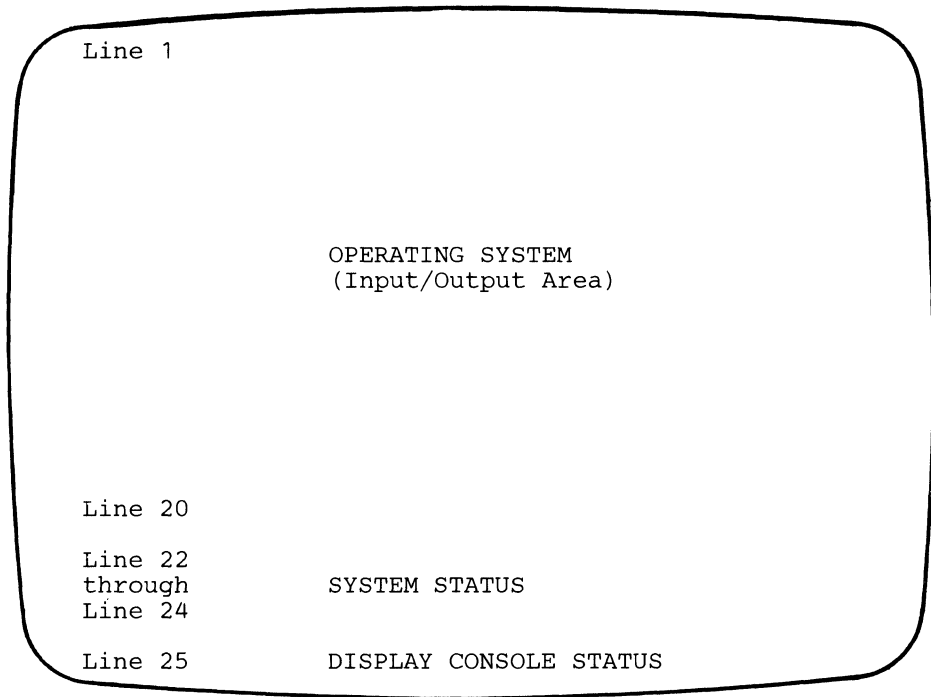
```
   Line 1




                        OPERATING SYSTEM
                        (Input/Output Area)






   Line 20

   Line 22
   through              SYSTEM STATUS
   Line 24

   Line 25              DISPLAY CONSOLE STATUS
```

Figure 11. Display Console Screen

Display Screen Switches and Controls

The switches and controls for the screen are on the left and right sides of the display screen.

Power On/Off and Normal/Test Switches: These switches make the display console *ready* (On and Normal positions) or *not ready* (Off or Test positions). When the display console is made not ready, *intervention required* is set in the sense byte, and Start I/O instructions to the device are rejected. Whenever a device is made not ready in this way, the current display console screen image is lost and cannot be recovered. The top 20 lines of the screen are blank when the device is made ready. When a not ready to ready transition occurs, a device end status is presented to the channel program.

Mono/Dual Switch: This switch determines whether alphabetic characters are displayed in lowercase or uppercase. When the switch is set to the *A* (mono) position, all alphabetic characters are entered and displayed in uppercase. When the switch is set to the *A,a* (dual) position, both uppercase and lowercase characters are displayed.

Contrast/Brightness and Alarm/Volume Controls: These controls adjust the display screen and alarm conditions appropriate to the operating environment. These controls have no effect on the operation of the device and do not cause any error conditions.

Two Color/Four Color (3279-2C only): This switch allows the operator to change from the basic four-color display presentation to a two-color (green/white) presentation. The two color presentation duplicates the 3278-2A monochrome presentation, with white being used for intensified fields.

Line 25 of the display console screen indicates the status of the display console. Normally, four fields (see following screen) can display status. Only one of the status messages can be displayed in each field at a given time.
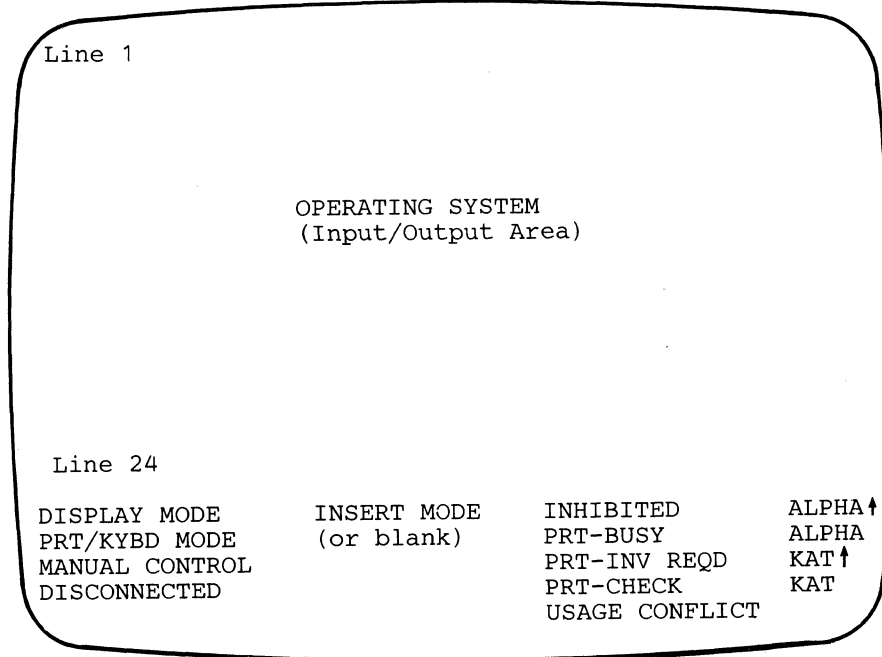
```
Line 1




                        OPERATING SYSTEM
                        (Input/Output Area)




    Line 24

  DISPLAY MODE        INSERT MODE      INHIBITED        ALPHA↑
  PRT/KYBD MODE       (or blank)       PRT-BUSY         ALPHA
  MANUAL CONTROL                       PRT-INV REQD     KAT↑
  DISCONNECTED                         PRT-CHECK        KAT
                                       USAGE CONFLICT
```

Figure 12. Display Screen Indicators

Display Mode: This indicates that the display console is available to the host operating system, using a 3272 control unit or equivalent support.

Prt/Kybd Mode: This indicates that the display console is available to the host operating system, using 1052, 3210, or 3215 console printer/keyboard support.

Manual Control: This indicates that the display console is under manual control and is not available to the operating system. In this mode, a Start I/O command to the display console is accepted but is held pending until the device is available to the operating system. If a Start I/O command is queued, the audible alarm sounds and CONSOLE I/O WAITING displays in the system status area of the screen.

Disconnected: This indicates that the device (1) is not logically connected to the 4381, or (2) is not available to the operating system, or (3) is not in use for manual functions. This condition exists when no unit address has been assigned to the display console.

Insert Mode: This displays after you press the INSERT key. In this mode, data entered from the keyboard is inserted at the present cursor position between any existing data. The Insert indicator and mode are turned off by pressing the RESET key.

Inhibited: This indicates that the keyboard is inhibited:

- An Attention key (PF key, ENTER, CNCL [PA2], REQ [PA1], MODE SEL, CHG DPLY, OR DIAG) was pressed.

- The operator attempted to alter a protected field.

- The operator attempted to insert a character into a field that had no nulls.

- A keyboard overrun (caused by simultaneous key entries) occurred.

- The START, STOP, INTR, MODE SEL, CHG DPLY, or DIAG keys were pressed when another display console was already in manual control mode, or when a previous request had not been completed.

When the keyboard is locked, the Inhibited indication is displayed. Certain functions, such as the Reset function, are accepted and processed when the keyboard is locked.

This indicator message is reset by either:

- The application program, which issues a Write command that specifies *keyboard restore*. (This also resets the PRT-BUSY, PRT-INTV REQD, AND PRT-CHECK indicators.)

- Pressing the RESET key.

Prt-Busy: This displays when a copy request is issued to a hard-copy printer that is busy with a previous copy request or with a Start I/O from the operating system. The copy request is ignored.

The Prt-Busy indicator is reset by pressing the RESET key.

Prt-Intv Reqd: This displays if a Copy request has been rejected because of an error condition that the operator can resolve, such as:

- End-of-forms

- No hard-copy device assigned

- Printer power is off

- Printer is in Test mode.

The Prt-Intv Reqd indicator is reset by pressing the RESET key.

Prt-Check: This appears when an equipment check condition is detected while attempting to perform a copy request. The indication is reset by pressing the RESET key.

Usage Conflict: This displays when a function is not allowed at the present time. This occurs if the START, STOP, INTR, MODE SEL, CHG DPLY, or DIAG key is pressed when another display console is already in manual control mode or when a previous request has not been completed. This indication is reset by pressing the RESET key.

The following four indicators apply only to the Katakana keyboard.

ALPHA ↑: This indicator is on when the processor display console is in alphameric uppercase mode.

ALPHA: This indicator is on when the processor display console is in alphameric lowercase mode.

KAT ↑: This indicator is on when the processor display console is in uppercase Katakana mode.

KAT: This indicator is on when the processor display console is in lowercase Katakana mode.

Display Console Keyboard

The primary (system) display console keyboard is the operator's primary input device to the system. The keyboard controls the display console and allows the operator to:

- Enter data

- Answer program-generated requests

- Perform manual functions

- Enter control information.

The functional key groups include: general entry keys, cursor control keys, input control keys, system function keys, and program function keys.

- The *general entry* keys enter alphameric characters, punctuation marks, and symbols onto the display screen.

- The *cursor control* keys move the cursor to a certain position on the display screen.

- The *input control* keys erase, insert, or otherwise modify the data entered from the general entry keys.

- The *system function* keys control operation of the system and the display console screens.

- The *program function* keys can be assigned by the application program to perform specific functions.
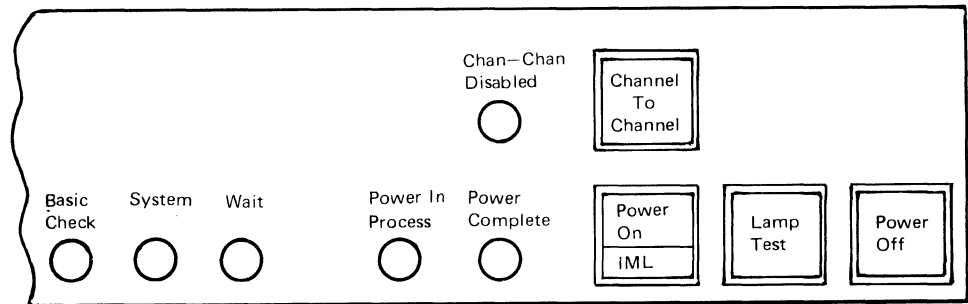
Operator Control Panel

Figure 13. Operator Control Panel

The operator control panel (OCP) is above the keyboard on the primary (system) display console. It is used with the display console to control and monitor 4381 operation. With the OCP, the operator can:

- Turn the system power on and off

- Load the support processor microcode

- Observe system status

- Enable and disable the channel-to-channel feature.

Display Console Operation

The following information is a general description of some of the functions encountered in the day-to-day operation of the display console. For detailed operating instructions, refer to the *IBM 4381 Processor Operations Manual*, GA24-3949.

System Power On

System power is turned on from the operator control panel, which is above the keyboard of the display console. Indicator lights on the panel show the status of the power-on sequence. The *Power In Process* light is on while power is applied in the following sequence:

1. Support Processor:

    - Diskette drives
    - 3278-2A or 3279-2C operator display console
    - Support bus adapter and local channel adapter
    - Remaining console I/O devices.

2. Processing unit

3. Channel-to-channel adapter (if installed)

4. Channel attached I/O devices. (Up to 32 control units, not to exceed eight per channel, can be turned on with the system.)

When the power sequence is complete, the *Power In Process* light turns off and the Power Complete light turns on.

Initial Microcode Load (IML)

When the power-on sequence is complete, the Program Load screen displays on the display console. This screen allows the operator to select the microcode from the diskette and load it into control storage. The microcode that is loaded determines the mode (System/370 or 370-XA) that the processor uses for program execution. After the proper mode is selected, an IML may be performed.

Once the microcode has been selected, you can choose (on the customer System Configuration screen) to have an IML done whenever the processor is powered on. This saves you from manually initiating an IML when the same mode of operation is repeatedly used. If an IML is desired at any time other than after power-on, the operator can return to the Program Load screen to select and initiate an IML.

Initial Program Load (IPL)

The initial program load (IPL) is performed from the Program Load screen (as is the IML). This screen allows the operator to specify the address of the IPL device and initiate the program load function. Once the IPL device has been specified, the operator can choose (from the customer System Configuration screen) to have an IPL done whenever the processor is powered on.

If an IPL is desired at any time other than after power-on, the operator can return to the Program Load screen to initiate an IPL.

Operator Console Operating Modes

There are two display console operating modes: *display* and *printer/keyboard*. The mode can be selected by the operator from the customer System Configuration screen.

In display mode, the 3278-2A Display Console (or 3279-2C Color Display Console) and the optional console printer are separately addressable devices. Data can be entered or displayed on the display console and separately printed on the hard-copy console printer. In display mode, lines 1 through 20 on the display screen are used as the input and output area as defined by the operating system.

In printer/keyboard mode, the display console and optional console printer share a single address. Operating messages to and from the system are displayed on the display console and are also printed on the coupled console printer. Printer/keyboard mode is used to emulate a 1052 for those operating systems and programs designed for that type of operator console.

In printer/keyboard mode, lines 19 and 20 of the screen display your input and also display printer/keyboard indicators. The top portion of the screen (lines 1 through 18) is used as the operating system display area to sequentially display the most recent operator input and system output messages.

Refer to "Programming Information" on this page for detailed information on the operator console operating modes.

Manual Control Operations

A network of manual control display screens give you access to internal 4381 Processor information for system control, monitoring, and analyzing. The initial screen in this chain is the General Selection screen. This screen displays a menu that allows you to quickly branch to other manual control screens, where the following functions are available:

- System configuration
- Storage alter/display
- Compare/trace
- Problem analysis
- Blocks and patches
- Error logs.

The General Selection screen can be displayed for manual control functions by pressing the MODE SEL key on the display console.

Display Console Testing

The 3278-2A and 3279-2C have their own facilities to test the refresh buffer, keyboard, and execution of device Write commands. A description of the available tests and procedures for each console is contained in each console's problem determination guide, which is in the console keyboard.

Programming Information

There are two operating modes: *Display* mode and *Printer/Keyboard Emulation* mode. The operating mode affects the way the operating system and application program work with the display console.

Display Mode Commands

Display mode supports the 3278-2A Display Console (or 3279-2C Color Display Console) and an optional printer.

The user screen size is limited to 20 lines; only 1600 bytes of device buffer for the 3278-2A or 3279-2C Display Console are available to the operating system. For the printer, 24 lines (1920 bytes) are available.

The display consoles and printers have unique unit addresses and are treated as independent devices. The device addresses hex 000 through hex 0EF can be selected by the operator at any time.

When the operating system or application program communicates with the display console, it issues a Start I/O to the channel. The channel starts the display console operation by issuing one of the 3270-mode CCW commands (Figure 14 on page 29). For more detailed information about 3270 commands, see the *IBM 3270 Information Display System Component Description*, GA27-2749.

Code	CCW Command	Initial Status	Ending Status	Async. Status
01	Write	00	CE	DE
05	Erase/Write	00	CE	DE
02	Read Buffer	00	CE,DE	
06	Read Modified	00	CE,DE	
0B	Select	CE	DE	
0F	Erase All Unprotected	CE	DE	
03	No Operation	CE,DE		
04	Sense	00	CE,DE	
E4	Sense I/O	00	CE,DE	

Figure 14. 3270 Mode CCW Commands

Device Status

The display console status byte presented to the operating system can be generated synchronously or asynchronously. Synchronous status is passed to the host channel as ending status to a command.

Bit	Status
0	Attention
1	Not Used
2	Not Used
3	Busy
4	Channel End
5	Device End
6	Unit Check
7	Unit Exception

Figure 15. Device Status Bits

Initial Status reflects the condition of the selected device upon receipt of a command, and indicates to the channel if the command can be executed.

Ending Status reflects the condition of the selected device after all channel interface operations of a non-immediate command are completed.

Asynchronous Status reflects ending status for: (1) an immediate command (other than No Operation), (2) a second ending status for a Write or Erase/Write command, (3) an equipment condition or operator action (attention) not associated with command execution.

Sense Byte

When an error is detected, the appropriate bits are set as follows to describe the error condition. This sense byte is sent to the host channel when a Sense command is executed. Sense data is reset by every command except No Operation.

Bit	Status
0	Command reject
1	Intervention required
2	Bus-out check
3	Equipment check
4	Data check
5	Unit specify
6	Control check
7	Operation check

Figure 16. Sense Byte Bits

Sense I/O: This command is used to identify device type. If the device is not busy or not ready, seven bytes of fixed data are presented:

Mode	Data Bytes
Display Mode	
3278-2A	Hex FF43810032782A
3279-2C	Hex FF43810032792C
3287	Hex FF438100328700
3268-2	Hex FF438100328700

Figure 17. Display Mode Sense Bytes

Write Data Record

Programming for a display console differs from most other I/O devices in that the CCW commands for a display console are fairly elementary, and the detailed data positioning and control attributes are imbedded within the data record that is transferred by the CCW.

To control the information displayed on a display console, the application program must supply a write data record that includes a write control character (WCC), buffer control orders, buffer address, attribute, and data. Only the attribute and data are stored in the device buffer. Invalid or undefined data (EBCDIC) in the data record is displayed as a hyphen.

Bit	Write Control Character (WCC)
0	Not Used
1	1
2,3*	Printout format
	00=the NL order in the data record; determines print line length
	01=specifies 40-character print line
	10=specifies 64-character print line
	11=specifies 80-character print line
4*	Start print
5	Sound alarm
6	Restore keyboard
7	Reset MDT

Figure 18. Write Control Character Bits

Code	Buffer Control Orders
1D	Start field (SF)
11	Set buffer address (SBA)
13	Insert cursor (IC)
05	Program tab (PT)
3C	Repeat to address (RA)
12	Erase unprotected to address (EUA)

Figure 19. Buffer Control Orders

Bit	Attribute Character
0	Determined by the contents of bits 2-7
1	1
2	0=Unprotected
	1=Protected Field
3	If bits 2 and 3=11, an automatic skip occurs.
4,5	00=Normal display
	01=Normal display
	10=Intensified display
	11=Nondisplay, nonprint
6	0
7	Modified data tag (MDT)
	0=Field has not been modified
	1=Field has not been modified by the operator or set by the program in the data record

Figure 20. Attribute Character

If a buffer address is specified past the end of the user buffer area (20 lines for the 3278-2A and 3279-2C, 24 lines for the 3268-2 or 3287), the operation check bit is set in the sense byte. The command is ended with device end and unit check status. When the operation check occurs because of an invalid buffer address, channel end (CE) may have been sent before the operation check was detected. The residual count field is unpredictable in this case and cannot be used to precisely determine the location of the error in the write data record. If data chaining is specified for the Write command, the CCW address stored in the CSW may also be past the CCW pointing to the invalid data. The write data record must be inspected to locate the invalid address specification.

Color Console and Printer

The colors presented on the color console and printer are determined by the existing protection and intensification attribute bits of the display field.

The attribute bits, their field characteristics, and colors presented include:

Bits	Attribute Characteristic	Color
00	Unprotected, Unintensified	Green*
01	Unprotected, Intensified	Red
10	Protected, Unintensified	Blue
11	Protected, Intensified	White

Figure 21. Attribute Characteristics

* Green and black may be interchanged on the 3287-1C or 2C printer when they are ordered.

Read Data Record

The following types of read data records can be generated, depending on the command.

Read Buffer data record: The read data record responds to the Read Buffer command with a three-character read heading that consists of the Attention Identification (AID) character, followed by a two-character cursor address.

The contents of all device buffer locations (lines 1 through 20 for 3278-2A or 3279-2C, lines 1 through 24 for 3268-2 or 3287) are transferred to the processor, including nulls. Start field (SF) order codes are inserted before each attribute character to identify the beginning of each field.

Read Modified data record: The application program issues a Read Modified command to the display console in response to an attention interruption (as a result of pressing the ENTER key or a program function key). The first three-byte read heading of the read data record is always the AID code and the two-byte cursor address.

Following the read heading is the data of each modified field (lines 1 through 20 for the 3278-2A or 3279-2C, lines 1 through 24 for 3268-2 or 3287). The data for each field is preceded in the data record by a set buffer address (SBA) order code, followed by the two-byte buffer address of the first character position in that field (the attribute address +1).

Data Fields

The concepts of protected or unprotected data and the modified data tag function are basic to the modes of operation.

Protected Data Autolock: A program controlled facility of the display console allows fields to be defined as *protected* or *unprotected*. The operator cannot alter the protected field in any way. If an attempt is made to enter an alphameric character when the cursor is in a protected field, the keyboard becomes disabled (by the autolock function).

In an unprotected field, the operator can enter, modify, and erase alphameric data.

Modified Data Tag: To identify data fields that have been modified, the modified data tag bit (bit 7 of the attribute character) is set to one. This process is called *tagging* the field.

Data in protected or unprotected fields can be tagged as having been modified. In protected fields, the tags are set under program control. In unprotected fields, modified data tags are also set at the keyboard. These tagged fields are the only fields transferred upon execution of a Read Modified command.

Display Mode Error Handling

When attempting any recovery after a unit check is reported to the operating system, use the error recovery procedures described in *IBM 3270 Information Display System Component Description*, GA27-2749.

3268 Model 2 and 3287 Printer

These optional printers print the information that is displayed on the 3278-2A or 3279-2C Display Console or written from the application program.

All 3270-mode CCW commands and data records to the display console can be issued to the printer. Printouts can be formatted the same way as a display image. Cursor information is ignored by the printer.

When a print operation is specified by a Write command, one of three print line formats can be specified as part of the command. These formats simply define the print line length: 40, 64, or 80 character positions per line. If the format is not specified, the line length is set to the default for the printer.

Printer control orders (NL, EM, and FF) are transferred as part of the data record from the application program. They are stored in the printer buffer as data.

Note: If a write buffer has been issued but the buffer has not printed, the printer appears *busy* to a copy key request.

Printer Error Handling: The recovery operations for errors detected by the 3268-2 and 3287 are:

- Automatic recovery—the Alphanumeric Readout (ANR) may indicate the reason code.

- Manual intervention recovery—The printer check light is turned on and the ANR indicates the reason code.

- Machine stop—The printer check light is turned on and the ANR indicates the reason code.

Printer/Keyboard Emulation Mode

Printer/keyboard emulation mode allows the processor to run operating systems and programs designed for devices such as the 1052, 3210, or 3215. Although physically different, these devices accept the same commands and respond in a similar fashion. They are emulated on a display console with an optional printer coupled as a hard-copy device.

Printer/keyboard emulation mode requires one 3278-2A or 3279-2C Display Console. Options allow up to three additional (3278-2A, 3279-2C, or 3268-2 or 3287) devices to be attached to the support processor and be configured as needed.
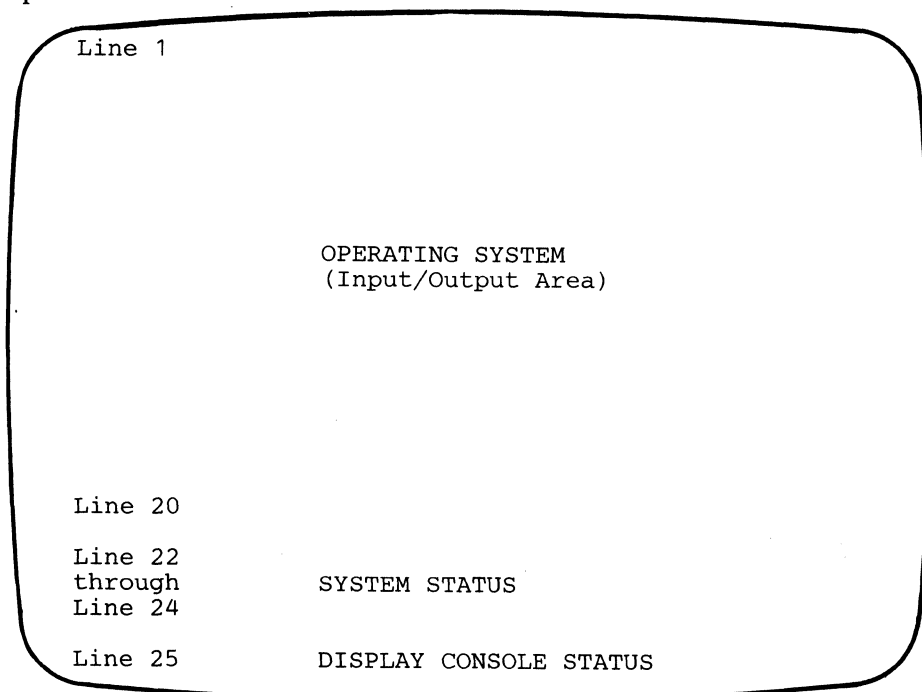
In *coupled* mode, all data read from or written to the device is printed on the printer. In *uncoupled* mode, only up to the last 18 lines of data are displayed on the 3278-2A or 3279-2C. No hard-copy record is made. To *couple*, assign the same device address to a display console and printer by using the System Configuration screen.

Both the display console and the printer appear to the operating system as one device. The device addresses are selected by the operator and can be modified at any time. A maximum of two printer/keyboard devices can be configured at a time.

In printer/keyboard emulation mode, the display console accepts printer/keyboard commands and responds with status and sense information. The data received or sent with the commands is formatted to appear on the display console and optional printer in a manner similar to the actual devices being emulated. Indicators and keys emulating printer/keyboard functions are displayed on the 3278-2A or 3279-2C Display Console to allow the functions to be performed by the operator.

Screen Management

When the display console is in printer/keyboard emulation mode, the entire screen is controlled by the emulation facility. The screen is initialized the first time printer/keyboard emulation mode is entered, either by operator action (pressing the attention keys or making the device ready) or by channel action (SIO or reset). After the screen is initialized, the operator can only enter data on the screen when a Read command is issued. At all other times, the entire display is protected from operator alteration.

```
  Line 1




                    OPERATING SYSTEM
                    (Input/Output Area)




  Line 20

  Line 22
  through             SYSTEM STATUS
  Line 24

  Line 25             DISPLAY CONSOLE STATUS
```

Figure 22. Printer/Keyboard Emulation Mode Screen Format

The screen is divided into three areas.

- **Lines 1-18** contain the message area for displaying the operator input and host program output messages.

- **Lines 19 and 20** contain the operator input area. Up to 126 characters are allowed for each read operation. Part of line 20 displays 1052 indicators (REQUEST, PROCEED, ALARM and INTV REQD).

- **Lines 22 through 24** display the system status. The character positions on line 25 are exclusively for indicating console device status.

A message in the input area transferred to the host program is also displayed in the message area. Input and output messages are displayed sequentially, starting from the top (line 1) as if they were printed on the printer/keyboard device.

When the display message reaches the bottom (line 18), scrolling takes place. The top six lines (lines 1 through 6) are rolled off the screen and the bottom six lines (lines 13 through 18) are made available for input.

Display Area: The display area starts in line 1, column 1, and ends on line 18, column 79. The display area is protected by an attribute at line 20, column 80. This area shows the last 18 lines of data that have been read from or written to the device. The data is organized into lines corresponding to lines of printer/keyboard output, with each new line beginning in column 1 of a display area line. A line longer than 80 characters (the display line length) wraps to the next line in the display area, up to a maximum of 126 characters.

To allow the maximum amount of data to be displayed, multiple new line characters (NL= hex 15) in a write data record result in only one blank line on the display console. This prevents data from being scrolled off the screen when new line characters are added to space the printer output. The new line suppression only applies within a command; each command is treated separately. Multiple blank lines caused by two or more commands are not suppressed.

Input Area: The input area is defined by an attribute at line 18, column 80, and contains 126 characters on lines 19 and 20. This area is unprotected *only* when a Read command is in progress (PROCEED is displayed). At all other times, it is protected from operator alteration.

Pressing the ENTER or CANCEL key transfers data in the input area across the channel. Data accepted by the channel for a Read command is then moved to the display area and is printed. If the channel finishes data transfer before all data entered by the operator has been sent, only that data accepted appears in the display area.

The field initially contains all nulls (hex 00) that are compressed out of the read data and not transferred to the channel. If a space (hex 40) is desired in the response, the SPACE key must be used to enter it. Cursor movement keys leave nulls in the input area. These nulls are compressed from the data.

Indicator Area: The indicator area is an intensified field defined by an attribute on line 20, column 47, and is 32 characters in length. This area contains the following visual indicators:

Proceed appears whenever a Read command is in progress for entry of data in the input area. Proceed is cleared when the Read command is ended by any of the following conditions:

- Normal ending caused by pressing the ENTER or CANCEL key
- A system or selective reset
- A halt device or halt I/O instruction issued to the device.

Request indicates that a REQ (Request) key attention status has been stacked because the device is busy executing a command. When the current operation completes, the attention status is presented to the channel, and the Request indicator is reset. A system or selective reset also resets the Request indicator.

Alarm appears and the audible alarm sounds whenever an Alarm command is received. The indicator is reset by:

- Pressing a program function (PF) key at any time
- Pressing the ENTER or CANCEL key when Proceed is not displayed
- A system or selective reset.

Intervention Required (INTV REQD) appears if the 3268-2 or 3287 Printer (defined as a hard-copy device) becomes not ready. This condition occurs when end-of-forms, power off, or other check conditions are present. At this time, a Start I/O is not accepted. When the check condition is cleared, the indicator is erased, and device end status is presented to the channel.

3278-2A and 3279-2C Console Keyboard Operation

The 3278-2A or 3279-2C Display Console keyboard communicates with the processor. In printer/keyboard emulation mode, the display console always contains a formatted screen that defines protected and unprotected fields. The different keys include:

Alphameric and Special Character Keys: These keys are used when an unprotected field is present, which is only during a Read command (Proceed indicator displayed). Using these keys at all other times causes the INHIBITED message to appear on line 25 of the display console. The inhibited condition can be cleared by pressing the RESET key.

REQUEST (REQ) Key: This key initiates communication with the system by sending an attention status (X'80'). If the request status cannot be sent immediately because of a busy condition, the Request indicator appears, and the attention is stacked. The FU Request indicator is reset.

> **Note:** Do not confuse the REQ and INTR keys. The red INTR key causes an External Interrupt, and is not used with printer/keyboard emulation mode operation.

ENTER Key: This key is used during a read operation when data entry is complete. The data is read and the input area is cleared and protected. This key is equivalent to the End-of-Block (EOB) or End keys on the emulated device. If no read is in progress, the alarm indicator resets and the keyboard unlocks.

CANCEL (CNCL) Key: This key performs the same function as the printer/keyboard CANCEL key. During a read operation, this key sends a cancel response to the channel. The cancel response is a channel end with unit exception (hex 09). The input area is cleared and protected, and an asterisk (*) is written in the display area; no data is transferred. If no read is in progress, the alarm indicator resets and the keyboard unlocks.

Program Function Keys (PF1-PF12): These keys reset the Alarm indicator and unlock the keyboard.

Cursor Movement Keys These keys move the cursor without causing any modifications to the screen. They may be used at any time and do not cause errors. The cursor is positioned at the start of the input area when a Read command is initiated. The cursor must be in the input area to enter data. The Tab and Backtab keys always position the cursor at the beginning of the input area if a Read is in progress. Pressing the New Line key places the cursor in the first column of either line 19 or 20.

ERASE and ERASE EOF Keys: These keys clear the input area when a Read is in progress. The ERASE INPUT key clears the entire field and relocates the cursor. The ERASE EOF (End-of-Field) key clears the field from the current cursor position to the end of the input area.

INSERT and DELETE Keys: These keys selectively add and delete characters as you enter and alter data in the input area.

3268 Model 2 or 3287 Printer

A 3268-2 or 3287 (optionally coupled as a hard-copy device in printer/keyboard emulation mode) can print all data that has been transferred. The data is arranged in lines of 126 or fewer characters, as they would appear on the emulated printer. Each line is printed when it is completed; that is, when any of the following conditions occur:

- 126 bytes of data have been received since the beginning of the line.
- A New Line character (hex 15) is found in a write or write-ACR command data record.
- After a read command is executed.
- A system or selective reset occurs.

    Note: After a Write command (hex 01) is executed, but a complete line has not been accumulated, the last partial line *is not* printed. The data is accumulated in the printer buffer and is printed when the line is completed by succeeding commands. The printer is busy to a copy key request at this time. If no data is in the buffer, a system or selective reset causes a line feed to be performed.

Printer/keyboard emulation mode accepts and executes all commands that are valid for the emulated device. The valid commands and the normal status responses received are shown in Figure 23.

Code	CCW Command	Initial Status	Ending Status	Async. Status
01	Write	00	CE	DE
09	Write ACR	00	CE	DE
0A	Read Inquiry	00	CE	DE
04	Sense	00	CE,DE	
03	NOP	CE,DE		
0B	Alarm	CE,DE		
E4	Sense I/O	00	CE,DE	

Figure 23. Printer/Keyboard Emulation Mode Commands

It is assumed that an alternate console printer has been coupled as a hard-copy device. If not, ending status for a command is presented to the channel after the data has been placed in the display console area.

Write: The Write command transfers data from the channel to an internal buffer and then sends the data (one line at a time) to the display area and prints it on the printer. When all the data has been received, channel end is returned and the last line is processed. If the last line is not complete (ended with new line character or exactly 126 bytes), device end is sent after the data has been placed in the display area and saved in the printer buffer without printing.

If the command ends with a complete line, device end is sent when printing is finished. The Write command continues requesting data from the channel until the channel stops data transfer (when the CCW count reaches zero). Therefore, incorrect length is always indicated with a zero residual count, unless the suppress incorrect length indicator (SILI) CCW flag is on.

Write-ACR (Automatic Carriage Return): This command is similar to the Write command except that at the end of processing the last line, an automatic carriage return (ACR) is performed.

Read Inquiry: When the Read Inquiry command is received, the input area is unprotected and the Proceed indicator is turned on. The command waits until the operator presses the ENTER or CANCEL key (this signals data is complete).

If the ENTER key is pressed, the data is read from the input area and transferred to the channel. (Channel end is presented after data transfer.) Any data the channel accepted is written to the display area and printed on the printer.

If the CANCEL key is pressed, a channel end with unit exception is presented to the channel, and an asterisk (*) is written to the display area and printed.

After printing completes, a device end is sent to complete the command.

Sense Byte

The Sense command transfers one byte of sense information. After the sense byte is accepted, channel end and device end are presented as ending status. The sense byte is reset at the initiation of any command except Sense. The sense byte:

Bit	Code	Sense Information
0	CR	Command Reject
1	IR	Intervention Required
2	BOC	Bus Out Check
3	EC	Equipment Check
4	–	Unused; always 0
5	–	Unused; always 0
6	–	Unused; always 0
7	–	Unused; always 0

Figure 24. Printer Sense Information

Sense I/O: This command identifies the device type. If the device is not busy or not ready, seven bytes of fixed data are presented:

Mode	Data Bytes
PRT/KBD	Hex FF438100105200

Figure 25. Printer Data Bytes

No Operation (NO-OP): This control command results in an immediate channel end and device end. No action is performed in the device. This command can be used to clear any pending status, or cause a command chain to end with a channel end and device end together.

Alarm: This control command sounds the audible alarm on the display console and displays the alarm indicator. If the display is not ready, the command functions as a NO-OP. Immediate channel end and device end are presented as initial status. The command is accepted even if an intervention required condition exists.

Device Status

The following bits are set:

Bit	Status
0	Attention
1	Not Used
2	Not Used
3	Busy
4	Channel End
5	Device End
6	Unit Check
7	Unit Exception

Figure 26. Device Status Bits

Unlike the display console, the following information is specific for the printer/keyboard read operation:

- The attention bit is set to one when the REQUEST key is pressed. This attention status is presented to the channel when no other operation is in progress. The host program reacts to the attention interruption by issuing a Read command.

- No AID is generated for an attention interruption.

Error Conditions

The following error conditions can occur while operating in printer/keyboard emulation mode:

3278-2A and 3279-2C Display Consoles Not Ready: The Sense and Alarm commands are always accepted. When the 3278-2A or 3279-2C is not ready because of one of the following conditions, a Write, Write-ACR, Read, or No-Op command is rejected.

Power Off: When the display console is not on, an intervention required condition exists and is reported to a Sense command.

Test Mode: When the 3278-2A or 3279-2C is in test mode (Test/Normal switch in Test position), an intervention required condition exists and is reported to a Sense command.

Device Not Functional: If the 3278-2A or 3279-2C hardware is failing, or the device is incorrectly configured or is not connected, an intervention required or equipment check condition exists and is reported to a Sense command.

Console Printer Not Ready: Any of the following conditions cause the 3268-2 or 3287 Printer to be not ready:

Power Off: When power is off to the 3268-2 or 3287, an intervention required condition exists and is reported to a Sense command.

Test Mode: When the printer is in test mode (by pressing the Test switch), an intervention required condition exists and is reported to a Sense command.

End-of-Forms: When *End-of-Forms* indicates that no paper is in the printer and a one-minute timeout occurs, an intervention required condition exists and is reported to a Sense command. The INTV REQD indicator is displayed only after the timeout condition occurs. This delay allows the operator to correct the end-of-forms condition and continue printing with no errors reported or software retry required. The end-of-forms condition causes the audible alarm to sound until *Hold Print* is pressed. The end-of-forms condition is cleared by pressing *Hold Print*, replacing the forms, and then pressing *Enable Print*.

Hold Print Timeout: When the Hold Print condition lasts longer than ten minutes, an intervention required condition exists and is reported to a Sense command. The INTV REQD indicator is displayed only after the ten minute timeout occurs.

Device Not Functional: When the console printer is not operating because of error conditions, incorrect connection, or invalid configuration, an intervention required or equipment check condition exists.

Restrictions and Functional Differences

When operating in printer/keyboard emulation mode, consider the following:

Timing: The length of time taken to execute a command may differ from the emulated devices. Typically, the time from Start I/O until the associated channel end is much shorter than with an actual device, and the time from channel end to device end is longer; printing is not started until a complete line is received.

The printing speeds of the 3268-2 and 3287 are much faster than the speed of the 1052 and the other emulated devices. You can increase throughput by using printer/keyboard emulation mode on the 4381.

When running in uncoupled mode (3278-2A or 3279-2C without a printer), a timing delay of 0.5 seconds per line improves display console readability.

Keyboard Differences: The 3278-2A or 3279-2C and emulated keyboards differ in both the number of keys and in the keyboard layout. Because all the keys on the 3278-2A or 3279-2C can be used even if the emulated printer/keyboard has no corresponding key, it is possible to read and write characters that are not implemented on the emulated device.

> **Note:** The CARRIAGE RETURN key on the emulated keyboard is not implemented. Programs that use this key are not supported in printer/keyboard emulation mode.

Facility Descriptions and Implementation

The following information describes the implementation of certain facilities and functions available on the 4381 Processor.

Instruction Set

The universal instruction set is implemented in the 4381 Processor. For details on instruction word formats and definitions, refer to the *IBM/System 370 Principles of Operation*, GA22-7000, or *IBM 370-XA Principles of Operations*, SA22-7085.

Elementary Math Library Assist (Model Group 2 only)

The Elementary Math Library (EML) assist is a standard feature of the Model Group 2. The assist improves the speed of calculations for single- and double-precision versions of square root functions, exponentiation of natural logarithms, and common logarithms. That is, *e to the power x* functions.

Engineering Scientific Assist

Engineering Scientific Assist is a standard feature on the 4381 that improves the performance of certain mathematical computations. The assist consists of one instruction: MULTIPLY AND ADD, which performs a combination of vector multiplication and addition operations. This can replace the inner loop of common matrix computations and reduce processor calculation time.

For further information, refer to *IBM Multiply—Add Facility*, GA22-7082.

4381 Model Dependent Information

Support for Remote Operator Consoles

Support for the remote operator consoles is supplied through a 3275-2 compatible connection. Any device supported by MVS/OCCF or by VM/Pass-Through may be used as a remote console when attached to a host processor using either software package.

MVS/OCCF and *VM/Pass-Through* provide emulation facilities that allow the console devices to use the 3275-2.

Segment Table Entry (STE)

The 4381 does not check bits 4 through 7 of the segment table entry for zeros.

Timing Facilities Damage

The 4381 does not distinguish among the failure of the three timing facilities: Time-of-Day (TOD) clock, central processing unit (CPU) timer, and clock comparator. Any failure of hardware timing facilities causes all three facilities to enter the error state.

Timer and Clock Resolution

The interval timer is updated every 3.328 milliseconds. The processor skips one update every 625 updates to derive the average of 3.333 milliseconds. A decrement update is lost if:

- The interval timer is *disabled*

- The processor is not in the operating state

- The rate control console function is set to *Instruction Step*.

The Time-of-Day clock resolution is one microsecond. The 1-MHZ oscillator has a tolerance of 0.0027 percent.

The CPU timer and clock comparator have the same resolution as the Time-of-Day clock. There are no conditions where the CPU timer is not decremented. Loss of updates caused by instruction retry are readjusted after the stopped state.

Reference and Change Recording

The recording of reference and change bits is accurate, with the following exceptions:

- The reference bit may be set due to storage operand fetching of a nullified or suppressed instruction.

- The reference bit may be set due to prefetching of instructions (instruction buffering). Prefetching can be from a minimum of one instruction to a maximum of eight instructions. This can be a minimum of twelve bytes, up to a maximum of sixteen bytes in advance of the current instruction.

- The reference bit may be set due to channel prefetching of CCW, IDAW, or data during an output operation.

- The change bit may be set due to storage operand storing of a nullified instruction caused by access exception, access retry (lack of pretest) and instruction retry.

PER

In the following situations, recognition of a PER event may appear to cause the instruction to be prematurely interrupted without concurrent indication of a program exception, without an interruption for any asynchronous condition, or without the stopped state being entered.

- *When channel activity requires an internal interrupt to be generated:* Channel internal interrupts are required to handle channel ending status and to make a program controlled I/O interrupt pending. For 370-XA mode, additional channel internal interrupts may be generated to perform certain I/O functions.

- *When an internal interrupt becomes pending to service the decrementer-to-zero condition:* This condition is an internal mechanism used to start the CPU timer and clock comparator. The condition occurs once per second and also when a CPU timer or clock comparator event becomes pending, whether or not the corresponding interrupts are allowed.

Nontransparent Suppression and Nullification

The channel may observe the effect of temporary storage change of a partially executed, (but nullified or suppressed) instruction. This can occur because of an operand access exception, access retry (due to a lack of pretest), or instruction retry.

Implementation of Store CPU ID Instruction

Bits 0 through 7 of the STIDP operand field contain hex '00' for the Model Group 2 and hex '02' for the Model Group 1. Bits 8 through 31 of the field contain the processor serial number. Bits 32 through 47 contain the processor model number. Bits 48 through 63 contain zeros.

Interruption Response Block (IRB)

In the extended control word (ECW) portion of the interruption response block (IRB), there are eight bytes of model-dependent information. The 4381 stores all zeros in this eight-byte area.

Subchannel Information Block (SCHIB)

In the subchannel information block, there are three words of model-dependent information (words 10 through 12). The 4381 stores all zeros in this three-word area.

Input/Output Suppression

If the STOP key is pressed while the 4381 is running, instruction processing is stopped as well as any I/O activity currently queued because of the SIOF queuing support. This state is indicated by **IOS** appearing on the display console.

When the START key is pressed, processing resumes.

Channel-to-Channel Adapter

The channel-to-channel adapter for the 4381 Processor deviates from the signal-resistance and signal-delay specifications as described in Chapter 2 in the section "Internal Cabling" in *IBM System/360 and System/370 I/O Interface Channel to Control Unit OEMI*, GA22-6974. These specifications allow a control unit to contribute a maximum of 1.0 ohm resistance to the interface lines, and to have a maximum signal delay of 15 nanoseconds between external pins. The 4381 channel-to-channel adapter contributes up to 2.9 ohms resistance to the interface lines and has a signal delay of 30 nanoseconds. This means that the 4381 channel-to-channel adapter requires three control unit positions on each of the two channels to which it is attached.

Implementation of Machine Check Handling

Machine check handling is implemented in the 4381 as shown in Figures 27 and 28.

Bits	Name	S/370	370-XA
0	System damage (SD)	X	X
1	Instruction processing damage (PD)	X	X
2	System recovery (SR)	X	X
3	Interval timer damage (TD)	X	X
4	Timing Facility Damage (CD)	X	X
5	External damage (ED)	X*	X
7	Degradation (DG)	X	X
8	Warning (W)	0	0
9	Pending CRW Report (CP)	0	X
10	Service Processor Damage (SP)	X	X
11	Channel subsystem damage (CK)	0	X
14	Back-up (B)	X	X
15	Delayed (D)	X	0
16	Storage error uncorrected	X	X
17	Storage error corrected	X	X
18	Storage key error uncorrected	X	X
19	Storage degradation (DS)	X	X
20	PSW-EMWP validity (WP)	X	X
21	PSW mask and key validity (MS)	X	X
22	PSW program mask and CC validity (PM)	X	X
23	PSW instruction address validity (IA)	X	X
24	Failing storage address validity (FA)	X	X
25	Region code validity (RC)	0	0
26	External damage code validity (EC)	X	0
27	Floating point register validity (FP)	X	X
28	General register validity (GR)	X	X
29	Control register validity (CR)	X	X
30	Logout validity (LG)	0	0
31	Storage logical validity (ST)	X	X
46	CPU Timer validity (CT)	X	X
47	Clock-comparator validity (CC)	X	X
48-63	Machine check extended logout (MCEL) length	0	0

Figure 27. Implementation of Machine Check Interruption Code (MCIC)

X = Can be set to one or zero.
0 = Always zero or not applicable.
* = Only bits 2, 3, and 4 of external damage code are supported.

CR14 BITS	Name	System/370		370-XA	
		Implemen-tation	State of Bit on Initial Request	Implemen-tation	State of Bit on Initial Reset
0	Check Stop Control (CS)	X	1	X	1
3	Channel Status Mask (CM)	0	0	X	0
4	Recovery Report Mask (RM)	X	0	X	0
5	Degradation Report Mask (DM)	X	0	0	0
6	External Damage Mask (EM)	X	1	X	1
7	Warning Mask (WM)	0	0	0	0
Explanation: X - May be set to one or zero. 0 - Always zero or not applicable.					

Figure 28. Implementation of Machine Check Masking (Control Register 14 Usage)

Error Handling

The 4381 error handling function attempts recovery from many types of hardware failures. For malfunctions that cannot be corrected, a machine check interruption is generated to assist in program damage assessment and recovery. If the malfunction makes it undesirable or impossible to continue operation, the 4381 halts all processing and enters the *check stop* state.

Error Retry

The *error retry* function makes intermittent, processor-detected hardware failures logically transparent to normal program processing. In general, retry is done on a machine instruction basis. The data in certain machine facilities is saved during instruction execution. This is called a *checkpoint*. To perform a retry when a malfunction occurs, this checkpoint data is restored in those machine facilities, and the instruction is re-executed. Each processing instruction initiates a checkpoint, except for a BC, BCR, LR, LTR, or LA instruction.

Because operand addressability is not verified by pretesting, the retry mechanism can also be invoked when an operand crosses a storage page boundary and an access exception occurs. This has the effect of logically backing up the processor to the state preceding the instruction so that a program interruption can be taken as if the instruction had been nullified.

There is no checkpointing or retry of malfunctions affecting channel operations. If possible, channel hardware failures are isolated to a particular channel and result in channel control checks and/or machine checks.

For both types of errors, (those that can be retried and those that cannot) the support processor performs an internal logout of hardware conditions for analysis. This information is stored on the diskette; up to nine logouts can be retained.

Dynamic Reconfiguration

Reconfiguration is a part of error retry. Reconfiguration is the automatic substitution of alternate (standby) facilities to replace malfunctioning hardware.

Reconfiguration is implemented in the following areas:

- High-Speed Buffer

    - An appropriate allocation of storage is reserved for standby.

    - A *Storage Error Uncorrected* is reported to the system control program (SCP).

- Control Storage

    - 2K of storage is reserved for standby.

    - The control store data in error is refreshed from the diskette.

- Channel Data Buffer

    - Four segments are reserved for standby.

    - A *Channel Control Check* is reported to the system control program after the switch to a standby channel data buffer.

- Swap Buffer

    - This condition is a portion of the swap buffer switched to a substitute array slot on a byte basis for an odd doubleword and on a doubleword basis for an even doubleword.

    - The lost modified data is reported as *Storage Error Uncorrected* to the system control program.

Reconfiguration is not apparent to the operator until reconfiguration is no longer possible and a reference code is displayed. For example, performance degradation resulting from reconfiguration of the high-speed buffer directory is reported to the operator by a console message. All reconfiguration information is written on the diskette.

Error Checking And Correction (ECC)

Error checking and correction of main storage supplies:

- Single bit error detection and correction

- Double bit error detection (for certain types of errors).

For all storage errors that cannot be corrected, a *Storage Error Uncorrected* is reported to the system control program.

Channel Command Retry

Channel command retry is an I/O control unit initiated procedure between the channel and the control unit. Not all control units have this ability. No I/O interruption is required. The number of retries is device-dependent.

Start I/O Fast Queuing Instruction Implementation

The following information applies to the Start I/O fast queuing instruction (SIOFQ).

- SIOFQ cannot be specified for a selector mode device.

- SIOFQ cannot be specified on a byte channel.

- SIOFQ cannot be specified for shared UCWs.

  The preceding statements mean that any nonshared non-selector mode UCW on a block multiplexer channel can have SIOFQ assigned to it.

- The entire accessible address range plugged for a control unit must be specified for a control unit assigned with SIOFQ.

- A control unit on a block multiplexer channel that has different type devices and different address ranges for each type device *must have* only one SIOFQ UCW entry covering the entire address range.

For example, a 3880 control unit that attaches to 3350 or 3330 devices (with addresses 440 through 443 and 450 through 453, respectively) must include both of these address ranges in a single UCW.

Application Program Errors

If application program errors occur, the operating system attempts to handle the exception and to supply operator messages. Refer to the applicable programming publications for the operating system that you use.

Problem Analysis

Problem Analysis is an automated routine that can be initiated when a system failure or operating problem is suspected. The Problem Analysis function is included in the basic microcode contained on the processor diskette. A separate *4381 Problem Analysis Guide*, GA24-3955, supplies the operating instructions.

Problem Analysis is designed to resolve problems quickly and get jobs running again. It collects and analyzes data related to the problem and guides operator actions through highlighted messages on the display screen. By using Problem Analysis, the operator can resolve some problems or, if assistance is needed, provide pertinent information to IBM service personnel before they arrive. In some instances this allows service personnel to bring the correct part for repair.

List of Abbreviations

ACR	automatic carriage return		IPL	initial program load
AID	attention identification		IR	intervention required
ALU	arithmetic logical unit		IRB	interruption response buffer
ANR	alphanumeric readout		K	1024 Bytes
BL	Block type for IOCP		M	1,048,576 Bytes
BOC	bus out check		MCIC	machine check interruption code
BY	Byte type for IOCP		MDT	modified data tag
CCW	channel command word		MVS/OCCF	Multiple Virtual Storage / Operator Communication Control Facility
CE	channel end		NOP	no operation (command)
CHPID	channel path identifier macro		ns	nanosecond (one-thousand-millionth of a second)
CNCL	cancel		OCP	operator control panel
CNTLUNIT	control unit macro		PER	program event recording
CR	command reject		PF	program function
CSW	channel status word		PSW	program status word
DAA	data access arrangement		PT	program tab
DASD	direct access storage device		RA	repeat to address
DDP	distributed data processing		REQ	request
DE	device end		ROCF	remote operator console facility
EBCDIC	extended binary-coded decimal interchange code		RSF	remote support facility
EC	equipment check		SBA	set buffer address
ECC	error checking and correction		SCHIB	subchannel information block
EOB	end of Block		SCP	system control program
EOF	end of field		SF	start field
EUA	erase unprotected to address		SILI	suppress incorrect length indicator
IC	insert cursor		SIO	start input/output (command)
ID	identifier macro		STE	segment table entry
IML	initial microcode load		STIDP	Store CPU ID instruction
INTV REQD	intervention required		UCW	unit control word
I/O	input/output		VM/370	IBM Virtual Machine Facility/370
IOCDS	input/output configuration data set		WCC	write control character
IOCP	input/output configuration program		XA	extended architecture
IODEVICE	input/output device macro			
IOS	input/output suppression			

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