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Systems

Reference Manual for IBM 3830 Storage Control Model 2

IBM

Preface

The IBM 3830 Storage Control Model 2 (3830-2) and its attached disk storage devices provide high speed direct-access storage for general purpose data storage and system residence. Attached to the central processing unit through a block multiplexer or selector channel, the 3830-2 operates under direct program control of the CPU.

For experienced programmers, this manual provides readily accessible reference material related to channel command words, sense bytes, and error recovery.

Less experienced programmers will find sufficient information to create channel programs to best use the standard and special features of the 3830 Storage Control Model 2.

This manual is organized by the following topics:

- INTRODUCTION – describes the basic units and lists highlights and functions.
- INPUT/OUTPUT – describes operation between the channel and the storage control.
- CHANNEL COMMANDS – lists each command and describes its use.
- CHANNEL PROGRAMS – gives programming examples and command usage.
- STANDARD FEATURES – describes command retry, rotational position sensing (with formula for calculating sector positions), and other standard features.
- SPECIAL FEATURES – describes two channel switch, two channel switch additional, and string switch operation.
- ERROR RECOVERY PROCEDURES – explains the error correction function and construction of restart channel command words.
- OPERATING INSTRUCTIONS – gives a complete description of switches and indicators on the 3830-2 operator panel for systems installation operators.
- SENSE DATA – a complete summary of sense information for the 3830-2 as well as the 3330/3333, 3340/3344, and 3350 storage devices.

Programmers should be familiar with the information contained in *IBM System/360 Principles of Operation,* Order No. GA22-6821, and *IBM System/370 Principles of Operation,* Order No. GA22-7000. Operators should be familiar with the material presented in the system summary for the parent system. Order numbers for system summary and other related publications can be found in the *IBM System/360 Bibliography,* Order No. GC20-0360, and *System/370 Bibliography,* Order No.GC20-0001.

Further details on devices normally attached to the 3830-2 will be found in *Reference Manual for IBM 3330 Series Disk Storage,* Order No. GA26-1615, *Reference Manual for IBM 3340/3344 Disk Storage,* Order No. GA26-1619, and *Reference Manual for IBM 3350 Direct Access Storage,* Order No. GA26-1638.

For definitions of terms used in connection with direct-access storage devices, see *Data Processing Glossary,* Order No. GC20-1699.

Note: Technical details of the 3830 Model 3 are contained in the *IBM 3850 Mass Storage System Principles of Operation*, Order No. GA32-0029.

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This publication is a major revision that replaces and makes Order No. GA26-1617-4 obsolete. All changes and additions contained in Technical Newsletter GN26-0327 have been incorporated into this edition. Technical changes incorporated in this edition are indicated by a vertical bar to the left of the change. Changes or additions to the specifications contained in this publication are periodically being made. Before using this publication in connection with the operation of IBM equipment, contact the local IBM Branch Office for revisions.

Copies of this and other IBM publications can be obtained through IBM Branch Offices.

A form for reader's comments is provided at the back of this publication. If the form has been removed, send your comments to the address below.

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Contents

Illustrations

The IBM 3830-2 Storage Control unit provides the logical capabilities necessary to operate and control IBM 3330, 3340/3344, and 3350 disk storage.

The 3830-2 can be attached to an IBM System/360 Model 195 or to IBM System/370 Models 135, 145, 155, 155-II, 158, 165, 165-II, and 168. When attached to the System/360 Model 195 or System/370 Models 165-II or 168, an IBM 2880 Block Multiplexer Channel is required. A system block multiplexer channel or system selector channel is required when the 3830-2 is attached to System/370 Models 135, 145, 155-II, and 158.

Combinations of IBM 3330, 3340, 3340/3344, and 3350 disk storage can be attached to the 3830-2 Storage Control.

A functional description of the 3830-2 and system data flow is shown in Figure 1.

FEATURES

The 3830-2 Storage Control provides or supports the following standard features:

- Command retry (3330 series and 3350)
- Multiple requesting – rotational position sensing (block multiplexer channel only)
- Multiple track operation
- Record overflow
- End-of-file

These special features are also available:

- Two channel switch
- Two channel switch additional
- Control store extension
- Expanded control store
- Register expansion
- String switch

Command Retry (3330 Series and 3350)

Command retry is a channel/storage control procedure that allows a command in a channel program to be automatically retried. The retry does not cause an I/O interrupt, and programmed error recovery procedures are not required.

Multiple Requesting

Use of block multiplexer channels and disk drives with rotational position sensing capabilities allows the 3830-2 and its attached drives to disconnect from the channel during mechanical delays resulting from execution of arm positioning Seek or Set Sector commands. Reconnection is attempted when the access mechanism is positioned at the desired track or when the specified rotational position has been reached.

During the time the channel and 3830-2 are disconnected, the Central Processing Unit (CPU) is free to initiate I/O operations on other drives attached to the 3830-2, even though the disconnected channel program is not complete. Thus, separate channel programs may be operating simultaneously on each drive attached to the storage control.

Multiple Track (M/T) Operation

On all search and most read commands, the 3830-2 can automatically select the next sequentially numbered head on a drive. This eliminates the need for Seek Head commands in a chain of read or search commands.

Record Overflow

The record overflow feature provides a means for processing logical records that exceed the capacity of a track. When using overflow records, the factor limiting the size of the record is the cylinder boundary.

A special channel command (Write Special Count, Key, and Data) is used to format the disk pack for record overflow operations.

End-of-File

An end-of-file record, used to define the end of a logical group of records, is written by executing a Write Count, Key, and Data command with a data length of zero. Execution of this command causes the 3830-2 to direct the addressed drive to write a data area consisting of one byte of zeros.

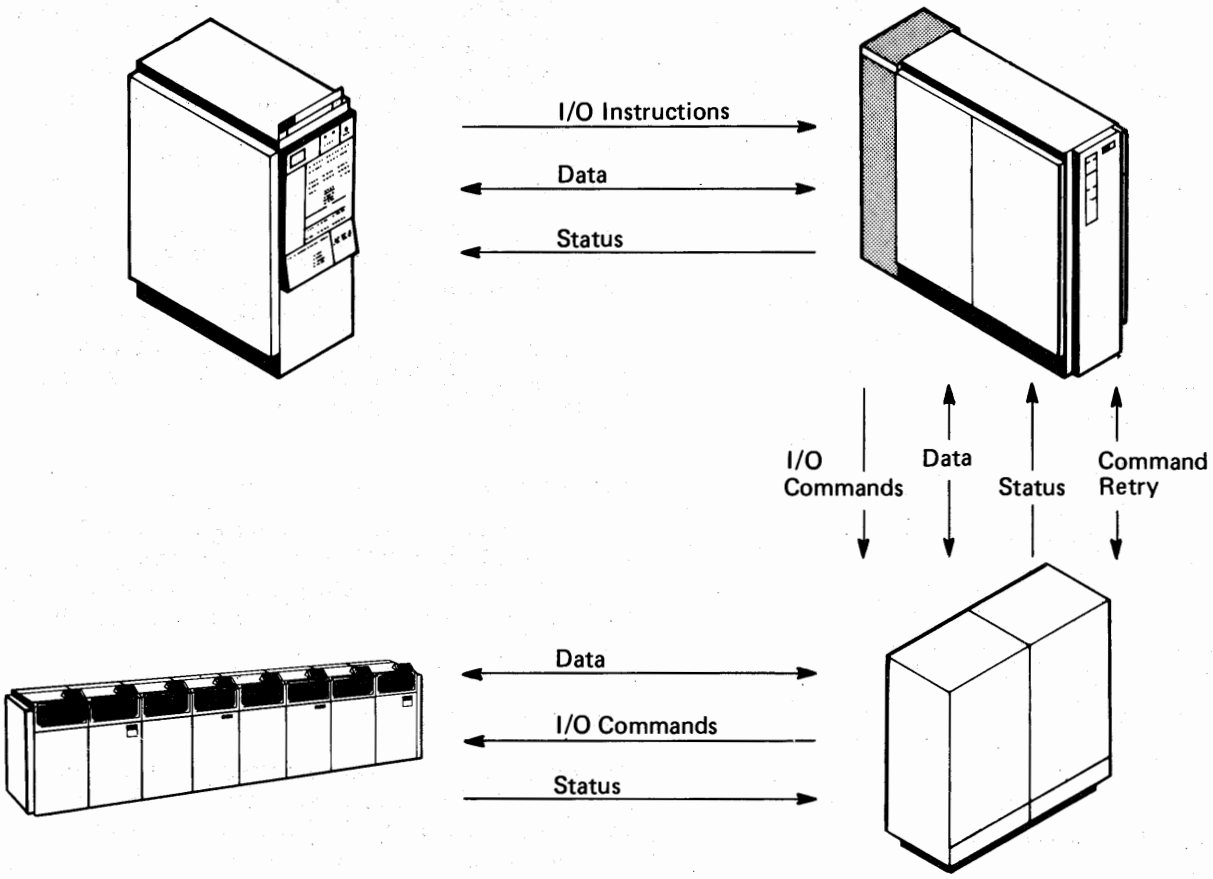
When the end-of-file record is processed, detection of the zero data length causes unit exception status to be generated.

CPU

- Issues I/O instructions.
- Stores data.
- Stores status.
- Stores channel program.

Channel

- Fetches channel address word.
- Fetches channel commands.
- Controls transfer of data between 3830-2 and CPU.



Disk Storage and Controller

- Responds to commands from 3830-2.
- Positions access mechanism.
- Selects head.
- Reads or writes data.
- Serializes and deserializes data.
- Performs error detection and correction.

3830-2

- Interprets and executes commands from channel.
- Controls channel and disk storage interfaces.
- Furnishes status to system.
- Performs diagnostic evaluation of storage control and drives.

Figure 1. Functional Description

Two Channel Switch

The two channel switch special feature allows the IBM 3830-2 Storage Control to be shared by two channels. The channels may be attached to either the same or different central processing units. Individual drives may be reserved for the exclusive use of either of the channels. Channel switching and device reservation are controlled by the channel program. Three special commands are used for two channel switch operation: Device Reserve, Device Release, and Unconditional Reserve.

Two Channel Switch Additional

The two channel switch additional special feature permits the 3830-2 to be accessed by up to four channels, two of which may be on the same CPU. Individual drives attached to the 3830-2 may be reserved for the exclusive use of any of the four channels. Channel switching and device reservation are controlled by the channel program. The commands used by the two channel switch (Device Reserve, Device Release, and Unconditional Reserve) are also used with this feature. Two channel switch is a prerequisite feature.

Control Store Extension

Control store extension provides additional control store in the 3830-2 for microprogram use. This additional control store is necessary for certain disk storage configurations (see Unit and Device Addressing) and is a prerequisite for expanded control store.

Expanded Control Store

Expanded control store supplies added control store for microprogram use. The 3830-2 requires this feature when 3350 storage or combinations of 3330, 3340, and 3350 storage devices are attached.

When the expanded control store feature is installed, hardware to support offset interlock during read, write, or search data transfer is also installed. The offset interlock is operational with 3330-1,3330-11, 3340, and 3350 (all modes) devices only for the micro program load that supports the 3350s and only if enabled by a hardware jumper. Details of the offset interlock operation are described in the 3830-2 Maintenance Library Manual (MLM), section CHL-I.

Register Expansion

Register expansion provides additional registers in the 3830-2 for microprogram use. This feature is required when strings of 3340/3344 or 3350 disk storage are attached to the 3830-2.

String Switch

The string switch feature (installed on the drive string controller) allows a 3333, 3340-A2, or 3350-A2 (and/or C2) and the attached string of disk storage drives to be dynamically shared by various storage control units. This feature is similiar to the two channel switch feature installed on the 3830-2 Storage Control.

ERROR DETECTION AND CORRECTION

Data errors are detected and corrected by two automatic recovery systems as well as by optional checks that can be incorporated by the programmer.

CPU Parity

To check data accuracy, a parity bit is associated with each byte within the CPU and channel. When a byte is formed, the parity bit is set to either 1 or 0 to maintain an odd number of 1-bits within the byte (that is, odd parity). Each byte of data to be written is checked for correct parity as it is received by the IBM 3830-2.

Error Correction Code

As data is transferred from the channel to disk storage (write operation), the 3333, 3340-A2, or 3350-A2/C2 removes the parity bit associated with each byte. It then computes the error correction code bytes which are written after each recorded area. The correction code bytes, coded to represent the data in the recorded area, are used for both error detection and correction.

As data is transferred from disk storage to the channel (read operation), each area is inspected and the error correction code bytes are recalculated for each area. The correction code provides for detection and correction of single burst errors.

With 3330 series drives, if a correctable data error is detected in the home address, count, or key areas, the storage control internally executes the error correction function through the use of command retry. (See the Command Retry section.) For all drive types, if a permanent uncorrectable data error is detected, or if a correctable data error is detected in a data area, the correction function is determined by the system error recovery procedures. (See Error Recovery Procedures.)

The correction code bytes are removed and proper parity is generated by the disk storage and control before the data is transferred to the 3830-2.

Data Integrity

Unless corrected immediately, undetected write errors cause read errors. Therefore, where data integrity is required, verification should be incorporated within the program. Thus, in the event of write errors, the record can be rewritten and verified before the original data is destroyed.

Either of two programming verification methods may be used: full read back check or correction code check.

FULL READ BACK CHECK

All of the data just written is read back into main storage and compared, byte-for-byte, with the original information.

CORRECTION CODE CHECK

A read operation is performed with the skip bit on. This method causes the storage control to check the validity of the record using the error correction code bytes.

Statistical Usage/Error Recording

The 3830-2 maintains a statistical data record of usage and error information for each attached device. The usage information provides accumulated counts as follows:

- For all drives, the number of access motions and the total number of bytes processed.
- For 3330 and 3350, the total number of seek errors, correctable data errors (except for 3350s), and uncorrectable data errors in which recovery by the retry procedure was attempted.

Also included in the error information is the total number of command and data overrun conditions that were retried.

The usage/error information is periodically sent to the system log area. The transfer takes place on the next Start I/O issued to the device having outstanding usage/error information. Each of the usage/error counters is reset to zero after the count is transferred to the channel.

Storage Control Diagnostics

To provide maximum facility availability, the 3830-2 can execute diagnostic tests on a drive concurrent with normal system operation on the remaining drives. This mode of operation allows the customer engineer to diagnose and repair most drive failures while the subsystem continues to operate other attached drives. The 3830-2 provides a transient block of 512 bytes (128 words) of control storage to allow temporary residence for a specific diagnostic test.

The transient area is loaded by the system under control of the On-Line Test Executive Program (OLTEP) or the On-Line Test Standalone Executive Program (OLTSEP). A special command (Diagnostic Write) loads a selected test into control storage and instructs the storage control to execute the test. This loading and execution may also be initiated from the CE panel of the 3333, 3340-A2, or 3350-A2/C2.

After the test, error message information or test results are transferred from the 3830-2 to main storage by a Read Diagnostic Status 1 command. If the CE panel is used, the test results are displayed on the CE panel indicators in the 3333, 3340-A2, or 3350-A2/C2.

Surface Defect Skipping (3340, 3344, and 3350)

Defect skipping allows data to be written before and after a surface defect. Thus, all of the track can be used except for that portion that has the defect. This also eliminates the access time that was formerly required to move the read/write heads to an alternate track.

Input/Output Operations

An input/output operation transfers data between the central processing unit (CPU) main storage and an I/O device. An I/O operation is started by a programmed instruction that generates a channel command. The storage control receives the command from the channel, decodes it, and starts the I/O device.

GENERAL DESCRIPTION

Operations requiring logical and arithmetical decisions are performed with the CPU in the problem state. For I/O operations, the CPU must be in the supervisor state.

The CPU is changed from problem to supervisor state when a supervisor call instruction (program initiated) is executed or when an I/O interrupt (device initiated) occurs. The system status that existed at the time of the change is stored in the program status word (see Program Status Word) so the program can be resumed after the interrupt has been serviced.

For a more detailed description of the CPU and channel operation, refer to the *IBM System/370 Principles of Operation* manual.

Supervisor State

When in the supervisor state, the CPU can execute the following instructions:

- Start I/O — This starts an I/O operation if the addressed channel, storage control, and disk storage device are available.
- Start I/O Fast Release — Initiates an I/O operation if the addressed channel is available. The storage control and disk drive are assumed to be available. If the storage control or disk drive is not available, the Channel Status Word (CSW) deferred condition code bits, 6 and 7, are set to indicate the appropriate condition.
- Halt I/O — The channel operation in progress is stopped, and the storage control is disconnected from the channel.
- Halt Device — This terminates the operation at the storage control but does not interfere with other channel I/O operations. This instruction should be used on IBM Block Multiplexer channels instead of Halt I/O.
- Test I/O — The condition code in the Program Status Word (PSW) is set to indicate the condition of the channel, sub-channel, storage control, and device.
- Clear I/O — The condition code in the Program Status Word (PSW) is set to indicate the condition of the channel, sub-channel, storage control, and device. This instruction should be used on IBM Block Multiplexer channels instead of Test I/O.

The I/O instruction format is shown in Figure 2.

Byte 0	1	2	3
Operation Code		B2	D2

Byte 0	Bits 0–7	Operation Code
Byte 1	Bits 0–6	Not Used
	Bit 7	On for Start I/O Fast Release or Halt Device.
Byte 2	Bits 0–3	Base address register location (B2) in CPU. Only the low-order 24 bits of the 32-bit register are used.
	Bits 4–7	Displacement (D2). D2 and the value in the base register specified by B2 are summed to identify the device addressed by the instruction.
Byte 3	Bits 0–7	

After summing, the last two bytes of the instruction indicate:

Byte 2	Bits 0–3	Must be zero.
	Bits 4–7	Channel address.
Byte 3	Bits 0–4	Storage control address.
	Bits 5–7	Device address.

Figure 2. I/O Instruction Format

CHANNEL OPERATION

The channel directly controls the I/O devices and storage controls. Depending on the System/370 model involved, there may be a single channel or several channels used in I/O operations.

After a channel has received and executed the I/O instruction, the channel selects and governs the storage control and drive addressed by the instruction. Reserved CPU main storage locations contain information and instructions that direct the channel how to complete the operations. A pointer to this data is contained in the Channel Address Word (CAW).

Channel Address Word

After the channel receives a Start I/O or Start I/O Fast Release, it fetches the channel address word. The Channel Address Word (CAW) is a 4-byte word located at CPU main storage address 72 (decimal). It points to the first Channel Command Word (CCW) in a chain of commands. The first half byte of the CAW contains a protection key, the second half of the first byte contains zeros, and the last three bytes contain the CCW address. The protection key is used by the channel to ensure that the user's data transfer operations are using the CPU main storage locations assigned to that user by the system control program.

The channel fetches the CAW, which must have been placed at address 72, before the I/O instruction is issued. The CAW format is shown in Figure 3.

Byte 0	1	2	3
Key 0000	Command Address		

Byte 0	Bits 0–3	Storage protection key (must match storage key).
	Bits 4–7	Always zero.
Byte 1	Bits 0–7	Command address.
Byte 2	Bits 0–7	Location of first CCW in
Byte 3	Bits 0–7	CPU main storage.

Figure 3. Channel Address Word

Channel Command Word

The channel fetches the first Channel Command Word (CCW) from the address specified by the CAW. The CCW indicates the operation to be done, the CPU main storage addresses to be used, and the action to be taken on completion.

After receiving the CCW, the channel selects the device specified by sending the address to all attached storage control units. If the indicated device is available, the command code from the CCW is sent to the storage control which returns an initial status byte to the channel. Should the channel, storage control, or drive be already in use, a busy signal is sent to the CPU which will retry the command a short time later.

The CCW format is shown in Figure 4.

CCW Functions

The channel command word consists of eight bytes.

BYTE 0

The first byte contains the command code. (See Channel Commands.) This byte specifies the operation to be performed. The two low-order bits or the four low-order bits (when the first two bits are 00) of the command code identify the operation to the channel. The channel recognizes write, control, read, sense, or transfer in channel operations. Commands that start I/O operations transfer all eight bits to the storage control.

BYTES 1, 2, and 3

These bytes specify the address of the area for operations involving data transfer.

BYTE 4

The flag byte is used for command modifying instructions. These bits are described in greater detail as follows:

Bit 0 – Chain Data Flag: When set to one, this bit specifies that the data is to be chained. The data rate of the device and system to which it is attached can limit the use of this bit.

Bit 1 – Chain Command Flag: This bit indicates that the commands are chained. It causes the operation specified by the command code in the next CCW to be started on normal completion of the current operation. This bit is ignored when bit 0 is on.

Bit 2 – Suppress Length Indicator (SLI) Flag: Bit 2 is used to suppress an incorrect length indication except when the CCW count is not exhausted, channel end is present, and data chaining is indicated. The SLI bit should be on for Restore, Recalibrate, No-op, and some space count commands.

Bit 3 – Skip Flag: When set to one, the skip bit specifies the suppression of a transfer of information to main storage during a read or sense operation. The data is checked just as if it were to be stored.

Bit 4 – Program Control Interrupt Flag: This bit causes the channel to generate an interrupt when the CCW is fetched.

Bit 5 – Indirect Data Address (IDA) Flag: When set to one, the IDA bit specifies indirect data addressing in both the BC (basic control) and EC (extended control) modes of operation.

Byte 0	1	2	3	4	5	6	7
Command Code	Data Address			Flags 00	Not Used	Count	

Byte 0 Bits 0–7 Command Code

Byte 1 Bits 0–7
Byte 2 Bits 0–7 } Data Address
Byte 3 Bits 0–7

Byte 4 Bit 0 Chain Data
Bit 1 Chain Command
Bit 2 Suppress Length Indicator (SLI)
Bit 3 Skip Flag
Bit 4 Program Control Interrupt
Bit 5 Indirect Data Address (IDA)
Bit 6-7 Always zero except for TIC (Transfer in Channel) where they are ignored

Byte 5 Bits 0-7 Not Used
Byte 6 Bits 0-7 } Count
Byte 7 Bits 0-7

Figure 4. Channel Command Word

Bits 6 and 7 – Not Used: These bits are always set to zero . Byte 4 is ignored when a TIC command is used. (See Transfer in Channel command.)

BYTE 5

Not used.

BYTES 6 and 7

Specify the number of byte locations in the main storage area designated by the data address.

Channel Status Word

The CSW for each chain of commands is placed in CPU main storage starting at location 64 (decimal). The CSW informs the CPU program of the I/O device status or condition.

Status information is presented twice, at the start of an operation and at its end. These commands present their status when the command is received, at the start of the physical motion, and following completion of the operation. Seek and Seek Cylinder commands present initial status, channel end (after seek address transfer), and device end after the access mechanism is positioned. The Set Sector command presents initial status, channel end (after the sector number is transferred), and device end (when the angular position is reached).

The CSW ending status is posted following completion of an operation. Should an operation be ended before completion, the bits in the status word indicate the reason for its termination.

The CSW, stored at location 64, remains unchanged until a later interruption or a new I/O instruction is processed. The channel status word format is shown in Figure 5.

Status Presentation

INITIAL STATUS

The initial status byte is zero for Test I/O and all non-immediate (data transferring) commands except when:

- The storage control is busy.
- A status condition is pending. (See Pending Status.)
- A unit check occurred.
- Initial status indicated command retry. (See Command Retry.)

Immediate commands (no data transfer) present channel end and device end for initial status.

ENDING STATUS

For most commands, the normal ending status presented is channel end and device end. The exceptions are noted in the individual command descriptions (see Channel Commands).

If an error occurred during the operation, unit check is posted along with channel end and device end.

PENDING STATUS

A pending status condition may exist for either the storage control or the disk storage drive.

Storage Control: Pending status for the storage control causes it to appear busy for all drives except the one with the existing status condition. If the storage control is not busy, it will request service to clear the pending status. The status is cleared when presented to, and accepted by, the channel.

The storage control has a pending status when:

- A disconnect was sent after a command but before channel end was accepted.
- Busy, channel end, or unit check status was stacked (not accepted) by the channel.
- The Test I/O response of zero was stacked by the channel.
- Storage control busy was sent to the channel.
- Unit check (error) was found in an operation after device end was cleared.
- Device end for a Set Sector command was stacked by the channel.

Disk Drive: Pending status for a drive causes the storage control to request service if neither the storage control nor drive is busy. The status is cleared when presented to, and accepted by, the channel.

The drive has pending status when:

- Channel end appears alone.
- Busy status is presented.
- The drive changes from not ready to ready.

CONTINGENT CONNECTION

A contingent connection exists in the storage control after the channel accepts a status byte with unit check. During the contingent connection state, the storage control appears busy to all other addresses except the one with the unit check.

The connection lasts until:

- A command (not Test I/O or No-Op) receives an initial status byte of zero for the storage control and drive address that generated the unit check.
- A selective or system reset occurs.

CSW Functions

The CSW consists of eight 8-bit bytes. The first four bytes (0–3) contain the protection key and the address of the next command in the CCW chain. Byte 4 gives the condition of the device just used and is analyzed in detail below. Byte 5 indicates the channel conditions, and the last two bytes contain the residual count from the last CCW executed.

The initial status byte returned to the channel is normally all zeros when a device is ready for data transmission. The ending status is returned after the device has finished the operation. The device and channel status are indicated in bytes 4 and 5 of the CSW. Storage of the CSW at address 64 causes an input/output interrupt which is analyzed by the I/O supervisor program.

BYTE 4 — DEVICE STATUS

Particularly important because the bits, singly and in combination, signal the condition of both the device and the storage control to the channel and the CPU. The bits in byte 4 are described in greater detail as follows:

Bit 0 – Attention: Not used by the 3830-2.

Bit 1 – Status Modifier: The status modifier is set whenever a Search High, Search Equal, or a Search High or Equal command has been successfully executed. When bit one and the busy bit are both set, the storage control is busy. When this and unit check are both set, an unusual condition in the last operation requires a retry of the last channel command.

The status modifier bit is also combined with channel end and device end to indicate that a retriable error was found.

Bit 2 – Control Unit End: Control unit end is set if a busy (bit 3) condition was previously indicated and the busy condition is no longer valid. The storage control busy was indicated by bits 1 and 3 both being set. The drive address associated with the control unit end is the lowest non-busy drive on the highest numbered string even though the drive addressed may not exist. For microcode supporting 3350, the drive address (regardless of device type) is that of the lowest non-busy device on the last string that was selected.

Bit 3 – Busy: The busy bit indicates that the addressed device is busy; when combined with status modifier, the storage control is busy. Busy can be combined with bit 2 (control unit end) and the CPU then reissues the Start I/O command.

Bit 4 – Channel End: Channel end is set at the end of each command. This informs the CPU that the last command has been executed and the storage control is ready for the next command.

Byte 0	1	2	3	4	5	6	7
Key 0000	CCW Address			Device Status	Channel Status	Residual Count	

Byte 0
- Bits 0–3: Protection Key (storage protection for chain of operations)
- Bit 4: Not used - - always zero
- Bit 5: Logout pending
- Bits 6,7: Deferred Condition code (SIO Fast Release)

Byte 1, Byte 2, Byte 3
- Bits 0–7: Command Address, an address eight bytes higher than the last CCW used.

Byte 4: Device Status
- Bit 0: Attention, not used by 3830-2
- Bit 1: Status Modifier
- Bit 2: Control Unit End
- Bit 3: Busy
- Bit 4: Channel End
- Bit 5: Device End

Byte 4
- Bit 6: Unit Check
- Bit 7: Unit Exception

Byte 5: Channel Status
- Bit 0: Program-controlled Interrupt
- Bit 1: Incorrect Length
- Bit 2: Program Check
- Bit 3: Protection Check
- Bit 4: Channel Data Check
- Bit 5: Channel Control Check
- Bit 6: Interface Control Check
- Bit 7: Chaining Check

Byte 6, Byte 7
- Bits 0–7: The residual count from the last CCW used.

Figure 5. Channel Status Word

Bit 5 – Device End: Device end is set when the device addressed is available for subsequent use. Device end and channel end are returned to the CPU on completion of all commands that do not require access motion.

Bit 6 – Unit Check: Unit check is set when an unusual or error condition is detected. When combined with status modifier, it indicates that command retry is requested.

Channel end and device end are always presented with unit check (bit 6) when a command retry is not requested. A system interrupt then occurs and the sense bytes provide detailed information about the unusual condition.

Bit 7 – Unit Exception: Unit exception (bit 7) indicates that an end-of-file was detected during a Read IPL, Read R0, Read CKD, Read KD, Read D, Write KD, or Write Data operation. Bit 7 is not set for Read Count, Write CKD, Search Key, or Search ID commands. The unit exception is the result of a data length of zero. The key area, if any, is transferred by the command.

Program Status Word

As soon as an interrupt occurs, all current status information and an identification of the cause of the interrupt is put into a Program Status Word (PSW). This old PSW is stored at a fixed location in the CPU. The control program then fetches a new PSW from a different location. Loading the new PSW causes the CPU to branch to a new instruction sequence and service the interrupt.

After the cause of the interrupt has been cleared, an instruction restores the old PSW as the current PSW and the system is returned to the pre-interrupt status and the interrupted routine continues.

The PSW can be in one of two modes: Basic Control (BC) or Extended Control (EC). For an explanation of these two operating modes, see *IBM System/370 Principles of Operation.*

The program status word format for EC mode is shown in Figure 6.

Command Chaining

The storage control can execute a series of channel commands from a single Start I/O instruction. This operation is called command chaining and is started by activating byte 4 bit 1 in the CCW.

When the channel senses that byte 4 bit 1 is on in the current CCW, it automatically fetches the next CCW on completion of the command. The I/O operation is then executed after device end has been sent to the channel. Completion of the current CCW does not cause an I/O interrupt, and the count (indicating the amount of transferred data) is not available to the program.

Byte 0	1	2	3	4	5	6	7
0 R 000 T I E 0	Key	EMWP C	00CC Mask	Always Zero	Instruction Address		

Byte 0
- Bit 0 — Always Zero
- Bit 1 — Program-Event-Recording (R)
- Bits 2–4 — Always Zero
- Bit 5 — Translation Mode (T)
- Bit 6 — Input/Output Mask (IO)
- Bit 7 — External Mask (E)

Byte 1
- Bits 0–3 — Protection Key
- Bit 4 — Extended Control Mode (EC)
- Bit 5 — Machine Check Mask (M)
- Bit 6 — Wait State (W)
- Bit 7 — Problem State (P)

Byte 2
- Bits 0,1 — Always Zero
- Bits 2,3 — Condition Code (CC)
- Bits 4–7 — Program Mask

Byte 3
- Bits 0–7 — Always Zero

Byte 4
- Bits 0–7 — Always Zero

Bytes 5, 6, 7 (Bits 0–7) — Instruction Address

Figure 6. Program Status Word, Extended Control Mode

Command chaining is normally used in all 3830-2 channel programs. The command chaining functions are executed during the time the gaps between record areas are passing the read/write heads.

Command chaining sequence restrictions are covered on the individual Channel Command pages.

Data Chaining

The data transferred between the CPU storage and a drive may be chained. This permits blocks of data to be transferred when they are stored in non-adjacent CPU storage locations.

Data chaining may be used to rearrange the information as it is transferred between the CPU and the drive. The process may also be combined with the skip flag bit so the program can place selected parts of a block of data into CPU storage.

When data chaining is specified (byte 4 bit 0 is on), the channel fetches a new CCW, specifying a new storage location, on completion of data transfer for the current channel command. Unless the command code specifies Transfer In Channel (TIC), the new CCW command code is ignored.

Data chaining occurs immediately after the last byte of data designated by the current CCW has been transferred to CPU main storage or accepted by the drive. If both data chaining and command chaining are indicated by the CCW, data chaining takes precedence and command chaining is ignored.

Note: *Data chaining capabilities are dependent on several variable factors including system type, I/O configuration, channel loading and so on. Because of these dependencies, read or write data chaining within record areas may cause unpredictable overruns or chaining errors. If these conditions are found or suspected, consult your IBM representative.*

Branching in Channel Programs

The next CCW in a chain of channel commands is normally taken from an address eight locations higher than the address of the current CCW. This sequence can be modified in either of two ways:

1. If command chaining is specified in a search command, and execution of the command results in a status modifier bit (search satisfied), the channel fetches the next CCW from a CPU main storage address sixteen positions higher than the current channel command.
2. The Transfer In Channel command (TIC) may be used to modify the sequence of a chain of commands. The data address part of the TIC CCW specifies the main storage location of the next channel command word. Therefore, the next CCW may be fetched from any valid CPU main storage location.

These methods for modifying the sequence of a CCW chain provide for branching capabilities within a channel program.

Unit Selection and Device Addressing

The I/O addresses of the storage control and drive are indicated by an eight bit binary number in an I/O instruction. These addresses consist of three parts: the storage control address (determined by the customer when the unit is installed), the address of the controller, and the disk drive address. The complete I/O address is specified in bytes 2 and 3 of the I/O instruction (see Figure 2).

3333/3330/3340 Configurations

The 3830-2 accepts any drive address from 000 through 111. If the specified drive is not attached or offline, the attempted operation is terminated with unit check in initial status. Multiple responses to an address due to duplicate logical address plugs or hardware failures also cause the operation to be terminated.

Note: *If less than the maximum configuration of drives is attached, all drive addresses are still required for 3830-2 operation (all 16 addresses for 16-drive addressing, and all 32 addresses for 32-drive addressing). The 3830-2 accepts any controller address, 0 or 1, for 16-drive addressing (00, 01, 10, or 11 for 32-drive addressing). If the storage control supports the string switch, condition code 3 results when a controller is powered down, disabled, or not physically attached.*

Basic 16 Drive Addressing

0 – 3	4	5 – 7
3830-2 Address	3333 or 3340-A2 Address	3330 or 3340 Address

Valid 16-Drive Addresses

00 – 0F	80 – 8F
10 – 1F	90 – 9F
20 – 2F	A0 – AF
30 – 3F	B0 – BF
40 – 4F	C0 – CF
50 – 5F	D0 – DF
60 – 6F	E0 – EF
70 – 7F	F0 – FF

32 Drive Addressing

0 – 2	3 – 4	5 – 7
3830-2 Address	3333 and/or 3340-A2 Address	3330 or 3340 Address

Valid 32-Drive Addresses

00 – 1F	80 – 9F
20 – 3F	A0 – BF
40 – 5F	C0 – DF
60 – 7F	E0 – FF

Note: *The addressing options provided in the 3830-2, coupled with addressing options provided by external switches, can cause difficulty in drive identification. For example, the same drive could be called 1A1, 2B1, 3C1, and 4C1 by system messages. This difficulty can be avoided by careful installation planning which will allow the CE installing the system to wire all interfaces identically. This causes addresses in the foregoing example to be the same – that is, 1A1, 2A1, 3A1, and 4A1.*

3340/3344 Configurations

For unit selection and device addressing with 3340/3344 configurations, see *Reference Manual for IBM 3340/3344 Disk Storage,* Order No. GA26-1619.

3333/3340/3350 Configurations

The 3830-2 can attach any combination of up to four 3333s, 3340-A2s, or 3350-A2/A2Fs. Each 3340-A2 can attach up to three 3340-B2/B2Fs. However, in each 3350 string, a 3350-C2/C2F alternate controller model can replace the end B2/B2F dual-drive unit. Each 3333 can attach up to three 3330s and each 3340 can attach up to three 3340-B2s.

The maximum configuration is 32 physical drives. When the attached device families are mixed, additional 3830-2 features are required. These features are: expanded control store, control store extension, and register expansion.

3350 MODES

The 3350 incorporates a selective format feature that allows each drive to be operated in one of three modes: 3330-1 compatibility mode, 3330-11 compatibility mode, or 3350 native mode. Operating modes can vary among the individual drives on each string.

In the 3330-1 compatibility mode, one 3350 drive contains two logical 3330-1 volumes. Each logical 3330-1 volume is equal to an actual 3330-1 volume in capacity and format.

In the 3330-11 compatibility mode, one 3350 drive contains one logical 3330-11 volume. Each logical 3330-11 volume is equal to an actual 3330-11 volume in capacity and format.

In the 3350 native mode, a 3350 drive is a single logical volume with maximum storage capacity of over 317 million bytes per drive.

The various configurations that can be attached to a 3830-2 are shown in Figure 10.

3350 Addressing

0 1	2	3 4	5 7
3830-2 Address	Logical Drive Selection (3330-1 Compatibility only)	3333,3340-A2, 3350-A2/C2 Address	Physical Drive Address

Bits 0 and 1 are the storage control address bits. When the configuration is maximum, bits 0 and 1 define the storage control address. When less than 64 addresses are configured, bits 2 through 4 may become part of the storage control address. These do not have to be contiguous addresses, but must be as shown in Figures 8 or 9.

Bit 2 selects the proper logical volume on a physical drive. There is only one logical volume on all actual 3330, 3340, or 3350 drives in either native or 3330-11 compatibility mode. There are two logical volumes on a 3350 drive in the 3330-1 compatibility mode. The selection of the volume is controlled by bit 2 of the address. When bit 2 is on (1), the secondary logical volume is selected. When bit 2 is off (0), the primary logical volume is selected. The secondary address is valid only for 3350 drives operating in the 3330-1 compatibility mode and is invalid in all other cases.

If there are no 3350 drives operating in the 3330-1 compatibility mode and if plugged for 32 drives or less, all addresses that include bit 2 are valid. Bits 3 and 4 are the string address bits; bits 5 through 7 are the physical drive addresses in the string.

ADDRESS PLANNING

Under the preceding addressing scheme, the 3830-2 can accept a maximum of 64 contiguous logical device addresses. Figure 7 illustrates a maximum 3350 configuration. If all 3350 drives in this configuration are operating in the 3330-1 compatibility mode, all 64 addresses accepted by the 3830-2 are valid.

Configurations requiring a maximum of 8, 16, or 32 logical device addresses are subsets of this maximum configuration. The 3830-2 may be installed so that it accepts only 8, 16, 32, or 64 logical device addresses as required by the attached 3350 or 3330/3340/3350 configuration. These addressing subsets are installed by the customer engineer by using wire jumpers on the 3830-2 address selection card.

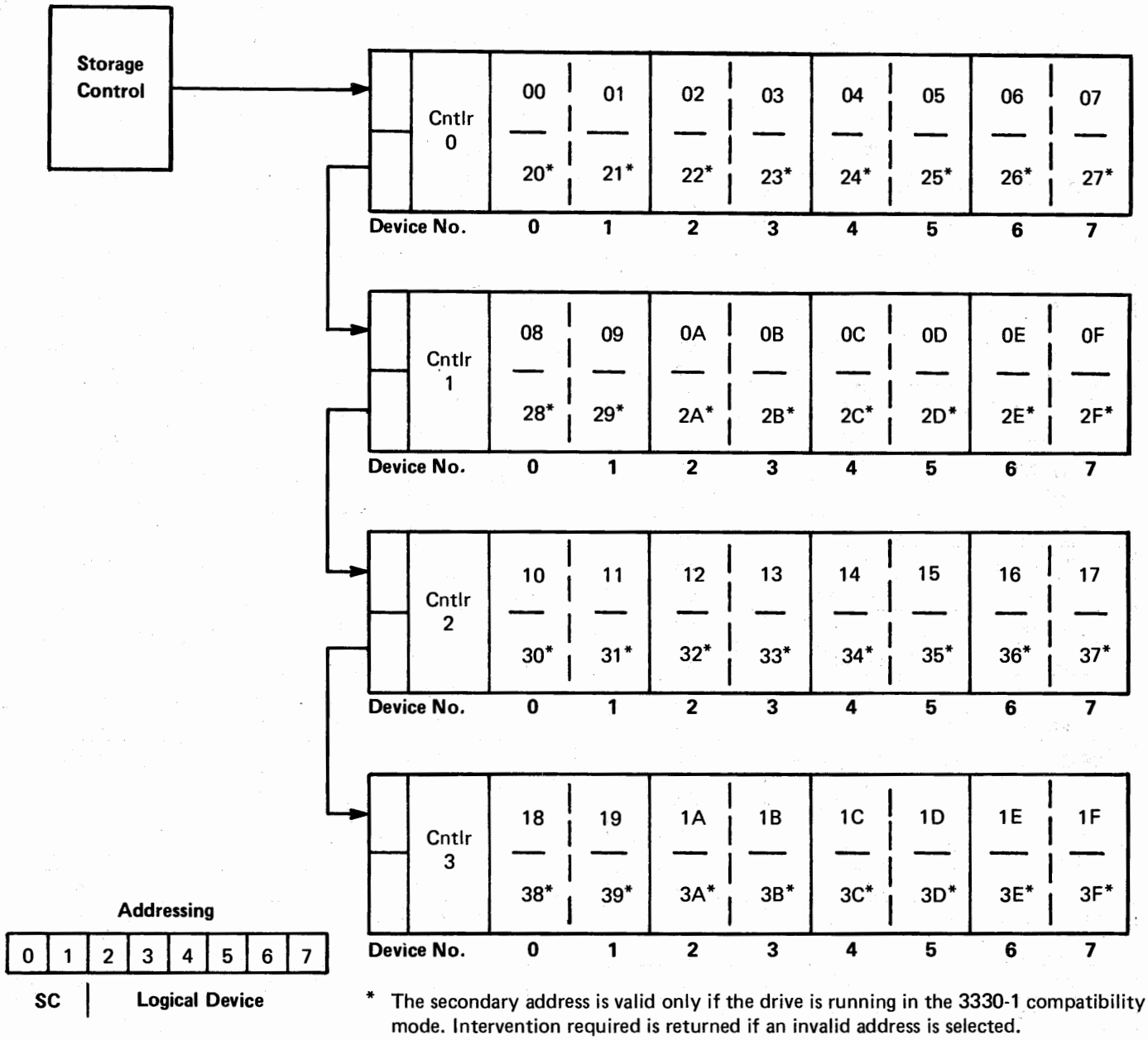
If either the Two-Channel Switch or the Two-Channel Switch Additional feature is installed, then bits 2, 3, and 4 must be assigned identically to all channel inputs.

Valid 3350 Addresses

When a 3350 is operating in the 3330-1 compatibility mode, there are 36 valid address ranges. The 3350 operates as two 3330-1s and requires two logical addresses per spindle: a primary and a secondary (see Figure 8). With 3330s, and/or 3340s, and/or 3350s attached to the storage control, only primary addresses shown in Figure 8 can be used.

When the 3350s are operating in either 3330-11 compatibility or 3350 native mode, 72 valid address ranges are available for each storage control. These address ranges are shown in Figure 9.

Maximum 3350 Configuration



* The secondary address is valid only if the drive is running in the 3330-1 compatibility mode. Intervention required is returned if an invalid address is selected.

Figure 7. Maximum 3350 Configuration

Primary Addresses	Secondary Addresses	Addresses Required
00-07	20-27	16
00-07, 10-17	20-27, 30-37	32
00-0F	20-2F	32
00-1F	20-3F	64
08-0F	28-2F	16
08-0F, 18-1F	28-2F, 38-3F	32
10-17	30-37	16
10-1F	30-3F	32
18-1F	38-3F	16
40-47	60-67	16
40-47, 50-57	60-67, 70-77	32
40-4F	60-6F	32
40-5F	60-7F	64
48-4F	68-6F	16
48-4F, 58-5F	68-6F, 78-7F	32
50-57	70-77	16
50-5F	70-7F	32
58-5F	78-7F	16
80-87	A0-A7	16
80-87, 90-97	A0-A7, B0-B7	32
80-8F	A0-AF	32
80-9F	A0-BF	64
88-8F	A8-AF	16
88-8F, 98-9F	A8-AF, B8-BF	32
90-97	B0-B7	16
90-9F	B0-BF	32
98-9F	B8-BF	16
C0-C7	E0-E7	16
C0-C7, D0-D7	E0-E7, F0-F7	32
C0-CF	E0-EF	32
C0-DF	E0-FF	64
C8-CF	E8-EF	16
C8-CF, D8-DF	E8-EF, F8-FF	32
D0-D7	F0-F7	16
D0-DF	F0-FF	32
D8-DF	F8-FF	16

Figure 8. Addresses for 3330-1 Compatibility Mode

Address Ranges from 00 to 7F	Addresses Required	Address Ranges from 80 to FF
00-07	8	80-87
00-07, 10-17	16	80-87, 90-97
00-0F	16	80-8F
00-1F	32	80-9F
08-0F	8	88-8F
08-0F, 18-1F	16	88-8F, 98-9F
10-17	8	90-97
10-1F	16	90-9F
18-1F	8	98-9F
20-27	8	A0-A7
20-27, 30-37	16	A0-A7, B0-B7
20-2F	16	A0-AF
20-3F	32	A0-BF
28-2F	8	A8-AF
28-2F, 38-3F	16	A8-AF, B8-BF
30-37	8	B0-B7
30-3F	16	B0-BF
38-3F	8	B8-BF
40-47	8	C0-C7
40-47, 50-57	16	C0-C7, D0-D7
40-4F	16	C0-CF
40-5F	32	C0-DF
48-4F	8	C8-CF
48-4F, 58-5F	16	C8-CF, D8-DF
50-57	8	D0-D7
50-5F	16	D0-DF
58-5F	8	D8-DF
60-67	8	E0-E7
60-67, 70-77	16	E0-E7, F0-F7
60-6F	16	E0-EF
60-7F	32	E0-FF
68-6F	8	E8-EF
68-6F, 78-7F	16	E8-EF, F8-FF
70-77	8	F0-F7
70-7F	16	F0-FF
78-7F	8	F8-FF

Figure 9. Address Ranges for 3350 Native or 3330-11 Compatibility Mode

STORAGE TYPE	CONFIGURATION
3330 Only	Up to four 3333s. Each 3333 can attach up to three 3330s. This configuration may require control store extension depending on the special features and number of the 3333s and 3830-2 path. Consult your IBM representative.
3340 Only	Up to four 3340-A2s. Each 3340-A2 can attach up to three 3340-B1/B2s. This configuration may require control store extension depending on the special features and number of 3340s on the 3830-2 path. Consult your IBM representative.
3333/3340	Up to four 3333s, 3340-A2s, or any combination of 3333s and 3340-A2s. Each 3333 can attach up to three 3330s, and each 3340-A2 can attach up to three 3340-B1/B2s. Configurations of mixed 3333s and 3340-A2s require control store extension and may require 32 contiguous device addresses regardless of the number of drives attached when string switch is installed. Consult your IBM representative.
3340/3344	Up to four 3340-A2s. Up to two of the 3340-A2s can attach from one to three 3344s and 3340-B1/B2s in any combination. One of the 3340-A2s can attach up to three 3340-B1/B2s and the other 3340-A2 can attach one 3340-B1/B2. Configurations using these devices require both control store extension and register expansion.
3350 Only	Up to four 3350-A2/A2Fs. Each A2/A2F can attach up to three 3350-B2/B2Fs. (A 3350-C2/C2F can be substituted for the end 3350-B2/B2F in any string.) The 3830-2 requires expanded control store, control store extension, and register expansion for this configuration.
3333/3340/3350	Up to four 3333s, 3340-A2s, and 3350-A2/A2Fs in any combination. Each 3333 can attach up to three 3330s. Each 3340-A2 can attach up to three 3340-B1/B2s, and each 3350-A2/A2F can attach up to three 3350-A2/A2Fs. (A 3350-C2/C2F can be substituted for the end 3350-B2/B2F in any string.) The 3830-2 requires expanded control store, control store extension, and register expansion for this configuration.

Figure 10. 3830-2 Configurations

STORAGE TYPE	CONFIGURATION
3330 Only	Up to four 3333s. Each 3333 can attach up to three 3330s. This configuration may require control store extension depending on the special features and number of the 3333s and 3830-2. Consult your IBM representative.
3340 Only	Up to four 3340-A2s. Each 3340-A2 can attach up to three 3340-B1/B2s. This configuration may require control store extension depending on the special features and number of 3340s on the 3830-2. Consult your IBM representative.
3333 and/or 3340	Up to four 3333s, 3340-A2s, or any combination of 3333s and 3340-A2s. Each 3333 can attach up to three 3330s, and each 3340-A2 can attach up to three 3340-B1/B2s. Configurations of mixed 3333s and 3340-A2s require control store extension and may require 32 contiguous device addresses regardless of the number of drives attached when string switch is installed. Consult your IBM representative.
3340 and/or 3344	Up to four 3340-A2s. Up to two of the 3340-A2s can attach from one to three 3344s and 3340-B1/B2s in any combination. One of the 3340-A2s can attach up to three 3340-B1/B2s and the other 3340-A2 can attach one 3340-B1/B2. Configurations using these devices require both control store extension and register expansion.
3350 Only	Up to four 3350-A2/A2Fs. Each A2/A2F can attach up to three 3350-B2/B2Fs. (A 3350-C2/C2F can be substituted for the end 3350-B2/B2F in any string.) The 3830-2 requires expanded control store, control store extension, and register expansion for this configuration.
3330 and/or 3340 and/or 3350	Up to four 3333s, 3340-A2s, and 3350-A2/A2Fs in any combination. Each 3333 can attach up to three 3330s. Each 3340-A2 can attach up to three 3340-B1/B2s, and each 3350-A2/A2F can attach up to three 3350-A2/A2Fs. (A 3350-C2/C2F can be substituted for the end 3350-B2/B2F in any 3350 string.) The 3830-3 requires expanded control store, control store extension, and register expansion for this configuration.

Figure 10. 3830-2 Configurations

Channel Commands

CONTROL COMMANDS

Control commands do not involve a transfer of data records between the storage control and main storage. However, in certain operations control bytes are transferred from main storage to the storage control. These bytes allow the operation to take place and are parity checked during transfer.

SEARCH COMMANDS

During the execution of search commands, the channel operates in write mode while the disk storage operates in read mode. The storage control compares the data coming from main storage against that coming from the drive. When the search requirement has been satisified (for example, compared equal, high, etc.) the storage control returns a status modifier bit with channel end and device end. This bit causes the channel to skip the following CCW in the chain and fetch the next command from a storage location 16 addresses higher than the current CCW.

Each search command operates on one record at a time. To search another record, the command must be reissued. This is normally done by chaining a TIC command to the search command, as follows:

Search Key Equal
TIC*-8
Read Data

If the search is unsuccessful, the TIC command following the search command causes the search to be repeated. When a search is successful, the status modifier causes the TIC command to be skipped and the Read Data command is executed.

At the end of every field searched, data validity is verified by the correction code bytes following the field that was searched. After the correction code check, the appropriate ending status is generated and presented to the channel.

If a data overrun or data check is detected, the storage control attempts recovery through use of command retry. If command retry is unsuccessful, channel end, device end, and unit check status are presented.

READ COMMANDS

A read command transfers information from disk storage to the central processing unit. Read commands may operate in either single track or multiple track mode.

Note: *Read IPL, Read Sector, and Read Multiple Count, Key, and Data do not operate in multitrack mode.*

On all read commands, a check is made of the validity of each record area as it is transferred. After the correction code bytes have been examined and data validity is established, the storage control sends an ending status byte of channel end and device end to the channel.

If a data overrun or data check is detected, the storage control normally attempts recovery through use of command retry. If command retry is unsuccessful or not used, channel end, device end, and unit check are presented to the channel.

WRITE COMMANDS

Write commands are of two types: formatting and update.

Formatting Write Commands

Formatting write commands initialize tracks and records, and establish the length of the areas within each record. Error correction code bytes are calculated and written after each record area.

The formatting write commands are:

- Write Home Address. (See Note in Write Home Address channel command description.)
- Write R0. (See Note in Write R0 channel command description.)
- Write Count, Key, and Data.
- Write Special Count, Key, and Data.
- Erase.

The command prerequisites and file mask settings for these commands are exact; any violation prevents command execution.

Channel Commands

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Control commands do not involve a transfer of data records between the storage control and main storage. However, in certain operations control bytes are transferred from main storage to the storage control. These bytes allow the operation to take place and are parity checked during transfer.

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TIC*-8
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If the search is unsuccessful, the TIC command following the search command causes the search to be repeated. When a search is successful, the status modifier causes the TIC command to be skipped and the Read Data command is executed.

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Note: *Read IPL, Read Sector, and Read Multiple Count, Key, and Data do not operate in multitrack mode.*

On all read commands, a check is made of the validity of each record area as it is transferred. After the correction code bytes have been examined and data validity is established, the storage control sends an ending status byte of channel end and device end to the channel.

If a data overrun or data check is detected, the storage control normally attempts recovery through use of command retry. If command retry is unsuccessful or not used, channel end, device end, and unit check are presented to the channel.

WRITE COMMANDS

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The formatting write commands are:

- Write Home Address. (See Note in Write Home Address channel command description.)
- Write R0. (See Note in Write R0 channel command description.)
- Write Count, Key, and Data.
- Write Special Count, Key, and Data.
- Erase.

The command prerequisites and file mask settings for these commands are exact; any violation prevents command execution.

Format write commands may be chained if each satisfies the chaining requirements. After the last format write command in a chain has been completed, the storage control causes the remaining portion of the track to be erased.

If a command (other than a format write command) is chained from a format write command, it is executed after the track has been padded. If the command is a control command, the storage control uses command retry to free the channel while the track is padded. If a new command chain is attempted before the end of the track is reached, a short control unit busy sequence (busy and status modifier bits) is presented to the channel. In this case, a control unit end signal is generated at the end of the track.

Update Write Commands

Update (non-formatting) write commands are used to update existing records and must operate on previously formatted tracks. Error correction code bytes are calculated and written after each key and/or data area in the record.

The update write commands are:

- Write Data
- Write Key and Data

Should a data overrun occur during an update write operation (excluding the second and subsequent segments of an overflow record), the storage control attempts recovery with command retry. If the retry is unsuccessful, channel end, device end, and unit check status are presented to the channel.

SENSE/TEST I/O COMMANDS

These commands are used to determine the status of the 3830-2 facility and identify any specific errors or unusual conditions that have occurred.

Note: *Since the Test I/O "command" is not the result of the channel executing a CCW, its operation is explained at this time instead of with the other channel commands. A Test I/O command (command code 0000 0000) is not written by the programmer. A command code of all zeros is considered invalid and causes a program check.*

The Test I/O command is automatically generated by the channel when the channel requires status information or is the result of processing a Test I/O instruction. In either case, it appears to the storage control as a command byte of all zeros and is treated as an immediate command. Test I/O requests the storage control to send all outstanding status information to the channel and normally presents an all-zero status byte. Stacked or pending status (if any) is presented in initial status.

The Sense I/O Type (E4) command transfers seven bytes of data to the channel that identify the storage control and device type of the selected units. The first byte is always 'FF', the next three bytes indicate the storage control type and model, and the last three bytes identify the drive type and model.

CHANNEL COMMAND SUMMARY

The Channel commands, command codes, and command description page numbers are shown in Figure 11.

CHANNEL COMMAND PAGES

The characteristics of each specific command are printed on separate command pages which follow the command summary page.

Note: *All channel command pages should have a sixth flag bit added to byte 4. This bit indicates that an indirect data address (IDA) is to be used, see Figure 4.*

COMMAND	COMMAND CODE				
	Multitrack Off		Multitrack On		
	Hex	Binary	Hex	Binary	Page
CONTROL					
No Operation	03	0000 0011			19
Recalibrate	13	0001 0011			20
Seek	07	0000 0111			21
Seek Cylinder	0B	0000 1011			22
Seek Head	1B	0001 1011			23
Space Count	0F	0000 1111			24
Set File Mask	1F	0001 1111			25
Set Sector	23	0010 0011			26
Restore	17	0001 0111			27
Transfer In Channel	x8*	xxxx 1000			28
Diagnostic Load	53	0101 0011			29
Diagnostic Write	73	0111 0011			30
SEARCH					
Home Address Equal	39	0011 1001	B9	1011 1001	31
Identifier ID Equal	31	0011 0001	B1	1011 0001	32
Identifier ID High	51	0101 0001	D1	1101 0001	33
Identifier ID Equal or High	71	0111 0001	F1	1111 0001	34
Key Equal	29	0010 1001	A9	1010 1001	35
Key High	49	0100 1001	C9	1100 1001	36
Key Equal or High	69	0110 1001	E9	1110 1001	37
READ					
Home Address	1A	0001 1010	9A	1001 1010	38
Count	12	0001 0010	92	1001 0010	39
Record Zero (R0)	16	0001 0110	96	1001 0110	40
Data	06	0000 0110	86	1000 0110	41
Key and Data	0E	0000 1110	8E	1000 1110	42
Count, Key, and Data	1E	0001 1110	9E	1001 1110	43
Multiple Count, Key, and Data**	5E	0101 1110	.	.	44
IPL	02	0000 0010	.	.	45
Sector	22	0010 0010	.	.	46
SENSE					
Input/Output (I/O) Type**	E4	1110 0100			47
Input/Output (I/O)	04	0000 0100			48
Read and Reset Buffered Log	A4	1010 0100			49
Device Reserve	B4	1011 0100			50
Unconditional Reserve***	14	0001 0100			51
Device Release	94	1001 0100			52
Read Diagnostic Status 1	44	0100 0100			53
WRITE					
Home Address	19	0001 1001			54
Record Zero (R0)	15	0001 0101			55
Erase	11	0001 0001			56
Count, Key, and Data	1D	0001 1101			57
Special Count, Key, and Data	01	0000 0001			58
Data	05	0000 0101			59
Key and Data	0D	0000 1101			60

* x not significant (addresses should not exceed storage capacity).
** Available only if 3830-2 uses microcode supporting 3344 or 3350 devices.
*** Available only if 3830-2 uses microcode supporting 3350 devices.

Use of command codes other than shown causes unit check in initial status. A subsequent sense operation indicates command reject.

Figure 11. Channel Command Summary

NO-OP

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 0011** Hex **03**	Not checked for validity; should not exceed addressing capacity.			SLI flag (bit 2) should be on			Must be non-zero; zero count causes a program check.	
Chaining and Special Requirements: See following description.								

NO-OP, an immediate command; causes no action at addressed device.

CHANNEL END is presented in initial status.

DEVICE END is presented in initial status.

INDISCRIMINATE USAGE must be avoided; a No-op resets orientation information and causes all or parts of records to be skipped.

EXAMPLE: a No-op between Read Count and Read Data reads the following record's data.

EXAMPLE: a No-op between a command that reads the data field of record n-1 and a command that must process the count area of record n, may skip record n and process the count area of record n+1.

NO-OP CCW count field must not be zero.

SLI FLAG must be on to avoid incorrect length indication.

ZERO COUNT will set the program check bit (byte 5, bit 2) in the CSW.

RECALIBRATE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0011** Hex **13**	Not checked for validity, but should not exceed addressing capacity.			SLI flag (bit 2) should be on			Must be non-zero: zero count causes a program check.	
Chaining and Special Requirements: If used, file mask must allow Seek commands.								

RECALIBRATE causes addressed drive to seek to cylinder zero, head zero.

INITIAL STATUS byte normally zero; not processed as an immediate command.

CHANNEL END presented in ending status.

DEVICE END presented when drive positions the access mechanism to cylinder zero, head zero.

FILE MASK must be set to allow Seek commands.

SLI BIT must be on in Recalibrate CCW to avoid incorrect length indication.

SEEK

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary 0000 0111 Hex 07	Specifies CPU main storage location of the seek address.			Used at the discretion of the programmer.			Six	
Chaining and Special Requirements: If used, file mask must allow Seek commands.								

SEEK transfers the six-byte seek address from channel to storage control.

INITIAL STATUS normally zero.

STORAGE CONTROL selects drive, moves access mechanism to proper cylinder, and selects proper head.

ACCESS MOTION, if any, initiated after seek address transfer.

CCW COUNT > SIX: transfers six bytes of address information.

CCW COUNT < SIX: Seek is not executed. Unit check, channel end, and device end are presented in ending status.

VALID SEEK ADDRESS	3333 and 3350 Compatibility Modes		3340 Only	3340/44	3350
	Models 1 and 2	Model 11	(35 Mb)	(70 Mb)	Native
Bytes 0, 1, and 4 must be:	0	0	0	0	0
Bytes 2 and 3 not greater than:*	410	814	348	697	559
Byte 5 not greater than:	18	18	11	11	29

* CE cylinders for 3344 are 2800 through 2804, for 3340 (35 mb) 349, (70 mb) 698 and 699, for 3350 (all modes) 1024.

INVALID SEEK ADDRESS: Seek not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

PARITY ERROR detected in seek address transfer: command not executed; unit check, channel end, and device end presented in ending status. A subsequent Sense command indicates bus out parity error.

COMMAND EXECUTION does not require preceding CCW.

FILE MASK must allow Seeks or unit check is presented in initial status.

CHANNEL END presented after seek address transfer.

DEVICE END presented with channel end if no movement; with movement, presented after access mechanism is positioned.

Note: *For 3330, several successive Seeks, without an intervening data read or write, may cause a seek incomplete condition in the storage control. The storage control uses its internal error recovery procedures to correct the failure. If it cannot correct the failure, unit check, with equipment check and permanent error, is posted in the sense bytes.*

SEEK CYLINDER

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 1011** Hex **0B**	Specifies the CPU main storage location of the seek address.			Used at the discretion of the programmer.			Six	
Chaining and Special Requirements: If used, file mask must allow Seek commands.								

SEEK CYLINDER transfers the six-byte seek address from channel to storage control. (Same as Seek command for 3830/3330 users.)

INITIAL STATUS normally zero.

STORAGE CONTROL selects drive, moves access mechanism to proper cylinder, and selects proper head.

ACCESS MOTION, if any, initiated after seek address transfer.

CCW COUNT > SIX: transfers six bytes of address information.

CCW COUNT < SIX: Seek Cylinder not executed. Unit check, channel end, and device end presented. A subsequent Sense command indicates command reject.

VALID SEEK ADDRESS	3333 and 3350 Compatibility Modes		3340 Only	3340/44	3350
	Models 1 and 2	Model 11	(35 Mb)	(70 Mb)	Native
Bytes 0, 1, and 4 must be:	0	0	0	0	0
Bytes 2 and 3 not greater than:*	410	814	348	697	559
Byte 5 not greater than:	18	18	11	11	29

* CE cylinders for 3344 are 2800 through 2804, for 3340 (35 mb) 349, (70 mb) 698 and 699, for 3350 (all modes) 1024.

INVALID SEEK ADDRESS: Seek not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

PARITY ERROR detected in seek address transfer: command not executed; unit check, channel end, and device end presented. A subsequent Sense command indicates bus out parity error.

COMMAND EXECUTION does not require preceding CCW.

FILE MASK must allow Seeks or unit check is presented in initial status.

CHANNEL END presented after seek address transfer.

DEVICE END presented with channel end if no movement; with movement, presented after access mechanism is positioned.

Note: *For 3330, several successive Seeks, without an intervening data read or write, may cause a seek incomplete condition in the storage control. The storage control uses its internal error recovery procedures to correct the failure. If it cannot correct the failure, unit check, with equipment check and permanent error, is posted in the sense bytes.*

SEEK HEAD

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1011** Hex **1B**	Specifies the CPU main storage location of the seek address.			Used at the discretion of the programmer.			Six	
Chaining and Special Requirements: If used, file mask must allow Seek commands.								

SEEK HEAD transfers the six-byte seek address from channel to storage control.

INITIAL STATUS normally zero.

STORAGE CONTROL selects drive and proper head.

CCW COUNT > SIX: transfers six bytes of address information.

CCW COUNT < SIX: Seek Head not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

VALID SEEK ADDRESS REQUIRED, however, only the head address specified in the sixth byte is significant.

VALID SEEK ADDRESS	3333 and 3350 Compatibility Modes		3340 Only	3340/44	3350
	Models 1 and 2	Model 11	(35 Mb)	(70 Mb)	Native
Bytes 0, 1, and 4 must be:	0	0	0	0	0
Bytes 2 and 3 not greater than:*	410	814	348	697	559
Byte 5 not greater than:	18	18	11	11	29

* CE cylinders for 3344 are 2800 through 2804, for 3340 (35 mb) 349, (70 mb) 698 and 699, for 3350 (all modes) 1024.

INVALID SEEK ADDRESS: Seek Head not executed. Unit check, channel end, and device end are presented. A subsequent Sense command indicates command reject.

PARITY ERROR detected in seek address transfer: command not executed; unit check, channel end, and device end presented. A subsequent Sense command indicates bus out parity error.

COMMAND EXECUTION does not require preceding CCW.

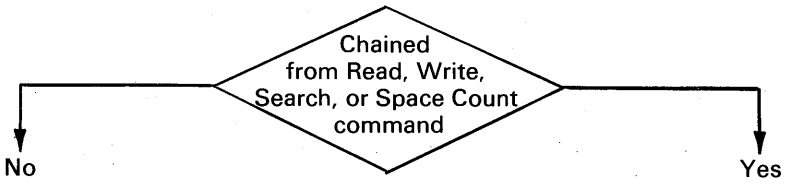
FILE MASK must allow Seeks or unit check is presented in initial status.

CHANNEL END/DEVICE END presented after seek address transfer.

SPACE COUNT

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 1111** Hex **0F**	Specifies CPU main storage location of the key and data lengths of the record to be recovered.			Used at the discretion of the programmer.			Three	
Chaining and Special Requirements: 1. Cannot be chained from a format write or Erase command. 2. Cannot be followed by a Write, Erase, Read IPL, or Set File Mask command in the same chain.								

SPACE COUNT bypasses a defective count area to allow data recovery in key and/or data areas following the defective area.



1. Searches for index.
2. Clocks through gap 1, home address and gap 2.
3. Spaces over R0 count area.
4. Receives key and data length transfer from channel.
5. Sets end-of-count-area internal orientation state indicator.
6. Presents channel end and device end to channel.

Using the above:

a. Space Count followed by Read Key and Data recovers or bypasses bad R0 count area.
b. Space Count followed by Read CKD reads R1.

1. Orients at start of next count area.
2. Spaces over the count area.
3. Receives key and data length transfer from channel.
4. Sets end-of-count-area internal orientation state indicator.
5. Presents channel end and device end to channel.

Note: *If the track is flagged defective, the Space Count should always follow a Search ID Equal to provide consistant results.*

Using the above:
Command chain (a) may be used to recover key and data areas of record (N≠0). Command chain (b) used to recover record N+1.

(a)	(b)
Set Sector	Set Sector
Search ID (record n-1)	Search ID (record n-1)
TIC*-8	TIC*-8
Space Count**	Space Count**
Read KD	Read CKD

** Must specify correct key and data lengths.

DATA TRANSFERRED FROM CHANNEL used by storage control as key length (first byte) and data length (last two bytes) of record to be recovered.

CCW COUNT > THREE: three bytes are transferred.

CCW COUNT < THREE: the specified number of bytes are transferred.

NO BYTES TRANSFERRED: storage control uses zero. Read Data and Read KD commands will receive unit exception status, Read CKD commands may find data checks.

INVALID TRACK format presented if index found before command execution.

SET FILE MASK

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1111** Hex **1F**	Specifies CPU main storage location of the mask byte.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: 1. Only one Set File Mask permitted in a CCW chain. 2. Should not be used in the same CCW chain with a Space Count command.								

SET FILE MASK sets the write and seek masks which protect the data, and defines command retry-PCI interaction.

Bit 0	Bit 1	Function	Bit 3	Bit 4	Function	Bit 5	Function	Bit 7	Function
0	0	Inhibit Write Home Address and Write R0.	0	0	Permit all Seek commands.	0	Inhibit Diagnostic Write commands and seeks to CE tracks.	0	Not PCI fetch mode. (3330and 3350 only.)
0	1	Inhibit all Write commands.	0	1	Permit Seek Cylinder and Seek Head.	1	Permit Diagnostic Write commands and seeks to CE tracks only.	1	PCI fetch mode. (The storage control presents unit check if command retry is used to recover from ECC uncorrectable errors.) (3330 and 3350 only.)
1	0	Inhibit all format write commands.	1	0	Permit Seek Head.				
1	1	Permit all Write commands.	1	1	Inhibit all Seek commands and head switching.				

Bits 2 and 6 must be zero, or unit check, channel end, and device end are presented in initial status. Bit 7 is used only by 3330s and 3350s and is ignored by other devices.

COMMAND EXECUTION allowed only once in CCW chain; more than one Set File Mask causes unit check in status.

COMMAND REJECT indicated by subsequent Sense command,

FILE MASK RESET to zeros at end of CCW chain.

WRITE COMMANDS violating file mask are not executed:

UNIT CHECK is presented in initial status,

COMMAND REJECT is indicated by subsequent Sense command.

SEEK COMMANDS violating file mask are not executed:

UNIT CHECK presented in initial status,

FILE PROTECTED indicated by subsequent Sense command (end-of-cylinder not set).

MULTITRACK/OVERFLOW operations violating file mask present unit check and file protect.

CHANNEL END/DEVICE END presented to channel after transfer of mask byte.

SYSTEM OR SELECTIVE RESET resets file mask to zeros.

START I/O following a reset without Set File Mask in CCW permits Seek and Write commands (except Write HA and Write R0).

DIAGNOSTIC WRITE violating file mask not executed and unit check is presented.

SET SECTOR

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0010 0011** Hex **23**	Specifies CPU main storage location of the desired sector.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: None.								

SET SECTOR (used on block multiplexer channels) allows the storage control to disconnect during rotational delay.

COMMAND EXECUTION transfers a sector number (0-127 on 3333 and 3350; 0-63 on 3340 or 3344) from CPU storage to the storage control.

ANGULAR POSITIONS checked for validity by the storage control. (All valid arguments, except for 255, are adjusted by the storage control to compensate for channel reselection delay.)

VALID ARGUMENT(0-127 or 0-63):

Storage control presents channel end and disconnects.

Device end signaled when angular position reached and channel reconnects; if interrupt stacked, request in is maintained until reconnection.

If no reconnection, storage control attempts reconnection on following revolutions.

ZERO ARGUMENT: Storage control attempts reconnection just before index.

ARGUMENT > 63, ARGUMENT > 127, or ARGUMENT < 255: Channel end, device end, and unit check presented in ending status. Command reject indicated in a subsequent Sense command.

ARGUMENT = 255:

1. Command treated as a No-op.
2. Channel end/device end presented in ending status.
3. Track orientation is destroyed.

Programming Note:

1. The Set Sector command does not guarantee record orientation. The Search commands must still be used for this function.
2. Indiscriminate use of Set Sector with multitrack search may result in missing the desired record. A Set Sector 0, Read HA, and Search M/T sequence will avoid this problem.
3. If a 3340 without RPS is addressed, channel end and device end are returned. No operation is performed; track orientation is not maintained.
4. Additional adjustment is made for 3350s running in 3330 mode to account for differences in track and record overheads.

RESTORE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0111** Hex **17**	Not checked for validity, but must not exceed addressing capacity.			SLI flag (bit 2) should be on			Not zero. Zero causes a program check.	
Chaining and Special Requirements: None.								

RESTORE is primarily for compatibility with other IBM Direct Access Storage Devices and causes no action to be performed.

INITIAL STATUS normally zero.

CHANNEL END/DEVICE END immediately follows initial status.

SLI BIT must be on in the Restore CCW to avoid incorrect length indication.

TRANSFER IN CHANNEL (TIC)

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **xxxx 1000** Hex **x8** x = ignored	Specifies CPU main storage location for the next CCW.			Ignored			Ignored	
Chaining and Special Requirements: 1. Cannot be first CCW designated by channel address word. 2. One TIC command cannot transfer directly to another.								

TRANSFER IN CHANNEL (TIC) provides chaining capabilities for CCWs not located in adjacent CPU main storage locations.

TIC DATA ADDRESS FIELD specifies next CCW to be fetched.

COMMAND EXECUTION does not initiate I/O operations or signal I/O device.

PROGRAM CHECK SIGNAL is generated when chaining requirements are not met or an invalid address is specified. (TIC CCW data address area does not specify a double word boundary.)

ERROR DETECTION ends the chaining operations.

Note: *TIC is the only CCW that allows a zero count. An incorrect length indication cannot occur since flags and count are ignored.*

ASSEMBLER LANGUAGE notation TIC*-8 indicates an unconditional branch to the TIC storage address (*) minus a count of eight. TIC*-16 indicates an unconditional branch to the TIC storage address (*) minus a count of sixteen.

DIAGNOSTIC LOAD

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0101 0011** Hex **53**	Specifies CPU main storage location of control byte.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: None.								

DIAGNOSTIC LOAD transfers a 512 byte block of data from the storage control read-only storage (ROS) to the storage control buffer. The transferred data block is a functional microprogram diagnostic test.

INITIAL STATUS normally zero.

CONTROL BYTE specifying diagnostic microprogram ID number transferred from CPU main storage to storage control.

ROS * TRACK ADDRESS (0-31) specified in bits 0-4.

ROS * SECTOR NUMBER (0-7) specified in bits 5-7.

* ROS refers to the Read Only Storage device attached to the storage control, not to a drive.

VALID CONTROL BYTE presents channel end in ending status.

STORAGE CONTROL disconnects from channel and transfers diagnostic test to buffer.

COMMAND EXECUTION allows any drive address to be used with the storage control address.

READ DIAGNOSTIC STATUS 1 command transfers the diagnostic test from storage control buffer to CPU main storage.

DATA TRANSFER COMPLETE causes storage control to present channel end and device end.

Caution: This command is intended for maintenance purposes only. Any use other than that provided by IBM diagnostic programs may yield unpredictable results.

DIAGNOSTIC WRITE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0111 0011** Hex **73**	Specifies CPU main storage location of diagnostic test.			Used at the discretion of the programmer.			512	
Chaining and Special Requirements: File mask must allow Diagnostic Write command (bit 5 = 1).								

DIAGNOSTIC WRITE transfers a 512 byte diagnostic test from CPU main storage to the storage control.

INITIAL STATUS normally zero.

DATA TRANSFER COMPLETE: test execution begins.

TEST COMPLETE: 16 byte error code message is stored in the storage control buffer.

COMPATIBILITY VERIFIED by storage control by comparing a key in the test against the engineering level of the microprogram.

INVALID COMPARISON command terminated; channel end, device end, and unit check presented in ending status.

CCW COUNT > 512: only 512 bytes transferred.

CCW COUNT < 512: only the specified number of bytes transferred, command terminated, channel end, device end, and unit check presented in ending status.

ERROR CODE MESSAGE (16 bytes) transferred from storage control buffer to CPU main storage by a following Read Diagnostic Status 1 (Diagnostic Sense) command.

CHANNEL END/DEVICE END presented after transfer of diagnostic test to the storage control and test completion.

Caution: This command is intended for maintenance purposes only. Any use other than that provided by IBM diagnostic programs may yield unpredictable results.

SEARCH HOME ADDRESS EQUAL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0011 1001** Hex **39** M/T Binary **1011 1001** Hex **B9**	Specifies main storage location of a cylinder number (CC) and head number (HH).			Used at the discretion of the programmer.			Four	
Chaining and Special Requirements: None.								

SEARCH HOME ADDRESS EQUAL causes storage control to search for index.

INITIAL STATUS normally zero.

CYLINDER AND HEAD NUMBERS from CPU main storage and the track home address area are compared by storage control after index is detected.

FLAG BYTE not transferred or compared during command execution.

COMPARISON EQUAL: channel end, device end, and status modifier presented to channel.

COMPARISON NOT EQUAL: channel end and device end presented to channel.

CCW COUNT > FOUR: only first four bytes used.

CHANNEL END/DEVICE END presented to terminate the command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FOUR: comparison of main storage and track data continues until CCW count = zero.

CHANNEL END/DEVICE END presented when home address and ECC bytes are read and checked.

STATUS MODIFIER presented if search is satisfied on a short field.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points detected.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel after second index found or parity error detected.

MULTITRACK USED: causes search to continue (as long as channel repeats command); head number automatically increments at index until search is satisfied or end-of-cylinder is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when end-of-cylinder is reached or parity error detected.

SEARCH ID EQUAL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0011 0001** Hex **31** M/T Binary **1011 0001** Hex **B1**	Specifies main storage location of a five-byte record identifier (CC HH R).			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

SEARCH ID EQUAL compares the CPU main storage ID and the count area ID. ID to be compared is next ID on track (including R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL: channel end, device end, and status modifier presented to channel.

COMPARISON NOT EQUAL: channel end and device end presented to the channel.

CCW COUNT > FIVE: only first five bytes used.

CHANNEL END/DEVICE END presented to terminate command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FIVE: comparison of main storage and track data continues until CCW count = zero.

CHANNEL END/DEVICE END presented to channel when ID and ECC bytes read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index or a parity error is detected.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

END OF CYLINDER generated after last track in cylinder is searched:

In 3330 (or 3350 compatibility modes), when head 18 is reached.
In 3340/3344, when head 11 is reached.
In 3350 (native mode), when head 29 is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

SEARCH ID HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0101 0001** Hex **51** M/T Binary **1101 0001** Hex **D1**	Specifies main storage location of a five-byte record identifier (CC HH R).			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

SEARCH ID HIGH compares the CPU main storage ID and the disk drive count area ID. ID to be compared is next ID on track (including R0).

INITIAL STATUS normally zero.

COMPARISON HIGH: channel end, device end, and status modifier presented to channel. ID on drive is higher than ID in main storage.

COMPARISON NOT HIGH: channel end and device end presented to channel.

CCW COUNT > FIVE: only first five bytes used.

CHANNEL END/DEVICE END presented to terminate command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FIVE: comparison of main storage and track data continues until CCW count = zero.

CHANNEL END/DEVICE END presented to channel when ID and ECC bytes read and checked.

STATUS MODIFIER presented if search is satisfied on the short count.

MULTITRACK NOT USED: search confined to single track, continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented when second index sensed or parity error is detected.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition is satisfied or end-of-cylinder reached.

END OF CYLINDER generated after last track in cylinder is searched:

In 3330 (or 3350 compatibility modes), when head 18 is reached.
In 3340/3344, when head 11 is reached.
In 3350 (native mode), when head 29 is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder or if parity error found.

SEARCH ID EQUAL OR HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0111 0001** Hex **71** M/T Binary **1111 0001** Hex **F1**	Specifies main storage location of five-byte record identifier (CC HH R).			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

SEARCH ID EQUAL OR HIGH compares the CPU main storage ID and the disk drive count area ID. ID to be compared is next ID on the track (including R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL OR HIGH: channel end, device end, and status modifier presented to the channel. ID on drive is equal to or higher than ID in main storage.

COMPARISON NOT EQUAL OR HIGH: channel end and device end presented to the channel.

CCW COUNT > FIVE: only first five bytes used.

CHANNEL END/DEVICE END presented to terminate command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < FIVE: comparison of main storage and track data continues until CCW count = zero.

CHANNEL END/DEVICE END presented to channel when ID and ECC bytes read and checked.

STATUS MODIFIER presented if search is satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is detected.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

END OF CYLINDER generated after last track in cylinder is searched:

In 3330 (or 3350 compatibility modes), when head 18 is reached.
In 3340/3344, when head 11 is reached.
In 3350 (native mode), when head 29 is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

SEARCH KEY EQUAL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0010 1001** Hex **29** M/T Binary **1010 1001** Hex **A9**	Specifies main storage locations to which key is compared.			Used at the discretion of the programmer.			Equal to length of the argument.	
Chaining and Special Requirements: When command chained from Search ID or Read Count, key is in same record as ID or count. Search Key Equal bypasses R0 unless chained from Search ID command which searched R0 ID.								

SEARCH KEY EQUAL compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL: channel end, device end, and status modifier presented to channel.

COMPARISON NOT EQUAL OR NO KEY: channel end and device end presented to channel.

CCW COUNT > KL: search operation completed when key area is read.

CHANNEL END/DEVICE END terminates command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < KL: track and main storage data compare continues until CCW count = zero.

CHANNEL END/DEVICE END presented after key area and following ECC bytes are read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is detected.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

END OF CYLINDER generated after last track in cylinder is searched:

In 3330 (or 3350 compatibility modes), when head 18 is reached.
In 3340/3344, when head 11 is reached.
In 3350 (native mode), when head 29 is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

COMMAND EXECUTION on record with zero KL does not set status modifier. If followed by a chained Read Data, the data area read is from next record.

SEARCH KEY HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0100 1001** Hex **49** M/T Binary **1100 1001** Hex **C9**	Specifies main storage location to which key is compared.			Used at the discretion of the programmer.			Equal to length of the argument.	
Chaining and Special Requirements: When command chained from Search ID or Read Count, key is in same record as ID or count. Search Key High bypasses R0 unless chained from Search ID command which searched R0 ID.								

SEARCH KEY HIGH compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

INITIAL STATUS normally zero.

COMPARISON HIGH: channel end, device end, and status modifier presented to channel. Key on drive is higher than main storage argument.

COMPARISON NOT HIGH: channel end/device end presented to channel.

CCW COUNT > KL: search operation completed when key area is read.

CHANNEL END/DEVICE END terminates command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < KL: track and main storage data comparison continues until CCW count = 0.

CHANNEL END/DEVICE END presented after key area and ECC bytes read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is detected.

MULTITRACK USED: search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

END OF CYLINDER generated after last track in cylinder is searched:

In 3330 (or 3350 compatibility modes), when head 18 is reached.
In 3340/3344, when head 11 is reached.
In 3350 (native mode), when head 29 is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

COMMAND EXECUTION ON RECORD with zero KL does not set status modifier. If followed by a chained Read Data, the data area read is from the next record.

SEARCH KEY EQUAL OR HIGH

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0110 1001** Hex **69** M/T Binary **1110 1001** Hex **E9**	Specifies main storage location to which key is compared.			Used at the discretion of the programmer.			Equal to length of the argument.	
Chaining and Special Requirements: When command chained from Search ID or Read Count, key is in same record as ID or count. Search Key Equal or High bypasses R0 unless chained from Search ID command which searched R0 ID.								

SEARCH KEY EQUAL OR HIGH compares main storage key to key area read from track. Key to be compared is next key on track (excluding R0).

INITIAL STATUS normally zero.

COMPARISON EQUAL OR HIGH: channel end, device end, and status modifier presented to channel. Key on drive equal to or higher than main storage argument.

COMPARISON NOT EQUAL OR HIGH: channel end and device end presented to channel.

CCW COUNT > KL: search operation completed when key area is read.

CHANNEL END/DEVICE END terminates command.

STATUS MODIFIER presented if comparison was equal.

CCW COUNT < KL: track and main storage data comparison continues until CCW count = 0.

CHANNEL END/DEVICE END presented after key area and ECC bytes read and checked.

STATUS MODIFIER presented if search satisfied on the short count.

MULTITRACK NOT USED: search confined to one track; continues (as long as channel repeats command) until search condition satisfied or two index points are sensed.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel when second index sensed or a parity error is detected.

MULTITRACK USED search continues (as long as channel repeats command); head number automatically increments at index until search condition satisfied or end-of-cylinder reached.

END OF CYLINDER generated after last track in cylinder is searched:

In 3330 (or 3350 compatibility modes), when head 18 is reached.
In 3340/3344, when head 11 is reached.
In 3350 (native mode), when head 29 is reached.

CHANNEL END/DEVICE END/UNIT CHECK presented to channel at end-of-cylinder.

COMMAND EXECUTION ON RECORD with zero KL does not set status modifier. If followed by a chained Read Data, the data area read is from the next record.

READ HOME ADDRESS

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1010** Hex **1A** M/T Binary **1001 1010** Hex **9A**	Specifies main storage location where home address is to be stored.			Used at the discretion of the programmer.			Five	
Chaining and Special Requirements: None.								

READ HOME ADDRESS transfers the F CC HH bytes of the home address to main storage.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following the area.

DATA OVERRUN/DATA CHECK, if detected, storage control tries command retry (3330 or 3350).

COMMAND RETRY, if unsuccessful, channel end, device end, and unit check presented.

PARITY BIT added to each byte before transfer to the channel.

CHANNEL END/DEVICE END presented to channel after home address ECC check.

READ COUNT

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0010** Hex **12** M/T Binary **1001 0010** Hex **92**	Specifies main storage location where first byte of count data is to be transferred.			Used at the discretion of the programmer.			Eight	
Chaining and Special Requirements: None.								

READ COUNT transfers the eight bytes (CC HH R KL DL DL) of the next count area on the track (excluding R0) from disk storage to main storage.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following the area.

DATA OVERRUN/DATA CHECK, if detected, storage control tries command retry (3330 or 3350).

COMMAND RETRY, if unsuccessful, channel end, device end, and unit check presented.

PARITY BIT added to each byte before transfer to the channel.

CHANNEL END/DEVICE END presented to channel after ECC check.

READ RECORD 0 (R0)

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0110** Hex **16** M/T Binary **1001 0110** Hex **96**	Specifies main storage location where first byte of R0 count data is to be transferred.			Used at the discretion of the programmer.			Specifies number of count, key, and data bytes to be read.	
Chaining and Special Requirements: None.								

READ R0 transfers count, key, and data areas of R0 from drive to the channel.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts command retry (3330 or 3350).

COMMAND RETRY, if unsuccessful, channel end, device end, and unit check presented.

PARITY BIT added to each byte before transfer to the channel.

Note: *If a correctable data error (error burst of 11 bits or less, 4 bits or less for the 3350 and 3340/3344) is detected in the data area, unit check is signaled to the channel so ERP can correct the error.*

COMMAND RETRY, if unsucessful, signals channel end, device end, and unit check to channel.

PARITY BIT added to each byte before transferring byte to channel.

STORAGE CONTROL searches for index, clocks through gap 1, home address, and gap 2.

DATA TRANSFER of the R0 count area is initiated by storage control.

COMMAND EXECUTION accomplished immediately if Read R0 is chained from a Search HA or Read HA command; with these commands, storage control does not search for index.

CHANNEL END/DEVICE END presented to channel at completion of ECC check of data area.

READ DATA

Byte 0	1	2	3	4	5	6	7
Command Code	**Data Address**			**Flags** **000**	**Not Used**	**Count**	
Binary **0000 0110** Hex **06** M/T Binary **1000 0110** Hex **86**	Specifies main storage location where first data byte is to be transferred.			Used at the discretion of the programmer.		Specifies number of bytes to be read.	
Chaining and Special Requirements: None.							

READ DATA transfers the data area of a record from drive to CPU main storage. The data read is:

1. Data area of record read by Search ID or Search Key from which Read Data is chained.
2. Data area of record read by Read Count from which Read Data is chained.
3. Data area of record following next count area on the track (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts recovery by command retry (3330 or 3350).

Note: *If a correctable data error (error burst of 11 bits or less, 4 bits for the 3350 and 3340/3344) is detected in the data area, unit check is signaled to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful; channel end, device end, and unit check presented.

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END presented to channel following ECC check of data area.

Note: *No ECC check is performed in the key area.*

READ KEY AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 1110** Hex **0E** M/T Binary **1000 1110** Hex **8E**	Specifies main storage location where first byte of key data is to be transferred.			Used at the discretion of the programmer.			Specifies the number of key and data area bytes to be read.	
Chaining and Special Requirements: None.								

READ KEY AND DATA transfers key and data areas of record from drive to main storage. The key and data areas are:

1. Key and data area of record read by Search ID from which Read KD is chained.
2. Key and data areas of record read by Read Count from which Read KD is chained.
3. Key and data areas of record following next count area on track (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts recovery by command retry (3330 or 3350).

Note: *If a correctable data error (error burst of 11 bits or less, 4 bits for the 3350 and 3340/3344) is detected in the data area, unit check is signaled to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful, sends channel end, device end, and unit check to channel.

KEY LENGTH = ZERO: command same as a Read Data command.

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END presented to channel following ECC check of data area.

READ COUNT, KEY, AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1110** Hex **1E** M/T Binary **1001 1110** Hex **9E**	Specifies main storage location where first byte of count data is to be transferred.			Used at the discretion of the programmer.			Specifies the number of count, key, and data bytes to be read.	
Chaining and Special Requirements: None.								

READ COUNT, KEY, AND DATA transfers the next record on the track from the drive to CPU main storage (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following each area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts command retry recovery (3330 or 3350).

Note: *If a correctable data error (error burst of 11 bits or less, 4 bits in the 3350 and 3340/3044) is detected in the data area, unit check is signaled to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful, signals channel end, device end, and unit check to the channel.

PARITY BIT is added to each byte before transfer to channel.

CHANNEL END/DEVICE END signaled to channel following ECC check of data area.

READ MULTIPLE COUNT, KEY, AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0101 1110** Hex **5E**	Specifies main storage location where first byte of count data is to be transferred.			SLI flag (bit 2) should be on			Larger than maximum track length: 3330 = 13,030 3340/3344 = 8,368 3350 modes; Native = 19,069 Compatibility = 13,030	
Chaining and Special Requirements: Set File Mask should precede this command to inhibit head switching if an overflow record is encountered. Valid only if issued to a storage control with microcode supporting 3344 or 3350.								

READ MULTIPLE COUNT, KEY, AND DATA transfers next record and all remaining records on the track from the drive to CPU main storage (excluding R0).

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes after each area.

DATA OVERRUN command not retried — posted to the ERP to retry CCW chain 10 times.

DATA CHECK uncorrectable, not retried — posted to the ERP to retry CCW chain 10 times; correctable — posted normally. After error is corrected, restart chain is required to read beyond record in error.

COMMAND RETRY not effective on data overrun, seek check, or uncorrectable data check (3330 or 3350).

Note: *For 3330, a CCW chain using Read Multiple CKD may not be as recoverable under error conditions as a CCW chain using commands in which retry can be invoked.*

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END presented to channel at end of track.

UNIT CHECK (command reject) results if command is attempted in multitrack mode. Also results if command issued to a storage control with microcode not supporting 3350 or 3344.

READ IPL

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 0010** Hex **02**	Specifies main storage location where first byte of data is to be transferred.			Used at the discretion of the programmer.			Specifies number of bytes to be transferred.	
Chaining and Special Requirements: Must not be preceded by Set a File Mask or Space Count in the same chain.								

READ INITIAL PROGRAM LOAD causes storage control to seek to cylinder 0, head 0 of selected drive and search for index.

DATA AREA READ, following index, is first record after R0.

COMMAND NORMALLY INITIATED by entering DASD address in Load Unit switches and pressing console IPL key.

INITIAL STATUS normally zero.

DATA VALIDITY verified by ECC bytes following data area.

DATA OVERRUN/DATA CHECK, if detected, storage control attempts command retry recovery (3330 or 3350).

Note: *If a correctable data error (error burst of 11 bits or less, 4 bits in the 3350 and 3340/3044) is detected in the data area, unit check is signaled to the channel so ERP can correct the error.*

COMMAND RETRY, if unsuccessful, presents channel end, device end, and unit check to the channel.

PARITY BIT added to each byte before transfer to channel.

CHANNEL END/DEVICE END signaled to channel following ECC check.

READ SECTOR

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0010 0010** Hex **22**	Specifies main storage location where sector number is to be stored.			Used at the discretion of the programmer.			One	
Chaining and Special Requirements: Not valid if command follows a Set Sector command when 3350 is operating in 3330 compatibility modes. If command follows a power-on reset, byte is zero.								

READ SECTOR transfers one byte of data from storage control to main storage.

INITIAL STATUS normally zero.

BYTE TRANSFERRED contains sector number required to access the last record processed.

Note:

(For 3330): If a drive power on sequence or system reset occurred, or a Seek or Set Sector command was executed after a record was processed, this byte is zero.

(For 3340 or 3350 native mode): The byte transferred to the channel contains the angular position number required to access the last record processed on the drive, or the value derived from the last Set Sector command if no record has been processed. The byte is zero if the Read Sector command follows a power on reset.

(For 3350 compatibility mode): The value is calculated in the storage control to access the last record processed. This is valid only when it follows a processing command.

COMMAND EXECUTION resets storage control orientation information.

Note: *If a 3340 without RPS is addressed, Read Sector returns a byte of zero to the system.*

ORIENTATION LOSS (similiar to No-op) follows execution.

CHANNEL END/DEVICE END presented after sector number is transferred.

SENSE I/O TYPE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **1110 0100** Hex **E4**	Specifies storage location where bytes are to be transferred.			Used at the discretion of the programmer.			Seven	
Chaining and Special Requirements: None.								

SENSE I/O TYPE transfers 7 bytes of sense data that indicates the storage control and drive type and model.

INITIAL STATUS normally zero.

STORAGE CONTROL/DRIVE TYPE indicated in code as follows:

DRIVE TYPE		STORAGE CONTROL			DEVICE		
	Byte 0	1	2	3	4	5	6
3330-1	FF	38	30	02	33	30	01
3330-11	FF	38	30	02	33	30	11
3340 (35mb data module)	FF	38	30	02	33	40	01
3340 (70mb data module)	FF	38	30	02	33	40	02
3344	FF	38	30	02	33	44	00
3350, all modes	FF	38	30	02	33	50	00

UNIT CHECK (Command Reject) results if the command sent to 3830-2 (or ISC) with microcode not supporting 3344 or 3350 drives.

UNIT CHECK (Intervention Required) results if the command is sent to a drive in the not-ready state.

SENSE I/O

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 0100** Hex **04**	Specifies main storage location where bytes are to be transferred.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: None.								

SENSE I/O transfers 24 bytes of sense information from storage control to the channel, then resets to zero.

INITIAL STATUS normally zero.

SENSE I/O DESCRIBES:

UNIT CHECK STATUS

CURRENT STATUS of the device that performed operation.

SYSTEM ERROR RECOVERY information.

UNIT CHECK should always be followed by a Sense I/O, whether or not the sense information is used; otherwise, expected future interrupts may not occur and some I/O access paths may be unavailable.

CONTINGENT CONNECTION: is established in storage control after the channel accepts a status byte containing unit check. In the contingent connection state, the storage control is busy to all drive addresses other than the one establishing the connection. The contingent connection lasts until a command (not Test I/O or No-op) receives an initial status byte of zero for the device address which generated the unit check.

CHANNEL END/DEVICE END presented after sense bytes are transferred.

See Sense Data for a description of the sense information concerning the storage control operations.

READ AND RESET BUFFERED LOG

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **1010 0100** Hex **A4**	Specifies main storage location of first error byte or usage data.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: None.								

READ AND RESET BUFFERED LOG transfers 24 bytes of usage or error information from storage control to the channel.

INITIAL STATUS normally zero.

USAGE OR ERROR INFORMATION, generated and available when their respective counters overflow, applies to storage control addressed by Start I/O and the drive identified in sense byte 4.

COUNTERS reset after data transfer.

CCW COUNT > 24: only 24 bytes transferred.

CCW COUNT < 24: the number of bytes specified are transferred.

CHANNEL END/DEVICE END presented after data transfer.

See Statistical Usage/Error Recording for more information.

DEVICE RESERVE

Byte 0	1	2	3	4	5	6	7
Command Code	**Data Address**			**Flags 00**	**Not Used**	**Count**	
Binary **1011 0100** Hex **B4**	Specifies main storage location where sense bytes are to be transferred.			Used at the discretion of the programmer.		Twenty-four	
Chaining and Special Requirements: Must not be preceded by a Set File Mask or Space Count command in the same chain.							

DEVICE RESERVE command includes all Sense I/O functions and reserves the addressed drive for the channel issuing the command if a two channel switch or two channel switch additional feature is installed, or if a 3333, 3340, or 3350 with string switch is attached.

INITIAL STATUS normally zero.

RESERVATION MAINTAINED until a Device Release or system reset is performed by the channel, or an Unconditional Reserve is performed through an alternate path.

SENSE INFORMATION (24 bytes) transferred to the channel.

NORMAL BUSY CONDITIONS cause a command reject; busy bit set in the CSW.

ABNORMAL FILE STATUS conditions (file unsafe, offline, etc.) do not halt command execution.

CHANNEL END/DEVICE END presented after sense byte transfer.

UNIT CHECK, causing command rejection, presented if:

1. Set File Mask or Space Count precedes command in same chain.
2. The 3333, 3340-A2, or 3350 string switch cannot be set.

UNCONDITIONAL RESERVE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0100** Hex **14**	Specifies main storage location where sense bytes are to be transferred.						Twenty-four	
Chaining and Special Requirements: Valid only for multichannel interfaces. Must be first command in CCW chain.								

UNCONDITIONAL RESERVE is a special command used to recover from hardware malfunctions. It includes all functions of the Device Reserve command and in addition reserves the device to the alternate path even when the device is reserved or in use through the original path. Reservation or in-use information for the original path is reset in the string switch and storage control through which this command is issued. Unconditional Reserve does not reset information in the original storage control.

COMMAND EXECUTION occurs regardless of any abnormal device status (offline or unsafe) except for:

SELECTION TAG: no controller response (condition code 3).

PRESELECTION CHECKS: unit check presented.

DEVICES AFFECTED by Unconditional Reserve command:

All 3350s operating in either native or 3330-11 compatibility mode.

UNIT CHECK issued to system by storage control without microcode that supports 3350 devices.

PROGRAMMING CONSIDERATIONS

1. Unconditional Reserve must be the first command in the CCW string, or unit check presented in initial status.
2. If system does not want the device reserved, next command must be Device Release.
3. Control of the device must be established by the system and the communication path must be not operational (condition code 3) before the command is issued. Device control is established if the system has the device reserved, or the system has a CCW chain in progress (between the Start I/O with a CC=0 and the ending interrupt).
4. The reservation in another system may be reset if the UR command is misaddressed. If the system issues a UR command to a device not assigned to it, the reservation of the other system may be affected in one of the following ways:
   a. If the device is idle and not reserved, no effect.
   b. If the device was reserved, a reservation is reset.
   c. If the device was disconnected between chained commands, an interrupt is lost.
   d. If the device was active when the command was executed, a recoverable equipment check is presented.

DEVICE RELEASE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **1001 0100** Hex **94**	Specifies main storage location where sense bytes are to be transferred.			Used at the discretion of the programmer.			Twenty-four	
Chaining and Special Requirements: Valid only for multichannel interfaces. Must be first command in CCW chain.								

DEVICE RELEASE terminates reservation of the addressed drive if a two channel switch or two channel switch additional feature is installed, or if a 3333, 3340, or 3350 with string switch is attached.

INITIAL STATUS normally zero.

SENSE I/O command functions are performed by a Device Release; 24 bytes of sense information are transferred to the channel.

NORMAL BUSY condition cause command rejection; busy bit set in the CSW.

ABNORMAL FILE status conditions (file unsafe, offline, etc.) do not halt execution.

CHANNEL END/DEVICE END presented after sense bytes transferred.

UNIT CHECK, causing command rejection, presented if:

1. Set File Mask or Space Count precedes the command in the same chain.
2. The 3333, 3340-A2, or 3350 string switch cannot be reset.

READ DIAGNOSTIC STATUS 1 (Diagnostic Sense)

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0100 0100** Hex **44**	Specifies main storage location where data accumulated during previous Diagnostic Load or Diagnostic Write is to be stored.			Used at the discretion of the programmer.			16 or 512	
Chaining and Special Requirements: Must follow Diagnostic Write or Diagnostic Load command.								

READ DIAGNOSTIC STATUS 1 performs one of two functions:

FOLLOWING A DIAGNOSTIC WRITE:

ERROR CODE MESSAGE (16 bytes) transferred from storage control to channel; the information accumulated during the previous command.

CCW COUNT FIELD should specify 16 bytes.

CHANNEL END/DEVICE END presented after transfer.

FOLLOWING A DIAGNOSTIC LOAD:

DIAGNOSTIC TEST (512 bytes) transferred from storage control to channel; the information accumulated during the previous command.

CCW COUNT FIELD should specify 512 bytes, if less, unit check presented.

CHANNEL END/DEVICE END presented after transfer.

INITIAL STATUS normally zero.

DIAGNOSTIC WRITE OR DIAGNOSTIC LOAD must precede the command, otherwise, 16 bytes of data are transferred from storage control buffer which normally contains error message.

CHANNEL END/DEVICE END presented after data transfer.

Caution: This command is intended for maintenance purposes only. Any use other than that provided by IBM diagnostic programs may yield unpredictable results.

WRITE HOME ADDRESS

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1001** Hex **19**	Specifies main storage location of home address bytes F CC HH (3333) SD F CC HH (3340), or SD SD SD F CC HH (3350). (SD represents 2 bytes.)			Used at the discretion of the programmer.			Five (3330) Seven (3340) Eleven (3350) (In compatibility mode, five bytes)	
Chaining and Special Requirements: Must be preceded by a Set File Mask permitting Write Home Address commands. For 3340 and 3350 (native mode): must be chained from a satisfied Search HA Equal (with a CCW count of four or more) unless the command is to flag the track as defective.								

WRITE HOME ADDRESS establishes track identity, a requirement for data operations on that track.

INITIAL STATUS normally zero.

STORAGE CONTROL orients on index, writes gap 1, home address, and ECC bytes.

FLAG BYTE transferred from main storage.

3330 (or 3350 COMPATIBILITY MODES)*

CCW COUNT < FIVE: storage control records zeros until five bytes are written.

CCW COUNT > FIVE: only first five bytes are written.

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CCW COUNT > SEVEN: only first seven bytes written.

CCW COUNT<7 but >3: storage control records zeros until seven bytes written.

CCW COUNT <3: command reject presented.

3350 (NATIVE MODE)

CCW COUNT > 11: only first eleven bytes written.

CCW COUNT <9, but >7: storage control records zeros until eleven bytes written.

CCW COUNT <7: command reject presented.

* Five bytes should be indicated in CCW count.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented.

WRITE PADDING on balance of track if command is last in CCW chain.

PARITY ERROR or DATA OVERRUN causes channel end, device end, and unit check at normal end. Data overrun causes zeros to be written to normal end.

CHANNEL END/DEVICE END presented after ECC bytes are written.

Note: *Home address is normally prewritten by the disk manufacturer. The use of this command should be limited to identifying defective tracks and assigning alternate tracks. Utility programs are available to perform these functions.*

For the 3340 and 3350, improper use can destroy surface defect skipping information recorded at manufacture.

WRITE RECORD 0 (R0)

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0101** Hex **15**	Specifies main storage location of R0 count, key, and data bytes.			Used at the discretion of the programmer.			Total number of bytes in R0 count, key, and data areas.	
Chaining and Special Requirements: Must be chained from a successful Write HA or Search HA Equal command.								

WRITE R0 causes specified data in main storage to be written on selected drive in the area following home address.

INITIAL STATUS normally zero.

COUNT AREA made up of first eight bytes from main storage.

Note: *The flag byte is generated by the storage control; the remaining data is written in the key and data areas as specified by the KL and DL bytes in the count area.*

CORRECTION CODE BYTES written by storage control following each record area.

CCW COUNT AREA specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

CCW COUNT < 8 + KL + DL: storage control writes zeros in remainder of record.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

WRITE PADDING on balance of track if command is last in CCW chain.

CHANNEL END/DEVICE END signaled after ECC bytes written for data area.

Note: *Record zero is normally written on the disk pack by the manufacturer. The use of this command should be limited to identifying defective tracks and assigning alternate tracks. Alternate and defective tracks are identified in the R0 count area instead of the normal CC HH bytes. Utility programs are available to perform these functions. Proper operation with IBM supported operating systems require an eight-byte field in R0.*

ERASE

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 0001** Hex **11**	Specifies main storage location where count, key, and data areas of the record are located.			Used at the discretion of the programmer.			Number of bytes in count, key, and data areas of the record.	
Chaining and Special Requirements: Must be chained from Write R0, Write CKD, Search ID Equal, or Search Key Equal (Search commands must compare equal on all bytes). Read Data or Read Key and Data may be inserted between Search and Erase commands.								

ERASE writes zeros in count, key, and data areas on selected drive.

INITIAL STATUS normally zero.

CHANNEL END/DEVICE END signaled following data area; remaining track is padded.

ERASED RECORD and all records following on track are unrecoverable.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

WRITE PADDING on balance of track if command is last in CCW chain.

FORMAT WRITE command must not be chained from an Erase command.

WRITE COUNT, KEY, AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0001 1101** Hex **1D**	Specifies main storage location where count, key, and data bytes of record are located.			Used at the discretion of the programmer.			Total number of bytes in count, key, and data areas.	
Chaining and Special Requirements: Must be chained from Write R0, Write CKD, Search ID Equal, or Search Key Equal (Search commands must compare equal on all bytes). Read Data or Read Key and Data may be inserted between Search and Write CKD commands.								

WRITE COUNT, KEY, AND DATA causes specified data in main storage to be written on selected drive.

INITIAL STATUS normally zero.

COUNT AREA made up of first eight bytes from main storage.

Note: *The flag byte is generated by the storage control; the remaining data is written in the key and data areas as specified by the KL and DL bytes in the count area.*

ERROR CORRECTION CODE BYTES written by the storage control following each record area.

CCW COUNT FIELD specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

CCW COUNT < 8 + KL + DL: storage control writes zeros for remainder of record.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

WRITE PADDING on balance of track if command is last in CCW chain.

UNIT CHECK (command reject) presented if Write CKD attempted after Write R0 on a defective track.

CHANNEL END/DEVICE END signaled to channel following ECC bytes written after data area.

WRITE SPECIAL COUNT, KEY, AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 0001** Hex **01**	Specifies main storage location where count, key and data areas of the record are located.			Used at the discretion of the programmer.			Number of bytes in the count, key, and data areas of the record.	
Chaining and Special Requirements: Must be chained from Write R0, Write CKD, Search ID Equal, or Search Key Equal (Search commands must compare equal on all bytes). Read Data or Read Key and Data may be inserted between Search and Write Special CKD commands.								

WRITE SPECIAL COUNT, KEY, AND DATA formats a segment of an overflow record; the last segment is written by a normal Write CKD command.

INITIAL STATUS normally zero.

COUNT AREA made up of first eight bytes from main storage.

FLAG BYTE contains a 1 in bit 4; generated and written by storage control, this bit indicates that another part of the record is located on the next track.

CORRECTION CODE BYTES written by storage control following each record area. 3350 detection code bytes written following count and key areas.

CCW COUNT FIELD specifies number of bytes (8 + KL + DL) to be transferred from main storage to the drive.

CCW COUNT < 8 + KL + DL: storage control writes zeros in remainder of record.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

WRITE PADDING on balance of track if command is last in CCW chain.

UNIT CHECK (command reject) presented if Write Special CKD attempted after Write R0 on a defective track.

CHANNEL END/DEVICE END signaled to channel after ECC bytes written for data area.

WRITE DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 0101** Hex **05**	Specifies main storage location of data used to update record.			Used at the discretion of the programmer.			Number of data bytes to be written.	
Chaining and Special Requirements: Must be chained from a Search ID Equal or Search Key Equal command (Search commands must compare equal on all bytes).								

WRITE DATA performs normal record updating after track formatting.

INITIAL STATUS normally zero.

COMMAND EXECUTION causes specified data in main storage to be written into data area of specified record.

NUMBER OF BYTES WRITTEN:

1. Specified in count area of the Write Data CCW.
2. May be less than data length specified in formatted record.

CORRECTION CODE BYTES written by storage control following data area.

CCW COUNT < COUNT AREA DL: storage control writes zeros in remaining data area; writes ECC bytes and sends channel end and device end to channel.

CCW COUNT > COUNT AREA DL: storage control writes only number of bytes indicated in the count area DL, then adds ECC bytes.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

CHANNEL END/DEVICE END sent to channel after ECC bytes written following data area.

WRITE KEY AND DATA

Byte 0	1	2	3	4		5	6	7
Command Code	**Data Address**			**Flags**	**000**	**Not Used**	**Count**	
Binary **0000 1101** Hex **0D**	Specifies main storage location of the data to be used for record update.			Used at the discretion of the programmer.			Number of key and data bytes to be written.	
Chaining and Special Requirements: Must be chained from a Search ID Equal command which compared equal on all bytes of the searched field.								

WRITE KEY AND DATA used for record updating after track formatting.

INITIAL STATUS normally zero.

COMMAND EXECUTION causes data from main storage to be written in key and data area of selected record.

NUMBER OF BYTES WRITTEN:

1. Specified in count field of Write Key and Data command.
2. May be less than key and data length specified in formatting record.

CORRECTION CODE BYTES written by storage control following each area.

CCW COUNT < KL/DL BYTE COUNT: storage control writes zeros in remaining areas, adds ECC bytes, and sends channel end and device end to channel.

CCW COUNT > KL/DL BYTE COUNT: channel end and device end are sent to channel after indicated number of bytes are written and ECC bytes added.

CHAINING REQUIREMENTS must be met; otherwise, unit check presented in initial status.

CHANNEL END/DEVICE END presented after ECC bytes are written for data area.

Note: *If KL = 0, command is same as Write Data.*

The following channel programs are typical examples of how CCWs are arranged to format, read, and write records using a 3830-2 and 3330 series, 3340 with the RPS feature, or 3350 disk storage. These examples do not include the CPU program used to start the channel program.

Unless otherwise noted, all numbers are hexadecimal.

TRACK FORMATTING

Example: Format track 6A on head 08 with records R1, R2, and R3 for customer records. Assume that R0 has a key length (KL) of zero and a data length (DL) of eight bytes, and that R1, R2, and R3 have a key length of six bytes and a data length of 0064 (100 decimal) bytes.

The channel program is:

Seek
Set File Mask
Set Sector
Search ID Equal (R0)
TIC*-8
Write CKD
Write CKD
Write CKD

Analyzing the commands:

SEEK

Command	Data Address	Flags	000	Count
0000 0111 '07'	03E8 = 00 00 00 6A 00 08 C C H H	01000	000	0006

Comments: The Seek command positions the access at the required cylinder and selects the proper head. All Seek commands transfer six bytes of data from main storage to the storage control (count = 6). The first two seek address bytes are always 0s, the cylinder number (6A) is specified in the third and fourth bytes, and bytes five and six indicate the required head (00 08 at 03EC and 03ED).

SET FILE MASK

Command	Data Address	Flags	000	Count
0001 1111 '1F'	03EE = C0	01000	000	0001

Comments: The Set File Mask command specifies the types of operations that can be performed in this channel program. The mask byte in this case (1100 0000 at address 03EE) permits all Write and Seek commands. The mask is reset to zero at the beginning of each command chain.

SET SECTOR

Command	Data Address	Flags	000	Count
0010 0011 '23'	1390 = 00	01000	000	0001

Comments: Execution of a Set Sector command with an argument at zero, orients the track to index. During the time that the storage control is waiting for index, the channel is available to perform other operations.

SEARCH ID EQUAL

Command	Data Address	Flags	000	Count
0011 0001 '31'	03EF = 00 6A 00 08 00	01000	000	0005

Comments: The Search ID Equal command causes the first ID found on the track to be compared with the argument. All unequal comparisons of IDs cause the 3830 to signal channel end and device end to the channel so the TIC command (back to Search ID Equal) is executed. When an equal comparison is found (ID of record 0), the 3830 signals channel end, device end, and status modifier to the channel. The status modifier causes the next command (TIC) to be skipped and the first Write CKD command is executed.

TRANSFER IN CHANNEL (TIC)

Command	Data Address	Flags	000	Count
xxxx 1000 'x8'	Address of last command	xxxxx	xxx	xxxx

Comments: TIC*-8 branches back to last command address.
x = positions ignored.

WRITE CKD

Command	Data Address	Flags	000	Count
0001 1101 '1D'	R1 C C H H R KL DL DL 0BB8 = 00 6A 00 08 01 06 00 64	01100	000	0008
	R2 0FA0 = 00 6A 00 08 02 06 00 64	01100	000	0008
	R3 1388 = 00 6A 00 08 03 06 00 64	00100	000	0008

Comments: Execution of the Write CKD commands causes a count area, key area (if not zero), and the data area with the length specified by the DL bytes, to be written on the disk.

The main storage locations specified in the data address are coded with the cylinder number, head number, record number, key length, and data length of each record. Since the KL = 6, a key area of six bytes is created. The data length specified is 0064 (100 decimal) bytes. Although the CCW byte count is only eight, and the channel byte count goes to zero after eight bytes are written, the storage control is committed to write a key area six bytes long and a data area 100 bytes long. Therefore, the storage control inserts zeros in the applicable track positions until the byte count reaches zero.

The difference in the channel byte count and the storage control byte count will cause an incorrect length indication, so the SLI flag (bit 34) is set in the CCWs.

In this example, six bytes of zeros are recorded in the key area and followed by the ECC bytes, a gap, 100 bytes of 0s, and more ECC bytes. The data that replaces the zeros can be recorded in the key and data areas at a later time with the following CCW sequence:

Set Sector
Search ID Equal (R1)
TIC*-8
Write KD
Search ID Equal (R2)
etc.

UPDATE PAYROLL RECORD

Example: Update Frank Smith's record. Assume: The disk is organized by key areas. Each key area contains an employee number. Frank Smith's number is 656151. This number is located in cylinder 0C, head 04. The key areas are six bytes long and the data areas 64 (100 decimal) bytes long.

Note: *The procedure is the same with 3340s or 3350s attached.*

The channel program is:

Seek
Search Key Equal
TIC*-8
Write Data

Analyzing the commands:

SEEK

Command	Data Address	Flags	000	Count
0000 0111 '07'	03E8 = 00 00 00 0C 00 04 C C H H	01000	000	0006

Comments: As explained in the first example, the Seek command transfers the track address to the storage control, moves the access mechanism, and selects the specified head.

SEARCH KEY EQUAL

Command	Data Address	Flags	000	Count
0010 1001 '29'	07D0 = F6 F5 F6 F1 F5 F1 (employee number)	01000	000	0006

Comments: After locating the correct cylinder and track, Frank Smith's record must be found. Since the disk is organized by keys, a Search Key Equal is executed. This causes the storage control to search the key area of the next record on the track. If the key is not equal to Smith's number (main storage locations 07D0 to 07D5), the storage control signals channel end and device end to the channel and the TIC (return to Search Key Equal) is executed. This continues until the correct record is found. The storage control then sends channel end, device end, and status modifier to the channel. The status modifier bit in the status byte causes the channel to skip the next command (TIC) and execute the Write Data command.

TRANSFER IN CHANNEL (TIC)

Command	Data Address	Flags	000	Count
xxxx 1000 'x8'	Address of last command	xxxxx	xxx	xxxx

Comments: TIC*-8 branches back to last command address.
x = positions ignored.

WRITE DATA

Command	Data Address	Flags	000	Count
0000 0101 '05'	0BB8 = xx xx xx to 0C1C (data to update record)	00000	000	0064

Comments: The Write Data command transfers the data to update Frank Smith's payroll record from main storage locations 0BB8 to 0C1C, to the disk.

If Frank Smith's payroll record had not been in cylinder 0C, head 04, the program would loop between the Search Key Equal and the TIC until every key on the track had been searched. The storage control would then signal unit check to the channel. A subsequent Sense I/O command would indicate no record found.

The data just written could be verified by chaining the following CCWs to the Write Data command:

Read Sector	(store sector address)
Set Sector	(locate sector)
Search Key Equal	(locate record)
TIC*-8	
Read Data	(verify data)

READ INSURANCE POLICY NUMBER

Example: Find and read Joe Brown's insurance policy number. Assume: The 3330 disk is organized by ID (no keys). Joe Brown's employee number is 12341. The data length of each record is 00AA (170 decimal) bytes. His policy number is in the data area.

Note: *If 3340s or 3350s are attached, the only difference would be the figures taken from the record capacity chart. The procedure remains the same.*

The 3330 record capacity chart shows that forty-three 170-byte records can be written on the track. Since the disk is organized by IDs (Joe Brown's = 12341), the track and record location can be found by dividing the ID by the number of records per track. In this case:

12341/43 = 287 (add 1 to the remainder to establish the address)

Thus Joe Brown's ID is 287 tracks from the beginning of the data set. There is no remainder so the first record on the track will be Joe Brown's.

The CC HH R for the Seek command is then determined by converting the 287 tracks to cylinders and adding the results to the beginning of the data set.

	Cylinder	Track	Record	C	C	H	H	R
Starting Address	10	00	0	00	0A	00	00	00
Displacement*	15	02	1	00	0F	00	02	01
Result:	25	02	1	00	19	00	02	01

* Determined by dividing 287 by 19.

The channel program is:

Seek
Search ID Equal
TIC*-8
Read Data

SEEK

Command	Data Address	Flags	000	Count
0000 0111 '07'	03E8 = 00 00 00 19 00 02 C C H H	01000	000	0006

Comments: The Seek command is executed to place the access mechanism at cylinder 19 (25 decimal) and select head 02.

SEARCH ID EQUAL

Command	Data Address	Flags	000	Count
0011 0001 '31'	05DC = 00 19 00 02 01 C C H H R	01000	000	0005

Comments: The Search ID Equal causes the first ID found on the track to be compared with Joe Brown's ID. All unequal comparisons of IDs cause the storage control to signal channel end and device end to the channel and the TIC (back to Search ID Equal) is executed. When an equal compare is found (ID of record 1) the storage control signals channel end, device end, and status modifier to the channel. Status modifier causes the next command (TIC) to be skipped and the Read Data command is executed.

TRANSFER IN CHANNEL (TIC)

Command	Data Address	Flags	000	Count
xxxx 1000 'x8'	Address of last command	xxxxx	xxx	xxxx

Comments: TIC*-8 branches back to last command address.
x = positions ignored.

READ DATA

Command	Data Address	Flags	000	Count
0000 0110 '06'	0BB8 = xx xx xx to 0C62 (insurance policy number)	00000	000	00AA

Comments: Execution of the Read Data command causes the data area, containing Joe Brown's insurance policy number, to be read into main storage at locations 0BB8 to 0C62.

Standard features are included with all 3830-2 storage controls.

MULTITRACK (M/T) OPERATION

Multitrack (multiple track) operation is the ability to automatically select the next sequentially numbered head on the drive under control of bit 0 of most Read or Search commands. If command code bit 0 is on (1), and the command data transfer has not started, the next sequential head is selected at index. This eliminates the need for Seek Head commands in a chain of Read or Search commands.

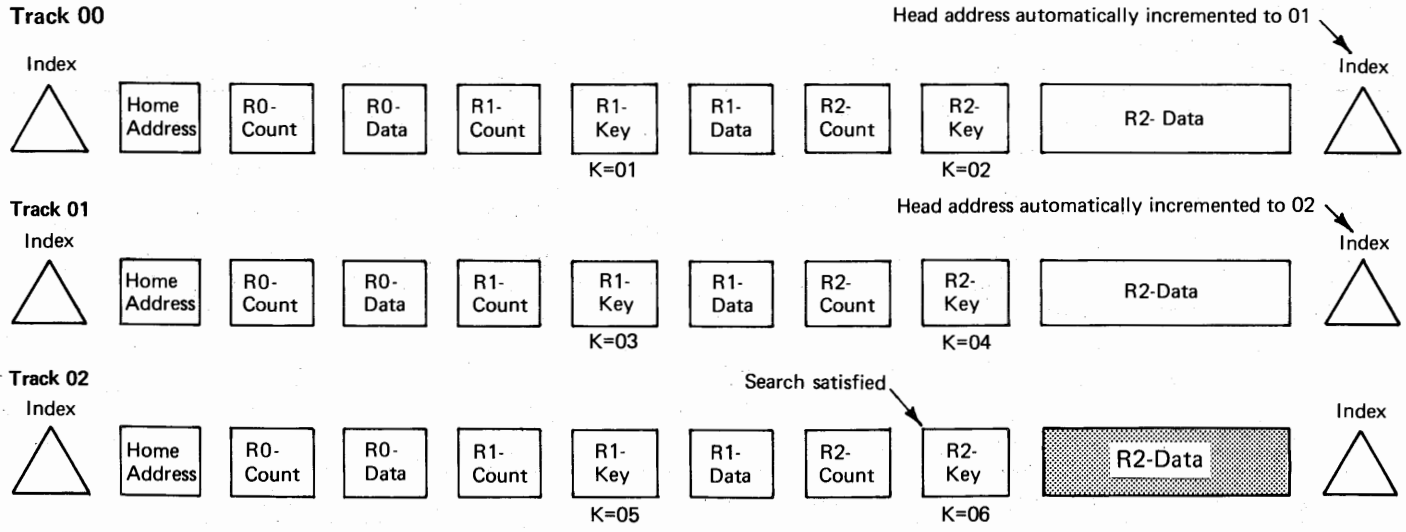
The M/T bit must be used with care. A starting point should be indicated before the M/T bit is used. If a multitrack search is started without a Read HA or Read R0, the required record may have passed the head before the search is started. The head sequencing would continue on the next track to the end of the cylinder without finding a comparison.

A Set Sector command with a value of zero might precede the multitrack command. Head switching could again occur before the record is reached.

Correct use of a multitrack command is shown in Figure 12.

Multitrack operations are not used with Read IPL, Read Sector, Read Diagnostic Status 1, or Read Multiple CKD commands.

Note: *If the head switching operation crosses a file-protected boundary or exceeds the cylinder limit, channel end, device end, and unit check are presented to the channel.*



Channel program using multitrack search.

Object:

Update John Doe's payroll record.

Assume:

The disk is organized by keys, and the physical address of the record is unknown.

Set File Mask	(allow Write and Seek commands)
Seek	(cylinder 02, head 00)
Read HA	(make sure all records are read)
Search Key Equal	(M/T bit on, argument = 06)
TIC*-8	
Write Data	(updates shaded area)

Figure 12. Multitrack Operation

RECORD OVERFLOW

The record overflow feature allows records that exceed the capacity of a track to be continued on the next available track within the cylinder. Each part of an overflow record is called a segment. Each segment contains count, key (optional), and data areas. The key and data lengths specified by KL and DL in each count area apply only to the record segment, not the entire record. Since the only significant key area is in the first segment, the remaining segments seldom have key areas.

Overflow Record Formatting

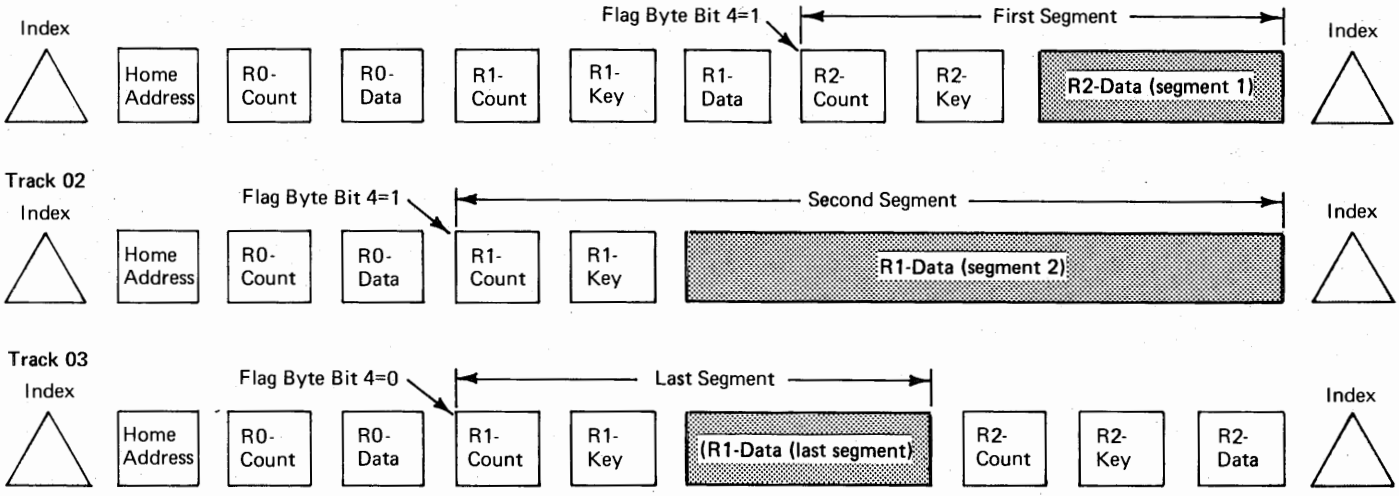
All overflow records (except the last segment) are formatted by the Write Special Count, Key and Data command. The last segment uses a normal Write CKD command. An example of an overflow record is shown in Figure 13.

In the Write Special CKD command, bit 4 is on in the flag byte for the record segment being written. This bit, identifying an overflow segment, indicates to subsequent record processing commands in the chain that the record continues on the next track.

All head switching must be done by the formatting program. (See Figure 13.) Head switching will not occur in violation of the file mask, past the end-of-cylinder, or to a defective or alternate track.

Except for the first, all record segments must be written immediately following R0, and all segments but the last must be the last physical record on their tracks.

OVERFLOW RECORD
Cylinder 02
Track 01



Typical channel programs for formatting, updating, and reading overflow records.

FORMATTING:

Set Sector	
Search ID R1	(track 1)
TIC*-8	
Write Special CKD	(segment 1)
Seek Head	(next track)
Search ID R0	(track 2)
TIC*-8	
Write Special CKD	(segment 2)
Seek Head	(next track)
Search ID R0	(track 3)
TIC*-8	
Write CKD	(last segment)

UPDATING:

Set Sector	
Search ID R2	(segment 1)
TIC*-8	
Write Data	(updates shaded areas)

READING:

Set Sector	
Search ID R2	(segment 1)
TIC*-8	
Read Data	(reads shaded areas)

Figure 13. Overflow Record

Overflow Record Processing

Overflow records can be read or updated with the following commands:

- Read Count, Key, and Data
- Read Key and Data
- Read Data
- Write Key and Data
- Write Data

When any of the above commands are used to process an overflow record, the operation will not terminate at the end of a record segment when the segment is flagged with bit four (on) in the flag byte. Instead, the head address is incremented by 1 at index and the operation continues in the data area of record one on the next track. If this record segment is also flagged with bit four (on) in the flag byte, the operation continues on the next track. When a segment is found that is not flagged, the operation terminates at the end of the data area. The net effect of this procedure is that the data areas of all the record segments appear as a single logical data area.

Should a data overrun occur during the first segment, the storage control attempts recovery through use of command retry. If a data overrun occurs during an operation involving the second (or subsequent) segments, unit check is signaled immediately during a read operation, or at the end of the associated segment during write operations.

If a data check or bus out parity error occurs, unit check is signaled at the end of the associated area.

Note: *If a write operation was in progress, unit check is signaled at the end of the record segment.*

If the CCW count is less than the number of bytes in the logical record, the operation continues to the end of the logical record before presenting ending status.

Spacing over overflow records does not occur automatically. The channel program must be written so that the entire logical record is spaced over, not just the first segment. For example, in the sequence:

Set Sector
Search ID (first segment)
TIC*-8
Read CKD (multitrack)

the Read CKD does not read the next logical record on the cylinder. It commences reading the overflow record at the count field of the second segment.

The sequence:

Set Sector
Search ID (first segment)
TIC*-8
Read Key and Data (skip and SLI flags on)
Read CKD (multitrack)

reads the count, key, and data of the next logical record.

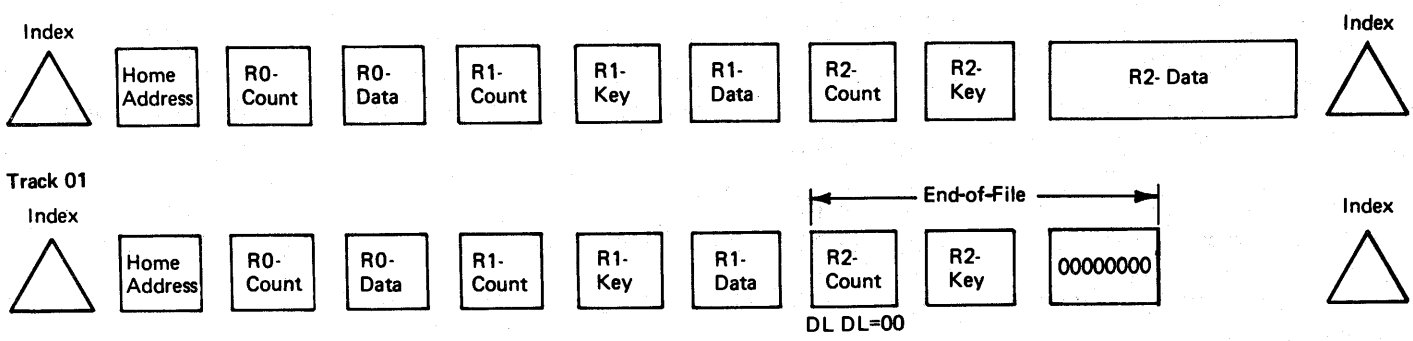
Multitrack operations should not be confused with overflow record operations. Head switching, when processing overflow records, occurs regardless of whether the M/T bit is on or off.

END-OF-FILE

An end-of-file record is used to define the end of a logical group of records, and is written by executing a Write CKD command with the DL bytes in the count area set to zero. When a Write CKD with a data length of zero is executed, the storage control writes a data area of one byte of zeros which is followed by the ECC bytes. (See Figure 14.)

The KL byte in the count area can be either zero or non-zero. If KL is zero, the end-of-file record contains only the contents of the count and data areas. If the KL is not zero, the key area is written as specified by the KL byte.

Unit exception status is generated if a zero data length is found and no data from the data area is sent to the channel. A Read R0, Read CKD, or Read KD transfers the key area (if any) to the channel. The unit exception is generated during execution of Read IPL, Read R0, Read CKD, Read KD, Read Data, Write KD, and Write Data commands.



Set File Mask	(allow Seek and Write Commands)
Seek	(cylinder 02, head 00)
Write Home Address	
Write R0	
Write CKD R1	
Write CKD R2	

Seek Head	(cylinder 02, head 01)
Write Home Address	
Write R0	
Write CKD R1	
Write CKD R2	(data length = 00)
	(end-of-file)

Figure 14. End-of-File

ROTATIONAL POSITION SENSING

Rotational position sensing (RPS) reduces the time required for the channel to search for a record. This feature lets a Search command be started just before the required record comes under the read/write head.

Rotational position sensing is accomplished by dividing the storage disks into sectors. Each track in the cylinder is divided into 128 equally spaced sectors and each track record has a sector location as well as a record address. Although not physically indicated on the tracks, the sector location is stored at the beginning of all Read, Write, and Search commands. When chained to a Read, Write, or Search CCW, the Read Sector command provides the sector location required to access the record that was processed by the previous command. A later Set Sector command fetches the sector location from CPU main storage and repositions the track at that record. This type of operation is particularly useful in write verification and sequential disk processing operations. (See Figure 15.)

The sector location of a record is determined by the length of all records that are ahead of it and its sequential position on the track. The sector location can be calculated with the following formulas.

- For 3330 series and 3350 drives in 3330 compatibility mode:

$$S(n) = \frac{1}{105}\left[237 + \sum_{i=1}^{n-1} (KL_i + DL_i + C)\right]$$

Where:
$C = 135$ if $KL_i = 0$
$C = 191$ if $KL_i \neq 0$

- For 3340 series drives:

$$S(n) = \frac{1}{140}\left[353 + \sum_{i=1}^{n-1} (KL_i + DL_i + C)\right]$$

Where:
$C = 167$ if $KL_i = 0$
$C = 242$ if $KL_i \neq 0$

- For 3350 series drives in native mode:

$$S(n) = \frac{1}{156}\left[389 + \sum_{i=1}^{n-1} (KL_i + DL_i + C)\right]$$

Where:
$C = 185$ if $KL_i = 0$
$C = 267$ if $KL_i \neq 0$

Note: *When an End-Of-File (EOF) mark is written, the DL in the count area must be zero. The storage control, however, adds a one-byte data area when writing the EOF mark. Programmers working with track balance routines must allow for this byte by subtracting one byte from the track balance remaining for every file record.*

The following example shows some of the advantages of using rotational position sensing to locate and retrieve records.

3340 Without RPS

Channel program 1.

Command	Channel and Storage Control Status
Seek	Available as soon as the storage control accepts the seek address.

Channel program 2.

Command	Channel and Storage Control Status
Search ID Equal	Busy (average 10.2 ms on the 3340)
TIC*-8	
Read Data	Busy

3330, 3340/3344, and 3350 with RPS

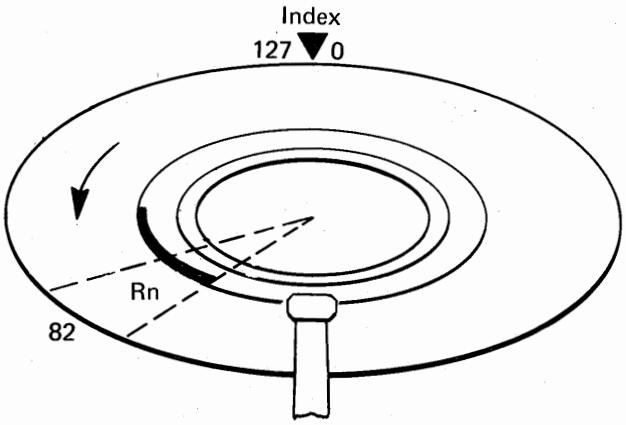
When the sector address is known or can be calculated, the following channel program can be used.

Command	Block Multiplexer Channel and Storage Control Status
Seek	Available during access movement.
Set Sector	Available until sector is located.
Search ID Equal	Busy (average 250 μs on the 3330)
TIC*-8	Normally the first ID read is that of the required record and the TIC is not executed.
Read Data	Busy

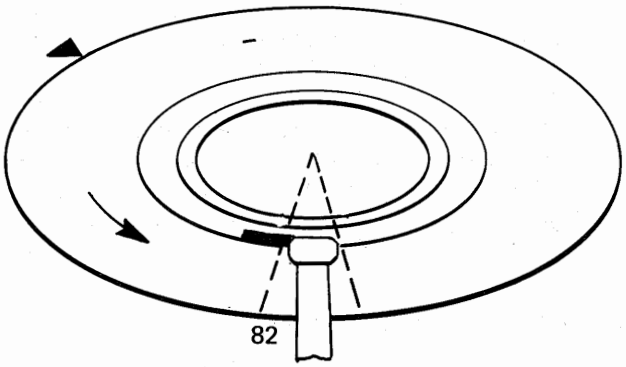
Note that with RPS only one channel program is required to locate the record and transfer the data. This eliminates a seek I/O interrupt and the I/O processing required to schedule a data transfer channel program.

Also, the channel and disk storage are available during access motion and rotational positioning, allowing Seek and Set Sector operations to be overlapped with other I/O operations on the storage control and channel.

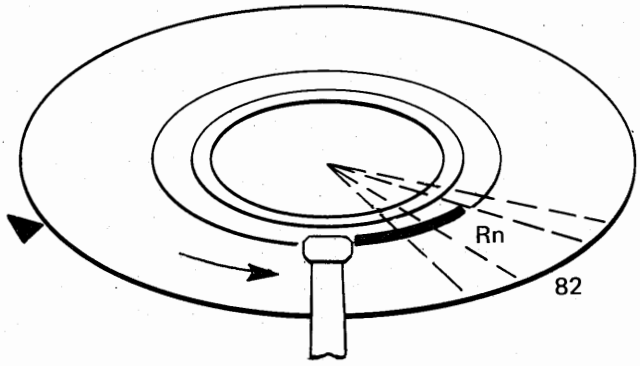
Seek: Transfers storage address to storage control which selects string, drive, cylinder, and head.



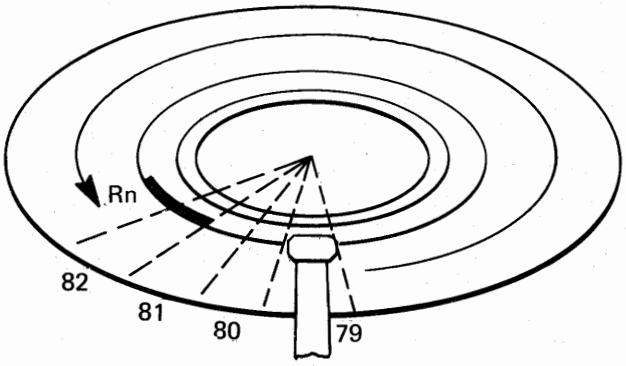
Search ID Equal Rn: Head reads address. If not equal to Rn, executes:
TIC*-8: and returns to Search command. When Rn is found, executes:



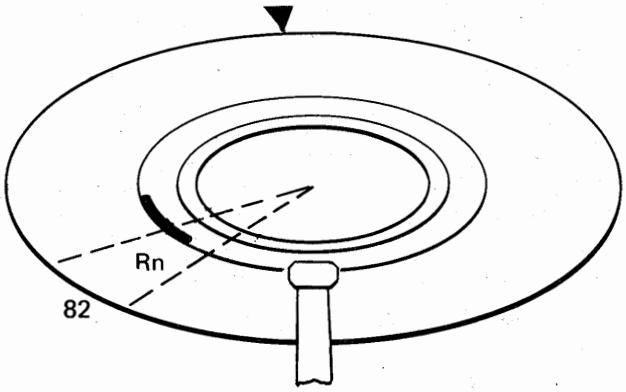
Write Data: Data transferred through channel. Then executes:
Read Sector: Reads sector number where Rn is located (82) using sector counter and stores pulse count, then executes:



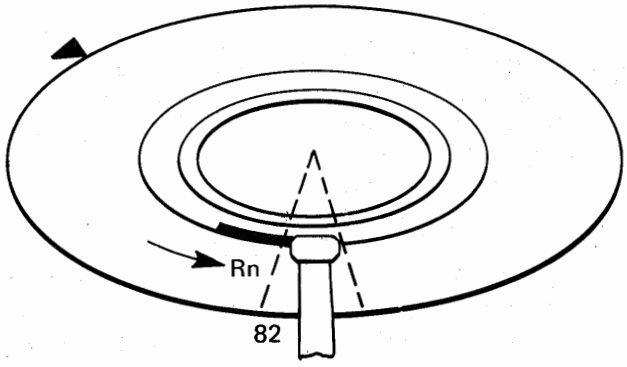
Set Sector (82): Channel disconnects until the sector three less than the one required is sensed (79). Channel is available for other activities during this period.



Channel reconnects when sector 79 is sensed by pulse counter. If channel not available, tries on next revolution.



Search ID Equal Rn: Head reads address. If not equal to Rn, executes:
TIC*-8: for address verification. When address is found, executes:



Read Data: Head reads back data from Rn and which is checked for validity by ECC bytes.

Write verification is complete.

Figure 15. Use of Rotational Positioning Sensing for Write Verification

MULTIPLE REQUESTING

Block multiplexer channels with rotational position sensing allow the 3830-2 to disconnect from the channel during mechanical delays caused by arm positioning Seek or Set Sector commands.

Reconnection is attempted just before the access mechanism is at the desired track or when the specified rotational position has been reached.

During the time the channel and storage control are disconnected, the CPU is free to start I/O operations on other drives attached to the storage control even though the disconnected channel program is incomplete. This allows separate channel programs to be operating on each drive attached to the storage control.

The storage control stores the Set File Mask, Seek, or Set Sector arguments required to complete the disconnected command chains.

COMMAND RETRY (3330 Series and 3350)

Command retry is a channel/storage control procedure that automatically retries a channel command without interrupting the control program. Therefore, no CSW is stored. When a command is improperly executed, the storage control signals the channel with a special combination of status bits (channel or device end, status modifier, and unit check). In response, the channel reissues the command for retry.

Command retry is normally used in seven different situations.

Command retry is used:

1. To recover from correctable data errors occurring during a search or read operation on a home address, count, or key area (3330 only) and in data areas on all devices (including 3340/3344).

   During a search or read operation, the new address, count, or key read from the disk is placed in a storage control buffer. If a correctable data error occurs, the storage control corrects the data in the buffer and requests the channel to reissue the command which caused the error. The storage control disconnects and frees the channel while the record is being reoriented. When the failing command is re-executed, the corrected data in the buffer is used instead of the actual data from the track.

2. When an uncorrectable data error is found in any record position during a read or search operation.

   The failing command is reissued by the storage control. If retry is successful, the channel program continues normally. If retry is not successful, the operation is retried again.

   After any retry, if the error becomes correctable, the procedure described in 1 (above) is used. If the error remains uncorrectable, the operation is ended and the program is interrupted.

3. When a seek access error is detected.

   The storage control retries the command and attempts to position the access mechanism correctly.

4. When an alternate or defective track is found before data transfer begins.

   The storage control determines the alternate or defective track location (from R0 on the track), initiates a seek to this track, orients on index, and reissues the command.

5. When a command overrun (or late command chaining) occurs because of interference by another channel or the CPU.

   The storage control initiates a retry of the late command.

6. When a data overrun occurs except: when the data overrun occurs during a record overflow operation in the second or subsequent segments; or the data overrun occurs during a format write.

7. During certain padding operations, command retry may be involved to allow channel disconnection while padding and to allow reconnection after padding is complete. Padding consists of adding zeros after the last record on a track up to the index point. Index orientation is not guaranteed upon channel reconnection following the pad operation.

Conditions Following Command Retry

Command retry execution may cause certain conditions to be detected by the initiating program:

1. A CCW with a PCI flag on may, if retried because of command retry, cause multiple PCI interruptions.
2. A channel program consisting of a single, unchained CCW specifying an immediate command may cause a condition code of a zero rather than a one to be set. This condition code setting occurs if the storage control signals command retry at the time that initial status is presented. The channel program then causes a later interrupt upon completion of the operation.
3. If an early stop to channel program execution occurs during a command retry, the residual count and command address in the CSW may not necessarily indicate the amount of main storage used.
4. If a CCW used in an operation is changed before that operation has been successfully completed, the results are unpredictable.

STATISTICAL USAGE AND ERROR RECORDING

The storage control keeps a statistical data record of usage and error information for each physical device in the subsystem. The usage information provides an accumulated count of the total number of access motions and the total number of data bytes read.

The error information provides an accumulated count of the total number of seek errors, correctable data errors (3330 only), and uncorrectable data errors recovered by the command retry procedure. Also included is the total number of command and data overrun conditions retried by the storage control. The specific details for each device are shown in the sense byte tables. (See Sense Data.)

Any time that the number of errors reaches a preset level, or the number of seeks or the number of data bytes processed reaches a preset level, the storage control generates a unit check signal. The unit check is presented to the channel when the next Start I/O instruction is addressed to the storage control.

The sense information associated with the unit check consists of environmental data present, sense byte 2, bit 3, and usage and error statistics, sense byte 7. The usage and error information is reset after being transferred to the channel by the Sense I/O command.

The Read and Reset Buffered Log command is used to retrieve the usage and error information after a pack change or at the end of a shift.

A system reset will reset the usage and error statistics for only those devices which have a pack change device end outstanding.

STORAGE CONTROL DIAGNOSTICS

To provide maximum availability, the storage control can execute diagnostic tests on a drive concurrent with normal system operations on the other drives. This capability permits the customer engineer to diagnose and repair most drive failures while the subsystem continues to operate the other attached drives. The storage control provides a transient block of storage for temporary residence of a specified diagnostic test.

The transient area is loaded by the system under control of the On-Line Test Executive Program (OLTEP). A special command (Diagnostic Write) loads a selected test into the storage control and instructs it to execute the test. This loading and execution may also be done from the CE panel.

After the test, error message information or test results are transferred to CPU main storage by a Read Diagnostic Status 1 command. If the CE panel is used, the results are displayed on the CE panel indicators.

STORAGE CONTROL USAGE METER

If the Enable/Disable switch on the 3830-2 operator panel is set to Enable when a power-up sequence occurs, meter time is logged as long as the CPU meter is recording, or until the usage meter and storage control are disabled from the channel.

The usage meter and storage control are disabled when all of the following conditions exist simultaneously:

- The Enable/Disable switch is set to Disable.
- The CPU is in a stop or wait state.
- Command chaining is not in effect.
- No channel is selected by the storage control channel selection switches (see Special Features).
- The storage control is not performing an operation.
- There is no pending status (see Pending Status).

The usage meter can then be enabled when:

- The CPU is in the stop or wait state.
- The Enable/Disable switch is in Enable.

FORMAT WRITE RELEASE

The 3330-11 and the 3350 (all modes) have a format write release feature that allows the storage control to disconnect from the device (under certain circumstances) following the last format write record on a track. The storage control can thus service other devices while the drive continues to erase to the end of the track. Index orientation is not guaranteed upon reconnection.

TWO CHANNEL SWITCH AND TWO CHANNEL SWITCH ADDITIONAL

The two channel switch special feature allows the storage control to be shared by two channels. The combination of two special features, two channel switch and two channel switch additional, permits the storage control to be shared by four channels. The channels may be attached to either the same or different central processing units.

With appropriate programming or operator action, the individual drives attached to the storage control may be reserved for the exclusive use of any of the channels. Channel switching and device reservation are controlled by the channel program.

Two special commands are used with multiple channel interfaces: Device Reserve and Device Release. Reservation of a device is made by executing the Device Reserve command. This same device reservation is ended by a Device Release command. Sense data is transferred to the channel when either command is executed.

Channel Enable/Disable Toggle Switches

Channel access is determined by up to four toggle switches (depending on the features) on the 3830-2 Storage Control. The four channels are identified as A, B, C, and D. Each toggle switch can be set to either Enable or Disable. When all four switches are in the Enable position, any one of the four channels can select the storage control. Should more than one channel attempt to connect at the same time, tie-breaking logic selects one of the channels. If a switch is placed in the Disable position, the channel identified by the switch cannot select the 3830-2.

Once the storage control has been selected by a channel, it remains connected until ending status has been presented. At that time, the storage control becomes available to all other enabled channels unless:

- The ending status byte includes device end to indicate chaining.
- Chaining is indicated in the ending status byte, the channel disconnects, and the storage control becomes busy for an error recovery procedure, execution of a Diagnostic Load or Write CCW, or completion of a format write operation.
- Chaining is indicated without device end and the channel does not disconnect.
- Chaining is indicated and a format write is in progress.
- The last status byte was part of a channel initiated signal sequence and was stacked by the channel.
- A contingent connection is established.
- Ending status associated with an interface disconnect has not been accepted by the channel.

Device Status

The Multitag switch on the 3830-2 Storage Control operator panel determines how the device end generated by the drive is presented to the channel. The switch has two positions: Multitag and Off.

In the Multitag position, the device end (going from not-ready to ready) status is presented to each enabled channel. This status condition must be accepted by each individual enabled channel before the channel can use the device.

When the switch is in the Off position, the device end status is presented to the first channel to accept the status byte. The device then becomes available to all enabled channels for use as required.

A device has a "tagged" status when a Device Reserve command is issued by one specific channel. The device remains committed exclusively to that channel until a Device Release command is issued by that channel. An attempt at device connection by any other channel will result in a busy status condition. The storage control attempts to present device end after the busy condition has ended. The address byte used with this status byte is the same as that used with the busy status byte.

Addressing

The base address (high-order bits) of the storage control on one channel is independent of the base address on the other channels and depends on the installed features. However, the low-order address bits for any attached device must be the same on all channels.

Resets

A system reset may be initiated by any channel at any time. It resets all reservations and status conditions stored in the storage control for the channel, ends all block multiplex command chains in progress on the channel, and resets all device interrupts not involving the other channels. Reservations, status, and device interrupts for the other channels, as well as block multiplex chains in progress on the other channels, are not affected.

If a channel initiates a system reset while the selection switch is connected to the other channels, a machine reset is performed when the channel select switch changes to Enabled. A selective reset has no effect on device reservations or status.

STRING SWITCH

String switch is a special feature of the disk storage device, not the 3830-2. This feature allows a 3333 Disk Storage and Control and its attached string of 3330 Disk Storage units, a 3340-A2 Disk Storage and Control and its attached string of 3340 Disk Storage units, or a 3350-A2/A2F (C2/C2F) and its attached string of disk storage units to be dynamically shared by various storage control attachments. This feature must be supported by the functional microcode.

The string switch is similar to the two channel switch feature for the 3830-2 Storage Control.

The 3333, 3340-A2, or 3350-A2/A2F (C2/C2F) has an Enable/Disable switch that allows either or both strings of drives to be partitioned from the storage control attachments.

Selection

Any storage control can select and reserve a drive using the Device Reserve CCW. Any conflicts that may occur when two storage control attachments attempt to reserve the same drive are resolved by hardware in the 3333, 3340-A2, or 3350-A2/A2F (C2/C2F). After the storage control has achieved selection of a drive, it may assign the drive for its exclusive use and continue extended operations such as read and write.

Note: *If the 3333, 3340-A2, or 3350-A2/A2F (C2/C2F) is powered-off or disabled when selection is attempted, the 3830-2 propagates select out which results in a condition code 3 from the channel.*

When the storage control completes its operation with the dedicated drive, and does not need to maintain its reservation, a Device Release CCW issued to the 3333, 3340-A2, or 3350-A2/A2F (C2/C2F) releases the drive and makes it available to any other storage control attachment.

3344 and 3350 String Switch Reservation

When a system reserves a logical volume on a drive that contains several logical volumes, such as the 3350 operating in the 3330-1 compatibility mode or a 3344 operating through one side of the string switch, the entire drive is reserved for that interface. All logical volumes sharing that drive appear to be busy until the reservation is ended.

Error Recovery Procedures

Error recovery procedures have some variations depending on the specific device attached to the storage control. The channel programmer should construct error recovery procedures based on the recovery action tables found in the reference manuals for the specific device involved.

The following is based on information common to all devices and their relationship to the storage control.

ERROR CORRECTION FUNCTION

The device recovery action tables use an error correction function as one step in data error recovery. This function is used when the storage control posts the data check and correctable sense bits in the sense information. These bits are posted if a correctable data error is found in any data area.

Correctable data errors in the home address, count, and key areas are corrected internally by the storage control (3330 only) using command retry. Data check and correctable sense bits are not posted and do not cause a system interrupt.

When the correctable and data check sense bits are included in the sense information, sense bytes 18 through 22 provide the error pattern and displacement.

Error correction is done by aligning the error pattern provided in sense bytes 18 through 22 with the erroneous data in main storage, and comparing the patterns through use of an exclusive OR.

The data error location in CPU main storage is found by using the displacement information from the sense bytes and the counts provided in the interrupted CCW chain. The storage control shows the error location in relation to the first error byte transferred in the operation where the error was discovered.

The displacement between the first byte transferred and the first error byte is found by subtracting the error displacement in sense bytes 18 and 19, from the restart displacement found in sense bytes 15 through 17. The result gives the forward error displacement and is used with the count specified in the interrupt CCW to locate the erroneous data in main storage.

If data chaining was used in the operation that posted the correctable error, the forward displacement may reference data from the second (or subsequent) CCW in the data chain.

Before applying the error correction function, determine whether any error bytes were not transferred because the skip bit was on, a short count in the CCW, or if the error bytes are not in adjacent main storage locations because of data chaining between CCWs.

- If any of the error bytes are in data specified by a CCW with the skip bit on, the error correction function cannot be used for the bytes that were not transferred to main storage
- If any of the error bytes are in data not transferred to main storage because of a short CCW count, the error correction function cannot be used for the bytes that were not transferred to main storage.
- If no short CCW count is found and bit 7 of sense byte 23 indicates channel cut off, the error correction function cannot be applied correctly.
- If the error pattern covers non-adjacent main storage boundaries because of data chaining, the error correction function must be selectively applied to the separate storage locations.
- If the error displacment in sense bytes 18 and 19 is less than 3, the error is partially or totally contained in the correction code bytes. The error pattern in sense bytes 20 through 22 is then constructed as follows:

  1. If the error displacement is zero, the error pattern must be set to zero by the error recovery programs (ERPs).
  2. If the error displacement is one, the two low-order error pattern bytes (bytes 21 and 22) must be set to zero by the ERP. The high-order bytes contain the correction syndrome.
  3. If the error displacement is two, the low-order pattern byte must be set to zero by the ERPs. The high-order bytes contain the correction syndrome.

  Note: *Case 1 also occurs if the error is totally contained in the gap that immediately precedes the data area.*

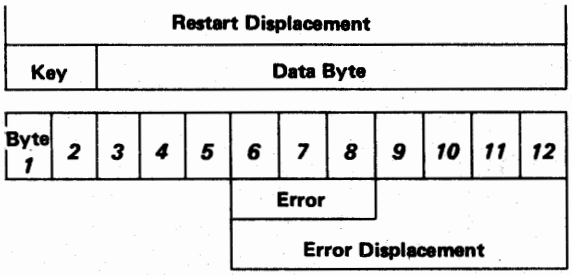
Error Correction Example (3330)

To clarify the correction procedure, examine the following:

Assume: Key length = 2 bytes
Data length = 10 bytes

The CSW-8 points to CCW 1 in the following chain:

CCW	Commands	Address	Count	Flags
1	Read KD	A	2	Data chain
2	TIC	CCW3	--	--
3	--	B	4	data chain, skip
4	--	C	1	suppress incorrect length



Suppose the error affected bytes 6 and 7 as follows:

Byte 6 ---- -- x x
Byte 7 x --- ----
where (—) is the correct bit
where (x) is the incorrect bit

This condition generates a restart displacement of 12 and an error displacement of 7. The error pattern would be generated as follows:

Pattern byte 1 (Sense byte 20) 0000 0011
Pattern byte 2 (Sense byte 21) 1000 0000
Pattern byte 3 (Sense byte 22) 0000 0000

Applying the error correction algorithm, as previously described, results in the following system recovery action.

1. Pattern byte 1 could not be applied to data byte six as this byte was not transferred to main storage because of the skip flag in CCW 3.
2. Pattern byte 2 would be exclusively ORed with location B, where data byte 7 resides.
3. Pattern byte 3 would not be applied to data byte 8 since this byte was not transferred to main storage because of the short count in CCW 4.

CCW Restart Construction

If sense byte 1, bit 7 (operation incomplete) is on, an error occurred after data transfer had started. The error recovery procedures can correct the error and continue the operation normally. The recovery action table specifies the restart CCW required, either 1 or 2. The restart CCW construction process details follow.

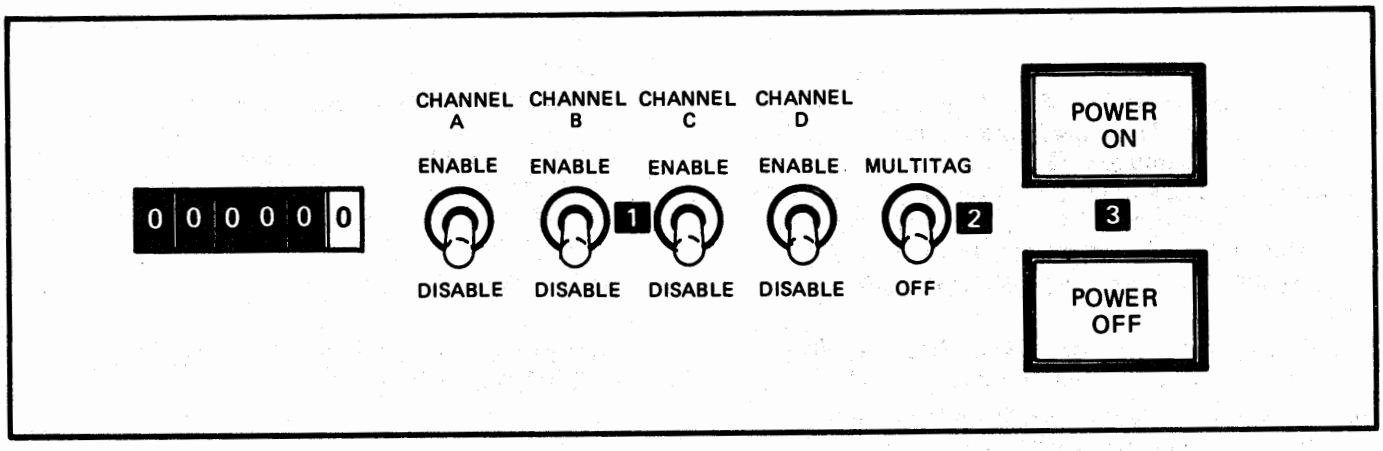
RESTART CCW 1 CONSTRUCTION

1. Get command code byte from sense byte 3.
2. Data address equals interrupted CCW address, plus the CCW count, minus CSW residual count.
3. Use interrupted CCW flags, except for PCI flag.
4. Use CSW residual for count. If zero, use one. If command was a write, specify a byte having '00'. If command was a read, turn on the skip bit.

RESTART CCW 2 CONSTRUCTION

1. Get command code from sense byte 3.
2. Construct count as follows:
   a. Get CCW count shown by CSW-8, and set a pointer to this CCW.
   b. Subtract restart displacement from count in (a). If positive, skip to step f; otherwise, continue.
   c. Check chain data flag of the CCW designated by the pointer. If flag not set, skip to step e; otherwise, continue.
   d. Advance pointer to next non-TIC CCW in data chain. Add this CCW count to count of all previous non-TIC CCWs in the chain. Return to step b.
   e. Truncation occurred. Set Restart CCW 2 count to 1. Skip to step 3 and include skip bit in restart CCW flags.
   f. Set restart CCW 2 count to step b result. Go to step 3.
3. Flags (except PCI) are same as those of CCW designated by pointer in step 2. Skip bit also set if step 2e was executed.
4. Data address equals that of CCW designated by pointer in step 2, plus the count of the CCW, minus restart CCW count from step 2.

   If another operation incomplete or an error in a Read Multiple CKD command occurs, a new restart CCW can be generated. Return to step 2 but don't destroy old restart CCW before generating a new one.



1 Toggle switch that must be in the Enable position before the 3830 Model 2 Storage Control is available to the channel. If two channel switch or two channel switch additional feature is installed, a separate switch is provided for each channel.

2 Toggle switch that determines how the device end generated by the drive in a not-ready-to-ready sequence, is presented to the channel.

Multitag Position: A drive is available to a channel after it clears the device end generated by the drive in a not-ready-to-ready sequence. Before any other channel can use the drive, it must also accept the not-ready-to-ready sequence device end.

Off Position: A drive is made available to all channels after one of the channels clears the device end generated by the drive in a not-ready-to-ready sequence.

3 **Power Off:** A momentary pushbutton that can be used to remove ac power from the 3830 Model 2 and its attached drives.

If system power is on when the pushbutton is pressed, ac power is removed from the 3830 Model 2 and its attached drives. If system power is later turned off, then on, ac power is reapplied to the 3830 Model 2 and its attached drives; operation of the Power On pushbutton is not required.

Power On: A momentary pushbutton that can be used to reverse the effect of the Power Off switch. If system power is on, and the Power Off switch is pressed to remove ac power from the 3830 Model 2 and its attached drives, then pressing the Power On switch will restore ac power to the 3830 Model 2 and its attached drives.

Whenever system power is brought up, ac power is applied to the 3830 Model 2 and its attached drives, regardless of what was previously done to the two pushbuttons.

See Usage Meter for meter operation.

Figure 16. 3830-2 Storage Control Panel

Sense Data

The status and condition of the 3830-2 is reported in the sense bytes. There are 24 bytes and seven different formats, 0 through 6. Four formats, 1, 4, 5, and 6, describe the disk storage (3330, 3340 or 3350). The remaining three formats, 0, 2, and 3, are associated with the 3830-2. A summary of sense data from the following publications is included on the pages that follow.

- *Reference Manual for IBM 3330 Series Disk Storage,* Order No. GA26-1615.
- *Reference Manual for IBM 3340/3344 Disk Storage,* Order No. GA26-1619.
- *Reference Manual for IBM 3350 Direct Access Storage,* Order No. GA26-1638.

SENSE BYTE SUMMARY

In all formats, the first eight bytes (bytes 0 – 7) contain high-level sense and error condition data. Sense byte 7 identifies the format of the remaining sixteen bytes:

- Bits 0 through 3 indicate the format type for bytes 8 through 24

0	1	2	3	Format
0	0	0	0	0
0	0	1	0	2
0	0	1	1	3

- Bits 4 through 7 define a message

4	5	6	7	Message
0	0	0	0	0
∣	∣	∣	∣	∣
∣	∣	∣	∣	∣
∇	∇	∇	∇	∇
1	1	1	1	F

Sense information related to the 3830-2 is found in Figures 17, 18, and 19.

Each of the formats concerned with the disk storage is summarized on the following pages. Figures 20, 21, 22, 23, 24, and 25 contain information relating to 3330 Disk Storage drives. The 3340/3344 sense data is in Figures 26, 27, 28, 29, 30, and 31. Sense data for the 3350 devices is in Figures 32, 33, 34, 35, 36, and 37.

3830-2 FORMAT MESSAGES (Sense Byte 7)

	FORMAT	
Message Number	**0**	**2**
0	No Message	No Message
1	Invalid Command	Not Used
2	Invalid Sequence	Not Used
3	CCW Count Short	S Register Load Check
4	Data Value Incorrect	CI Registers Valid
5	Invalid Diagnostic Write	
6	Channel Halted Retry	
7	Incorrect Retry CCW from Channel	
8	23FD Not Ready	
9	23FD Seek Check	
A	23FD Read Check	
B	Track Pointer Incorrect	
C	Not Used	
D	Index in Record Gap	
E	Not Used	
F	Not Used	

No messages are used with Format 3.

Figure 17. 3830-2 Formats 0 and 2 Messages

3830-2 FORMAT 2 SENSE BYTE SUMMARY (Equipment Errors)

	Bit 0	1	2	3	4	5	6	7
Byte 11 3830-2 Errors	Channel Buffer Parity	Channel A (or C) Check	Channel B (or D) Check	Data Transfer Check	CI Check	Load S Register	Compare Assist	Multicon-nect C or D Check
Byte 13 TA Register Contents (Message 4)								
Byte 14 MA Register Contents (Message 4)								
Byte 15 TD Register Contents (Message 4)								
Byte 20 Drive Interface Errors	3333 Check	Select Active Check	Bus In Parity Check	Unexpect-ed End	Tag Bus Parity Check	Bus Out Parity Check	DCI Transfer Check	Not Used

Figure 18. 3830-2 Format 2 Summary

3830-2 FORMAT 3 SENSE BYTE SUMMARY (Control Errors)

	Bit 0	1	2	3	4	5	6	7
Byte 8 Failing Instruction Address	High-order address byte of control storage word addressed when error was detected.							
Byte 9 Failing Instruction Address	Low-order address byte of control storage word addressed when error was detected.							
Byte 10 Error Latches Bit 0=1	1	Clock Error	CA Decode Even	CA Decode Odd	CB Decode Even	CB Decode Odd	Branch Status	Special Operation
Bit 0=0	0	Clock Error	CS Decode	0	A Register	B Register	ALU	23FD Parity
Byte 11 Byte 10, Bit 0=1	0	Storage Read Multiple 0/1	Storage ECC Multiple 2/3	Not Used	Cycle Control	CD Decode	Not Used	Not Used
Byte 10, Bit 0=0	Storage Address Bus 1–7	Storage Address Bus 8–13	Storage Write Bus 0/2	Storage Write Bus 1/3	Address Bus 1–13 Low	Address Bus 1–13 High	23FD Not Ready	0
Byte 12 Storage Error Pattern	Identifies the failing bits of a control storage cycle.							
Byte 13 TC Register Contents	Contents of the TC Register after unsolicited selective reset. Register is reset if selective reset is in response to disconnect in from storage control.							
Byte 14 TG Register Contents	Contents of the TG Register after unsolicited selective reset. Register is reset if selective reset is in response to disconnect in from storage control.							
Bytes 15–23 Not Used	Not Used							

No messages are used with 3830-2 Format 3.

Figure 19. 3830-2 Format 3 Summary

3333 SENSE BYTES 0 through 7 SUMMARY

	Bit 0	1	2	3	4	5	6	7
Byte 0	Command Reject	Inter-vention Required	Channel Bus Out Parity	Equipment Check	Data Check	Overrun	Not Used	Not Used
Byte 1	Permanent Error	Invalid Track Format	End of Cylinder	Not Used	No Record Found	File Protected	Write Inhibited	Operation Incomplete
Byte 2	Not Used	Correctable	Not Used	Environ-mental Data Pres-ent	Not Used	Not Used	Not Used	Not Used
Byte 3 Restart	Restart command (provided only when byte 1, bit 7 is on). '06' = Read operation; '05' = Write operation							
Byte 4 Physical Identity	Storage Control Identification		Physical Drive Identification 111000 = A 101010 = C 011100 = E 001110 = G 110001 = B 100011 = D 010101 = F 000111 = H					
Byte 5 Cylinder Address	Low-order Logical Cylinder Address 128	64	32	16	8	4	2	1
Byte 6 3330-1,2 Head Address	Not Used	Cylinder High Address 256	Not Used	Head Address 16	8	4	2	1
Byte 6 3330-11 Head Address	Not Used	Cylinder High Address 512	Cylinder High Address 256	Head Address 16	8	4	2	1
Byte 7 Format/ Message	Format (bits 0 through 3)				Message Code (bits 4 through 7)			

Figure 20. 3333 Sense Bytes 0 through 7 Summary

SENSE BYTE 0

Bit 0 Command Reject	1. Invalid command code. 2. Invalid command sequence. 3. Invalid or incomplete argument transferred by a control command. 4. Track formatted without home address. 5. Write portion of file mask violated. 6. Improper alternate or defective track pointer. 7. Write command issued with Write Inhibit switch in Read position (byte 1, bit 6 also on).
Bit 1 Intervention Required	1. Drive addressed not attached to system. 2. Drive addressed not ready. 3. Diagnostic Write or Load command issued and microdiagnostic is resident in control storage.
Bit 2 Bus Out Parity	The storage control has detected a parity error in the data transferred from the channel.
Bit 3 Equipment Check	An unusual hardware condition in the channel, storage control, or drive. (Condition further defined in bytes 7 through 23.)
Bit 4 Data Check	1. A correctable data error detected in information received from a drive. (Byte 2, bit 1 on, and correction data in bytes 15 through 22.) 2. An uncorrectable data error detected in information from a drive. (Condition defined in sense byte 7.)
Bit 5 Overrun	1. Storage control received byte from drive before last byte read was accepted by channel. 2. Data byte received too late from channel during write operation. *The storage control posts overrun only if condition occurs: (1) more than ten times in CCW chain, (2) in second or later segments of overflow record, or (3) during format write operation. Overrun detection stops data transmission. When writing, remaining part of record area is padded with 0s. All data overruns are retried by storage control except for overruns occurring on second or later record segments or overruns occurring during format write operations. If overrun exists after retry is exhausted, byte 1, bit 0 (permanent error) is posted.*
Bit 6,7	Not used -- set to 0.

Figure 21. 3333 Sense Byte 0 Description

SENSE BYTE 1

Bit 0 Permanent Error	1. Storage control retry attempted and not successful. 2. A drive unsafe condition detected and retry should not be attempted.
Bit 1 Invalid Track Format	1. An attempt was made to write data exceeding track capacity. 2. Index detected in count area or key area gap during read or search operation (programming error).
Bit 2 End of Cylinder	1. A multitrack read or search attempted to go beyond the cylinder boundary. 2. An overflow operation attempted to go past the cylinder boundary. (Byte 1, bit 7, operation incomplete, also set.)
Bit 3	Not used -- set to 0.
Bit 4 No Record Found	1. Two index points sensed in command chain with no intervening Read in home address or data area. 2. Two index points sensed in command chain with no intervening Write, Sense, or Control command.
Bit 5 File Protected	File mask violated by: 1. Seek command. 2. Multitrack read or search. 3. Overflow operation. (Byte 1, bit 7 also on.)
Bit 6 Write Inhibited	An attempt was made to write on drive with Write Inhibit switch set to Read, (byte 0, bit 0 also set).
Bit 7 Operation Incomplete	One of the following occurred when overflow record was processed: 1. Overflow to a file protected boundary. (Byte 1, bit 5 also set.) 2. Overflow beyond cylinder boundary. (Byte 1, bit 2 also set.) 3. Correctable data error found in data area - not last segment. (Byte 2, bit 1 and byte 0, bit 4 also set.) 4. Uncorrectable data error found in any area - not first segment. 5. Defective or alternate track found after start of data transfer. 6. Seek error found in second or later segment. See Sense Byte 3 for restart command, and the appropriate device reference manual for restart information.

Figure 22. 3333 Sense Byte 1 Description

SENSE BYTE 2

Bit 0	Not used -- set to 0.
Bit 1 Correctable	Indicates that data error posted in byte 0, bit 4 is correctable. Bytes 15 through 22 identify error pattern and displacement.
Bit 2	Not used -- set to 0.
Bit 3 Environmental Data Present	Indicates that bytes 8 through 23 contain either usage or error statistics for error log information. Byte 7 indicates format for bytes 8 through 23.
Bits 4–7	Not used -- set to 0.

SENSE BYTE 3

Bits 0–7 Restart Command	When byte 1, bit 7 is set, this byte shows the operation in process at the time of interrupt. 0000 0110 = Read 0000 0101 = Write

SENSE BYTE 4

Bits 0,1	Physical storage control identification.
Bits 2–7 Drive Identification	Physical address of each drive 111000 = A 101010 = C 011100 = E 001110 = G 110001 = B 100011 = D 010101 = F 000111 = H

SENSE BYTE 5

Bits 0–7 Cylinder-low	Identifies the low-order cylinder address of latest seek argument from channel.

Figure 23. 3333 Sense Bytes 2 through 5 Descriptions

3333 SENSE BYTES

SENSE BYTE 6

Bit 0		Not used, set to zero.
Bit 1	3330-1,2 Cylinder High	High-order bit (256) of cylinder address in sense byte 5.
	3330-11	High-order bit (512) of cylinder address in sense byte 5.
Bit 2	3330-1,2 Difference	Not used, set to zero.
	3330-11	High-order bit (256) of cylinder address in sense byte 5.
Bits 3-7	Head Address	Identifies head address of last seek (excluding retry seeks). Head address is updated during multitrack and overflow operations.
Note: If an alternate track condition is detected and operation incomplete is posted during an overflow operation, byte 6 is set in the head address of the defective track plus 1. This information is used by the ERPs to construct the seek argument to continue the operation. The remainder of the seek argument is obtained from the user, not the sense bytes.		

SENSE BYTE 7

Bits 0-3	Format	Specifies the format of sense bytes 8 through 23 as follows: 0000 = Format 0, programming or system check. 0001 = Format 1, disk drive equipment check (CE information). 0010 = Format 2, storage control equipment check (CE information). 0011 = Format 3, storage control control checks (CE information). 0100 = Format 4, ECC uncorrectable data checks. 0101 = Format 5, ECC correctable data checks*. 0110 = Format 6, usage/error statistics. * Also may be presented on errors which are not ECC correctable but which require restart displacement information.
Bits 4-7	Message	Describes the specific nature of the error conditions for each of the above formats. The message table that accompanies the format descriptions specifies the function of the message bits for the format.

Figure 24. 3333 Sense Bytes 6 and 7 Descriptions

3333 FORMAT MESSAGES (Sense Byte 7)

Message Number	FORMAT 1	FORMAT 4	FORMAT 5
0	No message.	HA area ECC uncorrectable.	Correctable HA area.
1	Set target error.	Count area ECC uncorrectable.	Correctable count area.
2	Microprogram detected error (see byte 18).	Key area ECC uncorrectable.	Correctable key area.
3	Not used.	ECC uncorrectable data checks.	ECC correctable data checks*.
4	Not used.	No sync byte in HA area.	
5	String switch error in resetting a primed interrupt (3333 string switch only).	No sync byte in count area.	
6	Transmit cylinder error.	No sync byte in key area.	
7	Transmit head error.	No sync byte in data area.	
8	Transmit difference error.	Not used.	
9	Unexpected file status.	No address mark detection on retry.	
A	Seek error.		
B	Retry seek incomplete.		
C	No interrupt from drive.		
D	ECC P2 or P3 compare failure.		
E	ECC P1 compare failure.		
F	Retry byte count/sector value incorrect.		

* Also may be presented on errors which are not ECC correctable but which require restart displacement information.

Figure 25. 3333 Format Messages

3340/3344 SENSE BYTES 0 through 7 SUMMARY

	Bit 0	1	2	3	4	5	6	7
Byte 0	Command Reject	Inter-vention Required	Channel Bus Out Parity	Equipment Check	Data Check	Overrun	Track Condition Check	Seek Check
Byte 1	Permanent Error	Invalid Track Format	End of Cylinder	Not Used	No Record Found	File Protected	Write Inhibited	Operation Incomplete (See Byte 3)
Byte 2	RPS Present	Correctable Data Error	Not Used	Environ-mental Data Pre-sent	3344 Drive	Data Module Size		
						35 MB '001'	70 MB '010'	Fixed Head '110'
Byte 3 Restart	Restart command (provided only when byte 1, bit 7 is on). '06' = Read operation; '05' = Write operation							
Byte 4 3340 Drive Identity	Drive A	Drive B	Drive C	Drive D	Drive E	Drive F	Drive G	Drive H
Byte 4 3344 Drive Identity	String Address		Not Used	Not Used	Not Used	Drive Address		
Byte 5 Cylinder Address	Low-order Logical Cylinder Address							
	128	64	32	16	8	4	2	1
Byte 6 Head Address	Not Used	Cylinder High Address 512	Cylinder High Address 256	3344 Cylinder Address 2048	Logical Head Address			
					8	4	2	1
Byte 7 Format/ Message	Format (bits 0 through 3)				Message Code (bits 4 through 7)			

Figure 26. 3340/3344 Sense Bytes 0 through 7 Summary

SENSE BYTE 0

Bit 0 Command Reject	1. Invalid command code. 2. Invalid command sequence. 3. Invalid or incomplete argument transferred by a control command. 4. Track formatted without home address. 5. Write portion of file mask violated. 6. Write command issued with Write Inhibit switch in Read position (byte 1, bit 6 also on). 7. A format write command is attempted after Write R0 on a track that is flagged as defective.
Bit 1 Intervention Required	1. Drive addressed not attached to system. 2. Drive addressed not ready. 3. Diagnostic Write or Load command issued and microdiagnostic is resident in control storage.
Bit 2 Bus Out Parity	The storage control has detected a parity error in the data transferred from the channel.
Bit 3 Equipment Check	An unusual hardware condition in the channel, storage control, or drive. (Condition further defined in bytes 7 through 23.)
Bit 4 Data Check	1. A correctable data error detected in information received from a drive. (Byte 2, bit 1 on, and correction data in sense bytes 15 through 21.) 2. An uncorrectable data error detected in information from a drive. (Condition defined in sense byte 7.)
Bit 5 Overrun	1. Storage control received byte from drive before last byte read was accepted by channel. 2. Data byte received too late from channel during write operation.
Bit 6 Track Condition Check	1. Any read or search command, other than Search HA, Read HA, or Read R0, is attempted on a defective track. 2. Any multitrack command that switches from a storage control known defective or alternate track.
Bit 7 Seek Check	The selected drive was not correctly positioned.

Figure 27. 3340/3344 Sense Byte 0 Description

SENSE BYTE 1

Bit 0 Permanent Error	Bit set by error recovery procedures (ERPs).
Bit 1 Invalid Track Format	An attempt was made to write data exceeding the track capacity.
Bit 2 End of Cylinder	1. A multitrack read or search attempted to go beyond the cylinder boundary. 2. An overflow operation attempted to go past the cylinder boundary. (Byte 1, bit 7, operation incomplete, also set.)
Bit 3	Not used -- set to 0.
Bit 4 No Record Found	1. Two index points sensed in command chain with no intervening read in home address or data area. 2. Two index points sensed in command chain with no intervening Write, Sense, or Control command.
Bit 5 File Protected	File mask violated by: 1. Seek command. 2. Multitrack read or search. 3. Overflow operation. (Byte 1, bit 7 also on.)
Bit 6 Write Inhibited	An attempt made to write on drive with Write Protect switch set to Read.
Bit 7 Operation Incomplete	One of the following occurred when an overflow record was processed: 1. Overflow to a file protected boundary. (Byte 1, bit 5 also set.) 2. Overflow beyond cylinder boundary. (Byte 1, bit 2 also set.) 3. Correctable data error found in data area - not last segment. (Byte 2, bit 1 also set.) 4. Correctable data error found in home address or count area - not first segment.

Figure 28. 3340/3344 Sense Byte 1 Description

SENSE BYTE 2

Bit 0 RPS Feature Present	The Rotational Position Sensing (RPS) feature is installed in the selected drive.
Bit 1 Correctable	Indicates that data error posted in byte 0, bit 4 is correctable. Bytes 15 through 22 identify error pattern and displacement.
Bit 2	Not used -- set to 0.
Bit 3 Environmental Data Present	Indicates that sense bytes 8 through 23 contain either usage or error statistics for error log information. Byte 7 indicates format for bytes 8 through 23.
Bit 4 Device Type	Indicates that the addressed device is not an actual 3340, but a 3344.
Bits 5–7 Data Module Size	Defines the size of the selected data module

DM Size	Bit 5	Bit 6	Bit 7
35 Mb	0	0	1
70 Mb*	0	1	0
Fixed Head**	1	1	0

* Posted on all 3344 logical addresses.
** Posted only on this primary logical volume of the 3344.

SENSE BYTE 3

Bits 0–7 Restart Command	When byte 1, bit 7 is set, this byte shows the operation in process at the time of interrupt. 0000 0110 = Read 0000 0101 = Write When byte 1, bit 7 is zero, this byte is zero.

SENSE BYTE 4

Bits 0–7 3340 Drive Identification	Physical address of each drive. 0 = Drive A 1 = Drive B 2 = Drive C 3 = Drive D 4 = Drive E 5 = Drive F 6 = Drive G 7 = Drive H				
Bits 0–7 3344 Drive Identification	Bits 0–1 String Address	Bit 2 Not Used	Bit 3 Not Used	Bit 4 Not Used	Bits 5–7 Drive Address

SENSE BYTE 5

Bits 0–7 Cylinder-low	Identifies the low-order cylinder address of latest seek argument from channel.

Figure 29. 3340/3344 Sense Bytes 2 through 5 Description

SENSE BYTE 6

Bit 0 Not Used	Set to zero.
Bit 1 Cylinder-High	High-order bit (512) of cylinder address in sense byte 5.
Bit 2 Cylinder-High	High-order bit (256) of cylinder address in sense byte 5.
Bit 3*	Set to zero for 3340. Bit indicates 2048 for the 3344.
Bits 4–7 Head Address	Head address of last seek (except retries). Head address is updated during multitrack and overflow operations. **Note:** *If an alternate track condition is found and operation incomplete is posted during an overflow operation, the entire seek argument should be obtained from the user's chain, not the sense bytes. The ERPs will add 1 to the defective head byte to continue the operation.*

*CE cylinders posted as 2800 through 2804 which results in cylinder bits 1 and 3 being set, plus the additional bits in byte 5. These are added together to determine the seek address of the CE cylinder.

SENSE BYTE 7

Bits 0-3	Format	Specifies the format of sense bytes 8 through 23 as follows: 0000 = Format 0, programming or system check. 0001 = Format 1, disk drive equipment check (CE information). 0010 = Format 2, storage control equipment check (CE information). 0011 = Format 3, storage control control check (CE Information). 0100 = Format 4, ECC uncorrectable data checks. 0101 = Format 5, ECC correctable data checks*. 0110 = Format 6, usage/error statistics. * Also may be presented on errors which are not ECC correctable but which require restart displacement information.
Bits 4-7	Message	Describes the specific nature of the error conditions for each of the above formats. The message table that accompanies the format descriptions specifies the function of the message bits for the format.

SENSE BYTES 8 through 21 NOT USED

SENSE BYTES 22 and 23

1. If a Sense command is chained to a successful Read HA, these bytes contain SD bytes of the track.
2. Not valid for other conditions.

Figure 30. 3340/3344 Sense Bytes 6 through 23 Descriptions

3340/3344 FORMAT MESSAGES (Sense Byte 7)

Message Number	FORMAT 1	FORMAT 4	FORMAT 5
0	No message	HA field data check	Not used
1	Transmit target error	Count field data check	Not used
2	Microprogram detected errors (See byte 18)	Key field data check	Not used
3	Transmit: (3340) fixed head error (3344) difference high error	ECC uncorrectable data checks	ECC correctable data checks*
4	Sync out timing error	No sync byte in HA area	
5	Unexpected drive status at initial selection	No sync byte in count area	
6	Transmit cylinder error (string switch only)	No sync byte in key area	
7	Transmit head error	No sync byte in data area	
8	Transmit difference error	Not used	
9	Unexpected file status during Read IPL or retry	Not used	
A	Seek verification check on physical address		
B	Seek incomplete or sector compare		
C	No interrupt from drive		
D	Defect skipping re-orientation check		
E	(3340 only) Data Module type undetermined at initial selection		
F	Not used		

* Also may be presented on errors which are not ECC correctable but which require restart displacement information.

Figure 31. Format Messages

3350 SENSE BYTE 0 through 7 SUMMARY

	Bit 0	1	2	3	4	5	6	7
Byte 0	Command Reject	Inter-vention Required	Channel Bus Out Parity	Equipment Check	Data Check	Overrun	Not Used	Not Used
Byte 1	Permanent Error	Invalid Track Format	End of Cylinder	Not Used	No Record Found	File Protected	Write Inhibited	Operation Incomplete
Byte 2	Not Used	Correctable	Alternate Controller Selected	Environ-mental Data Present	Compat-ibility Mode	Not Used	Not Used	Not Used
Byte 3 Restart	Restart command (provided only when byte 1, bit 7 is on). '06' = Read operation, '05' = Write operation							
Byte 4 Drive Identification	Drive 0	Drive 1	Drive 2	Drive 3	Drive 4	Drive 5	Drive 6	Drive 7
Byte 5 Cylinder Address	Low-order Logical Cylinder Address							
	128	64	32	16	8	4	2	1
Byte 6 Cylinder and Track Address	CE Cylinder (1024) oth-er bits off	Native or 3330-11 Mode		Logical Head Address				
		512	256					
		3330-1 Mode						
		256	0	16	8	4	2	1
Byte 7 Format/ Message	Format (bits 0 through 3)				Message Code (bits 4 through 7)			

Figure 32. 3350 Sense Bytes 0 through 7 Summary

SENSE BYTE 0

Bit 0 Command Reject	1. Invalid or uninstalled feature command code. 2. Invalid command sequence issued. 3. Invalid or incomplete argument transferred by a control command. 4. Track formatted without home address. 5. Write portion of file mask violated. 6. Write command received for device with Write Protect switch on (byte 1, bit 6 also on). 7. Format write attempted on defective track.
Bit 1 Intervention Required	1. Drive addressed not attached to system. 2. Drive addressed not ready (HDA not powered-up). 3. Diagnostic Write or Load command issued and microdiagnostic is resident in control storage. 4. Addressed device in CE mode and not available for use.
Bit 2 Bus Out Parity	The storage control has detected a parity error in the data transferred from the channel.
Bit 3 Equipment Check	An unusual hardware condition in the channel, storage control, controller, or drive. (Condition further defined in bytes 7 through 23.)
Bit 4 Data Check	1. A correctable data error detected in information received from a drive. (Byte 2, bit 1 on, and correction data in bytes 15 through 22.) 2. An uncorrectable data error detected in information from a drive. (Condition defined in sense byte 7.)
Bit 5 Overrun	1. Storage control received byte from drive before last byte read was accepted by channel. 2. Data byte received too late from channel during write operation. *The storage control posts overrun only if condition occurs: (1) more than ten times in CCW chain, (2) in second or later segments of overflow record, or (3) during format write operation. Overrun detection stops data transmission. When writing, remaining part of record area is padded with 0s. All data overruns are retried by storage control except for overruns occurring on second or later record segments or overruns occurring during format write operations. If overrun exists after retry is exhausted, byte 1 bit 0 (permanent error) is posted.*
Bit 6,7	Not used -- set to 0.

Figure 33. 3350 Sense Byte 0 Description

SENSE BYTE 1

Bit 0 Permanent Error **Note**: *This bit overrides all other bit settings.*	1. Storage control retry attempted and not successful. 2. No system error recovery procedure is required.
Bit 1 Invalid Track Format	1. An attempt was made to write data exceeding the track capacity. 2. Index detected in count or key area gap during read or search operation (programming error).
Bit 2 End of Cylinder	1. A multitrack read or search attempted to go beyond the cylinder boundary. 2. An overflow operation attempted to go past the cylinder boundary. (Byte 1, bit 7, operation incomplete, also set.)
Bit 3	Not used -- set to 0.
Bit 4 No Record Found	1. Two index points sensed in command chain with no intervening Read in home address or data area, or without a Write, Sense, or Control command. Access position is verified before the bit is posted (programming error). 2. Indicates a programming error or an expected programming condition occurred.
Bit 5 File Protected	File mask violated by: 1. Seek command. 2. Multitrack read or search. 3. Overflow operation. (Byte 1, bit 7 also on.)
Bit 6 Write Inhibited	An attempt was made to write on drive with Read Only switch on, (Byte 0, bit 0 also set).
Bit 7 Operation Incomplete	One of the following occurred when overflow record was processed: 1. Overflow to a file protected boundary. (Byte 1, bit 5 also set.) 2. Overflow beyond cylinder boundary. (Byte 1, bit 2 also set.) 3. Correctable data error found in data area - not last segment. (Byte 2, bit 1 and byte 0, bit 4 also set.) 4. Correctable data error found in home address or count area - not first segment. 5. Uncorrectable data error found in any area - not first segment. 6. Defective or alternate track found after start of data transfer. 7. Seek error found in second or later segment.

Figure 34. 3350 Sense Byte 1 Description

SENSE BYTE 2

Bit 0	Not used -- set to 0.
Bit 1 Correctable	Indicates that data error posted in byte 0, bit 4 is correctable. Bytes 15 through 22 identify error pattern and displacement.
Bit 2 Alternate Controller	Alternate controller selected
Bit 3 Environmental Data Present	Indicates that bytes 8 through 23 contain either usage or error statistics for error log information (format 6). Includes number of bytes read/searched, overruns by channel, and number of access motion seeks. Byte 7 indicates format for bytes 8 through 23.
Bit 4 Compatibility Mode	If 1, a 3350 is operating in 3330 compatibility mode. If 0, a 3350 is operating in native mode.
Bits 5–7	Not used -- set to 0.

SENSE BYTE 3

Bits 0–7 Restart Command	When byte 1, bit 7 is set, this byte shows the operation in process at the time of interrupt (zero with byte 1, bit 7 off). 0000 0110 = Read 0000 0101 = Write

SENSE BYTE 4

Bits 0–7 Drive Identification	Physical address of each drive indicated by active bit: 0 = Drive 0 1 = Drive 1 2 = Drive 2 3 = Drive 3 4 = Drive 4 5 = Drive 5 6 = Drive 6 7 = Drive 7

SENSE BYTE 5

Bits 0–7 Physical Drive Identification	Identifies low-order eight bits of the current seek argument.								
	Bit	0	1	2	3	4	5	6	7
	Cylinder	128	64	32	16	8	4	2	1

Figure 35. 3350 Sense Bytes 2 through 5 Descriptions

SENSE BYTE 6

This byte identifies the logical track address and cylinder used in the current seek. Bits 0 through 2 indicate the high-order address bit; bits 3 through 7 indicate the logical head.

Bit No.	Native or 3330-11 Mode	3330-1 Mode
0	CE Cylinder* (1024)	CE Cylinder* (1024)
1	Cylinder 512	Cylinder 256
2	Cylinder 256	Cylinder 0
3	Logical Head 16	
4	Logical Head 8	
5	Logical Head 4	
6	Logical Head 2	
7	Logical Head 1	

*When CE cylinder (1024) is addressed, bit 0=1 and all other cylinder bits of bytes 5 and 6 = 0. Bits 3 through 7 of byte 6 can show any address from 0 through 29. If an alternate track condition is detected and operation incomplete is posted during an overflow operation, byte 6 is set to the head address of the defective track plus 1. This information is used by the ERPs to construct the seek argument to continue the operation. The remainder of the seek argument is obtained from the use, not the sense bytes.

SENSE BYTE 7

Bits 0–3 Format	Specifies the format of sense bytes 8 through 23 as follows: 0000 = Format 0, programming or system check. 0001 = Format 1, disk drive equipment check (CE information). 0010 = Format 2, storage control equipment check (CE information). 0011 = Format 3, storage control control check (CE information). 0100 = Format 4, ECC uncorrectable data checks. 0101 = Format 5, ECC correctable data checks*. 0110 = Format 6, usage/error statistics. * Also may be presented on errors which are not ECC correctable but which require restart displacement information.
4–7 Message	Describes the specific nature of the error conditions for each of the above formats. The message table that accompanies the format descriptions specifies the function of the message bits for the format.

SENSE BYTES 8 THROUGH 17 NOT USED

SENSE BYTES 18 THROUGH 23

1. If a Sense command is chained to a successful Read HA, these bytes contain SD bytes of the track.
2. Not valid for other conditions.

Figure 36. 3350 Sense Bytes 6 through 23 Descriptions

3350 FORMAT MESSAGES (Sense Byte 7)

Message Number	FORMAT 0	FORMAT 1	FORMAT 4	FORMAT 5
0	No Message	No Message	HA Area Data Check	No Message
1	Invalid Command	Transmit Target Error	Count Area Data Check	No Message
2	Invalid Sequence	Microprogram Detected Errors	Key Area Data Check	No Message
3	CCW Count Too Small	Transmit Difference High Error	ECC Uncorrectable Data Checks	ECC Correctable Data Checks*
4	Invalid Argument	Sync Out Timing Error	No Sync Byte in HA Area	
5	Invalid Diagnostic Write	Unexpected Drive Status at Initial Selection	No Sync Byte in Count Area	
6	Channel Halted Retry	Transmit Cylinder Address (String Switch)	No Sync Byte in Key Area	
7	Incorrect Retry CCW from Channel	Transmit Head Error	No Sync Byte in Data Area	
8	MPL Not Ready	Transmit Difference Error	Not Used	
9	MPL Seek Check	Unexpected File Status in Read IPL or Retry	No Address Mark Detection on Retry	
A	MPL Read Check	Seek Error Address		
B	Track Pointer Incorrect	Sector Noncompare or Retry Seek Incomplete		
C	String Switch Hardware Inoperative	No Interrupt from Drive		
D	Not Used	Defect Skipping Re-orient Check		
E	Not Used	Device Type Undetermined		
F	Not Used	Retry Orientation check		

*Also may be presented on errors which are not ECC correctable but which require restart displacement information.

Figure 37. 3350 Format Messages

A

B

C

D

S

T

U

W

Numeric

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Previous Newsletters None

Reference Manual for IBM 3830 Storage Control Model 2

This Technical Newsletter provides replacement pages for the subject publication. Pages to be inserted and/or removed are:

5 through 12	77 through 80
15 through 18	87, 88
43, 44	93, 94
49, 50	99, 100
69, 70	

A change to the text or an illustration is indicated by a vertical line to the left of the change.

Summary of Amendments

1. Adds Clear I/O instruction to supervisor state.
2. Adds byte 4, bit 5 definition to channel command word.
3. Clarifies CSW Function.
4. Revises Figure 5 (CSW) to reflect S/370 specifications.
5. Adds PSW control modes.
6. Replaces Figure 6 to reflect Extended Control mode.
7. Adds addressing requirement for Two-Channel Switch.
8. Adds clarification to Figure 10, 3830-2 configurations.
9. Notes that all channel command pages now use a sixth flag bit.
10. Changes the chaining requirements for the Device Reserve page.
11. Modifies Note (Figure 11) regarding RPS track balance computation.
12. Adds qualification to generation of new restart CCW 2.
13. Changes 3333 Format 5 message.
14. Modifies Note (Figure 25) for 3340/3344, sense byte 6 head address bits.
15. Changes 3340/44 and 3350 Format 5 messages.

Note: *Please file this cover letter at the back of the manual to provide a record of changes.*

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